FACULTE DES SCIENCES ECONOMIQUES, SOCIALES, POLITIQUES ET DE LA COMMUNICATION

URBAN-RURAL MORTALITY DIFFERENTIALS IN ADULTS IN BURKINA FASO: MEASURES AND EFFECTS OF MIGRATION.

Thèse présentée par

Lankoandé Yempabou Bruno

En vue de l'obtention du grade de :
Docteur en Sciences Politiques et Sociales (Démographie)

Membres du Jury

Prof. Bruno Masquelier (UCL), Promoteur
Prof. Abdramane Soura (Université Ouaga I Pr Joseph Ki-Zerbo), Co-promoteur
Prof. Peter Byass (Umeå University), Examinateur externe
Prof. Philippe Bocquier (UCL), Membre du comité, et président du jury
Prof. Clémentine Rossier (Université de Genève), Membre du comité et secrétaire du jury
Prof. Ali Sié (Centre de recherche en santé de Nouna, Burkina Faso), Membre du comité

Septembre 2018

REMERCIEMENTS

Je souhaiterais adresser mes sincères remerciements à toutes les personnes qui ont contribué de près ou de loin à l'aboutissement de cette recherche doctorale.

Tout d'abord, merci à mon promoteur Bruno Masquelier, qui en plus de sa disponibilité, de son dynamisme, a fait preuve de compréhension, et d'humanisme tout au long de ces quatre années de collaboration. J'ai beaucoup appris auprès de lui, aussi bien sur le plan scientifique que sur le plan humain. Mes remerciements s'adressent également à Philippe Bocquier, par ailleurs, président du jury, pour la relecture de mes travaux, tout au long de la thèse, avec toute la rigueur qui s'impose.

Je témoigne ma gratitude également aux autres membres du jury. Merci à Abdramane Soura et à Clémentine Rossier pour avoir guidé mes premiers pas dans le monde de la démographie au sein de l'équipe de l'Observatoire de Population de Ouagadougou. Je remercie Peter Byass, relecteur externe de cette thèse, et Ali Sié, membre du jury, pour leurs remarques et suggestions lors de la défense privée. Mes remerciements vont également à l'endroit de Géraldine Duthé pour sa relecture de mes travaux.

C'est le moment aussi de remercier l'Administration des Relations Internationales de l'UCL pour l'appui financier dont j'ai bénéficié dans la conduite de mes travaux de recherche. Je remercie également toute l'équipe de coordination du projet DEMOSTAF qui a également contribué à la prise en charge de mes séjours de recherche hors de l'UCL. Je ne peux oublier de remercier l'ISSP qui m'a toujours accueilli dans un environnement convivial au cours de mes multiples séjours à Ouagadougou (Burkina Faso).

Je porte ma gratitude aux collègues du centre en recherche en démographie de l'UCL pour la convivialité qui a toujours régné au cours de mes différents séjours à l'UCL. Je remercie tout particulièrement, Norbert Kpadonou, mon compagnon de lutte, pour le soutien moral, et les encouragements. J'exprime ma reconnaissance à Isabelle Theys pour sa disponibilité et les mots d'encouragement.

Aux amis et membres de ma famille qui m'ont accompagné tout au long de cette aventure, je leur dis merci. Merci à Ouédraogo Issouf, Ouedraogo Youssouf, et à la famille Ponghi pour leur soutien. Je ne peux oublier de remercier mon épouse Isabelle pour son soutien et sa compréhension malgré mes long moments d'absence. Merci également à mon fils, Papi, dont

la naissance m'a donné le courage de continuer à un moment crucial du parcours doctoral. Merci à tous les autres membres de ma famille, plus particulièrement mon frère Hermann Lankoandé, pour son soutien indéfectible, et ma mère pour les nombreuses bénédictions.

Je ne saurai terminer sans saluer la mémoire de mon père qui nous a quitté dès ma première année de thèse. Celui là même qui a toujours fait de notre éducation une priorité malgré le manque de moyens financiers, je lui dédie cette thèse.

ABSTRACT

Evidence regarding differences in mortality between urban and rural areas of Sub-Saharan Africa has been largely based on the experience of children. Urban-rural mortality differentials in adults are often obtained by inferring from child mortality rates and model life tables. However, the rapid urbanization in Sub-Saharan Africa is associated with some health challenges specific to adults, such as HIV/AIDS, tuberculosis, occupational hazards, violence, road traffic accidents, and a growing burden of non-communicable diseases. For this reason, urban-rural mortality differentials in adults should be measured, and not modelled. Measuring these differentials, and making sense of the resulting estimates also requires to take into account the issue of migration. Urban and rural areas are historically interlinked through important migration flows. In this context, the main objectives of this dissertation are to contribute to the measurement of urban-rural mortality differentials in adults and to the analysis of the impact of migration on that differential in Sub-Saharan Africa. The analysis draws mainly on the case of Burkina Faso, and combines various sources of data, (including sample surveys, Health and Demographic Surveillance Systems, and censuses) to circumvent the scarcity of data on adult survival. This dissertation shows that mortality indicators derived from censuses in rural areas can be severely underestimated, in particular in women. The measurement of urban-rural mortality differentials based on census data can be affected by underreporting of deaths, age misreporting and misreporting of the place of residence of deceased persons due to the mobility of dying individuals. Apart from censuses, other sources of data on adult survival based on the survival of close relatives (parents and siblings) are also plagued by underreporting of deaths, and most importantly missing information on the place of residence of individuals exposed to the risk of dying. Despite these limitations, a systematic analysis based on all available data indicates that in Burkina Faso, adults living in urban areas still benefit from a health advantage compared to their rural counterparts. Regarding migration, positive selection of migrants in rural areas plays a role in shaping the urban health advantage. However, the health status of migrants tend to deteriorate with their duration of residence in cities. The dissertation suggests that innovative strategies are needed to improve the quality of data collected on adult survival in Africa.

Tables des matières

LISTE DES SIGLES ET ABREVIATIONS

SSA Sub-Saharan Africa

CSPS Centre de Santé et de Promotion Sociale

CRVS Civil Registration and Vital Statistics

DHS Demographic and Health Survey

GBM Growth Balance Method

HDSS Health and Demographic Surveillance System

ICD International Classification of Diseases

INDEPTH International Network for Demographic Evaluation of Populations and Their Health

IPUMS Integrated Public Use Microdata Series

MDGs Millennium Development Goals

MICS Multi Indicator Cluster Surveys

SDGs Sustainable Developments Goals

USAID U.S. Agency for International Development,

VA Verbal Autopsy

CHAPTER 1: GENERAL INTRODUCTION

1.1. Background

The onset of the mortality decline in Sub-Saharan Africa (SSA) is difficult to date, but most of the gains in life expectancy were achieved in the years following the Second World War. That is, nearly two centuries after the start of mortality reduction in Western Europe (Meslé and Vallin, 2000; Caselli et al., 2002; Riley, 2005). Unlike the experience of European countries, however, mortality reduction in SSA was not driven by improvements in living standards, hygiene, nutrition and sanitation. Rather, these countries mainly benefited from medical advances, in part supported by international organizations, to reduce mortality from infectious diseases, particularly in children. Immunization programs and the massive use of curative medicine (antibiotics, malaria chemotherapy and other drugs) have been key drivers of the mortality decline in SSA (Garenne, 2013). This large reliance on medical advances may explain the protracted and uncertain mortality transition in the region. With poorly organized health systems, countries in SSA are exposed to various uncertainties. With the exception of a few countries that experienced regular gains in life expectancy in recent decades, the mortality transition has been disrupted in many countries, for different reasons. For example, the effects of the structural adjustment programs in the 1980s in Congo, Nigeria, Angola, led to temporary losses in life expectancy. Armed conflicts and instability in Rwanda, Somalia, Ivory Coast, and the massive HIV epidemic in Southern and Eastern Africa also resulted in dramatic mortality increases (Vallin and Meslé, 2010). For example, in South Africa, the HIV epidemic led to a 9 year loss in life expectancy, from 62 to 53 years between the periods 1990-1995 and 2005-2010 (United Nations, 2017). This contrasts with the situation of Niger, one of poorest countries in the African region, which experienced an increase in life expectancy from 45 years to 55 years during the same period (United Nations, 2017). In addition to the variation in terms of the pace and timing of the mortality transition across countries in SSA, the health transition also progresses differentially according to social groups within each country. Health inequalities according to sex, social class, race, ethnicity, place of residence, have been highlighted in many communities (Tabutin and Masquelier, 2017). This issue of health inequalities was somewhat obscured in the Millennium Development Goals (MDGs) which focused mainly on average targets. However, in the new era of the Sustainable Developments Goals (SDGs), reducing health inequalities has received more attention (United Nations, 2015). Specifically, the third objective of the SDGs is to "ensure healthy lives and promote well being for all at all ages". This means that equity now plays a central role, and that "no one should be left behind".

A particular attention has always been paid to urban-rural differences in health outcomes in SSA, since the years following independences. Indeed, population living in urban areas benefited from health policies that have proven successful in European countries, and were later imported to protect the colonial population. Health facilities, sewerage systems, were set up to improve the health of the European population. Thus, many determinants of health such as sanitation, health care resources, and access to drinking water were historically better in urban areas compared to rural areas (Gould, 1998; Eloundou-Enyegue and Giroux, 2012). It is therefore common to assume that urban dwellers enjoy better health and consequently, the fight against diseases has been directed towards rural settlements. In recent years, however, the urban health advantage in SSA has been put in question because of the rapid and poorly managed urbanization as well as the nutrition transition (Günther and Harttgen, 2012). Although SSA is still the less urbanized region in the world with 39 % of his population living in urban areas, it has faced in recent years an unprecedented rate of urbanization in a context of low economic development (Cobbinah et al., 2015; United Nations, 2014). The United Nations (2014) estimated that more than half of the population will be living in urban areas by 2040 in Sub-Saharan Africa. Due to high urbanization rates and sustained population growth, the urban population increased at an average rate of 4% between 1990 and 2015 in this region (Unites Nations, 2014). This rapid urban growth coupled with the lack of investment in the industrial sector, the liberalization of trade, and limited progress in education, has led to the emergence of urban poverty (Boadi et al., 2005). Faced with unemployment, many urban poor settled down in informal settlements better known as "slums". These settlements contribute to the spatial expansion (or "urban sprawl") of African cites, outpacing urban planning systems. About 62% of the urban population in SSA lives in slums (UN-Habitat, 2013). Most of these informal settlements do not benefit from social services such as access to adequate water supply, sanitation and health services (Neiderud, 2015). Moreover, toxic wastes gathered in other parts of the cities are sometimes dumped in informal settlements, thus contributing to the deterioration of the population health. In addition to their high exposition to various infectious diseases, inhabitants of slums also bear the burden of non-communicable diseases linked to modernization. The adoption of lifestyles detrimental to health (tobacco consumption, harmful use of alcohol, diet rich in salt, fat ....) is also regularly observed among the urban poor. Risk factors for non-communicable diseases such as obesity affect both the affluent and the urban poor (Ziraba et al., 2009). In short, urban poor are more likely to face a "double burden of diseases" (Agyei-Mensah and Aikins, 2010).

Against this background, considerable research has been conducted on intra-urban health inequalities in SSA in recent years. The health of the urban poor is also regularly compared to that of rural residents. The main assumption is that rapid urbanization could slow down the mortality transition in the region. Focusing on child health, Günther and Harttgen (2012) showed that child survival was better in formal settlements than in informal settlements across SSA. For instance, in the city of Ouagadougou (Burkina Faso), even after adjusting for maternal characteristics, child mortality was 70% higher in informal neighborhoods compared to formal ones (Lankoande et al., 2016). In Kenya, the development of slums in cities has led to the narrowing of the gap in urban-rural mortality (Kimani-Murage et al., 2014). Even though child mortality decreased both in urban and rural areas of the country, the decline was faster in rural areas. This situation was attributed to the fact that most urban residents live in slums where health conditions remain precarious. Looking at the association between place of residence and child health (morbidity and mortality) in developing countries in general, Fink et al. (2014) pointed out that non-slum residents enjoy better health than slum residents. Furthermore, children living in informal settlements fare better than their rural counterparts. However, most of these differences tend to vanish if maternal education, household living standard, and access to health care are taken into account. In addition, despite the abundance of research on intra-urban health inequalities in children, results remain context-specific and dependant of the definition attributed to "slums" (Nolan, 2014). Defining slums based on household characteristics or relying on place-based definitions may yield different findings. Context also matters; for example, health conditions in informal settlements of the city of Ouagadougou are different of that of a city such as Nairobi (Soura et al., 2015).

If spatial health inequalities in children are well documented in SSA, the situation in adults remains under researched. The particular focus on child health has long been largely supported by international initiatives such as MDGs that promoted child wellbeing because of their vulnerability. Research on adult health and particularly spatial health inequalities in SSA has also been limited by the lack of reliable data (Reniers et al., 2011). However, the issue of adult health deserves much more attention, specifically in a context of reduction in child mortality. First, the population of Sub-Saharan Africa is still young with a rapid increase in the working age population. For example, according to United Nations (2017) estimates, from a level of 52% in 2015, the proportion of adults aged 15-59 in the population will increase steadily in the next decades to reach 59% in 2050 in this region. Second, adult health can directly or indirectly impact the health of other household members. For instance, it is well established that maternal deaths increase the risk of ill-health in children (Houle et al., 2015). Furthermore, in SSA, because of the lack of insurance coverage and high dependency ratios, the financial burden related to adult death is high and can push households in a cycle of poverty (Abegunde et al., 2007; Kankeu et al., 2013). This is particularly true is cases of chronic diseases because treatments are costly and span several years. Finally, in economic terms, poor health in adults can have a negative impact on productivity and investment at the national level (Waziri et al., 2016).

Adults living in urban areas of SSA face particular health challenges caused by the rapid urbanization, and changes in living arrangements that accompany it. Despite the reduction in the burden of many infectious diseases, urban environments are favorable grounds for the spread of some infectious diseases such as HIV/AIDS and respiratory infections (Neiderud, 2015). For instance, rural-urban migrations contribute to the dissemination of HIV/AIDS in urban areas. Because of the disruption of their family life, the relative weakness of social norms in cities, men migrants who move to cities without their spouses are more likely to engage in risky sexual behaviors such as regular contacts with commercial sexual workers (Peer , 2015). The urban poor are also exposed to respiratory diseases linked to indoor air pollution, pollution from traffic, and overcrowding. A typical example is the re-emergence of tuberculosis in some African cities because of overcrowding, poor ventilation in houses and, poor working conditions (Peer, 2015). Besides infectious diseases, road traffic injuries are typical of urban areas even though statistics on the issue are still scarce and uncertain. High congestion, lack of road infrastructures, and non-compliance with traffic rules contribute to this situation. It is estimated that African roads contribute to more than 10% of the world collision fatalities, while the continent has only 4% of the world's motor vehicles (Chen, 2010). Some urban areas are also plagued by crime and violence at levels not seen in rural areas (Hoove, 2013). Finally, occupational health problems are not negligible in urban areas (Boadi et al., 2005). Because of high rate of unemployment, urban dwellers are constrained to take unsafe jobs that can expose them to high health risks (unsafe machinery, toxic substances etc...), in a situation where health insurance is quasi inexistent.

Most importantly, the public health debate on urban health in SSA is centered on the rise of non-communicable diseases, particularly cardio-vascular diseases. Urbanization is identified as a key driver of the epidemiological transition occurring in SSA (Agyei-Mensah and Aikins, 2010). Advances in technology and globalization have profoundly changed lifestyles of urban dwellers. For example, the availability of means of communication and transport has led to a decrease in physical activity in cities. The nutrition transition, with the adoption of modern diets (rich in sugar, salt and fat), also progresses in the continent. At the same time, prevalence of smoking and harmful use of alcohol is rising in urban areas of SSA. These factors combined with the aging of the population are among the key drivers of the burden of non-communicable diseases in urban Africa (Vorster et al., 2011; Assah et al., 2011; Bosu, 2015). A growing body of evidence also showed that communicable and non-communicable diseases are not disconnected as previously thought. In particular, in SSA, it is likely that poverty, and malnutrition will exacerbate the burden of non-communicable diseases. According to the "thrifty phenotype hypothesis", developed by Hales and Barker (1992), children or foetuses exposed to under-nutrition develop adaptive mechanisms (for example lowering metabolic rate) that persist later in life. In adulthood, in an affluent environment (rich diets) for example, these children will be more vulnerable to obesity, type 2 diabetes, and cardiovascular diseases. This hypothesis was supplemented by the "thrifty genotype hypothesis" which stated that due to recurrent exposure to famine in human history, population are genetically selected to store fat, and this becomes disadvantageous when food supply become abundant (Amuna and Zotor, 2008). Furthermore, it is well established that infectious diseases interact with non-communicable diseases (Boutayeb, 2006). For instance, infections can cause liver and stomach cancers, while diabetes increases the risk of infections (eyes, feet,...). Taking together, these hypotheses and the overlap between communicable and non-communicable suggest that the epidemic of non-communicable diseases could possibly be worse in SSA compared to high income countries. Already, deaths from non-communicable diseases occur at younger ages in SSA compared to developed countries. Despite this alarming situation, health systems continue to pay more attention to the battle against infectious diseases (Kushitor and Boatemaa, 2018). In summary, it is simplistic to consider that urban adults enjoy better health compared to their rural counterparts. The study of urban-rural gap in terms of health merits particular attention. Insufficient research has been conducted on the subject, certainly because of the lack of reliable data, and the low priority devoted to the issue of adult health in the global health agenda, until recently.

Evidence regarding the health gap in terms of mortality between urban and rural areas of SSA is mainly built on the cases of children. Because of the lack of data on adult survival, it is common to derive adult mortality from child mortality combined with model life tables (Reniers et al., 2011). In this way, inequalities observed in children is systematically transposed into adults. However, as mentioned above, health risks faced by adults and children according to urban/rural residence may be different (Günther and Harttgen, 2002). It is then important to develop innovative ways in order to directly measure mortality inequalities between the two types of place of residence in adults. A better measurement of mortality inequalities can lead to the formulation and implementation of health policies to improve the health of disadvantaged subgroups. Reducing health inequalities is not only cost effective, but will also contribute to improve the health of the whole population. This is particularly true for countries where health conditions are still very poor compared to the rest of the world. Furthermore, health inequalities poses a moral problem particularly when this results from an unequal distribution of determinants of health. With the new framework of SDGs placing equity at the heart of the issue of health, the measurement of health inequalities is more important than ever.

In SSA, it is difficult to study urban-rural mortality differentials in adults without taking into account the issue of migration. The two types of areas are historically interlinked through important migration flows, particularly from rural to urban areas (Cobinnah et al., 2015). Migration may affect urban-rural differentials in different ways. On the one hand, migration affect the measurement of such differentials. With available data, it is difficult to grasp the place of residence of individuals exposed to the risk of dying. Only the place of residence of the survey respondent is generally known. On the other hand, through selective mechanisms, migration can contribute to widening health inequalities between urban and rural areas of SSA. The available literature on migration and health suggests that migrants are generally positively or negatively selected in terms of health (Boyle, 2004). Furthermore, their health status may improve or deteriorate after migration.

The main objective of this dissertation is to contribute to the measurement of urban-rural mortality differentials in adults and to the analysis of the impact of migration on that differential in SSA. The dissertation draws mainly on the case of Burkina Faso, a poor country of West Africa. In the following paragraphs, I discuss the challenges associated with the measurement of adult mortality by type of residence, and the potential effects of migration on urban-rural mortality differentials.

1.1.1. Measuring adult mortality by type of residence

Combined with regular censuses, data generated from complete civil registration systems remain the gold standard to derive all-cause and cause-specific mortality statistics around the world. These systems provide timely information on deaths by age and sex, with causes of death certified by a medical practitioner. However, civil registration and vital statistics (CRVS) systems are inefficient in most countries in SSA (Mikkelsen et al., 2015). The completeness of death registration is often less than 50%, and estimates of completeness are often uncertain (Masquelier et al., 2016a). Only some countries, such as South Africa and Mauritius, stand out as exceptions with a death registration considered complete. The completeness of death registration was also reported to be high in particular cities such as Dakar (Senegal), Bamako (Mali), Antananarivo (Madagascar), where a burial permit is often required (Masquelier and Kanté, 2017).

Considering the above, mortality levels and trends are generally derived from large-scale surveys, and censuses. In children, the monitoring of mortality levels and trends has been greatly facilitated by the collection of full birth histories in Demographic and Health Surveys (DHSs). But for various reasons, the situation is more complex in adults (Moultrie et al., 2013). First, adult deaths remain statistically rare, so that large sample sizes are required to come up with robust estimates. Second, if a mother can easily report the list of his biological children and provide information related to their survival, this is not the case in adults. Finding a respondent that can accurately report information related to adult deaths, including the ages at death and possibly their causes is not an easy task. Due to migration, child fostering and complex family structures, even adults born to the same mother may not be aware of the survival status or the age of her/his siblings. It is well documented that age misreporting is more common in adults compared to children in SSA, because adults are less likely to have attended school and less likely to have a birth registered (Moultrie et al., 2013).

To circumvent specific issues related to the estimation of adult mortality, it is still common to derive adult mortality from child mortality rates, combined with model mortality schedules (Reniers et al., 2011). There is an accumulating body of evidence, however, suggesting that this approach is problematic. Trends in adult mortality are sometimes disconnected from child mortality, even in the absence of HIV/AIDS (Masquelier et al., 2014). For example, in Burkina Faso, independent estimates of child and adult mortality revealed that adult mortality has stagnated in recent years while child mortality has continued to decline. The child-mortality matching approach is more problematic when it comes to estimating adult mortality by place of residence. Differentials in urban/rural mortality may vary by age. For example, child mortality rates are dominated by infectious diseases in both urban and rural areas. In adults, however, other health problems such as road traffic accidents and chronic conditions are typical of urban areas.

Standard sources of data on adult mortality in SSA are censuses and DHSs (Moultrie et al., 2013). In censuses, it is common to collect in each household the number of deaths that occurred during the twelve months preceding the interview. Information on place of residence, sex, and ages at death are also collected. This information, combined with population data, allows an estimation of mortality level by place of residence for all ages. But these data are likely to be affected by different errors such as underreporting of deaths, coverage errors, errors on the reference period, and age misreporting (Timæus, 1991). The extent of these errors might vary by place of residence, rendering the estimation of spatial inequalities uncertain. For example, age heaping is more common in rural areas than in urban areas (Johnson et al., 2009).

Another potential source of error that can affect the measurement of urban-rural mortality differentials based on census data is the mobility of dying individuals. This issue has been overlooked until now in the literature. Indeed, despite the continuous efforts made to improve rural health, access to health care is still far better in urban areas than in rural areas of SSA (Nwakeze and Kandala, 2011; Lemiere et al., 2011). Cities are generally home to the best health facilities of the country, with a high concentration of health workers (doctors, nurses, midwifes). In this context, some rural residents move to urban areas to access better health care. These movements can occur at advances stages of illness, and at the end of life. Urban dwellers can also move to rural areas at the end of life for different reasons. For example, rural-urban migrants that have lost hope to be cured may be willing to return to their home community, near family, to die. This movement may also be motivated by the fact that, death far from home is considered culturally as a bad death in some contexts of Africa (Van der Geest, 2004). These movements of dying individuals can lead to biases in estimates of urban-rural mortality differentials. For instance, a death of a rural resident may be classified as that of an urban resident if fieldworkers do not ask detailed questions.

It is well recognized that mortality indicators derived from censuses are affected by different errors, but their reliability is difficult to assess in the absence of a gold standard. One option to obtain such reference is to use data collected in Health and Demographic Surveillance Systems (HDSSs) to assess the reliability of mortality indicators. HDSSs usually share a common method of data collection (Sankoh et al., 2012). After an initial census in the area under surveillance, data on vital events (births, deaths, migrations and marriages) are collected on a regular basis. Because these data are prospectively collected, it is common to consider that mortality estimates derived from HDSS data are of higher quality than those obtained from standard surveys (Pison et al., 2005). For example, Masquelier et al. (2016b) used data from three rural HDSSs of Senegal (Mlomp, Bandafassi and Niakhar) to assess the reliability of mortality indicators derived from the 2002 and 2013 censuses, and showed that recent household deaths provided plausible estimates.

Information on the survival of parents asked in some censuses can also provide estimates of adult mortality using indirect methods (Moultrie et al., 2013). However, these estimates relate to the past, and the datation of estimates is only possible under strict assumptions, such as a linear and steady mortality decline. Regarding the estimation by place of residence, the fact that parents and children do not always share the same place of residence adds further complexity. In addition to data collected in censuses, adult mortality can be inferred from information collected in DHSs on siblings born to the same mother (Reniers et al., 2011). This information on siblings is usually derived from the "maternal mortality module" (and from the male questionnaire in a few DHSs). Here again, the issue of migration may lead to unreliable estimates by place of residence. Only the place of residence of individuals that report on the survival of their siblings is known. The respondent and his siblings do not always share the same place of residence. Estimates obtained by using the place of residence of respondent as a proxy for her sibling's place of residence are likely to be biased. Migration flows between urban and rural areas are so frequent in the context of SSA that this strategy is often unfeasible. In addition to issues raised by migration, estimates obtained from sibling survival data are also affected by under-reporting of deaths (Helleringer et al., 2014).

1.1.2. The effects of migration on urban-rural mortality differentials in adults

In SSA, health status of urban and rural residents cannot be compared without paying attention to the issue of migration. The two types of place of residence are historically interlinked through important migration flows, particularly from rural to urban areas (Cobinnah et al., 2015). Even though natural increase is now the driver of urban population growth in most of SSA, rural-urban migration still plays a key role (Mberu et al., 2017). Rural residents relocate to cities for different reasons (Cobinnah et al., 2015). Economic factors remain the main reasons pushing rural residents to urban areas. These include better education, and better employment opportunities. Other drivers of rural-urban migration also include improved access to health care, environmental hazards (drought, flood), family formation, conflicts and violence (Lucas, 2015; Clark et al., 2007).

Migration not only affects the measurement of urban-rural mortality differentials in adults, but can also shape this differential at a country level (Urquia and Gagnon, 2011). Migration flows between urban and rural areas are not independent of health status (Boyle, 2004). First of all, *"the healthy migrant hypothesis"* suggests that migration is selective with respect to health. In general, migrants in good health in deprived areas are more likely to undertake the difficult journey of migration than those who are less healthy. Good health status is required to cope with disruption caused by migration, to adapt in a new environment, and most importantly to integrate the labor market for young adults. The selection of healthier individuals in the migration process plays against the health of sending areas as a whole. Second, the "*adaptation hypothesis*" states that migrants can lost their health advantage over the years in destination areas. Regarding rural-urban migration, several studies point out that with the duration of residence migrants are more exposed to cardio-vascular diseases due to changes in nutrition (diet rich in sugar, salt, alcohol consumption, smoking) and the decrease in physical activity (Unwin et al., 2010; Peer, 2015). It is also important to mention that migrants health in cities is put at risk, because most of them settle down in informal settlements where health conditions are precarious (Rossier et al., 2011; Mberu et al., 2017). Third, the "*socialization hypothesis*" is opposed to the *adaptation effect* and states that migrants may continue to behave according to the norms and values learned at place of origin. Finally, the return of unhealthy migrants (the *unhealthy migrant hypothesis*) in rural areas can also contribute to the rural health disadvantage. In the recent literature, the search of supportive care was associated with the return of migrants. For example in South Africa, sick and dying migrants who cannot take advantage of the urban labor market anymore, tend to return home to die (Bocquier et al., 2014; Clark et al., 2007).

The previous paragraphs have showed the complexity of the study of migration in relation to adult health in SSA, a complexity still difficult to grasp in a context of data scarcity. Standard surveys such as DHSs collect only information on the previous migration in women on reproductive age, and sometimes in males. Despite not being included in all DHSs, these data were more useful to study migration and early life mortality (Bocquier et al., 2011; Mberu and Mutua, 2015). In this context, data collected in HDSSs thanks to their longitudinal and prospective nature offer an opportunity to investigate complex relations between migration and adult mortality (Bocquier, 2016).

1.2. Contributions of the PhD dissertation

To measure urban-rural mortality differentials mainly in Burkina Faso, and to assess the effect of migration on the differential, this dissertation is organized around four main contributions (chapters).

The second chapter focuses on the mobility of adults at the end of life in urban and rural contexts of Burkina Faso and Senegal. This chapter is the only one to include data from Senegal in addition to Burkina Faso, in order to take into account various contexts (for example the supply of health care) in the study of mobility before death. Our analysis reveals that in rural areas, the magnitude of mobility at the end of life depends on the supply of health care. These results confirm that mobility of dying individuals can contribute to biases the measurement of urban-rural mortality differentials if data are not collected with care. After highlighting this potential problem in the measurement of urban-rural mortality differentials that has been overlooked so far, in the third chapter, I assess the reliability of mortality indicators derived from census in a rural area of Burkina Faso. This is the first time that mortality indicators derived from a census are directly assessed in Burkina Faso using HDSSs as a standard. The analysis shows that the combined effects of different errors in the 2006 census led to an underestimation of mortality indicators, in particular in the elderly and in women. Even if a similar analysis was not conducted in an urban setting, due to data constraints, it is likely that the picture of urban-rural mortality differentials obtained from census data without any corrections is uncertain. Recognizing the limitations of census data, in the fourth chapter, I use other data sources in addition to census data to revisit the main avenues to measure urban-mortality differentials in adults. Previous studies on the topic in SSA were based on one source of data without any attempt to assess the effects of their limitations on urban-rural mortality differentials. Results show that on one side, the available data are plagued by underreporting of deaths, and possible age misreporting. On the other side, missing information on the place of residence of individuals exposed to the risk of dying may lead to spurious conclusions regarding urban-rural mortality differentials. A closer look at all available estimates indicates that in Burkina Faso, adults living in urban areas still benefit from a health advantage compared to their rural counterparts. Finally, the fifth chapter of the dissertation leaves aside measurement issues, and instead targets the net effects of migration on urban-rural mortality differentials in Burkina Faso. The available literature on migration and health in SSA, is extended in this analysis by disaggregating migration flows by destination. Results show that positive selection of migrants in rural areas play a role in shaping the urban health advantage. However, the health status of migrants tend to deteriorate with their duration of residence in cities.

The four chapters of the dissertation correspond to three papers already published in international journals and one manuscript in preparation for submission. The different abstracts are presented below.

Chapter 2: Returning home to die or leaving home to seek health care? Location of death of urban and rural residents in Burkina Faso and Senegal. Published in *Global Health Action* (Lankoande, Duthé, Soura and Pison, 2018).

In sub-Saharan Africa, the literature on end of life is limited and focuses on place of death as an indicator of access and utilization of health-care resources. Little is known about population mobility at the end of life. The objective of this paper is to document the magnitude, motivations and associated factors of short-term mobility before death among adults over 15 years of age in Burkina Faso and Senegal. The study was based on deaths of adult residents reported in three Health and Demographic Surveillance System (HDSS) sites in urban (Ouagadougou) and semi-rural areas (Kaya) of Burkina Faso, and rural areas of Senegal (Mlomp). After excluding deaths from external causes, the analysis covered, respectively, 536 and 695 deaths recorded during the period 2012–2015 in Ouagadougou and Kaya. The period was extended to 2000–2015 in Mlomp, with a sample of 708 deaths. Binary logistic regressions were used to examine the effects of socio-demographic characteristics on place of death (health facility or not) and location of death (within or outside the HDSS). In Mlomp, Kaya and Ouagadougou, respectively 20.6%, 5.3% and 5.9% of adults died outside the HDSS site. In Mlomp and Kaya, these deaths were more likely to occur in a health facility than deaths that occurred within the site. The reverse situation was found in Ouagadougou. Age is the strongest determinant of mobility before death in Mlomp and Kaya. In Mlomp, young adults (15–39) were 10 times more likely to die outside the site than adults in the 60–

79 age group. In Ouagadougou, non-natives were three times more likely to die outside the city than natives. At the end of life, some rural residents move to urban areas for medical treatment while some urban dwellers return to their village for supportive care. These movements of dying individuals may affect the estimation of urban/rural mortality differentials.

Chapter 3: Estimating Mortality from Census Data: an Assessment based on the Nouna Demographic and Health Surveillance System in Burkina Faso. Manuscript to be submitted.

Because of the absence of comprehensive death registration in most countries in Sub-Saharan Africa, mortality levels and trends are largely derived from large-scale surveys and censuses. The reliability of the corresponding estimates is difficult to assess without a gold standard. With the specific example of Burkina Faso, this paper compares mortality estimates from the 2006 national census with data collected in the Nouna Health and Demographic Surveillance System (HDSS). We extracted from the census database only the records referring to the population under longitudinal surveillance in the HDSS. Various direct and indirect methods were applied to estimate and compare mortality from both sources. We decomposed the differences in life expectancies into contributions of discrepancies in children, adults and the elderly. Child mortality rates obtained indirectly from numbers of children ever born and surviving were broadly consistent with HDSS estimates, especially among boys. By contrast, indirect estimates of adult mortality obtained from reports on orphanhood in the census were implausibly low. Life expectancies derived from the number of recent deaths in households also pointed to lower mortality than monitored in the HDSS, with a difference of 3.2 years for men and 6.8 years for women. Age misreporting or underreporting of deaths in the census among the population aged 60 and above accounted for about half of these differences. Triangulating national census data with demographic surveillance systems can help in assessing mortality rates derived from various estimation methods. Innovative strategies are required to improve data collection on ages, parental survival and recent household deaths.

Chapter 4: Monitoring adult mortality by type of residence in the absence of death registration: A perspective from Burkina Faso. Published in *International Journal of Population Studies* (Lankoande, 2016).

In the context of the post 2015 agenda, disaggregation of mortality indicators is needed to assess health inequalities within populations. However, producing sub-national estimates of adult mortality is notably difficult in the absence of death registration. Using Burkina Faso as a case study, this paper revisits the main avenues to quantify differences in adult mortality between the ages of 15 and 60 according to urban/rural residence. Estimates are based on reports on the survival of parents and siblings collected in surveys and in the 2006 census, and compared to levels inferred from recent household deaths or inferences based on child mortality. Results indicate that in Burkina Faso, adults living in urban areas still benefit from a health advantage compared to their rural counterparts. Thus, efforts made in reducing adult mortality in rural settings should be intensified. In terms of methods, this analysis shows the value of asking additional questions about the place of residence of close relatives to avoid misclassification errors. The approach adopted here could be implemented in other countries to facilitate the measurement of spatial inequalities in health indicators for all ages when monitoring Sustainable Development Goals (SDGs).

Chapter 5: Selective Adult Migration and Urban-Rural Mortality Differentials in Burkina Faso. Published in *Population* (Lankoande and Sié, 2017).

Taking the example of Burkina Faso, where massive rural exodus continues to drive the urbanization process, this study tests the net effects of migration on urban-rural mortality differentials among adults aged 15-74. The analysis is based on data collected in two HDSSs, one in a rural area (Nouna) and one in a city (Ouagadougou). The longitudinal data cover a recent period (2009-2013) and are analyzed using a semi-parametric Cox model. In a rural environment with poor health conditions, it is the healthy individuals who migrate to the city, thereby strengthening the urban health advantage over the short term. While rural-urban migrants are positively selected in terms of health, they tend to lose their advantage over time as they adapt to life in the city. This deterioration after several years of urban residence could hold back the mortality transition at national level, given that these migrants were in better health in their environment of origin. For return migrants (rural-urban-rural), the absence of a negative selection effect in Burkina Faso again reflects the complex interplay between migration and health. Beyond compositional and contextual effects, the positive selection of rural-urban migrants is accentuating the health disadvantage of rural areas.

1.3. Data and methods

In this dissertation, various sources of data available in Burkina Faso were used to compensate for the lack of data on adult mortality. Like most of countries in SSA, the country does not have a functional civil registration system. The coverage of birth registration was estimated at 76.9% in 2010 but that of death registration is unknown (WHO, 2017). Data on health and mortality indicators are then derived from censuses and various surveys. Four rounds of census have been conducted in Burkina Faso (1975, 1985, 1996 and 2006). These censuses were supplemented by four DHSs (1993, 1998-1999, 2003, 2010) and two Multi Indicator Cluster Surveys-MICS (1996, 2006) focusing on child and maternal health. In addition to international surveys implemented in the country, Burkina Faso runs a well-functioning health information system under the supervision of the ministry of health (Ministry of health, 2011). This system aims to collect and disseminate information related to the health of the population, with a particular focus on infectious diseases. A statistical yearbook on the health situation of the country is released annually. This report focuses on indicators related to child health (vaccination, malnutrition, malaria, etc.), maternal health (antenatal and postnatal care, contraception,…), access to health care (supply of health facilities, distribution of workforce), and to epidemiological surveillance (meningitis, measles, yellow fever, etc...). Although the health information system provides detailed information on causes of death, these data cannot be used to estimate cause-specific mortality rates at the population level because a larger fraction of deaths still occur at home (Bado et al., 2016). In this situation, data from HDSSs can also be of great importance. Four functional HDSSs are located in Burkina Faso, one in urban areas (Ouagadougou) and three in rural or semi-rural areas (Nouna, Kaya, and Nanoro) (Sié et al., 2014). These data are also valuable to analyze causal relationships between demographic events (Bocquier et al., 2017). From this pool of data sources in Burkina Faso, the dissertation was based on the followings:

- ✓ Data from the Ouagadougou and Kaya HDSSs in Burkina Faso, and data from the Mlomp HDSS in Senegal were used to document the magnitude, reasons and associated factors of the movements of dying adults;

- ✓ Longitudinal data collected in the Nouna HDSS combined with data of the 2006 census were combined to assess the reliability of mortality indicators derived from the 2006 census;
- ✓ The 2006 census, and DHSs data (the 1993, 1999, 2003, 2010 surveys) provided the basis to measure urban-rural mortality differentials in adults. These datasets were supplemented by data from the EMUIB's (Migration Dynamics, Urban Integration and Environment Survey) survey conducted in Burkina Faso in the 2000s;
- ✓ Longitudinal data from the Nouna and Ouagadougou HDSSs were used to test the migration effect on urban-rural mortality differentials.

In line with the diversity of data used, the methodology was made of different approaches:

- ✓ The analysis of the movements of dying individuals was based on binary logistic regressions;
- ✓ A decomposition of life expectancy (Arriaga method) was used to examine the contribution of each age group in the gap of life expectancy at birth, derived from the Nouna HDSS and the 2006 census;
- ✓ The measurement of mortality indicators was based on direct and indirect methods to estimate mortality, and Poisson regression. Confidence intervals around indirect estimates were obtained through a re-sampling technique (bootstrap);
- ✓ Finally, a Cox regression model helped to test the effect of migration on urban-rural mortality differentials.

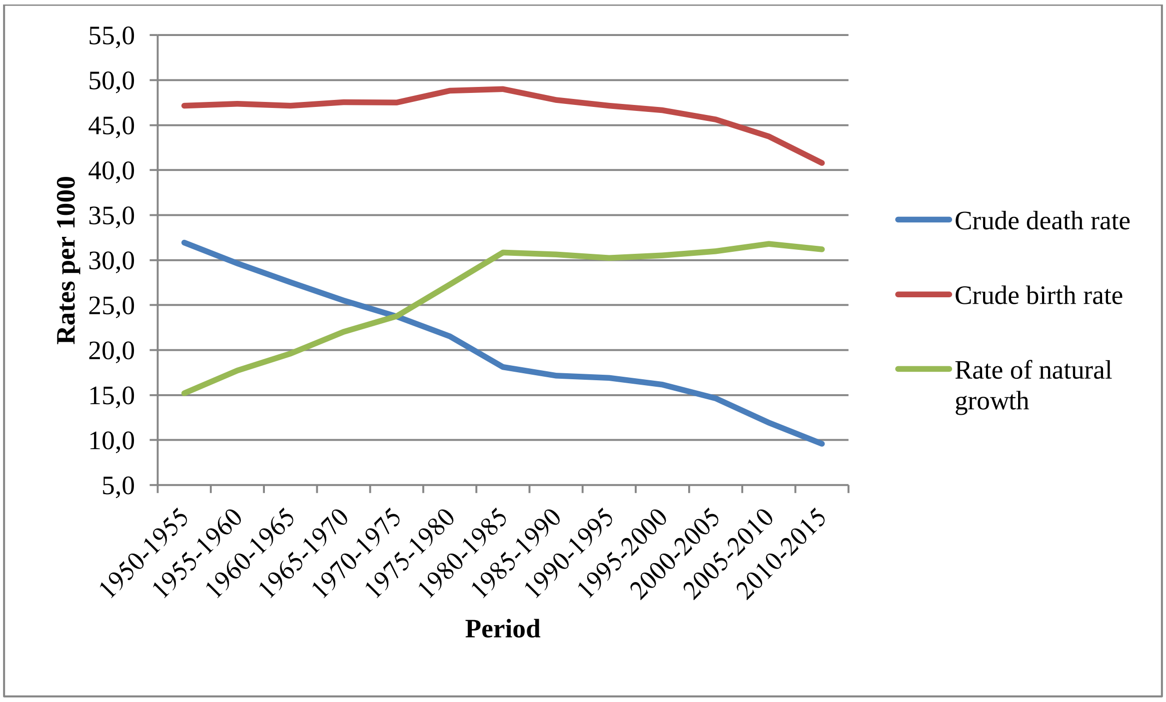
1.4. Research setting

Burkina Faso is a landlocked country in Western Africa that covers around 274.200 square kilometres. It borders six countries, Mali to the north; Niger to the east; Benin to the southeast; Togo and Ghana to the south, and Ivory Coast to the southwest. The country gained its independence from France in August 1960, after a period of colonial occupation that started in 1896 with the French annexation. Because of the lack of natural resources in Burkina Faso, its population was mainly used as a labor force for surrounding French colonies particularly Ivory Coast, during the colonization (Massa and Madiega, 1995). The economic situation is still weak with a small-scale agricultural sector that occupies 80% of the working population. In recent years, gold mining and cotton growing have gained in importance. These products are generally sold in international markets. Yet, Burkina Faso is considered at the international level as one the poorest country in the world with an Human Development Index

(HDI) value for 2015 of 0.402, ranking the country 185th out of 188 countries (UNDP, 2016). Despite the fact that French is the official language, half of residents in Burkina Faso speak the Moore language (INSD, 2009a). Other popular languages include Fulfude, Goulmancéma, Dioula, Bissa, and Bwamu. The majority of Burkinabe (about 60%) are Muslim. Christians and animist represent respectively 23% and 15% of the population (INSD, 2009a). In terms of education, great progress has been made over the years in school enrolment in Burkina Faso, but the level of education in the general population is still low. According to the last census, 71% of individuals aged 6 years and over never attended school (INSD, 2009a).

The population of Burkina Faso amounted to around 18 million individuals in 2015 (United Nations, 2017). This figure represents more than four times the population estimated in 1950 (around 4.3 millions). In recent years, the population has grown at the annual rate of 3%, one the highest growth rates in the world (United Nations, 2017). This rapid growth of the population is the consequence of a gradual decline in mortality in a context of high fertility (figure 1.1). Although the mortality level is still high, it has declined steadily over the years with a life expectancy that increased from 30.9 years in 1950-1955 to 58.7 years in 2010-2015 (United Nations, 2017). Like other African countries, child survival has greatly improved thanks to the support of international organizations. For example, the risk of dying before the fifth birthday was estimated at 100 per 1000 in the period 2010-2015. This risk was almost four times higher in the period 1950-1955 (377 per 1000). Regarding fertility, the transition started in early 1990s, much later than the mortality decline. In addition, it has only moderately declined since the peak in the 1980s. The total fertility rate (TFR) decreased from 7.2 in 1975-1980 to 5.6 in 2010-2015. The population growth in Burkina could have been much higher if the net immigration rate was not negative. Emigration flows from the country to neighboring countries have always been high. In particular, thousands of Burkinabe used to leave each year in a search of a better living in Ivory Coast. But the economic crisis in Ivory Coast in the 1980s and, more recently, the armed conflict in 1999 have led to the return of many Burkinabe to their country (Zongo, 2003). The net migration, however, is still negative and it was estimated that in 2010, 10% of Burkina Faso citizens were living in foreign countries (Guengant, 2011). As a country that started its demographic transition, the population is still young with a median age estimated at 17 years in 2015 (United Nations, 2017)

Figure 1.1 Trend in crude death rate, crude birth rate and population growth rate in Burkina Faso (1950-2015)



Source: United Nations, 2017

Burkina Faso is still a predominantly rural country with an urbanization rate estimated at 30.0% in 2015 (United Nations, 2014). It is expected that the urban population will take over the rural population in 2050. In the pre-colonial period, two entities were playing the role of towns in Burkina Faso (INSD, 2009b). First, Ouagadougou, the capital city in the centre of country was a cultural and political hub. In the West, Bobo-Dioulasso was better known for its commercial role. The colonial power first settled down in these two cities to organize the annexation of the remaining parts of the country. At the turn of the independence in 1960, Ouagadougou and Bobo-Dioulasso were the two major urban areas of the country with respectively 60.000 and 52.000 inhabitants. The population of Ouagadougou and Bobo-Dioulasso has grown rapidly over the years to reach respectively 1,475,223 and 489,967 in 2006 (INSD, 2009b). Despite the emergence of other towns, the two cities are still home to 62% of the urban population. Between the last two censuses (1996 and 2006), the urban population has grown at the annual rate of 7.1%, more than twice the annual growth of the entire population estimated at 3.1% (INSD, 2009b). Different reasons can explain this rapid urban growth. Firstly, from two cities in 1960, Burkina Faso now counts 48 cities according to the last census conducted in 2006 (INSD, 2009b). It should be noted, however, that various definitions have been used to characterize urban areas. For example, in the 1985 census, an urban area was defined as a district with a population size of more than 10.000 inhabitants that has access to electricity, schools, drinking water and administrative services. In the 1996 census, the criterion of population size was removed. In the reclassification of rural areas as urban, one can also include the annexation of surrounding rural areas in the process of spatial extension of cities. For example, the built up area of Ouagadougou, that was estimated at 49 kilometers squared in 1984, now reaches 250 kilometers squared (Guengant, 2009; INSD, 2009b). Secondly, the growth of the urban population is fueled by high rates of natural increase along with important flows of rural-urban migration. Like other African cities, the urbanization process was not accompanied by industrialization and economic development. This situation led to the emergence of an urban poverty. For example, in Ouagadougou, it was estimated that 30% of the population live in slums-like conditions (Guengant, 2009).

CHAPTER 2: RETURNING HOME TO DIE OR LEAVING HOME TO SEEK HEALTH CARE? LOCATION OF DEATH OF URBAN AND RURAL RESIDENTS IN BURKINA FASO AND SENEGAL.

AUTHORS

Bruno Lankoandé[(a)], Géraldine Duthé [(b)], Abdramane Soura[(c)], Gilles Pison[(b)(d)]

[(a)] (Corresponding author) Center for demographic research-Université catholique de louvain (UCL), Louvain-la-Neuve, Belgium

[(b)] French institute for demographic studies (INED), Paris, France

[(c)] Institut supérieur des sciences de la population (ISSP)- Université Ouaga 1 Pr Joseph Ki-Zerbo, Ouagadougou, Burkina Faso

[(d)] Museum national d'histoire naturelle (MNHN), Paris, France

JOURNAL

Manuscript published in *Global Health Action,* Volume 11, Issue 1, 2018

2.1. Abstract

In Sub-Saharan Africa, the literature on end of life is limited and focuses on place of death as an indicator of access and utilization of healthcare resources. Little is known about population mobility at the end of life. The objective of this paper is to document the magnitude, motivations and associated factors of short-term mobility before death among adults over 15 years of age in Burkina Faso and Senegal. The study was based on deaths of adult residents reported in three Health and Demographic Surveillance System (HDSS) sites in urban (Ouagadougou), and semi-rural areas (Kaya) of Burkina Faso, and rural areas of Senegal (Mlomp). After excluding deaths from external causes, the analysis covered, respectively, 536 and 695 deaths recorded during the period 2012-2015 in Ouagadougou and Kaya. The period was extended to 2000-2015 in Mlomp, with a sample of 708 deaths. Binary logistic regressions were used to examine the effects of socio-demographic characteristics on place of death (health facility or not) and location of death (within or outside the HDSS). In Mlomp, Kaya, and Ouagadougou, respectively 20.6%, 5.3% and 5.9% of adults died outside the HDSS site. In Mlomp and Kaya, these deaths were more likely to occur in a health facility than deaths that occurred within the site. The reverse situation was found in Ouagadougou. Age is the strongest determinant of mobility before death in Mlomp and Kaya. In Mlomp, young adults (15-39) were ten times more likely to die outside the site than adults in the 60-79 age group. In Ouagadougou, non-natives were three times more likely to die outside the city than natives. At the end of life, some rural residents move to urban areas for medical treatment while some urban dwellers return to their village for supportive care. These movements of dying individuals may affect the estimation of urban/rural mortality differentials.

Keys words: Location of death, short-term mobility, end of life, place of death, Health and Demographic Surveillance System, Burkina Faso, Senegal.

2.2. Background

According to Gu and colleagues (Gu et al., 2007), place of death goes through three evolutionary stages in societies. During the first stage, most people die at home because of poor access to healthcare resources. In a second stage, deaths in hospitals become more common due to health systems advances. In the last stage, the emphasis shifts to quality of care at the end of life, with the development of home-based care to meet people's preferences for death at home. During the different stages, cultural norms play a role in determining the place of death.

In developed countries, the public health debate is particularly centred on place of death as an indicator of quality of end-of-life care, with most people preferring to die at home rather than in hospitals or care homes (Gomes et al., 2012). In some countries such as Japan and Belgium, a large share of deaths still occur in hospitals, while in USA and Canada, death at home or in nursing homes is tending to replace death in hospital (Houttekier et al., 2011; Anezaki, 2008; Flory et al., 2004; Wilson et al., 2002).

Referring to the three-stage transition model of Gu et al. (2007), we assumed that developing countries, in sub-Saharan Africa (SSA) especially, are still in stage 1 or in transition from stage 1 to stage 2. People still face serious health issues, including the rise of non-communicable diseases in a context of endemic infectious diseases and poverty (Remais et al., 2012). Prevention and cure of infectious diseases remain a priority. Terminal care is pratically non-existent except in countries which were severely affected by the HIV epidemic such as Zimbabwe, Uganda, South Africa, Kenya (Gysels et al., 2011). Statistics on place of death (health facility versus home death) are limited because of the lack of exhaustive vital registration systems in most countries (Rao et al., 2004). In recent years however, a few population-based studies have examined where people die, particularly in Eastern and Southern Africa. Among adults aged 15 years and above, the proportion of deaths occurring in hospitals was estimated at 29% in Addis Ababa (Anteneh et al., 2013). In Zambia, a recent study showed that 51% of adults (15-59 years) died in hospital (Chisumpa et al., 2017). In Botswana, it was estimated that 64% of adult deaths (18 years and above) occurred in hospitals after excluding deaths from external causes and pregnancy-related deaths (Lazenby et al., 2010). In West Africa, a pioneering study on place of death was conducted by Bado and colleagues (2016), in a semi-rural setting of Burkina Faso. The authors showed that for all ages, 45% of deaths occurred in hospital but just 36% among adults aged 15 years and above (Bado et al., 2016).

It is recognized that socio-demographic, clinical, and ecological factors have an impact on place of death (Chisumpa et al., 2017; Houttekier et al., 2010; Cardenas-Turanzas et al., 2011). According to the Behavioral Model of Health Services Utilization developed by Phillips et al. (1998), socio-demographic factors such as age, gender, marital status and education have an impact on the ability to obtain care. For instance, in the African context, it may considered inappropriate for elderly people (or their relatives) to seek care for diseases of old age (Duthé et al., 2010). As found in Addis Ababa and Botswana, the elderly are more likely than young adults to die at home (Anteneh et al., 2013; Lazenby et al., 2010). The clinical component in the analysis of place of death refers generally to the cause of death. In the model developed by Phillips et al. (1998), the type of disease contributes to defining a patient's need for medical care. They hypothesize that some diseases such as cancer, renal failure, and cardiovascular diseases are difficult to manage at home and will probably lead to hospitalization. Contradictory evidence on the association between cause of death and place of death has emerged from the limited research conducted in SSA. In Addis Ababa, deaths due to cardio-vascular diseases occur more frequently in a health facility than deaths due to HIV/AIDS. But in Zambia, no association between place of death and cause of death has been found except for deaths from external causes and from HIV/AIDS. Finally, type of place of residence and living standard are commonly used as a proxy of enabling characteristics for care seeking. Type of place of residence mostly determines the availability of healthcare resources. Home death is more common in rural areas than in urban settings of SSA (Chisumpa et al., 2017; Bado et al., 2016). For example, in Zambia, adults living in urban areas were twice as likely to die in a health facility than rural residents (Chisumpa et al., 2017). This underscores rural-urban inequality in access to healthcare resources in favour of urban areas.

Despite the various investments made in the provision of health facilities in rural areas of SSA since the Alma Ata conference in 1978, the urban-rural gap in access to health care is still very wide (Nwakeze and Kandala, 2011; Ujoh and Kwaghsende, 2014). Health facilities and skilled health workers (doctors, nurses, midwives) are concentrated in cities (Lemiere et al., 2011). Furthermore, they offer a variety of services including care for some non-communicable diseases such as diabetes and hypertension that may not be available in rural remote areas. For example, in Senegal, it was estimated that the number of physicians per 1000 population was around 0.07 in rural areas and 2.33 in urban areas (Lemiere et al., 2011). Consequently, some rural residents in need of care must travel to urban areas to seek treatment while urban residents may have local access to health care.

In SSA, however, some urban residents may go back to rural areas at the end of their life to obtain the supportive care they need. In particular, urban dwellers with strong social ties in rural areas, such as rural-urban migrants, may decide to die in their home community. This is likely to happen when there is a little hope of a cure. Some chronic diseases, for instance, cannot be treated effectively, even in the largest city hospitals as treatments are too costly for both individuals and the state (Kankeu et al., 2013). A recent example is that of rural-urban migrants with HIV/AIDS in urban areas of South Africa who often returned to their village to receive supportive care and to die (Clark et al., 2007; Collinson et al., 2014). In addition to the need for supportive care, death far from home may be considered culturally as a "bad" death, as documented in rural Ghana (Van der Geest, 2004). Communities do not want their members to die alone, far away: in some cases, the bodies of people who die away from home are even repatriated at great expense and buried within the community. To avoid the prospect of being buried away from home, some terminally ill migrants will prefer to go home to die. This was shown in a qualitative study conducted among international migrants from Zimbabwe in South Africa (Nunez and Wheeler, 2012).

To sum up, the existing literature suggests that in African countries, the terminally-ill are a potentially mobile population. Some rural dwellers may travel to urban areas to seek care and die there, while urban patients in need of supportive care may return to their rural origins and die at home.

The paper aims to document the magnitude, motivations and associated factors of short-term mobility before death among adult residents in rural and urban contexts of West Africa. Regarding motivations, we hypothesized that the mobility of rural residents before death is linked to health seeking behaviour, these deaths are likely to occur in health facilities. Conversely, the mobility of urban residents may be due to the need for end-of-life supportive care, so that these deaths are likely to occur at home. Finally, to explain mobility before death, we relied on the traditional variables identified in the literature as associated with place of death. But, in addition to these variables, migration status was taken into account in urban areas as we expected rural-urban migrants to be more likely to return to rural areas before death than non-migrants.

The data used come from the Mlomp Health and Demographic Surveillance System (HDSS) in Senegal, and the Kaya and Ouagadougou HDSSs in Burkina Faso. These HDSSs are respectively located in rural, semi-rural and urban areas. Mobility before death was defined on the basis of information on the location of death, i.e. if the death occurred within the HDSS or outside the HDSS. But in the case of the Ouagadougou HDSS, to ignore mobility within the city, the location of death was defined in relation to the entire city. The mobility considered here is quite different from out-migration in its habitual sense, which generally involves a long-term change in place of residence. Here, we were only interested in the final movement of individuals within six months of death.

To the best of our knowledge, this is the first time that mobility before death has been investigated in the context of West Africa. The study provides useful information on the needs of ill and dying people living in urban and rural environments, and on their respective coping strategies. It also has implications for the measurement of spatial health inequalities, and of mortality indicators in particular. In censuses, and Demographic and Health Surveys, which remain the main sources of mortality statistics in West Africa, the death of an adult may be wrongly classified as an urban or rural death.

2.3. Data and methods

Data

In the context of SSA, data collected in censuses and standard household-based surveys such as the Demographic and Health Surveys (DHS) do not allow a detailed analysis of rural-urban migration in relation to adult health (Bocquier, 2016; Ginsburg et al., 2016). First, these surveys do not collect often information on migration flows between urban and rural areas. Second, the focus is on child and maternal health rather than on adult health. Finally, the few data available on migration concerns long term mobility leading to change in a place of residence. So, capturing short-term mobility and its relation to health is a particular challenge.

The data used here come from three HDSSs of Burkina Faso and Senegal. They will serve as case studies to explore mobility before death in different West African contexts. The first one is the Ouagadougou HDSS in Burkina Faso, which is the only fully urban HDSS of West Africa. Second, the Kaya HDSS will allow an analysis of mobility before death in a semi-rural context of Burkina Faso. The Kaya HDSS is covered by a regional hospital. Finally, the Mlomp HDSS located in rural Senegal offers a contrasting context compared to that of Kaya because the site is covered by a primary healthcare facility only. Furthermore, in this HDSS site in particular, information is collected on whether mobility is related to health care seeking . Such data allow a better understanding of the reasons for mobility before death in rural areas. While other HDSSs sites exist in West Africa, only data from these three sites were accessible and/or suitable for the analysis conducted here.

The three HDSS sites are members of the International Network for Demographic Evaluation of Populations and Their Health (INDEPTH) and share similarities in terms of methodology (Sankoh and Byass, 2012). Following an initial census in the area under surveillance, fieldworkers conduct regular household update rounds, and register vital events (births and deaths, migrations and marriages). In case of death, a verbal autopsy (VA) questionnaire is completed with the next of kin to determine the circumstances that led to the death, including the history of the illness and the specific symptoms that preceded death. VA data can be interpreted by physicians or using computer-based methods. In the first method, each VA is reviewed separately by two distinct physicians to determine the probable cause of death. In case of disagreement, the VA is reviewed by a third physician who assigns a consensus diagnosis. Otherwise, the cause of death is categorized as "indeterminate" (Fottrell and Byass, 2010). The most widely used automated-methods on INDEPTH sites is the one based on Bayes' theorem implemented in the InterVA-4 software (Byass et al., 2012).

The Ouagadougou HDSS was established in late 2008 in five neighbourhoods at the northern periphery of the capital city of Burkina Faso (Rossier et al., 2012). Two of them (Kilwin and Tanghin) are formal neighbourhoods with full access to public services, while the other three (Nonghin, Polesgo and Nioko 2) are informal settlements (like slums) without access to such services (Rossier et al., 2012). People living in the Ouagadougou HDSS are mostly from the Mossi ethnic group (90%), which is currently the majority ethnic group in the country. More than half of active adults work in the commerce and construction sectors (Rossier et al., 2011). The population under surveillance in the Ouagadougou HDSS totalled about 90,000 residents in 2015 and periodic household update rounds are conducted with an average periodicity of 10 months. VA data are interpreted by the InterVA-4 software to determine the probable causes of death. Health care provision in the city of Ouagadougou is better than in any other location in Burkina Faso, with a private sector representing two thirds of all care services. In addition, large teaching hospitals offering the country's highest standards of care are located in the city (Ministère de la santé, 2010).

The Kaya HDSS was established in late 2007 in the North Central region of Burkina Faso, 100 kilometres from the capital city, Ouagadougou. The site covers the town of Kaya and 18 villages (Kounda et al., 2013). The follow up population was estimated at 70,000 inhabitants in 2015. This population lives in semi-urban (70%) and rural (30%) areas. The site is easily accessible from Ouagadougou and is covered by seven health facilities and one regional hospital. Residents are mostly from the Mossi ethnic group and are of Muslim faith. Only half of the population have been to school and the main economic activities are small-scale agriculture and livestock breeding. In recent years, gold mining in the neighbouring villages of the HDSS has grown in scale. Although the site covers the town of Kaya, health indicators and fertility levels are typical of a rural area of Burkina Faso. Life expectancy was estimated at 54 years in 2013 and the total fertility rate was estimated at 7 children per woman. Households are visited every six months. In case of death, causes of deaths are certified by physicians based on information available in VA questionnaires. During the period considered in this study (2012-2015), a large share of VA questionnaires was not completed and available ones were not yet diagnosed by physicians. However, lay reporting of causes of death was available.

The Mlomp HDSS was set up in 1985 in the Southwest Senegal in the administrative region of Ziguinchor, nearly 500 kilometres from Dakar, the capital city (Pison et al., 2002). The site covers 11 villages. The population under surveillance belongs to the Diola ethnic group and is mostly animist or catholic. Rice cultivation is the main activity in the area but many adults migrate during the dry season, with men leaving to find work in wine palm harvesting and fishing in other regions. Young women are often employed as domestic servant in Dakar or in Banjul (the capital city of Gambia) before they get married. The educational level is relatively high in Mlomp with respect to other rural areas of Senegal. In the 2000s, while only a minority of women aged 15-49 years in rural Senegal as a whole had attended school, around half done so in Mlomp. Health indicators are also encouraging, thanks to a very dynamic private health centre opened in 1961 by French catholic nurses. However, to see a physician, patients must be referred to the local hospital at Oussouye, 10 kilometres from Mlomp. Advanced medical care including surgery is only available in the larger regional hospital at Ziguinchor, 50 kilometres from Mlomp. The follow-up population was estimated at 9,000 inhabitants in 2015 and vital events are updated on an annual basis. In case of death, physicians interpret the completed VA questionnaires to assign a probable cause of death.

Variables

Two outcome variables were considered in this analysis. First, place of death was grouped into two main categories: health facility versus non-health facility. We did not make any distinction between the types of health facility, for example, public versus private. The "Non-health facility" category mainly included deaths that occurred at home. Deaths that took place elsewhere or for which information was not available represent 5.1% of deaths in Ouagadougou, 2.4% in Kaya, and 2.1% in Mlomp.

Second, mobility before death was defined using information on location of death, i.e. if the death has occurred within or outside the HDSS. For the particular case of the

Ouagadougou HDSS, to ignore mobility within the city, location of death was defined on the basis of the entire city. Individuals were classified into two categories: those who died in Ouagadougou and those who died elsewhere. Furthermore, for deaths at Mlomp, it was possible to know if the deceased person had left the site to seek health care or not.

Independent variables included sex, age group at death, education, marital status, birth place and group of causes of death. We categorized the different variables in this way to ensure comparability across the three sites. Age of death was divided into four categories, 15-39, 40-59, 60-79, and 80 years and more. For education, two main categories were considered: individuals with no schooling, and those with at least one year of schooling. We defined three marital-status categories: married, single, divorced/widowed . In some cases, data on education and marital status were missing. These cases were coded as "unknown". Place of birth was taken into account only in the Ouagadougou HDSS, and two categories were defined: native of Ouagadougou and non-native. Finally, causes of death recorded in the sites of Ouagadougou and Mlomp were aggregated into three main categories, excluding deaths from external causes: malaria, HIV/AIDS, respiratory infections and other infections were classified as communicable diseases; diseases such as neoplasms, diabetes, stroke and other chronic diseases were grouped as "non-communicable diseases"; and indeterminate causes of deaths and deaths for which there was no VA were classified as "ill-defined".

Statistical analyses

In this study, we analyse adult deaths after 15 years of age. The analysis covers the period 2012-2015 in Ouagadougou and Kaya. Since the population of Mlomp is much smaller, the analysis was extended to cover deaths over the period 2000-2015. In Ouagadougou and Kaya, a six-months criterion is used to define residency in the HDSS, i.e. individuals are excluded from the follow-up after six months of absence. This is not the case in Mlomp due to a high volume of circular migrations. Individuals are excluded from the follow-up only after two successive years of absence. In order to approximate the same residence criteria in Mlomp as in the two other sites, the date of the most recent presence of the residents who died was compared to the date of their death. When the precise date of departure from the village was missing, it was estimated on the basis of information on the person's presence or absence during the dry and the rainy seasons recorded in the two last follow-up surveys. The deaths of individuals who reported as absent from the HDSS area more than six months are then excluded from the analysis.

As the analysis aims to highlight mobility before death for health reasons, deaths from external causes were excluded (8.4% of deaths in Ouagadougou, 4.5% in Kaya and 9.5% in Mlomp). In the Kaya site, causes of death based on VAs were not available for the period considered, so lay reporting of causes of deaths (disease, accident, suicide, murder, pregnancy-related deaths) by the relatives of the deceased person, was used to exclude deaths from external causes. To sum up, the analysis included 536 eligible deaths in Ouagadougou, 695 in Kaya, and 708 in Mlomp. In Mlomp, out of 809 deaths, 101 were discarded because the persons had been away from the site more than 6 months before their death.

Two sets of analyses were performed for each site. In a first step, in order to investigate the reasons for ultimate mobility, the net effect of the location of death on the place of death (in health structure or not) was assessed using a binary logistic regression. Covariates included sex, age group at death, marital status, education, and group of causes of death. In the second analysis, location of death was the outcome variable to determine factors associated with mobility before death. Its association with independent variables (sex, age group at death, marital status, education, and group of causes of death) was tested again using a binary logistic regression. For the particular case of Ouagadougou, place of birth was also included in the model to examine the effects of migration status (native or not) on location of death. All analyses were performed using STATA software, version 14.

2.4. Results

Location of death and Place of death

The proportion of adults who died outside the HDSS was rather low and similar in the sites of Ouagadougou (5.9%) and Kaya (5.3%). The situation was quite different in Mlomp where 20.6% of deaths occurred outside the HDSS. Regarding the association between place of death and location of death, different pictures emerged for each site (Table 2.1). In the urban setting of Ouagadougou, 45.7% of deaths occurring in the city took place in health facilities compared to 19.4% among deaths that occurred outside the city. The reverse situation was observed in the site of Kaya with 34.2% of deaths registered in health facilities among deaths that occurred within the HDSS compared to 70.3% for deaths that occurred outside. In the rural area of Mlomp, the differences in the proportions of health facility deaths by location of death, were much larger with 80.8% of deaths outside Mlomp occurring in health facilities. The figure was only 5.0% for deaths that occurred within the site .

Table 2.1 Proportion of deaths over 15 years of age that occurred in health facilities by location of death in Ouagadougou (2012-2015), Kaya (2012-2015) and Mlomp (2000-2015) HDSSs.

	Ouagadougou HDSS	Kaya HDSS	Mlomp HDSS
Location of death			
In the site	45.7%	34.2%	5.0%
Outside the site	19.4%	70.3%	80.8%
Proportion of deaths occurring in health facilities	44.1%	36.1%	20.6%

The results of the logistic regression presented in table 2.2 confirm the net effect of location of death on place of death in the three sites. This association was adjusted to the independent variables (sex, age group at death, education, marital status, place of birth in Ouagadougou, and group of causes of death in Ouagadougou and Mlomp). In the sites of Mlomp and Kaya, the odds of health facility death were higher for adults who died outside the HDSS than for those who died within the site. These results suggest that mobility before death in the two sites was motivated by health care seeking. This assumption is reinforced by the fact that in Mlomp, among those who died outside the site, in 91.1% of cases, their relatives reported that they left the village to seek health care. A contrasting picture emerged in Ouagadougou. The odds of dying in an health facility were lower for adults who died outside the city compared to those who died within the city. So, adults of Ouagadougou who moved before their death were probably not seeking medical care.

Table 2.2 Adjusted odds ratios of the binary logistic regression for the probability that a death occurred in a health facility in Ouagadougou (2012-2015), Kaya (2012-2015) and Mlomp (2000-2015) HDSSs.

	Ouagadougou HDSS		Kaya HDSS		Mlomp HDSS	
Died[(1)] outside the site	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
No	1		1		1	
Yes	0.2 (0.1-0.5)**	0.002	3.3 (1.5-7.1)**	0.003	77.9 (42.2-143.7)***	0.000

Source: Ouagadougou, Kaya and Mlomp HDSSs

Statistical significance:: *** p<0.001; ** p<0.05; * p<0.1

(1) Adjusted to sex, age group at death, education, marital status, birthplace for Ouagadougou and group of causes of death for Ouagadougou and Mlomp.

Socio-economic characteristics and location of death

The proportions of deaths outside each site by socio-economic characteristics are shown in table 2.3. In the Ouagadougou site, as expected, the proportion of deaths outside the city was twice as higher among non-natives (6.9%) as among natives (3.0%) of the city. In the three sites, the proportion of deaths outside the site decreased with age group. Compared to uneducated adults, a higher proportion of those who had at least one year of schooling died outside the sites in Kaya and Mlomp (17.1% vs 1.9% in Kaya; 37.1% vs 19.4% in Mlomp). But in Ouagadougou, the proportions of deaths occurring outside the city do not vary much by level of education. Regarding marital status, differences between single and married adults were more noticeable in Kaya and Mlomp, but not in Ouagadougou. Finally, in the sites of Mlomp and Ouagadougou, the proportion of deaths occurring outside each site was higher for deaths due to non-communicable diseases than for deaths from communicable diseases.

The adjusted odds ratio of the effects of the independent variables on the location of death are presented in table 2.3. For the particular case of Mlomp, results taking into account reasons for mobility before death are presented in the appendix (Table A2.1). Whether "death outside the village due to health care seeking", or simply "location of death" is used as the outcome variable, the results were similar. In the urban HDSS of Ouagadougou, the odds of dying outside for non-natives of the city were three times those of natives. Adult deaths due to non-communicable diseases were more likely to take place outside the city than deaths due to communicable diseases. The same goes for ill-defined deaths. However, in the rural site of Mlomp, there was no significant association between broad group of causes of death and location of death.

The age group had the strongest association with the location of death. Whatever the site, the elderly people were much less mobile before their death than young adults (aged below 40 years). In Kaya and Mlomp, there was a marked difference between people who died before age 40 and those who died at older ages. In the case of Ouagadougou, a significant association was found only between those aged 60 and more, and young adults.

Education does not affect location of death in either Ouagadougou or Mlomp. A strong effect was observed in Kaya, however. The odds of dying outside the site for adults who had at least one year of schooling was five times that of those with no schooling. The effect of marital status on location of death was only significant in the site of Mlomp.

Table 2.3 Proportion of deaths over 15 years of age that occurred outside the site by socio-demographic characteristics, and adjusted odds ratio of the binary logistic regression for the probability that a death occurred outside the site, in Ouagadougou (2012-2015), Kaya (2012-2015) and Mlomp (2000-2015) HDSSs

	Ouagadougou HDSS			Kaya HDSS[(1)]			Mlomp HDSS[(2)]		
Variables	%	OR (95% CI)	p	%	OR (95% CI)	p	%	OR (95% CI)	p
Birthplace									
Natives	3.0	1							
Non-natives	6.9	2.9 (1.0-8.8)*	0.056						
Sex									
Male	4.5	1		6.2	1		21.2	1	
Female	7.6	2.0 (0.8-4.7)	0.131	4.4	1.0 (0.4-2.1)	0.956	15.5	0.9 (0.5-1.3)	0.504
Age group at death									
15-39	8.9	1		17.2	1		45.5	1	
40-59	7.2	0.7 (0.2-1.9)	0.450	5.3	0.4 (0.2-1.1)	0.083	33.3	0.3 (0.1-0.7)**	0.007
60-79	3.6	0.2 (0.1-0.8)**	0.019	2.0	0.2 (0.0-0.5)**	0.002	18.4	0.1 (0.0-0.3)***	0.000
80+	4.3	0.2 (0.0-1.1)*	0.069	1.9	0.2 (0.0-0.7)**	0.015	6.3	0.0 (0.0-0.1)***	0.000
Education									
None	5.8	1		1.9	1		15.5	1	
Primary +	5.8	0.7 (0.3-1.7)	0.405	17.1	5.3 (1.8-16.0)**	0.003	37.1	1.2 (0.6-2.3)	0.633
Unknown	12.5	1.7 (0.2-17.2)	0.641	10.3	-	0.990	19.4	1.0 (0.6-1.5)	0.843
Marital status									
Married	5.5	1		2.5	1		24.2	1	
Single	7.6	1.2 (0.3-4.6)	0.755	17.9	1.6 (0.5-5.5)	0.453	28.1	0.3 (0.1-0.8)*	0.010
Divorced/Widowed	6.2	1.1 (0.4-3.1)	0.888	2.2	2.3 (0.6-9.7)	0.245	11.6	0.6 (0.4-1.0)*	0.053
Unknown				11.1	-		16.7	0.5 (0.1-3.5)	0.504
Group of causes of death									
Communicable diseases	3.2	1					16.7	1	
Non-communicable diseases	7.2	3.4 (1.3-9.0)**	0.014				20.2	1.2 (0.7-2.0)	0.451
Ill-defined	8.7	3.6 (1.0-14.4)*	0.064				16.9	1.1 (0.6-2.0)	0.839
Total	5.9			5.3			20.6		
Number of deaths		536			695			708	

Source: Ouagadougou, Kaya and Mlomp HDSSs

Statistical significance: *** p<0.01; ** p<0.05; * p<0.1

(1) In Kaya, people with unknown education and marital status are similar

(2) In the site of Mlomp, including a dummy variable in the model to control the effect of the period 2012-2015 does not change the results. The period does not have a significant effect at the 10% level.

2.5. Discussion

In this paper, we document the magnitude of short-term mobility before death in rural, semi-rural and urban areas of Burkina Faso and Senegal, along with the reasons for this mobility and the associated factors . The analysis was based on recent data on deceased adults (aged 15 years and above) collected in three HDSS sites (Ouagadougou, Kaya, Mlomp). To the best of our knowledge, this is the first time that short-term mobility before death was investigated in West Africa.

First of all, the results indicate that in rural and semi-rural areas, location of death is a good indicator for identifying health-care-seeking mobility at the end of life. Adults who moved outside their usual place of residence shortly before their death were clearly looking for medical care. Nonetheless, the magnitude of mobility depends on the supply of health facilities in each site. In Kaya, the supply of health facilities is acceptable, it includes a regional hospital, which is a referral centre for surrounding villages. This explains why the proportion of adults dying outside the area is rather low (5.3%). It is likely that adults who moved before their death were too seriously ill to be treated in Kaya. They were probably looking for specialized care in a larger city such as Ouagadougou, which is not far away. In the site of Mlomp, on the other hand, the supply of health services consists solely of one primary healthcare facility with a nurse and a maternity clinic. Since the area mostly provides mother and child health care, it is not surprising that seriously ill adults seek health care outside the village. The nearest hospitals in the region are in the small city of Oussouye, located 10 km from the HDSS area (presence of a physician), and in the larger city of Ziguinchor located 50 km from the HDSS area (more specialized care, including surgical facilities) . But some people may travel to distant cities, especially Dakar, where they have relatives to benefit from the family environment and seek medical care .

Our findings also show that adults in urban areas also move before their death despite the relative availability of healthcare. For example, the level of mobility found in the sites of Kaya (5.3%) and Ouagadougou (5.9%) are similar. But the reasons behind these mobility flows may be different. Our results showed that deaths outside Ouagadougou were more likely to occur at home, than deaths that took place in the city. Furthermore, the supply of health facilities is better in the city than in other locations in Burkina Faso (Ministère de la santé, 2010). It is likely that urban dwellers who moved before death did not have easy access to or desperately used the existing health care. Then, they preferred to find relief and comfort among their relatives in their home community. This was particularly the case for the non-natives of the city. The results confirmed the hypothesis that non-natives of the city were more likely to die outside the city than natives. It is quite probable that they went back to rural areas. In the Ouagadougou HDSS, around 70% of non-native adults over 15 years of age were born in rural areas (Rossier et al., 2011).

In rural and semi-rural areas, age was strongly associated with mobility before death, with younger adults being more mobile than the elderly people. This is consistent with the fact that functional limitations tend to increase with age and hinder elderly people's access to medical care (Debpur et al., 2010; Van Rooy et al., 2015). Their mobility may also be compromised by the lack of support from close relatives, especially the helping-hand of young adults who are generally involved in rural-urban migration. In addition to disability issues, cultural barriers also play a key role in explaining the decrease in health-care-seeking with age. Previous studies in Mlomp have found that older adults are generally more reluctant to use health facilities and prefer to rely on traditional medicine (Duthé et al., 2010). Furthermore, in the context of poverty, aging per se is rapidly conceptualized as a cause of death in itself. The community and family members are convinced that any treatment in favour of the elderly people will be ineffective. Sometimes, they prefer to invest more money in their funeral to ensure that their soul rests in peace (Sauerborn et al., 1996). Finally, older adults see themselves as unproductive and as a burden for their close relatives. For example, it has been reported in Senegal and Burkina Faso that after a certain age, some prefer to free themselves through death (Duthé et al., 2010; Sauerborn et al., 1996).

Regarding the causes of death, deaths due to non-communicable diseases were more likely to occur outside Ouagadougou than deaths due to communicable diseases. But, in the rural setting of Mlomp, we did not find a significant association between causes of death and mobility before death. Findings in Ouagadougou suggest that even in some cities access to health care for non-communicable diseases remains problematic. First, in the context of a poor country such as Burkina Faso, it is likely that the supply of specialized services for patients with these diseases is limited. Globally, health systems in West Africa continue to focus on infectious diseases despite global warnings on the rise of non-communicable diseases (Kushitor and Boatemaa, 2018). Second, because of lack of a palliative care, patients are obliged to develop coping strategies at the end of their life. It is probable that those suffering from chronic diseases have sufficient time to travel. Finally, cultural barriers or poverty can compromise patients' demand for health services. In particular, treatment of non-communicable diseases is generally costly in contexts where individuals have no health insurance (Kankeu et al., 2013).

In Mlomp, several mechanisms may explain the absence of differences in mobility before death between the groups causes of death. The concept of non-communicable diseases is not well understood into rural settings of Africa (Baldé, 2007). Rural residents are used to dealing with infectious diseases and may continue to resort to the same therapeutic itinerary, even in the cases of non-communicable diseases. A striking example is that of patients with hypertension and diabetes. It is reported that few are aware of their disease and even fewer seek care because of the lack of symptoms and the high costs of treatment (Kayima et al., 2013; Hall et al., 2011). In rural settings, health care seeking may perhaps also be seriously compromised by the lack of income. Patients need to have sufficient resources to undertake a difficult journey to seek care outside their place of residence.

In addition to age and group of causes of death, other variables such as education and marital status play a role in determining mobility before death in rural and semi-rural areas. While in Mlomp single adults are less mobile before their death than married ones, no effect was observed in Kaya. Consistent with some previous findings in SSA (Anteneh et al., 2013; Chisumpa et al., 2017), married adults can rely on the support of their partner to access medical care. But the effect of marital status may be blurred by the lack of information on standards of living. Married adults are likely to be wealthier than single adults. The confusion between the effects of marital status and standard of living may be higher in Kaya than in Mlomp. In this site, one can expect mobility before death to be more selective. As there is already a regional hospital in the area, it may be the most educated and wealthy residents who tend to travel to larger cities such as Ouagadougou to access the best health care services. This is confirmed by the fact that adults who went to school tend to be more mobile before their death in Kaya, whereas level of education had no impact in Mlomp.

It is important to point out various limitations of this study. First, in the three sites, deaths from external causes were excluded using different methods. However, in the west African context, sociability is so strong that these deaths generally do not go unnoticed in the community. It is thus likely that the different methods used to determine causes of deaths yield consistent results regarding deaths from external causes. Second, comparisons of causes of death in Mlomp and Ouagadougou are limited in this study because these causes are diagnosed using different methods (Physician certification in Mlomp and interVA-4 software in Ouagadougou). We cannot guarantee that interpretation of VAs and mobility before death are independent, particularly when VAs are reviewed by physicians. In Mlomp, the illness history section of the VAs may include some information on the patient's mobility before death that might influence the physician's interpretation. But the illness history is not taken into account in the inter-VA-4 software (Byass et al., 2012). Previous research has shown "a moderate agreement" between causes of death derived from the inter-VA software and diagnosed by physicians (Bauni et al., 2011; Tadesse, 2013). Furthermore, in this study inconsistency between the two methods of cause of death interpretation may be limited by the use of broad groups of causes of death. Third, in rural and semi-rural areas, it was not possible to distinguish between patient-initiated mobility and emergency referral to another hospital without passing through a relative's home. Such a distinction would refine the analysis. However, the reasons for mobility reported in Mlomp for deaths outside the site suggest that cases of emergency referral were limited. Four, representativeness of HDSSs cannot be guaranteed in this study. The different sites included may not represent the full diversity of urban and rural settings of West Africa. Finally, the effects of some variables on mobility before death may be biased by the lack of some information. Adults standards of living, and, for rural residents particularly, the existence of strong social ties in cities can influence mobility before death.

2.6. Conclusion

Despite these limitations, this study paves the way for future research on mobility before death in rural and urban areas of West Africa. Considering the evolutionary stages in societies related to place of death conceptualized by Gu et al. (2007), our findings show that many rural residents and urban residents of rural origin cannot obtain both medical and supportive care in the same place. Depending on their capacities (economic, networking, physical), they will develop coping strategies. Some rural residents leave home to seek health care, and some urban residents particularly those with rural origins return home to die. The two types of mobility do not necessarily occur at the same stage of the end of life: one is motivated by the hope of a cure and the other by the end of this hope. In this context, some individuals may be involved in circular mobility at the end of their life. Of public health importance, the movements of terminally-ill urban and rural residents can affect the estimation of urban/rural mortality differentials. The death of an adult who has moved away from home may be wrongly classified as an urban or rural death. This is likely to occur in large data collection operations such as censuses which focus on the number of deaths occurring in each household during the last 12 months.

2.7. Appendix

Table A2.1 Adjusted odds ratio of the binary logistic regression on the probability that a death occurred outside the site of Mlomp due to health care seeking (2000-2015).

Variables	OR (95% CI)	P. values
Sex		
Male	1	
Female	0.9 (0.6-1.4)	0.603
Age group at death		
15-39	1	
40-59	0.3 (0.1-0.8)**	0.015
60-79	0.2 (0.1-0.4)***	0.000
80+	0.1 (0.0-0.1)***	0.000
Education		
None	1	
Primary +	1.1 (0.6-2.3)	0.694
Unknown	1.0 (0.6-1.5)	0.879
Marital status		
Married	1	
Single	0.3 (0.1-0.8)**	0.013
Divorced/Widowed	0.7 (0.4-1.1)	0.105
Unknown	0.2 (0.0-2.4)	0.221
Group of causes of death		
Communicable diseases	1	
Non-communicable diseases	1.2 (0.7-2.0)	0.592
Ill-defined	1.0 (0.5-2.0)	0.908
Number of observations	708	

Source: Mlomp HDSS

Statistical significance:*** $p<0.01$; ** $p<0.05$; * $p<0.1$

Acknowledgments: The authors are particularly grateful to Bruno Masquelier and Philippe Bocquier for revising the first draft of this paper. We also thank Vincent Bagnoa for providing useful insights on the data collected in the site of Kaya.

Author's contribution: BL and GD analyzed the data and wrote the first draft of the paper. AS and GP revised it critically and approved the final manuscript.

Conflict of interest and funding: The authors report no conflicts of interest.

Ethics and consent: We did not seek ethical approval for this study. Ethical approval was the responsibility of the institutions which collected the data.

Funding information: The project leading to this work has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 690984: DEMOSTAF project. The funding promotes staff exchanges between institutions located in developed and developing countries.

Paper context: In Sub-Saharan Africa, the literature on end of life focuses on place of death. Little is known about population mobility at the end of life. This study documents short-term mobility before death among adults over 15 years of age in Burkina Faso and Senegal. Some rural residents move to access health care while some urban dwellers move to benefit from supportive care. These movements preceding death can affect the estimation of urban/rural mortality differentials.

CHAPTER 3: ESTIMATING MORTALITY FROM CENSUS DATA: AN ASSESSMENT BASED ON THE NOUNA DEMOGRAPHIC AND HEALTH SURVEILLANCE SYSTEM IN BURKINA FASO

AUTHORS

Bruno Lankoande[a], Hélène Zida[b], Bruno Masquelier[a], Pascal Zabré[c], Géraldine Duthé[d], Abdramane Soura[e], Gilles Pison[d][f], Ali Sié[c]

[a] (Corresponding author), Center for demographic research-Université catholique de louvain (UCL), Louvain-la-Neuve, Belgium

[b] Institut national de la statistique et de la démographie (INSD), Ouagadougou, Burkina Faso

[c] Centre de recherche en santé de Nouna (CRSN), Nouna, Burkina Faso

[d] French institute for demographic studies (INED), Paris, France

[e] Institut supérieur des sciences de la population (ISSP), Université Ouaga I Joseph Ki-Zerbo, Ouagadougou, Burkina Faso

[f] Muséum national d'histoire naturelle (MNHN), Paris, France

JOURNAL

Manuscript to be submitted

3.1. Abstract

Because of the absence of comprehensive death registration in most countries in Sub-Saharan Africa, mortality levels and trends are largely derived from large-scale surveys and censuses. The reliability of the corresponding estimates is difficult to assess without a gold standard. With the specific example of Burkina Faso, this paper compares mortality estimates from the 2006 national census with data collected in the Nouna Health and Demographic Surveillance System (HDSS). We extracted from the census database only the records referring to the population under longitudinal surveillance in the HDSS. Various direct and indirect methods were applied to estimate and compare mortality from both sources. We decomposed the differences in life expectancies into contributions of discrepancies in children, adults and the elderly. Child mortality rates obtained indirectly from numbers of children ever born and surviving were broadly consistent with HDSS estimates, especially among boys. By contrast, indirect estimates of adult mortality obtained from reports on orphanhood in the census were implausibly low. Life expectancies derived from the number of recent deaths in households also pointed to lower mortality than monitored in the HDSS, with a difference of 3.2 years for men and 6.8 years for women. Age misreporting or underreporting of deaths in the census among the population aged 60 and above accounted for about half of these differences. Triangulating national census data with demographic surveillance systems can help in assessing mortality rates derived from various estimation methods. Innovative strategies are required to improve data collection on ages, parental survival and recent household deaths.

Keywords: Burkina Faso, Demographic Surveillance System, mortality, indirect demographic techniques, national censuses

3.2. Background

Counting who is dying and what they are dying from is fundamental to generate accurate statistics for guiding the resource allocation within the health sector and evaluating the effectiveness of programs to reduce mortality. The ideal data source is a comprehensive system of civil registration and vital statistics (CRVS), providing information on deaths by age and sex, with causes of death certified by a medical practitioner. However, the registration of deaths is still inefficient at the national scale in most of Sub-Saharan Africa, and progress has been modest in this area in recent decades (Mikkelsen et al., 2015). One of the least developed countries, Burkina Faso, located in Western Africa, is no exception. In the interim, mortality rates have to be derived from survey or census data. While large-scale sample surveys have collected birth and sibling survival histories, allowing the direct estimation of mortality (Masquelier et al., 2014), national censuses have included questions on the survival of children, parents, and recent household members, mostly for indirect estimation (Moultrie et al., 2013).

A first set of questions in censuses aims to collect summary birth histories, that is, the number of children ever born and surviving of women of reproductive age. There is a general consensus in the literature that the proportion dead of children born to women by age (or duration since first birth) provide robust mortality estimates in the absence of abrupt mortality changes (Hill, 2013; Rajaratnam et al., 2010; Silva, 2012). Indirect estimates of adult mortality can also be derived from reports on orphanhood, but these are considered with more skepticism. The most pervasive problem is commonly known as “the adoption effect” (Blacker, 1977; Hill and Trussel, 1977; Robertson et al., 2008), caused by enumerators not systematically probing whether children observed in households are the true offspring of the adults being interviewed, or by foster parents deliberately or inadvertently claiming adopted orphans as their own children. Thirdly, censuses also regularly collect data on the number of deaths in each household in the year preceding the enumeration, which makes it possible to generate a complete life table. Biases are introduced by underreporting of deaths due to recall errors, dissolution of some households following the death of adults, but also coverage errors, and transfers of some deaths outside of the 12-month reference period (Bennett and Horiuchi, 1984; Hill, 1987; Timæus, 1991). A series of "death distribution methods" have been developed to adjust upwards mortality levels obtained from recent household deaths, but they are based on strong assumptions, such as a constant underreporting of deaths over a certain age limit (Moultrie et al., 2013). Finally, all estimation approaches are also sensitive to age misreporting (Ewbank, 1981) and under enumeration of some specific populations, especially young adults or the elderly (Randall and Coast, 2016).

The magnitude and direction of these errors are difficult to assess in the absence of a mortality gold standard. While census-based estimates have sometimes been evaluated in simulated environments (Hill et al., 2009; Murray et al., 2010; Verhulst, 2016) there have been few attempts to compare them to high-quality data from Health and Demographic Surveillance Systems (HDSS). In HDSS, the population of a locally defined population is followed regularly through repeated household visits. New individuals may enter the population through birth or immigration, and leave them by emigration or death. At each visit, investigators examine the composition of each household, check the lists of its members present at the previous visit and collect information on births, deaths, marriages, and migrations since the previous visit. This greatly limits the scope for omissions of vital events and age misreporting; making HDSS one the most accurate sources of mortality estimates in countries without vital registration, but referring only to specific geographical areas (Streatfield et al., 2014; Pison, 2005).

There are currently 49 HDSS sites in low-and middle-income countries federated in the INDEPTH Network, many of them in operation since several decades (Sankoh and Byass, 2012). Since these sites are included in the frame of exhaustive national censuses, they can be used to evaluate the reliability of census estimates. In Senegal, mortality estimates from the 2002 and 2013 censuses were evaluated against three rural HDSS (Bandafassi, Mlomp and Niakhar). Under-five mortality rates from censuses were lower than expected based on demographic surveillance. Estimates inferred from parental survival were implausibly low. By contrast, age-specific mortality rates based on recent household deaths were consistent with the follow-up data, except for infant mortality, which was significantly under-reported in 2002 (Masquelier et al., 2016).

In this paper, we use the Nouna HDSS, located in the northwest of Burkina Faso to extend the comparison and evaluate the reliability of mortality indicators derived from the last national census, conducted in 2006. The objective is to reveal the relative strengths and weaknesses of the available tools for mortality estimation based on censuses.

3.3. Data and methods

Our reference dataset is made of data collected regularly in the Nouna HDSS since the 1990s, administered by the *Centre de Recherche en Santé de Nouna* (CRSN). The HDSS was set up in 1992 in a rural area of Burkina Faso, about 300 kilometers from the capital city, Ouagadougou. After an initial census conducted in 1992, information on vital events (deaths, births and migrations) is collected three times a year (Sie et al., 2010). The population under surveillance was estimated at more than 80,000 individuals in 2006 and is spread over 58 villages and a small town.

The 2006 national census of Burkina Faso was conducted from 9 to 23 December. Based on the names of villages, we extracted individual-level data of the population under surveillance in the HDSS from the census database. We compared the size of population and its composition by sex and age according to the two sources. It should be stated at the outset that the definition of the residency used in the HDSS is more restrictive than the definition retained in the census. The concept of residence has changed in the Nouna HDSS over the years but in the present study we consider as resident an individual whose length of stay in the HDSS is at least 6 months. In the 2006 national census, a resident is any person who has been living in the enumerated household for at least six months or *who intends to do so*. As a result, the census will include migrants who arrived in the area recently and plan to stay, while these will not be considered as residents in the HDSS. Using the census records covering the area of the population under surveillance, we then produced various mortality indicators to compare with estimates obtained from the continuous follow-up in the HDSS, based on event-history analysis.

First, the census included a question on the number of children ever born to women aged 10 years and above, and the number of these children surviving at the time of the census. Under-five mortality rates were estimated indirectly from these numbers, using the North pattern of model life tables (Hill, 2013). This method uses a set of standard coefficients capturing variations in mortality and fertility patterns to convert proportions dead of children born to women by age group into the probability ${}_5q_0$, that is, the risk of a newborn dying before his or her fifth birthday. We discarded estimates derived from women aged 15 to 19 because these are usually plagued by selection biases associated with higher mortality of first-born children.

Second, the census asked about the survival of parents of individuals aged less than 30. We applied the standard orphanhood method (Timæus, 1992), which takes advantage of the close connection that exists between the proportion of non-orphans of age *a* and the probability of survival ${}_a p_M$, where *M* stands for the age of the respondent's parents at their birth. Estimates obtained for the different age groups of respondents were converted into the probability ${}_{45}q_{15}$ (the risk of an individual aged 15 dying before reaching 60 under the mortality rates prevailing in a given year), again using the North model life table.

Lastly, household respondents had to report on the number of deaths by age and sex in the last 12 months. We divided these numbers by the population enumerated in December 2006 to generate a complete life table. Since the census took place in mid-December, we adjusted upwards the number of deaths to account for the absence of deaths reported in last two weeks of 2006. We did not adjust for population growth. In the HDSS, we approached as much as possible the census enumeration method in 2006 to compute the population used as the denominator for rates. More precisely, since HDSS data are formatted for event history analysis, the population in the HDSS corresponding to the one which should have been enumerated in the 2006 census was obtained by splitting records in June 15 of 2006 (that is, 6 months before the date of enumeration). We compared summary indices of mortality between census and HDSS estimates, and decomposed the differences in life expectancies at birth into contributions of the major age groups (Arriaga, 1984).

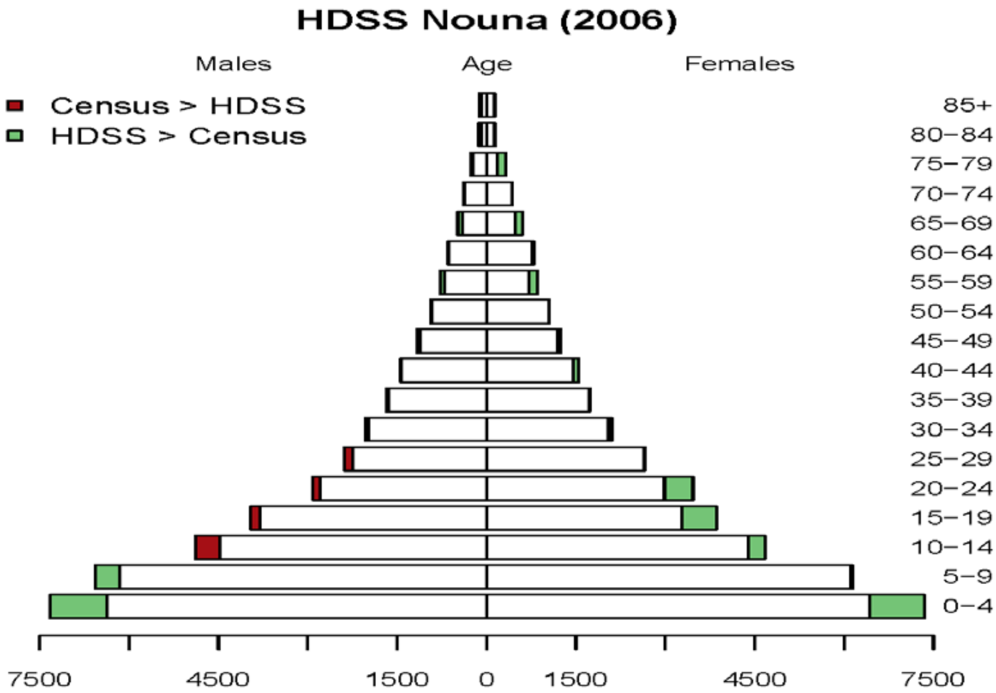
3.4. Results

Population by age and sex in 2006

Figure 3.1 shows the population pyramid according to the HDSS and the census. Overall, the census and HDSS populations are quite close. The male population is only 2% larger in the HDSS, but the female population is 7% larger in the HDSS, as compared to the census[1]. The most notable difference between the two populations relates to children aged less than 5 years, with a relative difference of - 13% in both sexes, which is most likely due to underenumeration of infants in the census. The same pattern applies to young women aged 10-24, with a relative difference of -11%. By contrast, the census enumerated more males aged 10-29 (+10%). There was a good congruence in the numbers of adults aged 30 to 59, with relative differences lower than 5%.

[1] Relatives differences are computed as $(n_{census} - n_{hdss})/n_{hdss}$ where n_{census} refers to the population of the census and n_{hdss} to the population of the HDSS.

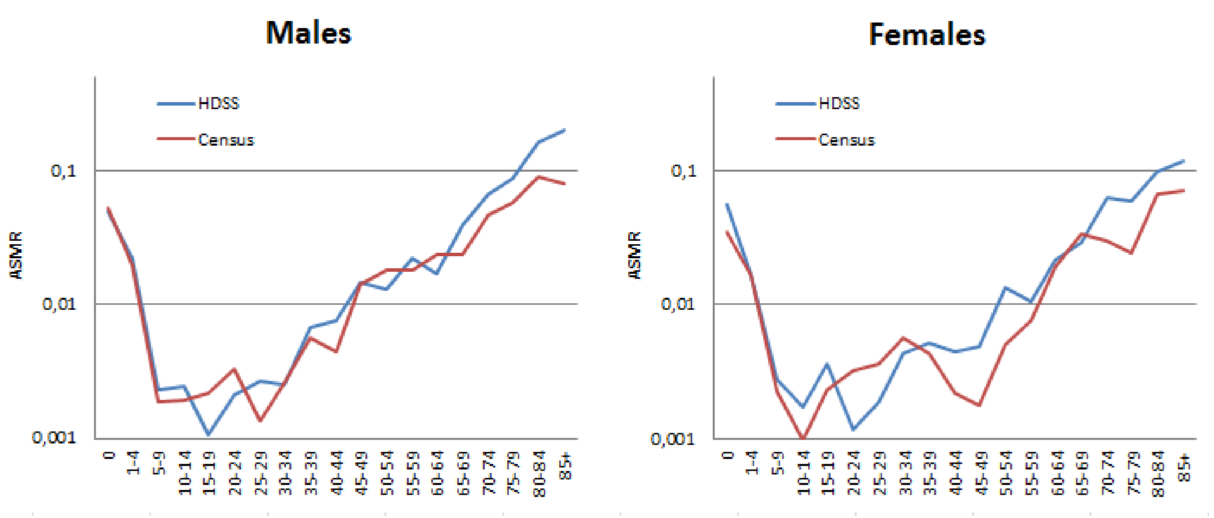
Figure 3.1 Population pyramid of the Nouna HDSS according to the demographic follow-up and the 2006 census (December 2006)



Reporting of deaths in 2006 according to the HDSS and the census

Figure 3.2 compares age-specific mortality rates as estimated from reported number of deaths in the 12 months preceding the census with HDSS estimates for the same year, for each sex. Table 3.1 presents the corresponding summary indices of mortality. The consistency between both series of estimates clearly varies by sex. Mortality levels in boys aged less than 5 and men aged 15-59 matched fairly well with HDSS rates, with relative differences lower than 5% in the probabilities ${}_5q_0$ and ${}_{45}q_{15}$. Still, we observe a difference of 3.2 years in life expectancy at birth, which is largely due to lower mortality among men aged 60 and above. In particular, the risk of dying between ages 60 and 80 among males was 18% lower in the census. Among women, infant mortality is lower in the census, as well as mortality rates in the age group 40-59. There is also a larger difference in mortality rates above age 60 among females. This results in an estimate of life expectancy at birth which is 6.8 years higher in the census for females, when compared to the HDSS. Mortality difference in the age group 60 and above contributes to 3.1 years in this difference in life expectancy at birth.

Figure 3.2 Age specific mortality rates (ASMR) inferred from the census and the HDSS data, Nouna, 2006



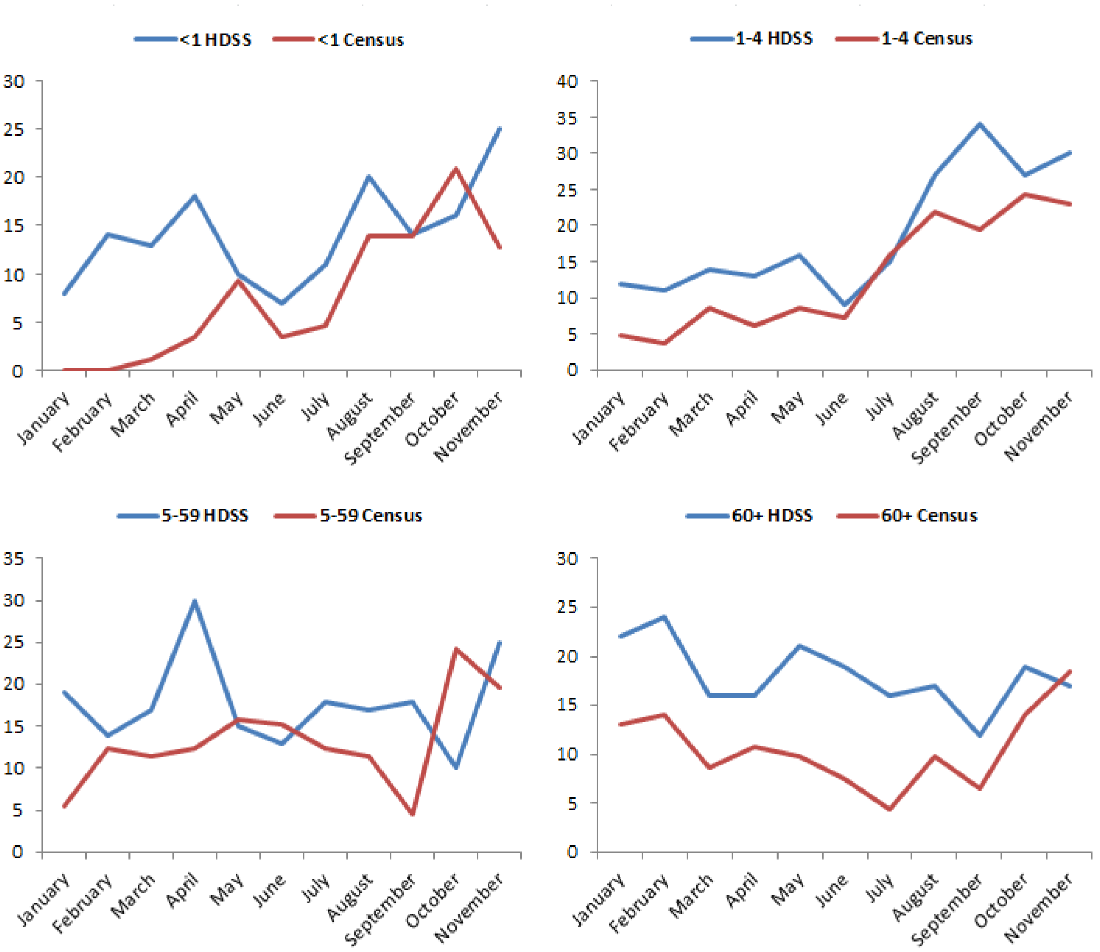
In Figure 3.3, we compare the number of deaths reported in the census by month and age group with the HDSS in 2006. In both sources, there are more deaths in the recent period preceding the census (August - November) than in the first half of the year, reflecting the seasonality of mortality with a typical excess of child deaths at the end of the raining season (due to malaria and diarrheal diseases) (Kynast-Wolf, 2006). However, we note that in all age groups, the ratio between the reported numbers of deaths in the census and in the HDSS is larger in the first half of the year, especially among infants for which the HDSS registered four times more deaths than the census in the period January-July 2006.

Table 3.1 Direct estimates of mortality in Nouna according to the HDSS and the reporting of deaths that occurred in households during the last 12 months in 2006 census

	Males				**Females**			
Mortality indices	**Census**	**HDSS**	**Relative diff.[1]**	**Contribution to diff.[2]**	**Census**	**HDSS**	**Relative diff.[1]**	**Contribution to diff.[2]**
Risk of dying (p. 1000)								
$_{5}q_{0}$	123	128	-3%	0.3	96	114	-16%	1.9
$_{10}q_{5}$	19	23	-19%	0	16	22	-28%	-0.8
$_{45}q_{15}$	296	304	-3%	0.9	164	219	-25%	2.5
$_{20}q_{60}$	535	653	-18%	2.1	414	581	-29%	3.1
Life expectancy (in years)				Difference				Difference
e0	61	57.8	6%	3.2	68.6	61.8	11%	6.8

Notes: (1) Relative difference = $\frac{rate_{census-rate_{HDSS}}}{rate_{HDSS}}$, (2) contributions of mortality difference in the age group to the difference in life expectancy at birth. The last estimate refers to mortality rates in the open-ended age group 60+.

Figure 3.3 Number of deaths reported by month in 2006 in Nouna according to the HDSS and the census, by age-group



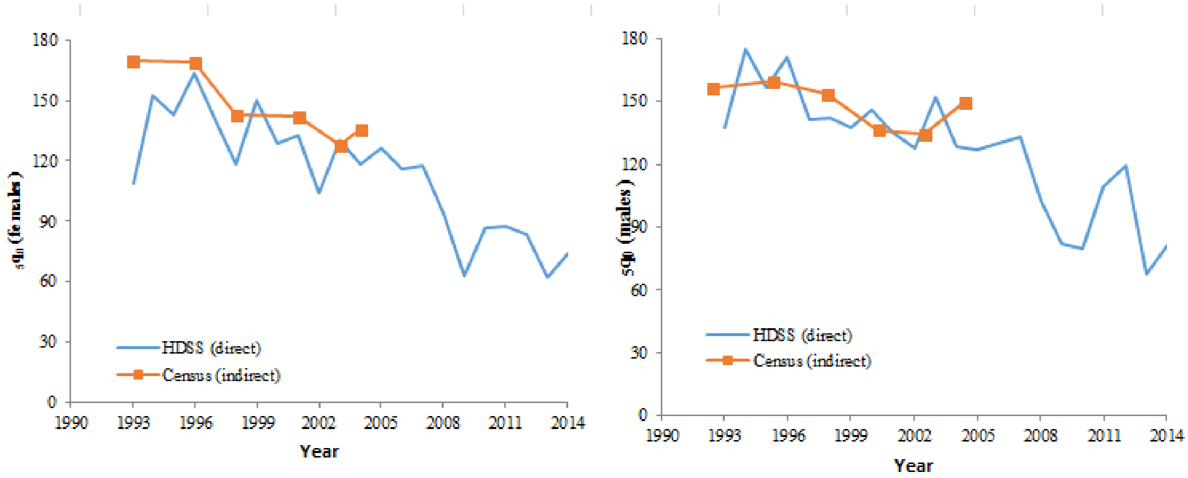
Note: the reported numbers for December are not shown because the census took place between Dec 9 and 23.

Indirect estimates of mortality in children and adults

- Among children

In both sexes, levels and trends in under-five mortality derived from census data on children ever born and surviving are fairly consistent with the HDSS estimates, with a slight difference by sex (Figure 3.4). As expected, census estimates are more smoothed, because the time-location of indirect estimates is based on an assumption of linear and unidirectional mortality decline. If we discard the period 1992-3, which was the start of the follow-up, and may have been affected by underreporting in the HDSS, census estimates for girls are on average 8% higher than estimated from the demographic follow-up during the period 1996-2004. Among boys, census estimates are on average 1% higher than estimates derived from the HDSS during the period 1995-2004. Considering that census and HDSS estimates do not necessarily refer to the same children (e.g. all children born to women residing in the area at the time of the census will be considered for indirect estimates, whereas only children who reside in the area should be included in HDSS estimates), this consistency is remarkable.

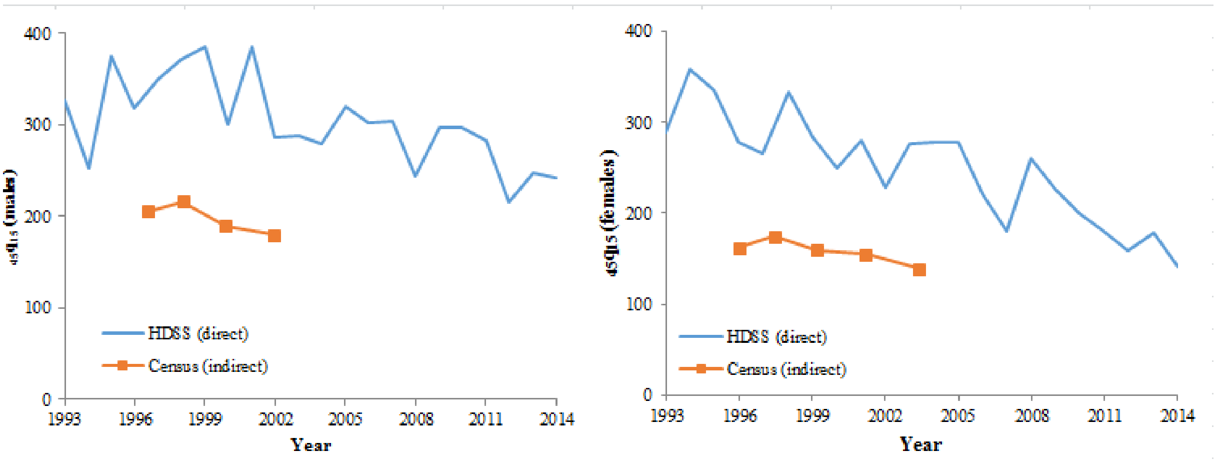
Figure 3.4 Comparison of indirect estimates of child mortality ($_5q_0$) inferred from the census with HDSS estimates



- Among adults (15-59 years old)

By contrast, Figure 3.5 indicates that adult mortality estimates derived from orphanhood data collected in the census are implausibly low, when compared to HDSS estimates. These are 43% lower on average in women during the period 1996-2003 and 40% lower on average in men during the period 1997-2002. Again, these two series do not necessarily refer to the same individuals, because census estimates are obtained from residents of the HDSS, whose parents do not necessarily live in the area, while the HDSS estimates refer to mortality experienced in Nouna. A question in the census on the place of residence of surviving parents showed that the percentage of children whose parents live in the same household declined rapidly by age, from 78% among adolescents aged 10-14 living with their mothers to 13% among 25- to 29-year-olds. 78% of children aged 10-14 whose father was alive at the time of the census also lived with their father, against only 16% of young adults aged 25 to 29. Adult mortality rates inferred from parental survival in the census are therefore a mix of local mortality conditions and conditions prevailing outside of the HDSS. However, the discrepancies between census and HDSS estimates are so large that they indicate a considerable amount of underreporting of deaths of parents, for both maternal and paternal orphanhood.

Figure 3.5 Comparison of indirect estimates of adult mortality (${}_{45}q_{15}$) inferred from the census with HDSS estimates



3.5. Discussion

Many demographic methods have been developed to detect and adjust for recall errors in censuses and surveys, in particular by examining the external validity or the internal consistency of the estimates (Moultrie et al., 2013). Comparison of different data sources is often used, but it is difficult to reach solid conclusions in the absence of a reference that is often also affected by errors. In this paper, we used high-quality mortality data from one HDSS in Burkina Faso to evaluate estimates inferred from one census. We found a good agreement in population counts, despite some deviations in children aged less than 5 and in young adults. The larger number of young males in the census could be related to recent arrivals in the area of men who intend to stay but have not yet spent 6 months in the HDSS. However, the undercounting of young women is more difficult to explain. One can speculate that some young women who temporarily left the HDSS area for educational or professional reasons were still considered as resident in the HDSS despite not being counted as such in the census. Indeed, in the site of Nouna, some young females are engaged in seasonal outmigration (during the dry season) towards the towns of Ouagadougou and Bobo Dioulasso.

In terms of mortality, reports on the numbers of children ever born and surviving provide the most reliable estimates, when compared to levels observed in the HDSS. By contrast, the orphanhood method performed poorly, for both male and female mortality. This suggests that the adoption bias is pervasive, or that questions were not well understood by census enumerators or by the respondents. The adoption effect is usually less pronounced in reports relative to older adults, partly because at older ages, both biological and foster parents are more likely to be dead, but the question was limited here to the population aged less than

30. Higher quality of reports on paternal orphanhood status are usually expected, due to a higher likelihood of paternal orphans to live with their surviving mother (as compared with maternal orphans with their surviving father), as well as by higher remarriage rates among widowers (Robertson et al., 2008). However, we did not observe here that deviations were larger for maternal orphanhood.

Finally, we note substantial discrepancies between HDSS and census estimates of female mortality from recent household deaths, with a better congruence for males. As indicated earlier, one key assumption underpinning the demographic methods designed to adjust data on recent household deaths is that underreporting is invariant by age. Our analysis clearly indicates that this assumption would be violated in the census data, even when restricting the analysis to adults.

A number of reasons may be put forward to explain these deviations with HDSS estimates. First, deaths could be underreported in the census, either because enumerators did not systematically ask about household deaths, which remain a relatively rare event, because respondents were unwilling to talk about their deceased relatives, or because some deceased were not clearly identified as members of one specific household (e.g. recent migrants). Second, like in many other censuses, there is a mismatch between the reference period used for recent household deaths in the census (12 months) and the period used to define the resident population (6 months). For instance, an individual who died 8 months prior to the census should be reported in the census, but a migrant who left the area 8 months prior to the census should not be considered as resident, even if he contributed to the exposure time when calculating mortality rates conventionally. In cases of large flows of seasonal migration, this mismatch could distort mortality estimates. Third, the ages of the deceased and the surviving population could be exaggerated, and age misreporting could be more pervasive among women, leading to larger deviations from HDSS estimates. Finally, some households may disperse and recompose after the death of one of their members, making it more likely that this death goes unreported in the census. This kind of selection bias will be more prevalent for deaths that occurred in the more distant past, as compared to deaths immediately preceding the census.

We showed that the number of reported deaths declines as the number of months between their occurrence and the census increases. This decline cannot solely be explained by the seasonality in mortality observed in Nouna. This could point to some selection biases, but the fact that this decline is stronger among infants point rather in the direction of recall errors.

The patterns observed here are slightly different from previous comparisons made in Senegal, where direct estimates based on recent household deaths were plausible beyond the age of five, while indirect estimates of under-five mortality too low in the censuses (Masquelier et al., 2016). This reinforces the need to undertake similar analysis in other HDSS sites in Burkina Faso (Saponé, Ouagadougou, Nanoro, Kaya) and also other Sub-Saharan countries where vital registration systems are incomplete. Direct evaluation studies conducted at the individual level are also required, by linking reports in the census with the demographic data contained in the HDSS database for census respondents.

Finally, this study also highlights the need for renewed efforts to improve data quality by seeking to limit the use of proxy respondents in censuses, and developing innovative ways to improve the reporting of age and demographic events, such as historical calendars.

3.6. Conclusion

Triangulating national census data with demographic surveillance systems can help in assessing mortality rates derived from various estimation methods. Given that the HDSS puts heavy emphasis on the collection of accurate demographic data with regular visits, it is likely that mortality rates in children as well as in adults were underestimated in the 2006 census in this area, especially among women. Further analysis is needed to better understand the sources of discrepancies between the census and the demographic follow up.

Ethical approval: We did not seek ethical approval for this study because it is based on secondary analysis of aggregate census and HDSS data, with no record linkage involved. Ethical approval was the responsibility of the institutions which collected the data.

Consent for publication: Not applicable

Availability of data and materials: This study used an extract of the complete database of the 2006 national census of Burkina Faso. While this extract cannot be made publicly available, a representative sample of the national census is available through the IPUMS program (https://international.ipums.org/international/). The datasets referring to the HDSS in Nouna analysed during the current study are available from the last author on reasonable request.

Competing interests: The authors declare that they have no competing interests.

Funding: The project leading to this work has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 690984: DEMOSTAF project.

Authors' contributions: BL, HZ and BM analyzed the census data, PZ and BL analyzed the HDSS data. BM, HZ and BL wrote the first draft of the paper. All authors read and approved the final manuscript.

Acknowledgements: Not applicable.

Authors' information: Not applicable.

CHAPTER 4: MONITORING ADULT MORTALITY BY TYPE OF RESIDENCE IN THE ABSENCE OF DEATH REGISTRATION: A PERSPECTIVE FROM BURKINA FASO

AUTHOR

Bruno Yempabou Lankoande, Centre for demographic research, Université catholique de louvain (UCL), Louvain-la-Neuve, Belgium

JOURNAL

Manuscript published in *International Journal of Population Studies*, Volume 2, Issue 1, August 2016.

4.1. Abstract

In the context of the post 2015 agenda, disaggregation of mortality indicators is needed to assess health inequalities within populations. However, producing sub-national estimates of adult mortality is notably difficult in the absence of death registration. Using Burkina Faso as a case study, this paper revisits the main avenues to quantify differences in adult mortality between the ages of 15 and 60 according to urban/rural residence. Estimates are based on reports on the survival of parents and siblings collected in surveys and in the 2006 census, and compared to levels inferred from recent household deaths or inferences based on child mortality. Results indicate that in Burkina Faso, adults living in urban areas still benefit from a health advantage compared to their rural counterparts. Thus, efforts made in reducing adult mortality in rural settings should be intensified. In terms of methods, this analysis shows the value of asking additional questions about the place of residence of close relatives to avoid misclassification errors. The approach adopted here could be implemented in other countries to facilitate the measurement of spatial inequalities in health indicators for all ages when monitoring Sustainable Development Goals (SDGs).

Keywords: adult mortality, Burkina Faso, indirect techniques, urban, rural, SDGs

4.2. Background

Historically, European cities were long characterized by higher mortality rates, a phenomena referred to as the “urban penalty”, while cities in Sub-Saharan Africa have long benefited from a comparative advantage, due to colonial health policies that were very favorable to large urban centers (Leon, 2008). As many health determinants (such as education, sanitation, access to health services, and wealth) are better on average in urban areas, it is generally assumed that urban residents in Sub-Saharan Africa benefit from better health conditions compared to their rural counterparts (Leon, 2008; Montgomery, 2009). Hence, mortality rates by urban/rural location are regularly monitored to track progress made in reducing the gap in mortality, initially with a focus on rural health, but with a particular attention on urban health in recent years (Fink et al., 2014; Bocquier et al., 2011). Yet, most of these studies were limited on child survival and findings, mainly based on the Demographic and Health Surveys (DHS), show that the urban advantage is weakening overtime. This is partly due to the development of slums associated with rapid and poorly managed urbanization in Sub-Saharan Africa (Kimani-Murage et al., 2014). This particular focus on child survival fit well within the context of the Millennium Development Goals (MDGs), but adult health is now as important on the global health agenda. Coupled with the strong desire to place equity in a central role in the Sustainable Development Goal (SDG) framework (“no one should be left behind”), disaggregation of adult mortality indicators by urban/rural location is now imperative to track progress in a world that is becoming both older and more urban (United Nations, 2015).

A better monitoring of adult mortality by place of residence is more important than ever in Sub-Saharan Africa; available evidence shows that rapid urbanization could be a threat to adult health. In contrast to most rural areas where infectious and parasitic diseases remain the leading causes of deaths, urban settings of Sub-Saharan Africa are often characterized by a “double burden of diseases,” particularly among urban poor (Ramroth et al., 2012; Awini et al., 2014; Agyei-Mensah and de-Graft Aikins, 2010). While wealthy adults are at higher risk of non-communicable diseases due to lifestyle (smoking, alcohol consumption, physical inactivity), and inadequate diet habits (diets too rich in sugar, salt, fat), the urban poor bear simultaneously the burden of infectious and non-communicable diseases (Soura et al., 2014; Mberu et al., 2015). For instance, slums are a favorable ground for some infectious diseases such as malaria and tuberculosis, and at the same time their inhabitants tend to consume cheaper energy dense food that promote obesity, a risk factor for non-communicable diseases (Neiderud, 2015; Zeba, 2012). Furthermore, mental disorders and injuries seem to be more prevalent in urban settings of Sub-Saharan Africa (Dyson, 2003; Kobusingye et al., 2001). In summary, it is simplistic to always consider the urban environment as a “safer place” for adults, compared to rural areas. Poor sanitary and living conditions experienced by rural dwellers may be offset by health problems related specifically to urban residence.

Despite its relevance for the global health agenda, research on urban/rural differentials in adult mortality in Sub-Saharan Africa is still largely limited by the scarcity of data. While much is known about child mortality, the measurement of adult mortality is hampered by the lack of reliable data and the absence of very robust estimation methods. In the absence of civil registration data, estimates derived from surveys and censuses are prone to recall errors and selection biases (Reniers et al., 2011). These problems are magnified when looking at differentials.

Census reports on the number of household members who died in the last 12 months are a common source of data on adult mortality by place of residence. However, these data are subject to many errors, including omissions of deaths due to recall errors and household dissolutions after a death of an adult, but also fieldworkers’ related errors, coverage errors, and errors on the reference period (Timæus, 1991). Adult mortality rates published in census reports are sometimes also inferred from child mortality rates combined with model life tables, but this practice is not recommended because mortality in children and adult do not always evolve in the same direction (Masquelier et al., 2014). This approach is even more problematic when deriving estimates of adult mortality by place of residence, because nothing guarantees that urban/rural differentials are invariant by age. Child mortality rates are dominated by infectious diseases which are more prevalent in rural areas, while chronic conditions that disproportionately affect adults are typical of urban areas.

Apart from census estimates, it is possible to derive mortality rates from survey reports on the survival of close relatives, such as parents or siblings. Nevertheless, estimates based on these methods are also not exempt of problems (Helleringer et al., 2014; Reniers et al., 2011). Mortality rates obtained from the survival of parents are related to the past and dating estimates is only possible under some assumptions. Data on survival of siblings provide the opportunity to directly estimate adult mortality but estimates may be altered by underreporting of deaths. Nevertheless, beyond these general issues related to the estimation, deriving estimates of adult mortality by place of residence is even more challenging since information on the place of residence of close relatives is not collected in surveys such as DHS. To the best of my knowledge, no attempt was made in the literature to estimate adult mortality by place of residence based on orphanhood data. However, few studies have used sibling survival data collected in the “maternal mortality module” of the Demographic and Health Surveys (DHS) to explore urban/rural differences in adult mortality in Sub-Saharan Africa. Their findings are not consistent, and this is likely due to the different approaches adopted to circumvent the issue raised by the lack of information on the place of residence or death of the siblings. De Walque and Filmer (2013) assumed that women and their siblings share the same place of residence and concluded to a slightly higher mortality in rural areas of Sub-Saharan Africa. It was an analysis of pooled data on sibling survival collected in 84 DHS surveys from 46 countries (33 of which were in Sub-Saharan Africa). The datasets covered the period of 1975–2004 and adult mortality was measured as the risk of dying between the ages of 15 and 55. In addition to the issue of the sibling’s place of residence, the aggregated analysis conducted by the authors will hide cross-country variations in the urban/rural disparities in adult mortality. Also based on sibling survival data of the DHS datasets, Günther and Harttgen (2012) documented urban/rural mortality differences at the country level in 14 Sub-Saharan countries. The risk of dying between the ages of 15 and 45 was used as a measure of adult mortality. In complement to the approximation made by De Walque and Filmer (2013), their analysis was restricted to siblings reported by women who spent their entire life in an urban (rural) area. They found that in the 2000s, out of 14 countries, urban adult mortality rates were *higher* than rural mortality rates for 11 countries. For example, in Burkina Faso, urban/rural adult mortality ratio rose from 1.09 during the 10 years before the 1998 DHS to 1.33 also ten years before the 2003 DHS. These results were totally inconsistent with estimates published in Burkina Faso’s census reports where an excess mortality in rural areas was documented in 1984, 1995, and 2006 (INSD, 1989; 2000a; 2009a).

Faced with these inconsistent results and limitations inherent in the different methods, this paper uses Burkina Faso as a case study to explore new strategies for providing better disaggregated mortality indicators in countries lacking vital registration. Existing research on differentials in adult mortality by urban/rural location are extended in two directions. First, I revisit together, the main estimation methods that were used in isolation in previous studies despite their limitations. This includes the application of the orphanhood method that has never been used to look at mortality differentials by urban/rural location. Second, the impact of limitations related to the different techniques on mortality differentials is assessed by further analysis and thanks to the use of a specific survey conducted in 2000 which included questions on the place of residence and deaths of parents. The study covers approximately the 1989–2006 period and starts with the presentation of the study setting. Adult mortality by urban/rural location is then computed using indirect methods and multiple data sources. The estimates are discussed and reconciled to offer a coherent picture of urban/rural adult mortality differences in Burkina Faso. Lastly, I discuss technical issues related to adult mortality estimation by place of residence in Sub-Saharan Africa in general, and draw conclusions for the measurement of differentials.

4.3. Data and Methods

Study Setting

Burkina Faso is one of the poorest countries in the world, with a population estimated at 14 million inhabitants in 2006 (INSD, 2009b). The population size has grown at an annual rate of 3.1% between the two last censuses (1996–2006), but the annual growth rate in the urban areas is as high as 7.1%, more than twice the national average (INSD, 2009b). In recent years, the country has experienced a rapid and poorly managed urbanization. As a result, a growing number of urban dwellers live in slum-like conditions. For example, the share of slum dwellers was estimated at 30% in Ouagadougou, the capital city (Boyer and Delaunay, 2009). The urbanization process is mainly driven by rural exodus, emergence of new cities, and spatial extension of large urban centers such as Ouagadougou (INSD, 2009c). The capital is among the fastest-growing cities in the world. Even though the population is essentially rural (77% in 2006), it is expected that urban population will take over in 2050 (United Nations, 2014). However, the health indicators in Burkina Faso are not very encouraging. The under-five mortality rate is still high, reaching a level of 10.4% in urban areas and 15.6% in rural areas (INSD, 2012). Data on adult mortality are scarce, but the probability ${}_{45}q_{15}$, estimated at 30.4% in men and 26.8% in women in 2005, was higher than that observed in countries such as Senegal and Niger (IHME, 2014). According to IHME (2015), in 2013, communicable diseases were the leading causes of death in adults aged 15–49 while non-communicable diseases represented the major causes of death in adults aged 50–69.

Data

Adult mortality is measured as the probability of dying between 15 and 60 years of age (${}_{45}q_{15}$). Three types of data sources are used in this paper to estimate mortality levels. The corresponding sample sizes by urban/rural location are presented in the Appendix (Table A4.3). It is important to mention that the definition of urban and rural residence changes over time, from one census to another. An economic criteria was used in the 1996 census, but an economic and population size criteria was retained in 2006 (INSD, 2009c). The definition used in DHS is based on the definition adopted in the most recent census (INSD, 2004; INSD, 2012).

Census Reports on Recent Household Deaths

To date, four censuses have been conducted in Burkina Faso to monitor demographic trends (1975, 1985, 1996, and 2006). However, it is unclear whether data from the 1975 census have been properly archived. Samples of individual-level data from censuses conducted in 1985 and 1996 are freely available online through the Integrated Public Use Microdata Series (IPUMS), but the urban/rural status is missing. Thus, only the census of 2006 is used here to estimate adult mortality, based on data collected on the number of deaths in each household in the twelve months preceding the census.

Data on Sibling and Parental Survival from Demographic and Health Surveys (DHS)

Data from DHS conducted in Burkina Faso in 1993, 1998/1999, 2003, and 2010 are used in this study. Funded by the U.S. Agency for International Development (USAID), these surveys are a key data source to assess population dynamics and their health in countries lacking vital registration systems. The data are freely available online and are representative at the urban/rural level. In the 1993, 2003, and 2010 surveys, children aged less than 15 years were asked about the survival status of their parents (mothers and fathers). In surveys conducted in 1998/1999, 2003, and 2010, each woman interviewed was also asked to list all her siblings born to the same mother. For each sibling, information was collected on their date of birth, sex, survival status, current age for those who were alive, age at death, and number of years since death for those who had died prior to the survey.

Orphanhood Data from the Migration Dynamics, Urban Integration and Environment Survey (EMUIB)

Census and DHS data are complemented with a survey (EMUIB) conducted in Burkina Faso in 2000 by the Demography department of the University of Ouagadougou and has never been used so far to estimate mortality. This survey was representative at the national and urban/rural levels. In total, 9188 individuals aged between 15 and 64 years old were interviewed. The overall objective was to provide reliable and relevant information on urban planning in Burkina Faso and topics such as migration and employment were covered (for a full description of the survey design, see Poirier et al. (2001)). The questionnaire included a set of questions on parental survival and, unlike in other surveys, the place of residence at the time of survey or at the time of death of parents was also collected. This is an added value compared with DHS data where information on parents' place of residence at the time of the survey or at the time of death is usually not collected.

Methods

The different techniques used to estimate differences in urban/rural mortality levels in Burkina Faso are presented in this section. The choice of these methods was mainly guided by the availability of data. For each method, adult mortality rates, and confidence intervals around estimates (if relevant) were computed according to urban/rural residence for each sex. The datasets used in each estimation technique, the reference period for the estimates, the sample description, and the approximations of the place of residence are reported in Table 4.1.

Estimating Adult Mortality from the Growth Balance Method

Data collected on the number of deaths in each household were discarded by the National Institute of Statistics (INSD) when deriving mortality estimates from the 2006 census. The published estimates of adult mortality were obtained from child mortality rates combined with model life tables. Even though the estimation method is not entirely clear in the official report, it seems that child mortality rates were estimated indirectly from reports on the number of children ever born and still alive (INSD, 2009). This approach is inadequate because trends in child and adult mortality do not always evolve in the context of Sub-Saharan Africa. In Burkina Faso, DHS estimates indicate that child mortality rates have declined substantially in recent decades, while adult mortality rates have mostly stagnated, although the reason for these divergent trends is undetermined (Masquelier et al., 2014).

To move away from the child-mortality matching approach used by the INSD, I estimated for each place of residence, adult mortality using the Growth Balance Method (GBM) developed by Brass (1975). Its principle is to estimate the completeness of the reporting of deaths relative to an estimate of the population under the assumptions that the population is stable, is closed to migration and that the completeness of underreporting of deaths is constant above a certain age limit. This estimate which is an indicator of data quality, is then used to adjust mortality rates upward to account for incompleteness of death reporting (Moultrie et al., 2013). To reduce the sensitivity of the method to internal migration, which can be a great concern in a country such as Burkina Faso, the completeness estimates were obtained solely from reported deaths among adults aged 35 and above, because they are less likely to migrate (Beauchemin, 2011). With this method, there was no need to compute confidence intervals because estimates were derived from the census data.

Estimating Adult Mortality from Orphanhood Data

The rationale behind the orphanhood method is to convert proportions of respondents classified by five-year age groups whose mother (father) is still alive into survivorship ratios using a set of coefficients (obtained from simulations). The mean age at childbearing of women (men) is used to control for variations in the fertility schedule, which affects the exposure time. Survivorship ratios are then converted into summary indices of adult mortality using one parameter of a relational logit model table (Moultrie et al., 2013). Finally, estimates are located in time under the assumption that mortality trends have been linear. Coefficients used in this paper to convert proportions into survivorship ratios are those proposed by Timæus (1992), and the time location procedure is the method developed by Brass and Bamgboye (1981). In addition, since DHS and EMUIB data are samples of the entire population, confidence intervals are required to statistically compare levels of adult mortality between urban and rural areas. Orphanhood estimates are seldom presented with confidence intervals, and there is no standard way to obtain them. Here, I computed 95% bootstrap-based confidence intervals of estimates in each place of residence (2000 replicates). The bootstrap technique has proven useful over the years to estimate robust confidence interval without making strong assumptions about the distribution of estimates (Efron and Tibshirani, 1993). To the best of my knowledge, this method has never been used to compute confidence intervals based on orphanhood data.

The estimates derived from the DHS and EMUIB data were obtained from the survival of parents of young children (5–9, 10–14 years old), and young adults (15–19, 20–24, 25–29 years old) respectively. I also applied the orphanhood method on data collected during the 2006 census and the multiple indicator cluster survey (MICS) conducted in 2006. The corresponding results are not commented in the main text because there are in line with estimations derived from EMUIB and DHS data (see Appendix, Table A4.1 and Figure A4.1).

The orphanhood method does not assume that the population is closed to migration, but a major issue in applying the method with data disaggregated by place of residence is the lack of information on the urban/rural status of parents. In DHS surveys, only the place of residence of children at the time of the survey is known. I used this information as a proxy for the parents' place of residence at the time of the survey or at the time of death. By contrast, in the EMUIB survey, it is possible to correct for this and assess the impact of misclassification of parent's place of residence on differences in urban/rural adult mortality. For this survey particularly, to investigate the variation in the quality of data by place of residence that may affect the estimates, I compared by urban/rural location and for each age group, the proportion of surviving parents, reported by men and women (Appendix, Table A4.2).

Estimating Adult Mortality from Sibling Survival Data

Unlike the two methods presented above, sibling survival data provide an opportunity to “directly” estimate adult mortality rates. With the information provided by each interviewed woman (15 to 49 years) on her siblings, it is possible to compute mortality rates by dividing the number of deaths by the population at risk for a given period and age group. However, because adult mortality is a relatively rare event, and sample sizes in DHS are too small to derive age- and period-specific estimates without introducing some smoothing, mortality rates were derived from a quasi-Poisson model for this analysis. The data file was reshaped in person-periods and the dependent variable was the number of deaths. The age group, sex, and place of residence (urban/rural) were used as explanatory variables. This approach, introduced by Timæus and Jassey (2004), also generates confidence intervals. As suggested by Masquelier (2013), no attempt was made to weigh the data to account for selection biases, and I assume that mortality does not vary with the number of adult siblings.

Although the sibling survival method does not rely on many assumptions, the quality of data is an issue, particularly the underreporting of deaths due to recall biases. Evidence abounds of decay in the completeness of death reporting among siblings when the time interval between the death and the survey increases (Masquelier et al., 2014; Obermeyer et al., 2010). To account for this, mortality estimates were restricted to the 6 years prior to each survey. The choice of this cutoff point also helped to keep the sampling errors at an acceptable level for the analysis and to attenuate the effect of heaping for five years prior to the survey (Bicego, 1997).

A major drawback also related to the estimation of adult mortality by place of residence using sibling survival data is the difficulty to apprehend siblings’ place of residence. The DHS surveys do not collect information on the place of residence of siblings at the time of survey or at the time of death. To address this issue, the place of residence of interviewed women was tested as proxy for the place of residence of their siblings. Misclassification of siblings’ place of residence may thus lead to misinterpretation of differences in urban/rural mortality levels, particularly when migrations flows are important (Bicego, 1997).

Table 4.1 Datasets used, reference period, sample description and approximation of the place of residence for each estimation method

Estimation method	Datasets	Sample description	Approximation of the place of residence	Reference period for male mortality	Reference period for female mortality
Growth balance	Census 2006	Household heads reporting on deaths among adults aged 15–60 years old	Household's place of residence	2006	2006
Direct estimation from sibling survival data	DHS 1999	Women aged 15–49 years old reporting on the survival of their siblings	Women's place of residence	1992–1997	1992–1997
	DHS 2003			1998–2003	1998–2003
	DHS 2010			2004–2009	2004–2009
Orphanhood	DHS 1993	Children aged 5–9 years old and 10–14 years old, reporting on the survival of their parents	Children's place of residence	1988	1987,2; 1989,4
	DHS 2003			1998,5	1997,8;2000,0
	DHS 2010			2005,6	2004,8; 2007,0
	EMUIB 2000	Young adults aged 15–19 years old; 20–24 years old and 25–29 years old, reporting on the survival of their parents	Parent's place of residence	1989,8; 1991,4	1989,4; 1990,9;1992,6

4.4. Results

Growth Balance Method (GBM)

Estimates of adult mortality obtained by place of residence and by sex in 2006 from the GBM, and from the census official report are presented in Table 4.2. The completeness of death reporting was higher in urban areas compared to rural areas (80.5% and 73.5% respectively), suggesting that data quality issues are more prevalent in rural areas. The estimates were also higher than those published in the census report (except for women in rural areas). Disregarding these methodological differences, the value of the probability ${}_{45}q_{15}$ was higher in rural areas than urban areas according to both sources. In the estimates presented here, the urban-rural differentials in mortality were lower among men with a ratio of urban to rural mortality of 0.7. This ratio rose to 0.9 in women. As expected, the levels of male mortality were higher than those of female mortality.

Table 4.2 Estimates of ${}_{45}q_{15}$ (per 1000) from the GBM and results published in the census' official report by sex and according to urban/rural residence in Burkina Faso in 2006

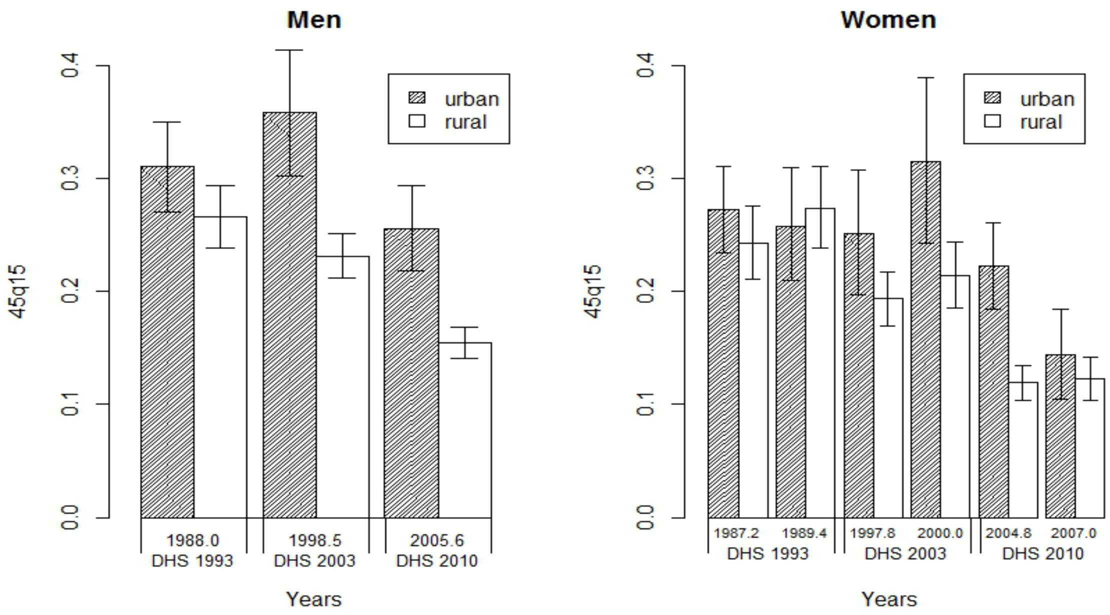
	Men			Women		
	Urban	Rural	Urban/rural Ratio	Urban	Rural	Urban/rural Ratio
GBM	270.2	366.1	0.7	215.2	248.6	0.9
Census report	220.0	321.5	0.7	183.6	280.3	0.7

Orphanhood Method

Figure 4.1 presents trends in adult mortality obtained from orphanhood data collected in the 1993, 2003, and 2010 DHS according to place of residence and sex of parents. For men, only one estimate was obtained from each dataset (because the estimation of male mortality requires that reports from two adjacent age groups be combined). For women, two estimates were derived from each dataset (based on 5–9 and 10–14 year-olds).

Overall, in urban as well in rural areas, adult mortality rates seem to have fallen since 1988 to 2005 for men, and since 1987 to 2007 for women. Quite surprisingly, urban residents seem to have experienced a slight mortality increase in the late 1990s and the early 2000s. This counterintuitive result is likely due to the issue raised by the approximation of parents' place of residence (those who are at risk of dying) by their children's place of residence. Over the whole period considered, values of ${}_{45}q_{15}$ were on average higher in urban areas compared to rural areas. In men, these inequalities in mortality seem to have widened over time in favor of the rural settings. In women, the gap of urban/rural mortality was most pronounced in the first half of the 2000s.

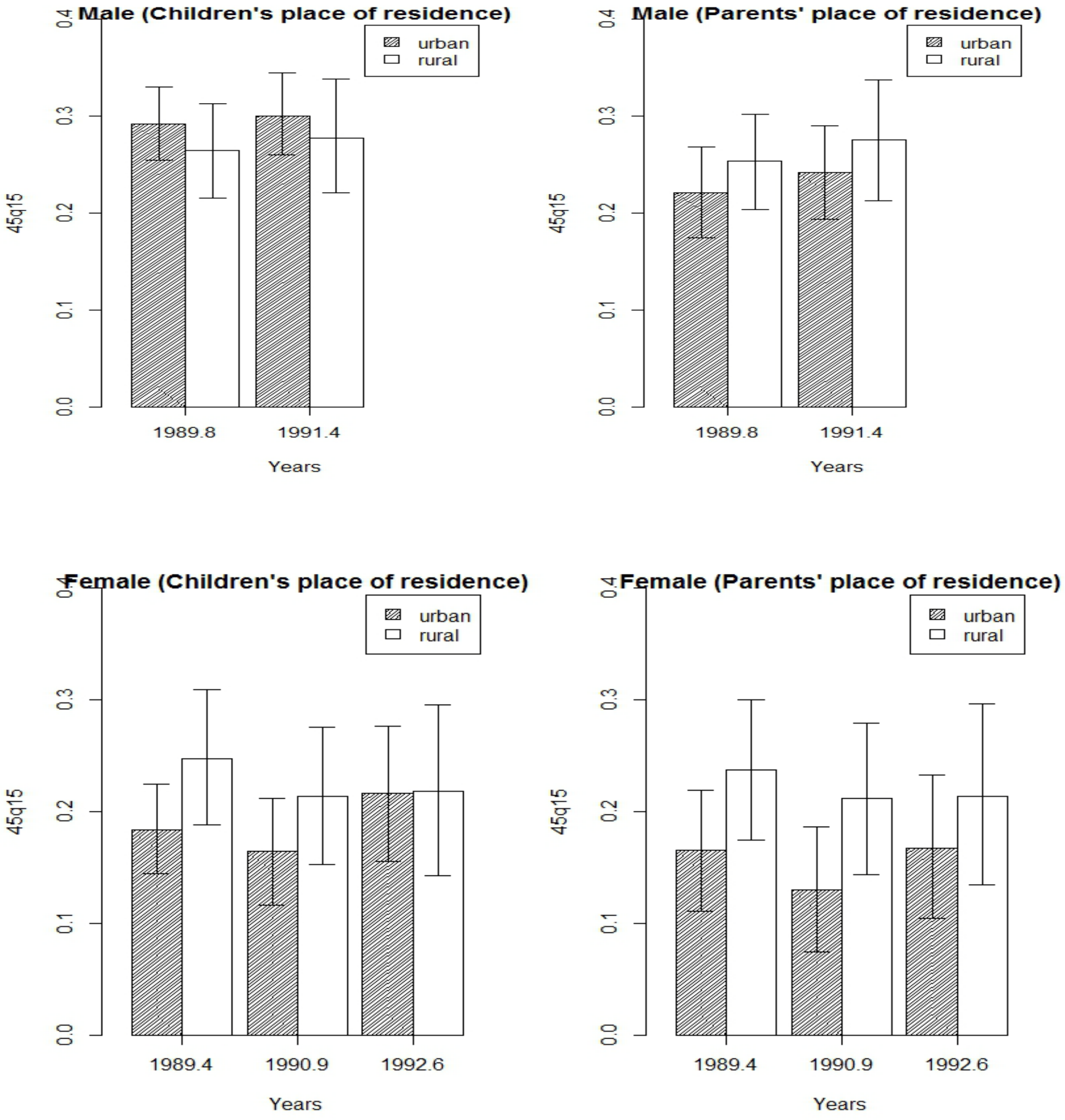
Figure 4.1 Estimates of adult mortality with bootstrap confidence intervals (95%), by sex and according to place of residence (DHS orphanhood data).



By using parents' place of residence in the estimation, thanks to data collected in the EMUIB survey (Figure 4.2), the mortality differentials were reversed in favor of urban areas in men, and the gap widened in favor of urban areas in women. In men, when children's place of residence is used as proxy for their parent's place of residence, values of ${}_{45}q_{15}$ were far higher in urban areas than in rural areas. However, a lower mortality in urban areas was obtained when parents' place of residence at the time of the survey or at the time of death is used to assess the gap in mortality. In women, estimates obtained by using children's place of residence yielded an urban advantage. This advantage was reinforced when parent's place of residence were taken into account.

These results suggest that information on children's place of residence is not a good proxy for their parents' place of residence. In addition, misclassification errors seem to operate differentially according to the sex. Nevertheless, even if urban areas benefit from a slight advantage, this difference is not significant at the 0.05 level, because confidence intervals considerably overlap in each period.

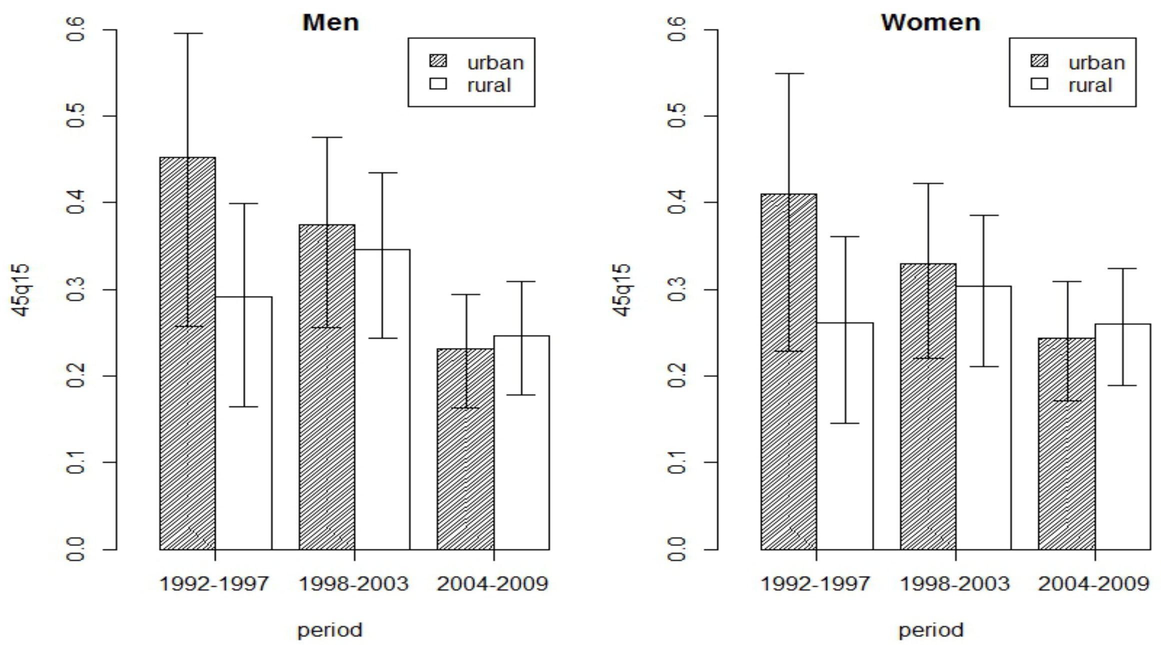
Figure 4.2 Estimates of adult mortality with bootstrap confidence intervals (95%), by sex and according to place of residence (EMUIB orphanhood data).



Sibling Survival Histories

Estimates of adult mortality based on sibling histories are presented in Figure 4.3 for both types of residence. The dating procedure is more precise here (compared to orphanhood estimates) and the availability of three surveys provides a rough idea on the trend in mortality. On the one hand, adult mortality rates have decreased since 1990s to 2000s in urban areas. This mortality decline was more marked among men. On the other hand, rural areas experience stalls, sometimes reversals, in adult mortality. Rural areas tend to have an advantage in terms of adult mortality that fades over time. In the period of 1992–1997, for men as well as women, the value of ${}_{45}q_{15}$ in urban areas was around 0.4 while this value was less than 0.3 in rural areas. An inverse situation was observed in the period of 2004–2009, with higher mortality in rural areas. However, for each period, confidence intervals largely overlap, indicating that DHS sample sizes are too small to detect any significant difference. Again, I should reiterate that the place of residence of interviewed women was used as a proxy for their sibling's place of residence.

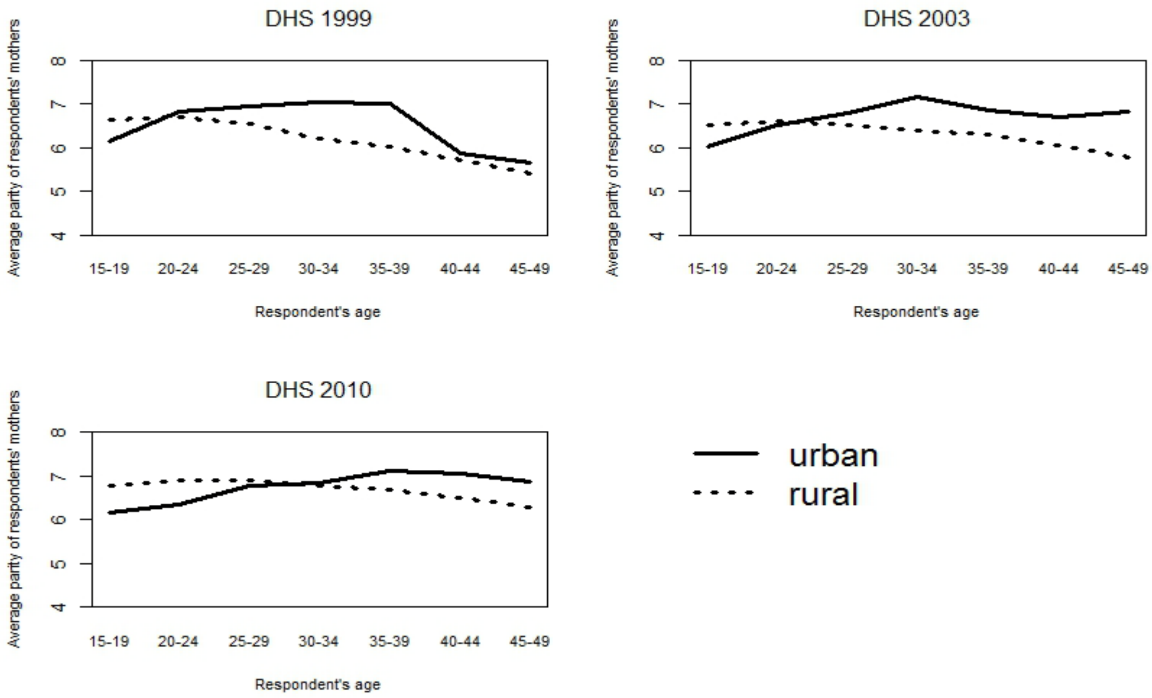
Figure 4.3 Estimates of adult mortality with 95% confidence interval, by sex and according to place of residence based on siblings survival data from 1992 to 2009 (DHS data).



To assess the quality of sibling survival histories in the different DHS, Figure 4.4 shows the mean number of siblings reported by the five-year age group of respondents. This number is the average parity of the respondents' mother; it should be closed to the completed fertility in Burkina Faso, and should increase with the respondents' age since fertility has declined in recent decades. Two major observations stand out from these plots. First, the average parity is globally higher in urban areas compared to rural areas in 1999 and 2003. The same pattern is observed in the 2010 DHS among older respondents (30–49 year-olds). Second, the average number of siblings declines with the respondent's age in rural areas, and it remains stable in urban areas. These results are surprising, because fertility is higher in rural areas in Burkina Faso, and over the years, it has declined both in urban and rural areas

(Shapiro and Gebreselassie, 2009). The patterns observed here are likely caused by rural exodus of women or a pronounced omission of women's siblings in rural areas. As reported by Stanton et al. (2000), as well as Masquelier and Dutreuilh (2014), it is likely that older respondents disproportionately omit to report all of their siblings. These omissions seem to be more marked in rural areas, and if related to adult death, it is likely that adult mortality will be underestimated, particularly in these settings. This could be explained by the low level of education among interviewed women and misunderstanding of local language by fieldworkers in rural areas (Johnson et al., 2009).

Figure 4.4 Average parity of respondents' mothers by respondents' age and place of residence according to each round of survey (DHS data).

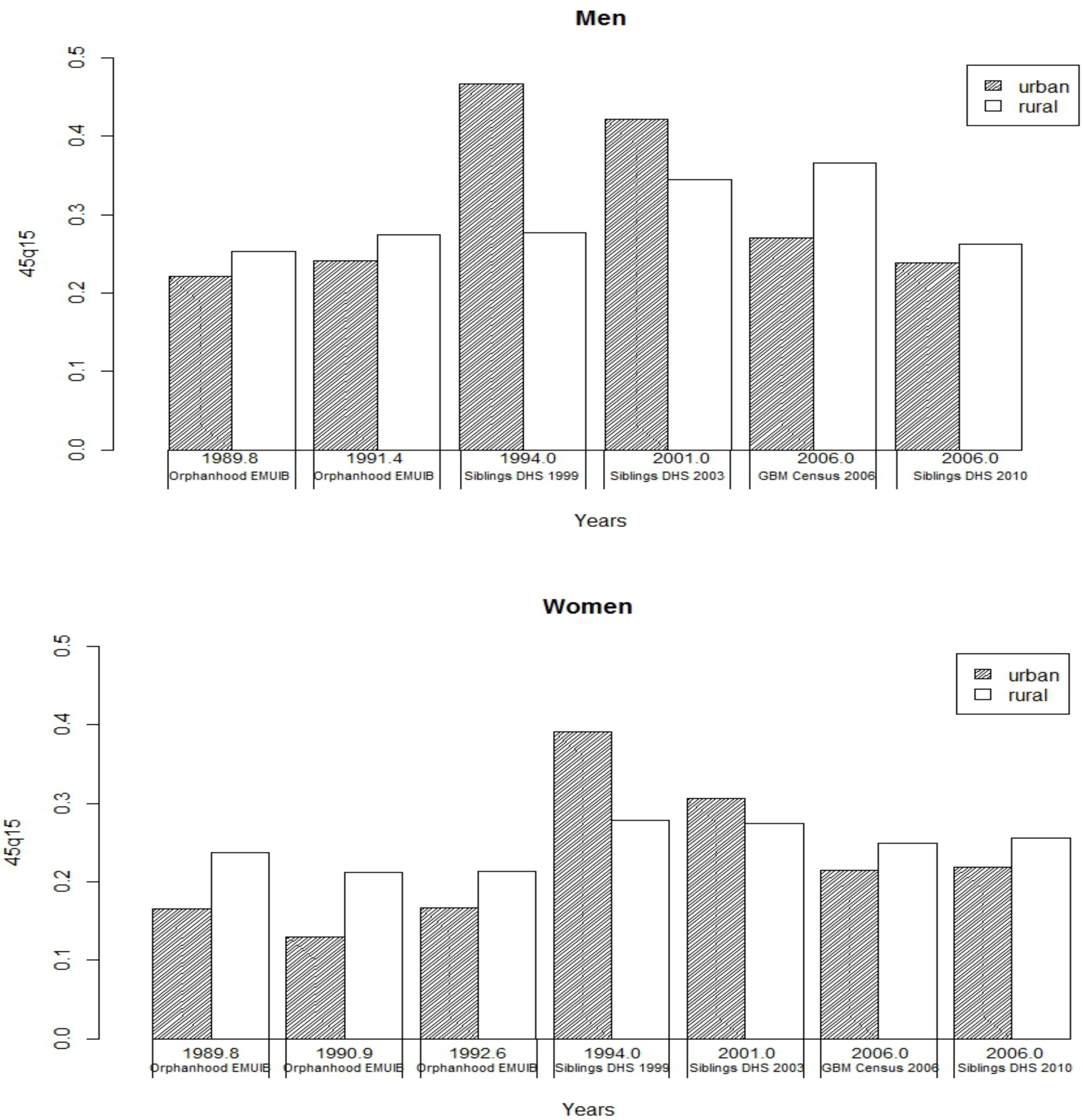


Summary

Figure 4.5 presents estimates of differentials in urban/rural mortality derived from the different sources and methods. Estimates derived from the orphanhood method applied on DHS are discarded from this plot, since those obtained from the EMIUB survey are to be preferred.

Among men as well as women, an urban penalty is unlikely from 1989 to 2006, if one remembers that sibling survival data overestimate adult mortality in urban areas and underestimate adult mortality in rural areas. It is only since around 1994 that adult mortality appears to be particularly lower in rural areas. These estimates were derived from sibling survival data of the DHS conducted in 1998/1999. A cursory evaluation of data quality indicates that this survey is not as reliable as the others. For example, the percentage of deaths which were reported without any information on “age at death” and “years since death” was respectively 2.7% and 0.2% in 2003 and 2010 respectively, while it was as high as 8.5% in 1998/1999 (INSD, 2000b; 2004; 2012).

Figure 4.5 Estimates of adult mortality in Burkina Faso by place of residence and sex according to different sources and methods, from 1989 to 2006.



4.5. Discussion

At first glance, the picture of differentials in urban/rural mortality derived from the different methods is inconsistent. While the orphanhood method produced mixed results, the growth balance method tends to conclude to an urban advantage in the recent period, and sibling histories data suggest that urban areas suffer from a penalty that is vanishing overtime. This highlights the crucial need to restrain from drawing any firm conclusion on differentials based on a particular technique of estimation in isolation. The different estimates have to be screened in order to come up with a better measurement of urban/rural differentials in adult mortality. Despite technical issues related to the estimation (issues of assumptions, data quality, and selection effects), and the administrative problem in defining urban areas, a systematic analysis shows that an urban disadvantage in terms of mortality is unlikely in Burkina Faso.

A common limitation of the application of the growth balance method to measure adult mortality in sub-geographical units is the issue of migration. The method could be adjusted to take into account internal migration flows between urban and rural areas, but such data are rarely available (Bhat, 2002; Hill and Queiroz, 2010). In the case of urban/rural differentials in mortality in Burkina Faso where migration flows are mainly from rural to urban areas, discarding migration effects will result in an underestimation of mortality in urban areas and an overestimation in rural areas (Moultrie et al., 2013). The approach adopted here by limiting the estimation of the completeness of the reporting of deaths on people aged 35 years and more, seems to yield consistent results. Estimates do not seem to be affected by migration since it is possible to get a straight line in each case by plotting the partial births against the partial deaths (Figures A4.2 and A4.3 in the Appendix). In addition, the completeness of death registration was high enough, both in urban (80.5%) and rural areas (73.5%). This limits the effect of adjusting for completeness on the final mortality estimates in the two settings (Moultrie et al., 2013). In summary, estimates derived from the growth balance method for each place of residence are acceptable.

The EMUIB survey allows bypassing a major problem encountered when applying the basic orphanhood method in sub-national geographic units using DHS data, as respondents and parents do not always share the same place of residence (Moultrie et al., 2013). Indeed, the urban disadvantage observed in orphanhood estimates in DHS data (based on reports from children), is likely due to the effect of the practice of child fostering in Burkina Faso. A common practice in the country is to move children from one family to another for schooling or housework (Dabiré, 2001; Serra, 2009). Based on the definition adopted by Grant and Yeatman (2012), the DHS data indicate that the prevalence of child fostering varies greatly with place of residence in Burkina Faso. For example, in 2010, only 7.6% of children under 15 were fostered in rural areas whereas this figure rose to 17.2% in urban settings. In addition, orphanhood prevalence was higher in fostered children compared to non-fostered ones in both urban and rural areas. By using children's place of residence as a proxy for their parent's place of residence, a fraction of deaths occurring in rural areas was therefore transferred to urban areas, and those of the urban areas were allocated to rural areas. The problem raised by the misclassification of parent's place of residence is likely to play against urban areas because flows from rural to urban areas are more important. A great share of urban growth in Burkina Faso is still explained by internal migration (Guengant, 2009). I can conclude that mortality levels based on DHS data are overestimated in urban areas, and underestimated in rural areas, yielding a spurious "urban penalty." When data on the survival of young adult's parents were used to estimate the difference in mortality between urban and rural areas, the urban disadvantages vanishes, as shown in Figure 4.2, even though the difference in favor of the urban advantage is not significant. In addition, these estimates are not impacted by variation in the quality of data according to urban/rural location (Appendix, Table A4.2). Except, for the 20–24 year-old age groups in rural areas, proportions of surviving parents reported by men and women are not statistically different at the threshold of 5%. The urban/rural mortality differentials derived from data on young adults collected during the EMUIB survey are probably the most reliable, but they are only available for the late 80s and early 90s.

Estimates based on sibling histories present the advantage of depicting the trend in adult mortality by place of residence in a relatively long period. However, the major issue related to these estimates is the approximation of the place of residence of the siblings of interviewed women. In the absence of migration data, I made the assumption that siblings and interviewed women share the same place of residence. This approach has been adopted in previous studies (Bicego, 1997; De Walque and Filmer, 2013); however, it is problematic when migration flows are important. Another possibility was to limit the analysis to siblings of interviewed women who had never migrated before the survey as experimented by Günther and Harttgen (2012). This may lead to a selection bias if siblings of migrant women are affected by lower or higher mortality compared with siblings of non-migrant women. In contrast with previous research which ignored or did not quantify the impact of these approximations of sibling's place of residence on mortality differentials, further analysis shows that adult mortality is likely overestimated in urban areas and underestimated in rural areas. First, from the experience I have drawn from the orphanhood method applied on data collected during the EMUIB survey, it is clear that a large amount of deaths occurring in rural areas are transferred to urban areas and the opposite is done with deaths occurring in rural areas, but with a lesser magnitude. This suspicion is strengthened by the higher sibships reported in urban areas compared to rural areas on average. Second, from the analysis of the mean number of reported siblings, I saw that there is a more pronounced underreporting of siblings in rural areas and if related to adult deaths, it is likely that mortality is underestimated in rural areas. In summary, an urban disadvantage is not likely, what appeared in early periods is probably spurious and generated by the misclassification of sibling's place of residence, and by the poor data quality mainly in rural areas.

By carefully analyzing the case of Burkina Faso, the results presented in this paper showed that the urban disadvantage in adult mortality put forward by Günther and Harttgen (2012) is improbable, even though the differences in favor of the urban areas found here are not significant. Such a conclusion is reinforced by estimates derived from the different Health Demographic Surveillance Systems (HDSS) located in Burkina Faso. By taking the HDSS of Ouagadougou as a proxy for the urban areas and the other HDSS located in the country (Nouna, Nanoro, Kaya) as proxies for rural areas, one can again observe that adult mortality (45q15) is lower in urban areas (for the period of 2009–2011) (Sié et al., 2015). Taken together, these results support the argument that urban adults in Burkina Faso still benefit from better health conditions. Although the dynamic of differentials in urban/rural mortality is still somewhat erratic and difficult to depict based on the available evidence, the urban environment continues to be negatively associated with adult mortality in Burkina Faso. Despite the global concern about the rising burden of non-communicable diseases in least developed countries associated with urbanization, urban dwellers still live longer than their rural counterparts in Burkina Faso. Efforts made in reducing adult mortality in rural settings should therefore not be abandoned.

Beyond the case of Burkina Faso, this paper highlighted the need for additional information on the type of residence of close relatives to obtain a better picture of adult mortality differences by urban/rural location in countries without death registration. Given that expansion of data collection in large programs such as DHS will not happen in a near future, the comparative approach taken here could be implemented in other countries when measuring spatial inequalities in health indicators for all ages in the context of the SDGs. The availability of untapped sources of data particularly on migration (e.g., EMUIB in Burkina

Faso, the 2009 migration and remittances household surveys in Senegal), may help to correct data on the survival of siblings and parents for a better measurement of the levels and trends in spatial inequalities in mortality.

Conflict of Interest and Funding

No conflict of interest has been reported by the author

Acknowledgments

The author is particularly grateful to Bruno Masquelier who gave useful insights on indirect techniques of mortality estimation. I also thank Philippe Bocquier, Abdramane Soura and Andrea Verhulst for revising the first draft of this paper. Thanks are also given to researchers involved in EMUIB's project, who allowed me to have access to the data.

4.6. Appendix

Table A4.1 Estimates of adult mortality (per 1000) by sex and according to place of residence (MICS orphanhood data)

Men			Women		
Date	Urban	Rural	Date	Urban	Rural
2001.3	243.2	231.1	2002.7	206.4	133.1
			2000.6	149.0	141.7

Figure A4.1 Estimates of adult mortality by sex and according to place of residence (Census Orphanhood data)

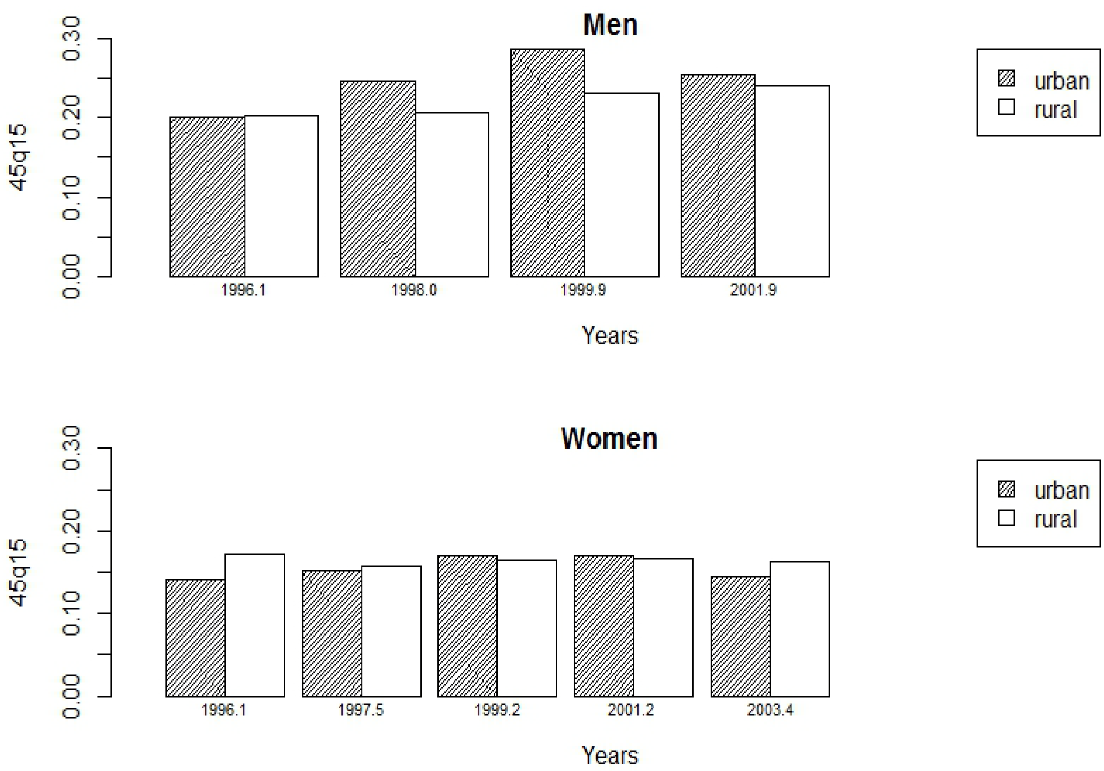


Figure A4.2 Diagnostic plots from GBM, by sex in urban areas, census 2006.

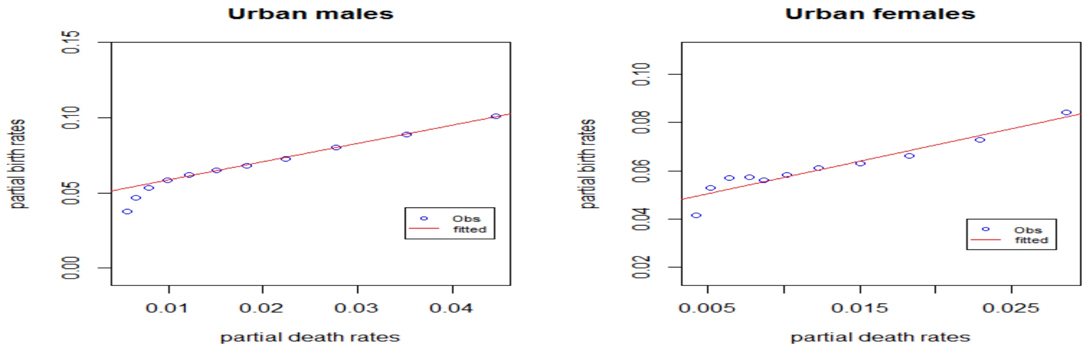


Figure A4.3 Diagnostic plots from GBM, by sex in rural areas, census 2006.

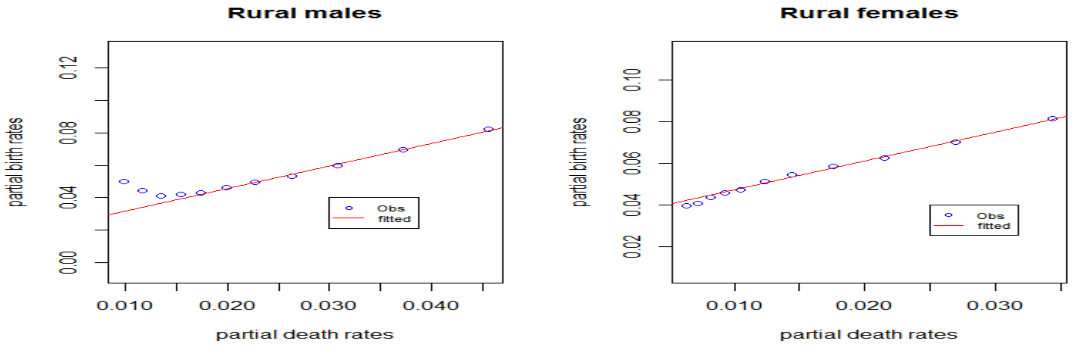


Table A4.2 Comparison of the proportion of surviving parents reported by men and women, according to urban/rural location

		Urban			Rural		
Sex (parents)	Age group	Male	Female	Proportion-test (P. values)	Male	Female	Proportion-test (P.values)
Male	15-19	0,8775	0,8475	0,5728	0,7957	0,8493	0,6095
	20-24	0,7384	0,813	0,3232	0,8082	0,742	0,0177
	25-29	0,7224	0,7347	0,7111	0,6632	0,6876	0,4166
Female	15-19	0,9567	0,9311	0,1371	0,9505	0,8948	0,2875
	20-24	0,9505	0,9257	0,1249	0,9056	0,8786	0,5382
	25-29	0,9202	0,843	0,1725	0,8717	0,7936	0,9615

Table A4.3 Sample size by sex and place of residence for each data set

Estimation method	Datasets	Sample description	Individuals reported in sample size	Number of individuals				Number of deaths			
				Men		Women		Men		Women	
				Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Growth balance method	Census 2006	Household heads reporting on deaths among adults aged 15-60	Individuals aged 15-60	936320	2173654	920183	2736823	3522	13595	2663	11039
Direct estimation from sibling survival data	DHS 1999	Women aged 15-49 reporting on the survival of their siblings	Siblings aged 15-60 (6 years prior the survey, persons years are reported)	9537	46146	9626	43430	74	221	58	189
	DHS 2003			24386	84901	23740	81228	114	485	143	336
	DHS 2010			47305	132551	46624	126872	169	511	173	509
Orphanhood method	DHS 1993	Children aged 5-9 and 10-14, reporting on the survival of their parents	Parents of the interviewed children	3683	6513	3683	6513	338	455	171	293
	DHS 2003			3249	14987	3249	14987	357	951	155	525
	DHS 2010			5840	19412	5840	19412	424	847	193	413
	EMUIB 2000	Young adults aged 15-19; 20-24 and 25-29, reporting on the survival of their parents	Parents of the interviewed adults	1261	2272	1261	2272	277	637	120	280

CHAPTER 5: SELECTIVE ADULT MIGRATION AND URBAN-RURAL MORTALITY DIFFERENTIALS IN BURKINA FASO

AUTHORS

Bruno Lankoande[(a)], Ali Sié[(b)]

[(a)] (Corresponding author), Center for demographic research-Université catholique de louvain (UCL), Louvain-la-Neuve, Belgium

[(b)] Centre de recherche en santé de Nouna (CRSN), Nouna, Burkina Faso

JOURNAL

Manuscript published in *Population*, Volume 72, Issue 2, 2017

5.1. Abstract

Taking the example of Burkina Faso, where massive rural exodus continues to drive the urbanization process, this study tests the net effects of migration on urban-rural mortality differentials among adults aged 15-74. The analysis is based on information collected at two demographic surveillance sites, one in a rural area (Nouna) and one in the city (Ouagadougou). The longitudinal data cover a recent period (2009-2013) and are analysed using a semi-parametric Cox model. In a rural environment with poor health conditions, it is the healthy individuals who migrate to the city, thereby strengthening the urban health advantage over the short term. While rural-urban migrants are positively selected in terms of health, they tend to lose their advantage over time as they adapt to life in the city. This deterioration after several years of urban residence can hold back the mortality transition at national level, given that these migrants were in better health in their environment of origin. For return migrants (rural-urban-rural), the absence of a negative selection effect in Burkina Faso again reflects the complex interplay between migration and health. Beyond compositional and contextual effects, the positive selection of rural-urban migrants is accentuating the health disadvantage of rural areas.

Keys words : Burkina Faso, migration, adult mortality, positive selection, rural, urban.

5.2. Background

In sub-Saharan Africa, child and adult mortality are lower in urban than in rural areas (De Walque and Filmer, 2013; Lankoande, 2016; Leon, 2008). This traditional health advantage of cities is under threat, however, because of rapid and often uncontrolled urbanization. Several mechanisms explain this urban advantage, which dates back to the end of the nineteenth century (Fink et al., 2014; Kimani-Murage et al., 2014; Van de Poel et al., 2009). First, radical public health measures were rapidly introduced in urban centres of the colonies, through policies that had proved effective in reducing urban mortality in Europe (Gould, 1998). African countries thus, for the most part, inherited policies very favourable to the cities, which were also the colonies' economic powerhouses. Historically, the urban environment is thus characterized by better conditions of hygiene, and easier access to potable water and health facilities. In addition, urban residents benefit, on average, from higher socioeconomic status and a higher level of education than rural dwellers (Eloundou-Enyegue and Giroux, 2012). The urban health advantage can thus be explained by the combined effects of context and composition. But clearly, urban and rural areas cannot be compared as if they were isolated, since they are affected by substantial migration flows, and migration, due to its effects on health, can shape this urban advantage (Boyle, 2004). The objective of this research is to exploit data from two demographic surveillance sites (DSS) in urban and rural Burkina Faso in order to analyse the net effects of migration on the differences in adult mortality (all causes) between the two places of residence.

Burkina Faso’s population was estimated at 18 million in 2015 (United Nations, 2015a). Like other countries in sub-Saharan Africa, the percentage urban, estimated at 30% in 2015, has increased very rapidly in recent years, and will probably exceed 50% by 2050 (United Nations, 2015b). Despite the scarcity of recent data on urban-rural migration flows, studies of the population in the capital, Ouagadougou, indicate that its urban growth is still fuelled by rural outmigration (Guengant, 2009). In terms of health, the average mortality of urban residents is lower than that of rural residents, and this advantage is observed for both children and adults (INSD, 2012; Lankoande, 2016). This urban-rural mortality differential seems to reflect a difference in epidemiological profiles, particularly among adults. In rural areas, infectious and parasitic diseases still dominate because of limited health knowledge, lack of access to care, poor sanitation, environmental factors, and poverty (Ramroth et al., 2012). Conversely, non-communicable diseases dominate in urban areas due to population ageing, reduced physical activity, obesity and increased consumption of tobacco and alcohol (Rossier et al., 2014a; Soura et al., 2014).

To test the effects of migration on the urban-rural adult mortality differential, data from the Ouagadougou and Nouna DSSs are utilized. After reviewing the different research hypotheses and presenting the data and methods, the results obtained are discussed.

5.3. Literature review and hypotheses

Research on interactions between migration and health, even if more focused on international migration, has given rise to several hypotheses that can contribute to a better understanding of the urban-rural mortality differential at the country level (Boyle, 2004).

First of all, the positive selection hypothesis suggests that because of the stress induced by the process of migration, the need to adapt to a new environment and to enter the labour market, new migrants constitute a positively selected group in terms of health from among the population at origin. These migrants, generally young adults, leave economically disadvantaged zones for more favoured zones, in search of better living conditions (Gerritsen et al., 2013). In both developed and developing countries, empirical results tend to confirm the importance of positive selection among adults. For example, Norman et al. (2005) show that positive selection of migrants in deprived areas contributed to increased health inequalities between deprived and non-deprived regions of England and Wales. In Indonesia, Lu (2008) has also documented this positive selection of migrants, particularly among the young, using longitudinal data. Similar results were found for rural-urban migrants in China, with selection becoming stronger as migration distance increases (Lu and Qin, 2014). Nauman and her colleagues (2015) also observed positive selection of young rural-urban migrants in Thailand.

In addition to being positively selected at origin, the health of new migrants is typically better than that of long-term residents at destination. However, they seem to lose this advantage as time goes by. This process of adaptation has been analysed in detail with regard to rural-urban migration in developing countries, where migrants tend to gradually adopt lifestyles that are prejudicial to health (Peer, 2015). This includes lack of physical activity, alcohol and tobacco consumption and a diet rich in sugar and fat, which are all risk factors for cardiovascular diseases. Because of the lack of data on morbidity and mortality, the existing literature tends to focus on how risk factors for cardiovascular disease change for these migrants as their duration of residence in the city increases. For example, one study done in Cotonou, the capital of Benin, found that the risk of overweight and hypertension is positively associated with duration of residence in the city (Sodjinou et al., 2008). In Tanzania, a decline in physical activity and an increase in body mass index were observed among rural-urban migrants after only one year of urban residence (Unwin et al., 2010). Similar results were obtained in Cameroon for rural migrants who had moved to the city within the previous two years (Sobngwi et al., 2004). More recently, Carillo-Larco et al. (2016) found the same results in Peru for body mass index.

Finally, after several years of residence in the city, some rural-urban migrants return home. These return migrants were historically considered as a fringe of the migrant population, positively selected at initial migration, who later returned to their place of origin to benefit from the capital accumulated in the city (Gerritsen et al., 2013). However, in certain contexts like South Africa and eastern Africa, these migrants are also disproportionately affected by chronic diseases, and may return home in search of social support in their place of origin (Bocquier et al., 2014; Clark et al., 2007; Collinson et al., 2014; Levira et al., 2014). In the same way as new migrants become used to living in their areas of destination, return migrants may well readapt to their communities of origin by following the behaviours that prevail there, and this may affect their health.

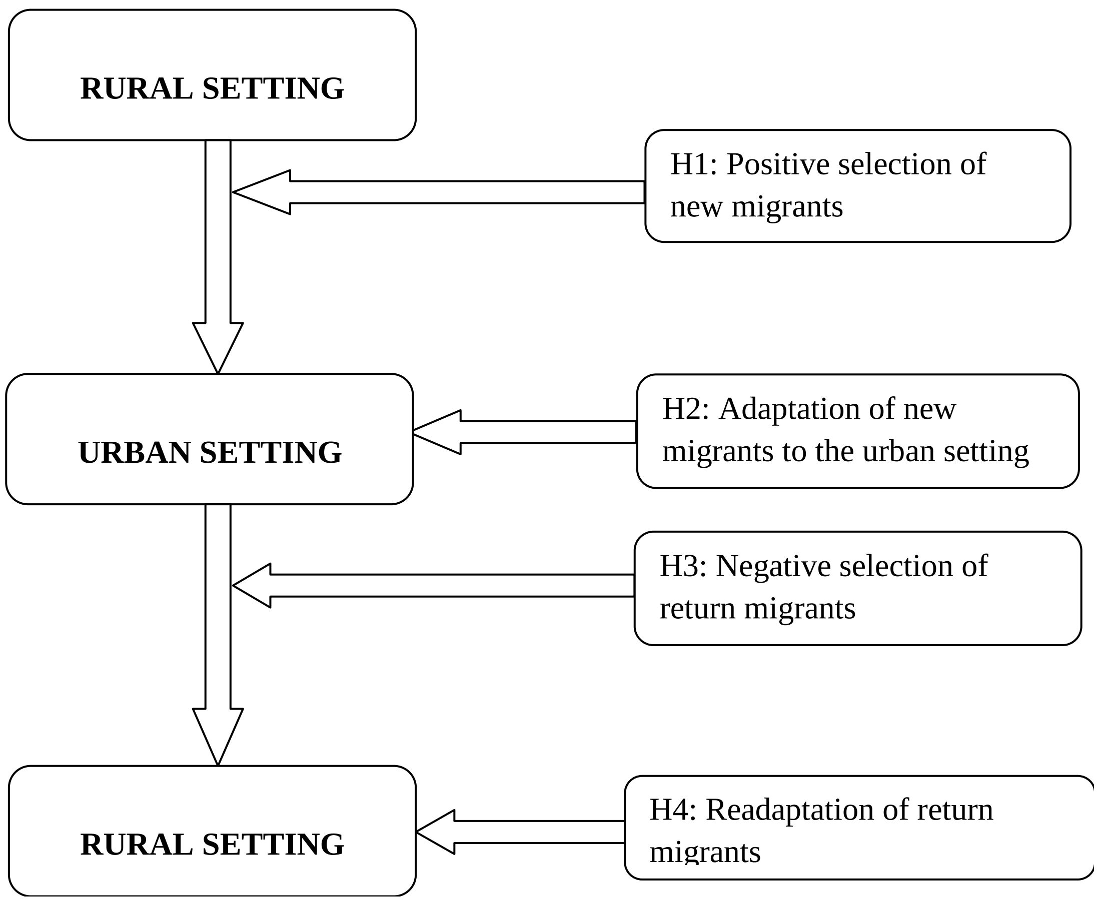
In sub-Saharan Africa, because of the lack of data on migration and adult health, research on the relationships between migration and health has focused on children and, more recently, on adolescents (Bocquier et al., 2011; Mberu and Mutua, 2015). Some research in South Africa has looked at adults, but specifically in relation to return migration (Bocquier et al., 2014; Clark et al., 2007). A pioneering and exhaustive study on adults was conducted by Ginsburg and colleagues (2016) using data from demographic surveillance sites across sub-Saharan Africa. They tested most of the hypotheses on the links between migration and mortality, and in so doing revealed the diversity of situations. For example, in some contexts migrants are not necessarily selected, and when this selection does take place, it may be positive or negative. The authors also propose an interesting methodology to study links between migration and health. This is principally based on data relative to migration status and duration of residence in the destination zones. For new migrants, however, the results of this research are difficult to interpret as assumptions must be made about the health risks they encounter before and after migration. The formulation of these hypotheses poses a particular problem in countries like Burkina Faso where, in both rural and urban areas, migrants come from different backgrounds characterized by different health risks (Dabiré, 2016). In urban areas, migration is principally of rural origin, and occurs alongside urban-urban migration and migration from Côte d'Ivoire. In rural areas, rural-rural migration occupies a very important place, and adds to the migration from Côte d'Ivoire and from the country’s urban zones.

Migration flows must therefore be broken down by provenance to better grasp the net effects of migration on health.

Focusing on migration of rural origin, Figure 5.1 conceptualizes the migration process and the expected interactions with health. We empirically verify these hypotheses in relation to mortality, for all causes of death combined, using data from the two urban and rural demographic surveillance sites. The hypothesis of positive selection of rural-urban migrants (H1) will translate to lower mortality of these migrants compared with permanent rural residents. To verify the hypothesis of adaptation (H2) of these migrants in the city, not only must the mortality of recent rural-urban migrants be lower than that of permanent urban residents, but the mortality of long-term rural-urban migrants must also be similar to that of permanent urban residents. Higher mortality among recent urban-rural return migrants compared to that of permanent urban residents would confirm the third hypothesis on the negative selection of return migrants (H3). Finally, if the return migrants readapt after returning home (H4), one would expect the mortality of long-term rural-urban-rural return migrants in rural areas to be similar to that of permanent rural residents.

Figure 5.1 Interactions between migration processes and health in Burkina Faso

Migration process Hypothesis



5.4. Data and methods

Data

Data on urban-rural exchanges of migration flows are scant in Burkina Faso. At the same time, measuring adult mortality by place of residence remains problematic due to the lack of reliable data and a robust estimation method (Lankoande, 2016). In this context, data from demographic surveillance sites provides an alternative solution for the detailed study of certain adult demographic phenomena (Bocquier, 2016). Burkina Faso currently has four functional demographic surveillance sites, one in a city (Ouagadougou) and three in rural areas (Nouna, Nanoro, Kaya). To ensure comparability of migration status in urban and rural areas, this study is based on data from the sites of Ouagadougou and Nouna only. The Nouna DSS is the oldest of the rural sites (1992); the other rural sites were established after 2007 (Sié et al., 2015). In considering the Ouagadougou DSS as a collection of typical urban districts and that of Nouna as a typical rural area, we test the different hypotheses mentioned earlier among adults aged 15-74 over the period 2009-2013.

The Ouagadougou and Nouna demographic surveillance sites

The Ouagadougou and Nouna demographic surveillance sites are both part of INDEPTH, an international network for the demographic evaluation of populations and their health, and follow a methodology similar to that of other DSSs. This entails collecting data on principal demographic events (births, deaths, unions, arrivals, and departures) at regular intervals, after an initial census in the surveillance zone (Sankoh and Byass, 2012). When a death occurs, a verbal autopsy questionnaire is administered to the closest relative, to record the circumstances that led to the death. The verbal autopsy data are interpreted with the interVA-4 software recommended by the WHO to determine the likely causes of death with the related probabilities (Byass et al., 2012). They are then analysed to establish the likely causes of death in accordance with version 10 of the International Classification of Diseases (ICD). More specifically, the Ougadougou DSS is a research and intervention platform established in 2008 by the Institut supérieur des sciences de la population (ISSP) of the University of Ouagadougou in five districts of the northern suburbs of Burkina Faso's capital (Rossier et al., 2012). The population under surveillance was estimated at 86,694 individuals in 2013, and a follow-up survey is carried out every 10 months on average. The five districts followed by Ougadougou DSS are quite representative of the city suburbs and may be grouped in two categories, formal districts (Tanghin, Kilwin) and informal districts (Nonghin, Nioko2, Polesgho). The latter are informal settlement areas where health conditions are most precarious, with populations having difficult access to basic social services such as electricity, potable water, and health infrastructure. Many residents are young families in search of low-cost housing who move to the area in the hope of claiming ownership of a plot when the area is later developed. Unlike residents of formal districts, the people living in informal districts are generally of rural origin, and are poorer and less educated on average. In both the formal and informal districts, more than half of all economically active individuals work in commerce or construction. Government employees, while not very numerous, more frequently live in the formal districts. In the zone followed by the Ouagadougou DSS, 9 out of 10 people are from the Mossi ethnic group, the majority group in Burkina Faso.

The Nouna DSS was created in 1992 by the Centre de recherche en santé de Nouna (CRSN) in rural Kossi province, 300 km from Ouagadougou (Sié et al., 2010). Data on vital events are collected there three times a year. Unlike the Ouagadougou site, each verbal autopsy file is interpreted independently by two physicians to establish the principal cause of death. In case of disagreement, the opinion of a third physician is sought. The reference population totalled 96,030 inhabitants in 2013, living in 58 villages and in the town of Nouna. The main ethnic groups are the Soninke, the Bwaba, the Mossi, the Fula, and the Samo. Agriculture and animal husbandry are the main activities. In health terms, the area covered by the Nouna DSS represents a quarter of the Nouna health district. It is served by a hospital in the town of Nouna and 17 health and social care centres (Centre de santé et de promotion sociale, CSPS) distributed among the different villages. The semi-urban zone of Nouna has better health conditions and lower levels of fertility and mortality than the villages followed. However, this mortality differential between the two types of zones only concerns children under age 5. There is no significant difference in adult mortality between the villages and the semi-urban zone.

The variables

In this analysis, migration status is the main independent variable, and its effect on all-cause mortality is tested controlling for the determinants of mortality for which data are available at both sites – namely, age, sex, level of education, marital status, and religion. In a context of low educational levels, religious affiliation may be expected to influence lifestyle and health behaviours. As an example, alongside the parents' socioeconomic and demographic characteristics, religion is a key variable in explaining variations in child vaccination coverage in Ouagadougou (Soura et al., 2013).

Drawing on the work of Ginsburg et al. (2016), we used information on the provenance and duration of residence of individuals in the two demographic surveillance sites to define different categories of migration status. Since the Nouna DSS was first set up in 1992, this information is directly available from the complete migration history (entries to and exits from the surveillance zone). The Ouagadougou site being more recent (end of 2008), the definition of migration status is based on information collected in the retrospective "migration history" module, namely place of residence before the first arrival at Ouagadougou and year of first arrival. We thus obtain comparable definitions of migration status in the two sites. All individuals who have lived on one or other site for 10 years or more are considered as permanent residents, and those having resided less than 10 years are considered as migrants. These latter are divided into two categories based on their duration of residence: recent migrants (less than 5 years) and long-term migrants (5-9 years). Migrants are also grouped by provenance in order to distinguish urban-rural migrants from rural-urban migrants. Finally, in the rural areas, because data on migration dynamics are available for a long period, new migrants (recent and long-term) are separated from return migrants (recent and long-term). For these latter, the effects of health risks incurred during their urban residence are controlled for in the analysis by the variable "duration of urban residence".

Data on causes of death are used solely to illustrate the different epidemiological profiles of the two sites because the proportion of missing data is high, especially in the rural areas. Indeed, 40% of adult deaths at ages 15-74 are from unknown causes in the Nouna DSS (Niamba et al., 2016). This is due mainly to incomplete information recording and to the absence of respondents for households that have dispersed after an adult death. For these reasons, the data on causes of death are used solely to illustrate the different epidemiological profiles of the two sites. For similar reasons, causes of death were not established for 25% of the deaths in Ouagadougou (Rossier et al., 2014b). In light of the limited sample size, the causes of death are grouped into five main categories to show the recurrent diseases prevalent in rural and urban Burkina Faso. Our analysis therefore focuses on malaria, other infectious diseases, cardiovascular diseases, other non-communicable diseases, and deaths from external causes (accidents and injury).

Analysis methods

The analyses are limited to adults aged 15-74 during the period 2009-2013. This truncation at age 75 gets around the recurrent problems of data quality at advanced ages without eliminating a large number of observations, given that the study populations are relatively young (Rossier et al., 2012; Sié et al., 2010). The descriptive part consists of comparing adult mortality rates (all causes combined) and by group of causes, between the Ouagadougou and Nouna sites. These rates are obtained in classic fashion by taking the ratio of the number of deaths to the duration of exposure during the period considered. To take account of differences in age structure, these rates were standardized, using the average age structure of the two sites as the reference. For mortality by cause, deaths from unknown causes were redistributed proportionately across the known causes, on the assumption that under-reporting affects all causes equally.

The data from each DSS was formatted to allow event history analysis. This entails retracing the sequence of life events of each individual from their time of entry into the DSS, with the relevant dates. Under this approach, migration status evolves over time, and certain characteristics such as level of education and marital status may vary likewise. We subsequently merged the Ouagadougou and Nouna databases for the period 2009-2013 to obtain a single database for analysis. Database merging has already been applied in previous research in the social sciences, especially for surveys that share the same methodologies, as in the present case (Hatt and Waters, 2006; Soura et al., 2015). Moreover, re-sampling techniques such as bootstrap (2,000 replications) can be used after modelling to obtain robust estimates of the precision of results.

A semi-parametric Cox model[2] was used to test the effects of migration status on all-cause mortality, controlling for the set of variables cited earlier. Unlike the descriptive analysis, the multivariate model is implemented for both sexes combined due to the limited number of cases. Given that the age of individuals is used as the analysis time, it is not included as a control variable in the Cox model; its effect is taken into account in the non-parametric part of the model.

5.5. Results

Differences in all-cause and cause specific mortality

For the period 2009-2013, the standardized mortality rates (ages 15-74) are higher on the Nouna site than on that of Ouagadougou, for both sexes and for all ages (Table 5.1). For example, among male adults aged 15-24, mortality rates are, respectively, 1.1 per 1,000 in Ouagadougou and 2.1 per 1,000 in Nouna. This health disadvantage in Nouna can be partly explained by the different epidemiological profiles of the two sites (Figure 5.2). Mortality

[2] A robustness test was performed on a limited sample that excluded the semi-urban population of Nouna. The results obtained are generally similar to those presented here where the entire zone followed by the Nouna DSS is taken into account in the analysis.

there is predominantly infectious; malaria and other infectious diseases such as pneumonia, HIV/AIDS, diarrhoea, meningitis, tuberculosis, typhoid fever, etc., are the leading causes of death for both sexes. This situation suggests that the epidemiological transition has hardly begun in this area. In contrast, the epidemiological transition seems to be more advanced in Ouagadougou, where cardiovascular diseases and other non-communicable diseases (cancers, diabetes, etc.) are the leading causes of death. Deaths from external causes are not infrequent on the two sites, particularly among men.

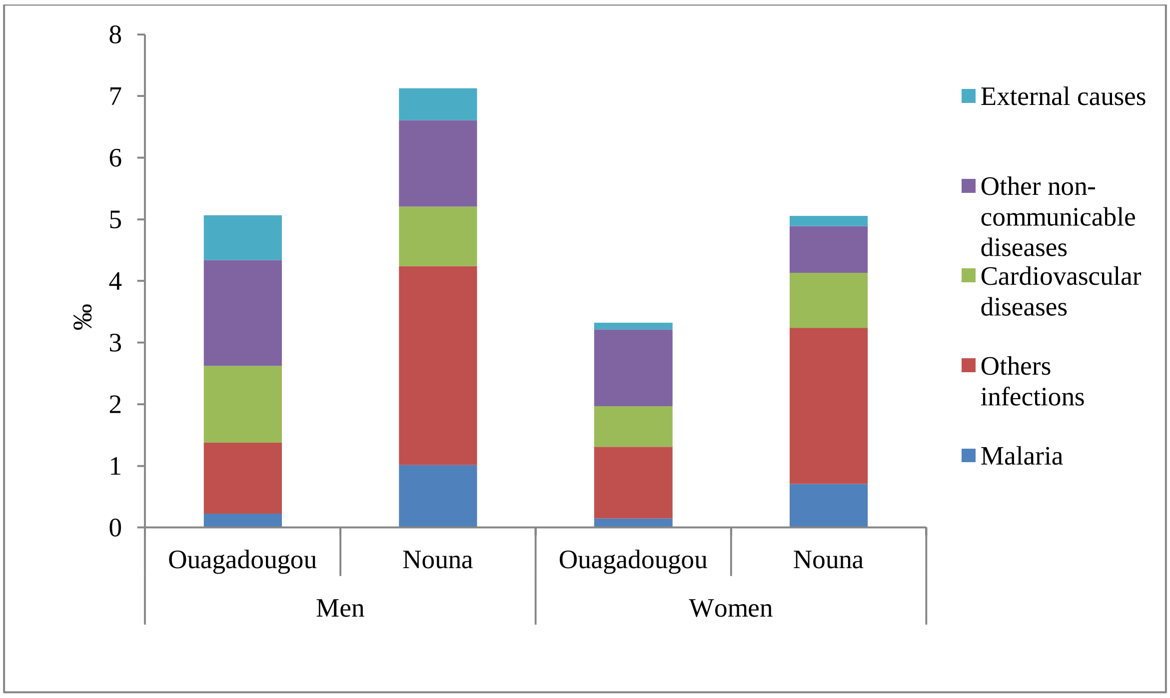
Table 5.1 Adult mortality rate, per 1,000, all causes, Ouagadougou and Nouna, by sex and age group, 2009-2013

	Men		Women	
Age group	Ouagadougou	Nouna	Ouagadougou	Nouna
15-24	1.1 (0.8-1.5)	2.1 (1.7-2.6)	1.1 (0.8-1.4)	1.8 (1.4-2.2)
25-34	1.9 (1.5-2.4)	3.0 (2.4-3.7)	2.3 (1.8-2.8)	2.5 (2.0-3.1)
35-44	3.6 (2,9-4,5)	5.2 (4.2-6.4)	2.9 (2.2-3.9)	4.3 (3.4-5.3)
45-54	9.2 (7,6-11,1)	12.4 (10.5-14.5)	4.1 (3.0-5.6)	7.0 (5.8-8.6)
55-64	20.0 (16,3-23,6)	24.2 (21.0-28.0)	8.8 (6.6-11.8)	16.4 (14.0-19.3)
65-74	35.6 (28,8-44,1)	52.0 (46.0-59.0)	25.6 (20.0-32.6)	34.3 (30.0-39.3)
Standardized rates (15-74 years)	5.0	7.1	3.3	5.0

Note: 95% confidence intervals in parentheses.

Sources: Ouagadougou and Nouna DSSs (authors' calculations).

Figure 5.2 Mortality rates (ages 15-74) by sex and by standardized group of causes on the Ouagadougou and Nouna sites, 2009-2013



Sources : Ouagadougou and Nouna DSSs (authors' calculations).

Migration

On the two demographic surveillance sites, the majority of the resident population are permanent residents (Tables 5.2 and 5.3). They represent 75.5% of the adults aged 15-74 on the Ouagadougou site and 56.3% on that of Nouna. The differences in sex distribution are more visible on the Nouna site, where the proportion of permanent residents among women (50.8%) is smaller than among men (62.2%). Migration to the cities is predominantly of rural origin. Table 5.2 shows that 71.8% of the migrants in Ougadougou come from rural areas and that the majority are long-term migrants. In comparison to men, the proportion of recent migrants is higher among women. Migration to the Nouna site is also of rural origin; migrants make up 35.2% of the resident population and they are predominantly women. Urban-rural migrants, all categories combined, represent only 4.8% of the resident population. Among this group, the proportions of long-term migrants and of rural-urban-rural return migrants are very small.

Table 5.2 Sample characteristics by migration status in Ouagadougou, 2009-2013

Migration status		Men	Women	Total
Permanent residents	Person-years	82,074.1	75,151.4	157,225.5
	Proportion (% of person-years)	78.4	72.5	75.5
	Number of deaths	365	230	595
Recent migrants from rural areas	Person-years	4,777.4	8 174.5	12,951.9
	Proportion (% of person-years)	4.6	7.9	6.2
	Number of deaths	6	18	24
Long-term migrants from rural areas	Person-years	10,877.3	12,774.3	23,651.6
	Proportion (% of person-years)	10.4	12.3	11.4
	Number of deaths	29	23	52
Other migrants*	Person-years	6,965.4	7,514.5	14,479.9
	Proportion (% of person-years)	6.6	7.3	6.9
	Number of deaths	26	10	36
Total	Person-years	104,694.2	103,614.7	208,308.9
	Proportion (% of person-years)	100	100	100
	Number of deaths	426	281	707

* Côte d'Ivoire-urban migrants (57%) and urban-urban migrants (39%).

Source: Ouagadougou DSS (authors' calculations).

Table 5.3 Sample characteristics by migration status in Nouna, 2009-2013

Migration status		Men	Women	Total
Permanent residents	Person-years	67,193.4	58,212.1	125,405.5
	Proportion (% of person-years)	62.2	50.8	56.3
	Number of deaths	611	438	1,049
Recent urban-rural migrants	Person-years	2,603.2	3,606.2	6,209.4
	Proportion (% of person-years)	2.4	3.1	2.8
	Number of deaths	14	13	27
Long-term urban-rural migrants	Person-years	888.4	1,154.6	2,043
	Proportion (% of person-years)	0.8	1	0.9
	Number of deaths	7	8	15
Recent rural-urban-rural return migrants	Person-years	847.6	766.4	1,614
	Proportion (% of person-years)	0.8	0.7	0.7
	Number of deaths	3	5	8
Long-term rural-urban-rural return migrants	Person-years	446.4	375.9	822.3
	Proportion (% of person-years)	0.4	0.3	0.4
	Number of deaths	3	4	7
Rural-rural migrants	Person-years	31,560.9	46,773.1	78,334
	Proportion (% of person--years)	29.2	40.8	35.2
	Number of deaths	152	183	335
Other migrants*	Person-years	4,510.5	3,809.5	8,320
	Proportion (% of person-years)	4.2	3.3	3.7
	Number of deaths	37	19	56
Total	Person-years	108,050.4	114,697.8	222,748,2
	Proportion (% of person-years)	100	100	100
	Number of deaths	827	670	1.497

* Principally migration from rural Côte d’Ivoire (73%).

Source: Nouna DSS (authors' calculations).

Effect of migration status on mortality

Table 5.4 summarizes the results of the multivariate analysis, which tests the net effect of migration status on all-cause mortality. The same results are presented with different reference categories of migration status in order to test the hypotheses formulated earlier. In the first column (test of Hypotheses 1 and 4, Model 1), rural permanent residents are the reference group for migration status, while in the second column (test of Hypotheses 2 and 3, Model 2) urban permanent residents are the reference category. For the control variables, the reference groups are unchanged. First of all, we observe that rural permanent residents have a significantly higher mortality risk than their urban counterparts, other things being equal. The risk of death is 40% higher in the rural setting than in the urban one when only permanent residents of the two places of residence are considered (Model 2). For the other control variables, the results are as expected. Notably, women have lower risks of death than men. A higher level of education, particularly secondary and above, is associated with a lower risk of mortality. Living in union proves to be protective. On the other hand, and less expected, being Christian translates to a higher risk of death than being Muslim (even if the result is only significant at the 10% level). An analysis by site shows that this excess mortality of Christians is observed only in the Nouna site, which suggests a reporting bias, most likely animists reporting themselves to be Christian.

We will now examine the specific effect of migration on all-cause mortality, considering, respectively, rural permanent residents (Model 1) and urban permanent residents (Model 2) as the reference categories for migration status. The risk of death is 50% lower among recent rural-urban migrants than among rural permanent residents; this result is significant at the 1% level (Model 1). This confirms a positive selection of migrants. Their risk of death is also 30% lower than that of urban permanent residents. The results are similar among long-term urban migrants, but with a smaller advantage than that of recent migrants (Model 1). For recent rural-urban-rural return migrants, the relative mortality risk is not significantly different from that of rural permanent residents. The situation is similar for long-term rural-urban-rural return migrants, even if the associated coefficient (1.2) is greater than that of recent rural-urban-rural return migrants (Model 1). A statistical comparison of the mortality levels of the two categories of return migrants (recent and long-term) indicates that they are not significantly different at the 10% level. Finally, the odds ratio associated with the variable measuring duration of urban residence, pertinent only for return migrants, suggests that a long period of urban residence is accompanied by a higher risk of death for these migrants (OR 2.6 in Model 1).

The health advantage of recent rural-urban migrants is also visible among those still living in the urban setting; they have a 30% lower risk of dying than urban permanent residents. This result is only significant at the 10% level, however (Model 2). This advantage disappears for long-term rural-urban migrants, whose risk of death is almost the same as that of urban permanent residents, all other things being equal (Model 2). Urban-rural migrants, both recent and long-term, have a higher risk of death than urban permanent residents (Model 2).

Finally, in terms of mortality, recent and long-term rural-urban-rural return migrants are not significantly different from urban permanent residents. To check that this result was not due to the small number of return migrants in the sample, we combined the two categories of return migrants (recent and long-term), and their mortality was compared to that of urban permanent residents. The results obtained remained unchanged; return migrants and urban permanent residents have the same levels of mortality, all other things equal. In other words, there is no selection effect (either negative or positive) among return migrants in terms of risk of death.

Table 5.4 Relative risks (odds ratios) of death at ages 15-74, 2009-2013

	Variables	Test of H1 and H4 (Model 1)	Test of H2 and H3 (Model 2)
	Migration status	OR	OR
RURAL	Permanent residents (reference group column 1)	1	1.4*** (0.081)
	Recent urban-rural migrants	1.2 (0.238)	1.7*** (0.348)
	Long-term urban-rural migrants	1.5 (0.378)	2.1*** (0.551)
	Recent rural-urban-rural return migrants	0.8 (0.300)	1.2 (0.438)
	Long-term rural-urban-rural return migrants	1.2 (0.468)	1.8 (0.682)
	Rural-rural migrants	1.0 (0.067)	1.5*** (0.107)
	Other migrants	1.2 (0.175)	1.8*** (0.261)
	Period of urban residence (return migrants)		
	< 5 years	1	1
	≥ 5 years	2.6*** (0.782)	2.6*** (0.782)
URBAN	Permanent residents (reference group column 2)	0.7*** (0.038)	1
	Recent rural-urban migrants	0.5*** (0.104)	0.7* (0.152)
	Long-term rural-urban migrants	0.6** (0.086)*	0.8 (0.126)
	Other migrants	0.7** (0.121)	1.0 (0.178)
Level of education			
	None	1	
	Primary	1.1 (0.073)	
	Secondary or higher	0.8** (0.071)	
	Don't know[(a)]	1.8*** (0.163)	
Sex			
	Male	1	
	Female	0.6*** (0.029)	
Union status			
	In union	1	
	Not in union	1.4*** (0.073)	
	Don't know [(b)]	0.4** (0.151)	
Religion			
	Muslim	1	
	Christian	1,1* (0.052)	
	Other	1.6*** (0.131)	
Number of individuals		140,087	
Person-years		430,268.5	
Number of deaths		2,165	

(a) Data on education were missing in 7% of cases in Nouna and in 1.5% of cases in Ouagadougou.

(b) Information on union status was missing in 0.7% of cases in Nouna.

Statistical significance: *** p < 0.01; ** p < 0.05; * p < 0.1. Standard deviations are in parentheses.

Sources: Ouagadougou and Nouna DSSs (authors' calculations).

5.6. Discussion

In a context where rural-urban migration still contributes strongly to the process of urbanization in Burkina Faso, this research uses data from demographic surveillance sites in urban and rural areas to highlight the net effects of migration on the adult mortality differential between these two settings. The longitudinal data are collected prospectively (longitudinal monitoring) and cover a recent period. Moreover, they can be used to compute migration status and other independent variables as time-varying covariates. Finally, the approach consisting of disaggregating the migration flows by origin and combining the data from two DSSs allowed us to test the different hypotheses suggested by the literature. In particular, by comparing the mortality of recent rural-urban migrants with that of rural permanent residents, we can verify the hypothesis of positive selection.

The results on the mortality differential between urban and rural permanent residents confirm the rural health disadvantage, even after controlling for certain classic determinants of mortality such as sex, level of education, religious affiliation, and marital status. These results thus suggest that the two residential settings present different contextual risks (health environment, access to care), and this finding is consistent with earlier studies on the possible sources of excess rural adult mortality (Van de Poel et al., 2009). The various hypotheses tested were confirmed for new migrants (Hypotheses 1 and 2) but not for return migrants (Hypotheses 3 and 4).

Positive selection and adaptation of rural-urban migrants

Rural-urban migrants are positively selected in terms of health, as found in with earlier research on rural-urban migration in developing countries (Lu and Qin, 2014; Nauman et al., 2015). Ginsburg et al. (2016) arrive at the same results for men on the urban demographic surveillance sites of Ouagadougou and Nairobi, although their focus was on migration from all origins combined. Over the long run, migrants adapt to their urban environment and present levels of mortality similar to those of permanent residents. This is consistent with the findings of Ginsburg et al. (2016), who demonstrate that the selection effect is generally followed by an adaptation effect. Different mechanisms explain urban migrants' declining health status over time. First, in cities like Ouagadougou, rural migrants with limited economic resources and a desire to claim ownership of a building plot, tend to settle in informal districts where health conditions are more precarious than elsewhere in the city (Rossier and Ducarroz, 2012; Rossier et al., 2011). Informal districts are poorly served by public services, and the populations who live there have more limited access to potable water, electricity, public schools, and health infrastructure (Rossier et al., 2011) than in formal districts. Of the three informal districts covered by the Ouagadougou DSS, only one, Polesgho, has a health centre (Centre de santé et de promotion sociale) (Lankoande et al., 2016). Moreover, in addition to their unfavourable health conditions, and as observed in other African cities, rural-urban migrants rapidly adopt typically urban behaviours such as alcohol consumption, smoking, and high-fat diets (Sobngwi et al., 2004; Sodjinou et al., 2008). For example, migrants who have lived in Ouagadougou for more than 10 years have higher blood pressure than permanent residents (Rossier et al., 2013). Their exposure to non-communicable diseases increases with their duration of residence in the city. On the other hand, in parallel to these unhealthy behaviours, these rural-urban migrants may develop a more proactive attitude to their health by consulting health professionals more frequently in case of illness; but affordability may be an obstacle here.

Finally, for the specific case of Burkina Faso, higher rural migrant mortality in the cities may also be linked to high urban road traffic mortality. As public transport is limited, many people own a motorbike or scooter, not only as an essential means to travel around the city, but also as a sign of upward social mobility. For the specific case of rural migrants, the risk of accidents may be higher because they do not know or respect the traffic regulations.

No negative selection of rural-urban-rural return migrants

The hypotheses relative to return migrants were not confirmed by the results. These migrants are not negatively selected in the urban setting, so we cannot validate the hypothesis of re-adaptation. Both short-term and long-term return migrants and rural permanent residents have similar levels of mortality. The absence of negative selection of return migrants in Burkina Faso contrasts with evidence from South Africa, where return migrants affected by chronic illnesses such as tuberculosis or HIV, return home in the hope of finding support (Clark et al., 2007). The vulnerability of migrants to chronic illnesses could also explain the negative selection of return migrants in eastern Africa (Ginsburg et al., 2016). In contrast to the countries of southern and eastern Africa, which were hit hard by the HIV epidemic, HIV prevalence in Burkina Faso among adults aged 15-49 has never exceeded 4% (UNAIDS, 2016). While it is known that migrants settle in informal districts, principally in Ouagadougou, the general context does not expose them to disproportionate risks of chronic diseases such HIV or tuberculosis (Rossier et al., 2011; Soura et al., 2014). Even if they do fall ill, those with the necessary means may deliberately choose to remain in the city, given that Burkina Faso is a poor country where access to health care is clearly better in urban than in rural settings (Haddad et al., 2004). Poor migrants, for their part, may count on their social capital in the city, particularly the extended family, to ensure better access to care. In the context of Burkina Faso, return migration because of illness after a period of residence in the city may be perceived as a failure, by both the migrants and their families (Rossier et al., 2012). In a country where traditional beliefs are strong, city dwellers of rural origin with chronic illnesses may return to their community of origin to inquire about the natural or mystical character of their malady, but these migrations are probably temporary.

5.7. Limitations of this research

It is important to point up certain limitations of this research. First, because of the limited sample size (random variation of the number of deaths from one age group to another, for example) it is practically impossible to test the different hypotheses on specific age groups and by sex. For example, it would have been interesting to test the hypothesis of positive selection among the young, since they are more likely to migrate to the city in search of better living conditions. Next, the data used in this work, while of a longitudinal nature, does not allow us to follow the health status of individual migrants by duration of urban or rural residence. The different categories of migrants, recent and long-term migrants for example, may not have exactly the same characteristics. Finally, this work is based on the assumption that the Ouagadougou and Nouna demographic surveillance sites are representative of the urban and rural settings in Burkina Faso. The results would undoubtedly be strengthened by using samples that cover larger areas of the two environments.

5.8. Conclusion

Despite these limitations, our research has allowed us to examine the role of migration in the urban-rural health inequalities observed in sub-Saharan Africa. Alongside composition and contextual effects, positive selection of rural-urban migrants contributes to the rural health disadvantage. In a setting where health conditions are already unfavourable, it is those in better health who migrate to the cities, thereby widening, over the short term, the urban-rural mortality gap. The adaptation of migrants after several years of urban residence is probably holding back the mortality transition at the national level, given that these migrants were in better health in their place of origin. With regard to return migrants, the absence of a negative selection effect in Burkina Faso again reflects the diversity of links between migration and health. Rural Burkina Faso is not only a source of rural-urban migration, but also of international migration to Côte d'Ivoire. The potential health effects of this international migration must also be analysed to gain a better understanding of health in rural areas.

CHAPTER 6: GENERAL CONCLUSION

In September 2015, the United Nations adopted the Sustainable Development Goals (SDGs) which intend, among other goals, to "ensure healthy lives and promote well being for all at all ages" (United Nations, 2015). More than ever, reducing health inequalities is central to the global health agenda, and there is also a growing recognition that the health of populations should be improved whatever their age. In the past, including in the MDG framework, heavy emphasis was put on child health, with limited attention to mortality rates in adolescents, adults (except maternal mortality and HIV-related mortality) and the elderly. Limited attention was also devoted to socio-economic inequalities in health and the monitoring of progress towards the MDGs was mostly conducted at the national level. This dissertation fits well in the new context of the SDGs by focusing on spatial health inequalities in adults in Burkina Faso, a country with scant demographic data. Precisely, the objective was to contribute to the measurement of urban-rural mortality differentials in this country and to assess the effects of migration on these differentials in adults. Burkina Faso is one of the poorest countries of West Africa and has experienced rapid urbanization in recent years in a context of low economic development. The topic investigated here has long been under-researched both because of the global interest oriented towards child and maternal health, and the noticeable lack of data on adult health in SSA, including in Burkina Faso.

6.1. Contributions and findings

In terms of scientific contributions, the existing literature on the measurement of urban-rural mortality differentials in adults, and on the effects of migration on that differential has been extended in four directions. The second chapter highlighted a potential bias in the measurement of urban-rural mortality differentials linked to the mobility of adults at the end of life in urban and rural areas of Burkina Faso and Senegal (Lankoande et al., 2018). To the best of my knowledge, this was the first time that such a quantitative analysis was conducted in the context of West Africa. At the end of life (within 6 months before death), some rural residents in need of health care move to urban areas and die, while some urban residents return to their home community to benefit from supportive care and die. In rural areas, age was strongly associated with mobility before death. Young adults were more likely to move to access health care than the elderly. The conceptualization of aging as a cause of death in rural Africa, and the functional limitations associated with aging contribute to explain why older adults have a limited access to health care outside their place of residence. In urban areas, rural-urban migrants were more likely to die outside the city. In Ouagadougou, deaths from non-communicable diseases were more likely to occur outside the city that deaths due to communicable diseases. There are reasons to suppose that access to health care for non-communicable diseases in Ouagadougou is limited. Furthermore, because of lack of palliative care, patients are forced to develop their own coping strategies at the end of life. All of these results bring us to the conclusion that there are movements of dying individuals at the end of life in urban and rural areas of Burkina Faso, and Senegal. Some social groups are more affected than others. These movements of dying individuals may affect the estimation of urban/rural mortality differentials. Particularly, in censuses, the death of a rural resident that has just moved to a city to access health care can be counted as the death of an urban resident. In future data collection, fieldworkers should be particularly cautious when asking questions about deaths that occurred in each household during the twelve months preceding the census. Beyond these methodological issues, this work also has implications for the provision of care at the end of life.

The impact of the different potential errors encountered in census on mortality measures was further explored in the third chapter. Few studies have assessed the validity of mortality indicators derived from censuses in SSA, despite various concerns, hinting at a possible underestimation of mortality. This dissertation contributed to this debate by assessing mortality indicators derived from the 2006 census of Burkina Faso against high-quality data in Nouna, a rural HDSS. Because of the continuous follow-up, HDSS estimates were used as a gold standard in this analysis. Results showed that census-based child mortality rates obtained from indirect techniques were broadly consistent with HDSS estimates. However, indirect estimates of adult mortality obtained from reports on orphanhood in the census were implausibly low, and reports on recent household deaths also resulted in a distinct under-estimation of mortality rates over all ages. Age misreporting or underreporting of deaths in the census among the population aged 60 and above were two major sources of biases in the estimated life expectancies. Attempts to correct for underreporting of deaths based on the death distribution methods would not necessarily improve the estimates. Indeed, these methods are based on some strong assumptions, including that the extent of under reporting of deaths does not vary by age. However, in Nouna, our results suggested that the under reporting of deaths was more pronounced in children and in adults aged 60 and over. Innovative ways to improve data collection on recent household deaths in censuses should be explored, for example through additional recall cues.

Acknowledging the limitations of census data, the objective of the fourth chapter was to review the demographic tools for estimating adult mortality by type of residence in SSA, with Burkina Faso as a case study (Lankoande, 2016). Building on previous research on the topic, the analysis took into account the effects of data quality and migration on urban-rural mortality differentials. Although different methods yielded variable and sometimes discrepant estimates, the final results provided a coherent picture of urban-rural mortality differentials. Adults living in Burkina Faso continue to benefit from a slight but detectable health advantage compared to their rural counterparts. This result contrasts with previous findings concluding to the existence of an urban penalty in adults in SSA, including in Burkina Faso (Günther and Harttgen, 2012). Overlooking the issue of data quality and migration can lead to spurious conclusions regarding urban-rural mortality differentials. First, as indicated in the third chapter, direct estimates of adult mortality derived from censuses or surveys in SSA should not be taken at face value, especially for exploring mortality differentials. Estimates obtained without any correction are likely to be affected by under-reporting of deaths and various forms of age misstatements. Second, migration disturbs the measurement of urban-rural mortality differentials in adults, obtained from data on siblings and parental survival. With the available data, only the place of residence of the respondent is reported. Using this information as a proxy for his parents' or siblings' place of residence is likely to lead to misclassification errors. The assumption that parents and their children on one side, or siblings born to the same mother on the other side, share the same place of residence is unrealistic in the context of SSA, due to high volume of child fostering and internal or international migration. In the future, increased efforts should be devoted to the design and field testing of questions about the place of residence of close relatives to avoid misclassification errors. In short, with the available data, the estimation of urban-rural mortality differentials in adults is erratic and using solely one data source, such as sibling survival histories (Gunther and Harttgen, 2012) can be very misleading. Higher recall errors in rural areas, and migration effects can conceal the urban advantage.

Migration does not only affect the measurement of urban-rural mortality differentials in adults, it can also explain this differential through different mechanisms. In addition to socio-economic circumstances usually put forward in the literature, selection and adaptation mechanisms can shape the urban health advantage (McCartney et al., 2013). However, the abundant literature on the interactions between migration and health has been mainly focused on international migration. This is in spite of the high volume of internal migration observed in many countries (Bell et al., 2015). Findings in chapter 5 confirmed that rural-urban migrants are selected in terms of health in rural areas (Lankoande and Sié, 2017). This is in line with previous findings in low-income and middle income countries. In settings where health conditions are not favorable, those who enjoy better health are more likely to undertake the difficult journey of migration to cities. This situation contributes to widening (in the short-term) the urban-rural mortality gap in favor of urban areas. Recent rural-urban migrants do not only fare better in terms of health than their rural counterparts left behind; they also tend to have better health status than urban permanent residents. With the duration of residence in cities, however, the level of mortality of migrants converges to that of urban permanent residents. This result is consistent with the findings of Ginsburg et al. (2016), who demonstrate that the selection effect (negative or positive) is generally followed by an adaptation effect. Different explanatory mechanisms are behind the deterioration of the health advantage of rural migrants in cities of Burkina Faso. For instance, in the city of Ouagadougou, they tend to settle down in informal settlements as a strategy to access formal plots in the long run (Rossier et al., 2011). The problem is that population in these settlements is exposed to unsanitary health conditions. In comparison with formal settlements, access to health facilities, safe drinking water, public schools and electricity is limited. In addition to the precarious health conditions encountered by migrants in informal settlements, with the duration of residence, they rapidly adopt unhealthy behaviors such as harmful use of alcohol, smoking, and a diet too rich in fat and sugar. In sum, their exposure to non-communicable diseases increases with their duration of residence in cities. For the particular case of urban areas of Burkina Faso, where the use of motorbikes is widespread, road traffic accidents could also contribute to the degradation of the health of migrants. Because of their rural origin, and their limited knowledge of traffic rules, one can expect migrants to be more frequently involved in road traffic accidents. The literature also suggests that the negative selection of return migrants in terms of health could play against rural health. In countries such as South Africa, sick migrants in cities suffering from tuberculosis or HIV/AIDS are used to return to their community to benefit from supportive care and die (Clark et al., 2007; Collinson et al., 2014). However, our findings did not support this hypothesis in Burkina Faso. Sick migrants seem to stay in cities to take advantage of the available health care. Cultural beliefs may also prevent some sick migrants to return to their home community because the return will be perceived as a failure. To sum up, in Burkina Faso, among all potential interactions between migration and health, the positive selection of rural-urban migrants at the place of origin has the largest impact on rural health.

Based for the most part on the case of Burkina Faso, this dissertation highlights the various challenges related to the measurement of urban-rural mortality differentials in adults in SSA. These issues should also be present in the other countries of SSA where CRVS systems are not functional. Indeed, censuses and standard surveys such as DHS remain the primary sources of data to derive mortality levels and trends in the region. In order to estimate mortality, questions included in the different surveys and censuses tend to be similar. However, the overall effect of data quality and migration flows on mortality differentials according to place of residence may vary depending on the context of each country. First, the quality of data collected in the different surveys might vary across countries. This is observed, for instance, when considering ages reported in DHSs during the period 2010-2015. A combined score for incompleteness, heaping, and displacement of ages was estimated at 1.12 and 1.82 in Niger and Mali, respectively (countries in the poorest quintile of data quality for ages). This score of data quality for ages was only -0.62 in Zimbabwe, which was in the highest quintile (Pullum and Staveteig, 2017). Second, lower migration flows between rural and urban areas is likely to be associated with lower impact on the measurement of urban-rural mortality differentials in adults. Despite the noticeable lack of data on migration, intensity of rural-urban migration probably differs from one country to another. For example, the intensity of internal migration (whatever the destination) tend to be high in countries such as Tanzania, Kenya, and Senegal (Bell et al., 2015). Regarding the selective effects of migration in particular, the case of Burkina Faso is different from that of more industrialized countries of the region. In particular, it is not surprising that we did not find any evidence of a negative selection in terms of health of return migrants from cities. First, migrants from rural areas of Burkina tend to settle down definitively in cities with their family or in order to start a new one. They are less engaged in temporary migration. Second, they are not exposed to risks of chronic diseases at levels seen in southern and eastern African countries. The prevalence of a diseases such as HIV/AIDS is particularly low in Burkina Faso, compared to some African countries (UNAIDS, 2016). Furthermore, the low level of industrialization in Burkina Faso may protect migrants from diseases such as tuberculosis. In South Africa, for example, this disease is prevalent in some subpopulations such as migrant mine workers (Peer, 2015).

6.2. Future research directions

This dissertation paves the way for different directions for future research on the measurement of urban-rural mortality differentials in adults as well as on the effect of migration on these differentials. Chapters 3 and 4 showed that one major problem in measuring urban-rural mortality differentials is the issue of data quality, specifically the underreporting of deaths. For censuses, the reliability of mortality indicators was evaluated in rural Burkina thanks to data collected in the Nouna HDSS. However, this comparison was made only on a geographical basis. Individuals or households can be included in one source of data, and not in the other. To better understand the sources of discrepancies, further analysis is required at individual level, by linking reports in the census with the demographic data contained in the HDSS database. In addition, patterns observed in Burkina Faso were slightly different from similar comparisons made in Senegal (Masquelier et al., 2016). In Senegal, life tables derived from recent household deaths were close to the underlying mortality rates obtained from the HDSS. Therefore, further comparisons should be conducted in other HDSS sites of Sub-Saharan countries where vital registration systems are incomplete to be able to generalize these context-specific patterns. With respect to urban-rural mortality differentials, the analysis should also be conducted in urban areas in order to compare findings with rural areas. The magnitude of the under-estimation of mortality in the census is likely to vary within countries and by type of residence. For the particular case of Burkina Faso, data collected in the Ouagadougou HDSS, combined with data of the coming census (2018) could be used to conduct such analyses, in several HDSS. Potentialities also exist in countries such as Kenya which runs HDSSs in both urban (Nairobi) and rural areas (Kisumu, Kombewa, Mbita) and where the next census will be conducted in 2019. Finally, beyond the issue of spatial differentials in mortality, various assessments of mortality indicators derived from censuses may be a starting point to inform adjustments made to census estimates in SSA.

Data on recent household deaths collected in different censuses generally provide estimates of mortality by type of residence for a single calendar year. As censuses are conducted every 10 years at best, other data sources such as DHSs are needed to closely monitor adult mortality by type of residence. In particular, sibling survival data can be useful for that purpose. However, innovative approaches are needed to improve their quality, especially the issue of underreporting of deaths. For example, in Senegal, the Niakhar HDSS was used to test a new sibling questionnaire to improve the collection of adult deaths in DHSs (Helleringer et al., 2015). Second, survey programs and national statistical offices should consider collecting additional information on the type of residence of close relatives.

However, it is unlikely that such expansion of the questionnaires will be adopted soon in large survey programs such as DHSs. Therefore, it would be interesting to test the comparative perspective used in chapter 4 in a larger set of countries.

The analysis of effects of migration on urban-rural mortality differentials (discussed in chapter 5) can be extended in different directions. First, a straightforward extension is to test the different hypotheses on specific age groups and by sex. For instance, the positive selection of migrants in rural areas may be more substantial among young adults than older ones. Such a detailed analysis will only be possible in the future in the Ouagadougou and Nouna HDSSs, when the sample sizes get bigger. In the meantime, other HDSSs sites in SSA could be put to contribution. Second, selection and adaptation mechanisms can operate differently according to various dimensions of health. Chronic conditions are more likely to impede the migration decision than acute diseases (Lu, 2008), for example. In the same vein, testing the adaptation effect of rural-urban migrants in cities with respect to cause-specific mortality will help to specify the reasons behind the deterioration of their health status with duration of residence. Higher mortality rates due to non-communicable diseases among long-term rural-urban migrants compared to recent ones would support the idea that migrants adopt typically urban behaviors such as alcohol consumption, smoking, and high-fat diets. Finally, Burkina Faso and Ivory Coast are historically linked with important migration flows so that the interactions of these migrations flows with health deserve special attention.

6.3. Practical implications

This dissertation leads to the formulation of some practical recommendations for policymakers and leaders of national statistical offices:

- ✓ Efforts made in reducing adult mortality in rural settings of Burkina Faso should continue ;
- ✓ In rural remote areas of West Africa including Burkina Faso, more proactive policies are needed to improve the health of the elderly, particularly their access to health care;
- ✓ To tackle the epidemic of non-communicable diseases in urban areas of Burkina Faso, initiatives to sensitize recent rural-urban migrants on specific risk factors (including the harmful use of alcohol; smoking, physical inactivity and diets rich in sugar and fat) are required;
- ✓ Caution is required when collecting data on recent household deaths in the censuses. Fieldworkers must be aware that deaths of non-residents can be registered as residents, and that some deaths are more likely to be under-reported, especially among older adults.
- ✓ Whenever possible, follow-up questions on the place of residence of close relatives should be added in survey questionnaires and census forms to enable a better estimation of spatial inequalities in adult mortality in SSA.

BIBLIOGRAPHY

Abegunde, D. O., Mathers, C. D., Adam, T., Ortegon, M., & Strong, K. (2007). The burden and costs of chronic diseases in low-income and middle-income countries. *The Lancet*, 370(9603), 1929-1938.

Agyei-Mensah, S., & Aikins, A. D. G. (2010). Epidemiological transition and the double burden of disease in Accra, Ghana. *Journal of urban health*, 87(5), 879-897.

Amuna, P., & Zotor, F. B. (2008). Epidemiological and nutrition transition in developing countries: impact on human health and development: The epidemiological and nutrition transition in developing countries: evolving trends and their impact in public health and human development. *Proceedings of the Nutrition Society*, 67(1), 82-90.

Anezaki, H. Transition of the place of death and total number of death in Japan (2008). *Asian Pacific Journal of Disease Management*. 2(4), 97-101.

Anteneh, A, Araya, T, Misganaw, A. Factors associated with place of death in Addis Ababa, Ethiopia (2013). *BMC palliative care*. 12(1), 14.

Arriaga, E. E. (1984). Measuring and explaining the change in life expectancies. *Demography*, *21*(1), 83-96.

Assah, F. K., Ekelund, U., Brage, S., Mbanya, J. C., & Wareham, N. J. (2011). Urbanization, physical activity, and metabolic health in sub-Saharan Africa. *Diabetes Care*, 34(2), 491-496.

Awini, E., Sarpong, D., Adjei, A., et al. (2014). Estimating cause of adult (15+ years) death using InterVA-4 in a rural district of southern Ghana. *Global Health Action*, *7*(1), 25543.

Bado, A. R., Kouanda, S., & Haddad, S. (2016). Lieu du décès au Burkina: influence des caractéristiques sociodémographiques et environnementales. *African Population Studies*, 30(1).

Baldé, N.M. Ampleur du diabète en Guinée: défis et initiatives locales (2007). *Médecine des maladies Métaboliques*. 1(3), 99-103.

Bauni, E., Ndila, C., Mochamah, G., et al. Validating physician-certified verbal autopsy and probabilistic modeling (InterVA) approaches to verbal autopsy interpretation using hospital causes of adult deaths (2011). *Population health metrics*, 9(1), 49.

Beauchemin, C. (2011). Rural–urban migration in West Africa: towards a reversal? Migration trends and economic situation in Burkina Faso and Côte d'Ivoire. *Population, Space and Place*, 17(1): 47–72.

Bell, M., Charles-Edwards, E., Ueffing, P., Stillwell, J., Kupiszewski, M., & Kupiszewska, D. (2015). Internal migration and development: comparing migration intensities around the world. *Population and Development Review*, 41(1), 33-58.

Bennett, N. G., & Horiuchi, S. (1984). Mortality estimation from registered deaths in less developed countries. *Demography*, *21*(2), 217-233.

Bhat, P. N. M. (2002). General growth balance method: a reformulation for populations open to migration. *Population Studies*, 56(1): 23–34.

Bicego G. (1997). Estimating adult mortality rates in the context of the AIDS epidemic in sub-Saharan Africa: analysis of DHS sibling histories. *Health Transition Review*, 7(Suppl 2): 7–22.

Blacker, J. G. (1977). The estimation of adult mortality in Africa from data on orphanhood. *Population Studies*, *31*(1), 107-128.

Boadi, K., Kuitunen, M., Raheem, K., & Hanninen, K. (2005). Urbanisation without development: environmental and health implications in African cities. *Environment, Development and Sustainability*, 7(4), 465-500.

Bocquier, P., Sankoh., O., & Byass., P. (2017). Are health and demographic surveillance system estimates sufficiently generalisable?. *Global health action*, 10(1), 1356621.

Bocquier, P. (2016). Migration analysis using demographic surveys and surveillance systems. In *International Handbook of Migration and Population Distribution* (pp. 205-223). Springer, Dordrecht.

Bocquier, P., Collinson, M. A., Clark, S. J., Gerritsen, A. A., Kahn, K., & Tollman, S. M. (2014). Ubiquitous burden: the contribution of migration to AIDS and Tuberculosis mortality in rural South Africa. *African population studies*, 28(1), 691.

Bocquier, P., Madise, N. J., & Zulu, E. M. (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.

Bosu, W. K. (2015). An overview of the nutrition transition in West Africa: implications for non-communicable diseases. *Proceedings of the Nutrition Society*, 74(04), 466-477.

Boutayeb, A. (2006). The double burden of communicable and non-communicable diseases in developing countries. *Transactions of the Royal society of Tropical Medicine and Hygiene*, 100(3), 191-199.

Boyer, F., & Delaunay, D. (2009). Peuplement de Ouagadougou et développement urbain: Rapport provisoire. *IRD*, Ouagadougou.

Boyle, P. (2004). Population geography: migration and inequalities in mortality and morbidity. *Progress in Human Geography*, 28(6), 767-776.

Brass, W. (1985). Methods for estimating fertility and mortality from limited and defective data. Chapel Hill, NC.

Brass, W., & Bamgboye, E. A. (1981). The time location of reports of survivorship: Estimates for maternal and paternal orphanhood and the ever-widowed.CPS Working Paper no. 81-1, *University of London, London, England*.

Byass, P., Chandramohan, D., Clark, S., et al. (2012). Strengthening standardised interpretation of verbal autopsy data: the new InterVA-4 tool. *Global health action*, 5(1), 19281.

Cárdenas-Turanzas, M., Torres-Vigil, I., Tovalín-Ahumada, H., et al. (2011). Hospital versus home death: results from the Mexican Health and Aging Study. *Journal of pain and symptom management*. 41(5), 880-892.

Carrillo-Larco, R. M., Bernabé-Ortiz, A., Pillay, T. D., Gilman, R. H., Sanchez, J. F., Poterico, J. A., ... & Miranda, J. J. (2016). Obesity risk in rural, urban and rural-to-urban migrants: prospective results of the PERU MIGRANT study. *International journal of obesity*, 40(1), 181.

Caselli, G., Meslé, F., & Vallin, J. (2002). Epidemiologic transition theory exceptions. *Genus*, 9-51.

Chamchan, C., Chan, W. K., & Punpuing, S. (2014). A longitudinal study of migration and health: Empirical evidence from Thailand and its implications (No. 2014-9). *UNRISD Working Paper*.

Chen, G. (2010). Road traffic safety in African countries–status, trend, contributing factors, countermeasures and challenges. *International journal of injury control and safety promotion*, 17(4), 247-255.

Chisumpa, V. H., Odimegwu, C. O., & De Wet, N. (2017). Adult mortality in sub-saharan Africa, Zambia: Where do adults die?. *SSM-population health*, *3*, 227-235.

Clark, S. J., Collinson, M. A., Kahn, K., Drullinger, K., & Tollman, S. M. (2007). Returning home to die: circular labour migration and mortality in South Africa 1. *Scandinavian Journal of Public Health*, 35(69_suppl), 35-44.

Cobbinah, P. B., Erdiaw-Kwasie, M. O., & Amoateng, P. (2015). Africa's urbanisation: Implications for sustainable development. *Cities*, 47, 62-72.

Collinson, M. A., White, M. J., Bocquier, P., McGarvey, S. T., Afolabi, S. A., Clark, S. J., ... & Tollman, S. M. (2014). Migration and the epidemiological transition: insights from the Agincourt sub-district of northeast South Africa. *Global health action*, 7(1), 23514.

Dabire, H. (2016). Migration au Burkina Faso : Profil migratoire 2016. *Organisation internationale des migrations*, 124 p.

Dabiré, B. (2001). Le confiage des enfants, alternative à une transition de crise. Les transitions démographiques des pays du Sud . *Aupelf-Uref, Éditions Estem, Paris*, 407–421.

De Walque, D., & Filmer, D. (2013). Trends and socioeconomic gradients in adult mortality around the developing world. *Population and Development Review*, *39*(1), 1-29.

Debpuur, C., Welaga, P., Wak, G., & Hodgson, A. (2010). Self-reported health and functional limitations among older people in the Kassena-Nankana District, Ghana. *Global health action*, *3*(1), 2151.

Duthé, G., Pison, G., & Laurent, R. (2010). Situation sanitaire et parcours de soins des personnes âgées en milieu rural africain Une étude à partir des données du suivi de population de Mlomp (Sénégal). *Autrepart*, (1), 167-187.

Dyson, T. (2003). HIV/AIDS and urbanization. *Population and Development Review*, *29*(3), 427-442.

Efron B, & Tibshirani. (1993). An Introduction to the Bootstrap. Chapman & Hall, Boca Raton, 436.

Eloundou-Enyegue, P. M., & Giroux, S. C. (2012). Demographic change and rural-urban inequality in sub-saharan africa: theory and trends. *In International Handbook of Rural Demography* (pp. 125-135). Springer Netherlands.

Ewbank, D. C. (1981). Age misreporting and age-selective underenumeration: sources patterns and consequences for demographic analysis. *Committee on Population and Demography,* Report No. 4.

Fink, G., Günther, I., & Hill, K. (2014). Slum residence and child health in developing countries. *Demography*, *51*(4), 1175-1197.

Flory, J., Young-Xu, Y., Gurol, I., Levinsky, N., Ash, A., & Emanuel, E. (2004). Place of death: US trends since 1980. *Health Affairs*, *23*(3), 194-200.

Fottrell, E., & Byass, P. (2010). Verbal autopsy: methods in transition. *Epidemiologic reviews*, *32*(1), 38-55.

Garenne, M. (2013). La récupération après les crises sanitaires: Etudes de cas sur les tendances de la mortalité des jeunes enfants en Afrique sub-saharienne. *Ralentissements, Résistances et Ruptures dans les Transitions Démographiques (Coll. Actes de la Chaire Quetelet 2010). Leuven, Belgium: Presses Universitaires de Louvain*, 213-234.

Gerritsen, A., Bocquier, P., White, M., Mbacke, C., Alam, N., Beguy, D., ... & A. Collinson, M. (2013). Health and demographic surveillance systems: contributing to an understanding of the dynamics in migration and health. *Global health action*, *6*(1), 21496.

Ginsburg, C., Bocquier, P., Béguy, D., Afolabi, S., Augusto, O., Derra, K., ... & Soura, A. (2016). Healthy or unhealthy migrants? Identifying internal migration effects on mortality in Africa using health and demographic surveillance systems of the INDEPTH network. *Social Science & Medicine*, 164, 59-73.

Gomes, B., Higginson, I. J., Calanzani, N., Cohen, J., Deliens, L., Daveson, B. A., ... & Meñaca, A. (2012). Preferences for place of death if faced with advanced cancer: a population survey in England, Flanders, Germany, Italy, the Netherlands, Portugal and Spain. *Annals of oncology*, *23*(8), 2006-2015.

Gomes, B., & Higginson, I. J. (2008). Where people die (1974—2030): past trends, future projections and implications for care. *Palliative medicine*, *22*(1), 33-41.

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

Grant, M. J., & Yeatman, S. (2012). The relationship between orphanhood and child fostering in sub-Saharan Africa, 1990s–2000s. *Population Studies*, *66*(3), 279-295.

Gu, D., Liu, G., Vlosky, D. A., & Yi, Z. (2007). Factors associated with place of death among the Chinese oldest old. *Journal of Applied Gerontology*, *26*(1), 34-57.

Guengant, J. P. (2017). Africa’s Population: History, Current Status, and Projections. In Africa's Population: *In Search of a Demographic Dividend (pp. 11-31). Springer, Cham*.

Guengant, J. P. (2011). Comment bénéficier du dividende démographique. La démographie au centre des trajectioires de développement dans les pays de l'UEMOA. Analyse pays Burkina Faso. Agence française de développement.

Guengant, J P. (2009). Evolution passée et future de la ville de Ouagadougou. In Boyer F & Delaunay D (coord.), Peuplement de Ouagadougou et développement urbain : rapport provisoire, *Ouagadougou (BKF), Paris: IRD, Université Paris 1*, 42–49. (in French).

Günther, I., & Harttgen, K. (2012). Deadly Cities? Spatial Inequalities in Mortality in sub-Saharan Africa. *Population and Development Review*, 38(3), 469-486.

Gysels, M., Pell, C., Straus, L., & Pool, R. (2011). End of life care in sub-Saharan Africa: a systematic review of the qualitative literature. *BMC Palliative Care*, *10*(1), 6.

Haddad, S., Nougtara, A., & Ridde, V. (2004). Les inégalités d’accès aux services de santé et leurs déterminants au Burkina Faso. *Santé, société et solidarité*, *3*(2), 199-210.

Hall, V., Thomsen, R. W., Henriksen, O., & Lohse, N. (2011). Diabetes in Sub Saharan Africa 1999-2011: epidemiology and public health implications. A systematic review. *BMC public health*, *11*(1), 564.

Hatt, L. E., & Waters, H. R. (2006). Determinants of child morbidity in Latin America: a pooled analysis of interactions between parental education and economic status. *Social science & medicine*, *62*(2), 375-386.

Helleringer, S., Pison, G., Masquelier, B., Kanté, A. M., Douillot, L., Ndiaye, C. T., ... & Delaunay, V. (2015). Improving survey data on pregnancy-related deaths in low-and middle-income countries: a validation study in Senegal. *Tropical Medicine & International Health*, 20(11), 1415-1423.

Helleringer, S., Pison, G., Kanté, A. M., Duthé, G., & Andro, A. (2014). Reporting errors in siblings' survival histories and their impact on adult mortality estimates: results from a record linkage study in Senegal. *Demography*, *51*(2), 387-411.

Hill, K., & Queiroz, B. (2010). Adjusting the general growth balance method for migration. *Revista Brasileira de Estudos de População*, 27(1), 7-20.

Hill, K., You, D., & Choi, Y. (2009). Death distribution methods for estimating adult mortality: sensitivity analysis with simulated data errors. *Demographic Research*, *21*, 235-254.

Hill, K. (1987). Estimating census and death registration completeness. In *Asian and Pacific population forum/East-West Population Institute, East-West Center* (Vol. 1, No. 3, pp. 8-13). The Asian & Pacific Population Forum.

Hill, K., & Trussell, J. (1977). Further developments in indirect mortality estimation. *Population Studies*, *31*(2), 313-334.

Houle, B., Clark, S. J., Kahn, K., Tollman, S., & Yamin, A. E. (2015). The impacts of maternal mortality and cause of death on children's risk of dying in rural South Africa: evidence from a population based surveillance study (1992-2013). *Reproductive health*, 12(1), S7.

Houttekier, D., Cohen, J., Surkyn, J., & Deliens, L. (2011). Study of recent and future trends in place of death in Belgium using death certificate data: a shift from hospitals to care homes. *BMC public health*, *11*(1), 228.

Houttekier, D., Cohen, J., Bilsen, J., Addington-Hall, J., Onwuteaka-Philipsen, B., & Deliens, L. (2010). Place of death in metropolitan regions: metropolitan versus non-metropolitan variation in place of death in Belgium, The Netherlands and England. *Health & place*, *16*(1), 132-139.

Hove, M., Ngwerume, E., & Muchemwa, C. (2013). The urban crisis in Sub-Saharan Africa: A threat to human security and sustainable development. Stability. *International Journal of Security and Development*, 2(1).

INSD (2012). Enquête démographique et de santé et à indicateurs multiples (EDSBF-MICS IV) 2010. Institut national de la statistique et de la démographie (Burkina Faso*), ICF International (USA)*, 525 p.

INSD. (2009a). Analyse des resultats definitifs, Theme 1: Etat et structure de la population. Recensement General de la Population et de l'Habitation de 2006 (RGPH-2006).

INSD. (2009b). Analyse des resultats definitifs, Theme 7: Mortalite. Recensement General de la Population et de l'habitation De 2006 (RGPH-2006).

INSD. (2009c). Analyse des resultats definitifs, Theme 9: Croissance urbaine. Recensement General de la Population Et de l'habitation de 2006 (RGPH-2006).

INSD. (2004). Enquête Démographique et de Santé Burkina Faso 2003. Institut National de la Statistique et de la Démographie (Burkina Faso), ORC Macro.

INSD. (2000a). Analyse des résultats du Recensement Géneral de la Population et de l'Habitation de 1996 Volume 2: Les phénomènes démographiques.

INSD. (2000b). Enquête Démographique et de Santé, Burkina Faso 1998–1999. Institut National de la Statistique et de la Démographie (Burkina Faso), Macro International Inc.

INSD. (1989). Analyse des résultats définitifs. Recensement général de la population, 1985.

Institute for Health Metrics and Evaluation (IHME). (2015). GBD compare. Seattle, WA: IHME, University of Washington, viewed 19 April 2016, <http://vizhub.healthdata.org/gbd-compare>.

Institute for Health Metrics and Evaluation (IHME). (2014). Mortality visualization. Seattle, WA: IHME, University of Washington, viewed 19 April 2016, <http://vizhub.healthdata.org/mortality/>.

Johnson, K. , Grant, M. , Khan, S., et al. (2009). DHS analytical studies No. 19: Fieldwork-related factors and data quality in the demographic and health surveys program. *ICF Macro Calverton, Maryland, USA.*

Kankeu, H. T., Saksena, P., Xu, K., & Evans, D. B. (2013). The financial burden from non-communicable diseases in low-and middle-income countries: a literature review. *Health Research Policy and Systems*, 11(1), 31.

Kayima, J., Wanyenze, R. K., Katamba, A., Leontsini, E., & Nuwaha, F. (2013). Hypertension awareness, treatment and control in Africa: a systematic review. *BMC cardiovascular disorders*, *13*(1), 54.

Kimani-Murage, E. W., Fotso, J. C., Egondi, T., Abuya, B., Elungata, P., Ziraba, A. K., ... & Madise, N. (2014). Trends in childhood mortality in Kenya: the urban advantage has seemingly been wiped out. *Health & place*, 29, 95-103.

Kobusingye, O., Guwatudde, D., & Lett, R. (2001). Injury patterns in rural and urban Uganda. *Injury prevention*, *7*(1), 46-50.

Kouanda, S., Bado, A., Yaméogo, M., Nitiema, J., Yaméogo, G., Bocoum, F., ... & Sondo, B. (2013). The Kaya HDSS, Burkina Faso: a platform for epidemiological studies and health programme evaluation. *International journal of epidemiology*, *42*(3), 741-749.

Kushitor, M. K., & Boatemaa, S. (2018). The double burden of disease and the challenge of health access: Evidence from Access, Bottlenecks, Cost and Equity facility survey in Ghana. *PloS one*, 13(3), e0194677.

Kynast-Wolf, G., Hammer, G. P., Müller, O., Kouyaté, B., & Becher, H. (2005). Season of death and birth predict patterns of mortality in Burkina Faso. *International journal of epidemiology*, *35*(2), 427-435.

Lankoandé, B., Duthé, G., Soura, A., & Pison, G. (2018). Returning home to die or leaving home to seek health care? Location of death of urban and rural residents in Burkina Faso and Senegal. *Global health action*, *11*(1), 1475040.

Lankoande, B., Sié, A. (2017). Selective adult migration and urban-rural mortality differentials in Burkina Faso. *Population, English Edition*, 72(2), 197-218.

Lankoande, B. Y. (2016a). Monitoring adult mortality by type of residence in the absence of death registration: A perspective from Burkina Faso. *International Journal of Population Studies*, 2(1).

Lankoande, B., Soura, A., Millogo, R., Compaoré, Y., & Rossier, C. (2016b). Surmortalité des enfants dans les quartiers informels de Ouagadougou: effet de composition ou effet de contexte?. *Etude de la Population Africaine*, 30(1).

Lazenby, M., Ma, T., Moffat, H. J., Funk, M., Knobf, M. T., & McCorkle, R. (2010). Influences on place of death in Botswana. *Palliative & supportive care*, *8*(2), 177-185.

Lemiere, C., Herbst, C., Jahanshahi, N., Smith, E., & Soucat, A. (2010). Reducing geographical imbalances of health workers in sub-Saharan Africa: a labor market perspective on what works, what does not, and why (Vol. 209). World Bank Publications.

Leon, D. A. (2008). Cities, urbanization and health. *International Journal of Epidemiology*, 37(1): 4–8.

Levira, F., Todd, J., & Masanja, H. (2014). Coming home to die? The association between migration and mortality in rural Tanzania before and after ART scale-up. *Global health action*, *7*(1), 22956.

Lu, Y., & Qin, L. (2014). Healthy migrant and salmon bias hypotheses: a study of health and internal migration in China. *Social Science & Medicine*, *102*, 41-48.

Lu, Y. (2008). Test of the 'healthy migrant hypothesis': a longitudinal analysis of health selectivity of internal migration in Indonesia. *Social science & medicine*, 67(8), 1331-1339.

Lucas, R. E. (2015). Internal migration in developing economies: An overview. KNOMAD's Working Paper 6. KNOMAD.

Maher, D., Ford, N., & Unwin, N. (2012). Priorities for developing countries in the global response to non-communicable diseases. *Globalization and health*, *8*(1), 14.

Masquelier, B., & Kanté, A. M. (2017). Mortality, Health, and Aging in Sub-Saharan Africa. In Africa's Population: In Search of a Demographic Dividend (pp. 267-281). *Springer, Cham*.

Masquelier, B., Mathenge, G. (2016a). Counting who is dying in Sub-Saharan Africa and what they are dying from: an imperative for the post-2015 agenda. Published on N-IUSSP.ORG March 7, 2016.

Masquelier, B., Ndiaye, C. T., Pison, G., Dieme, N. B., Diouf, I., Helleringer, S., ... & Delaunay, V. (2016b). Evaluation des estimations indirectes de mortalité dans trois observatoires de population au Sénégal. *African Population Studies*, 30(1), 2227-2241.

Masquelier, B. (2014a). Sibship sizes and family sizes in survey data used to estimate mortality. *Population, English edition*, *69*(2), 221-238.

Masquelier, B., Reniers, G., & Pison, G. (2014b). Divergences in trends in child and adult mortality in sub-Saharan Africa: Survey evidence on the survival of children and siblings. *Population studies*, *68*(2), 161-177.

Masquelier, B. (2013). Adult mortality from sibling survival data: a reappraisal of selection biases. *Demography*, *50*(1), 207-228.

Massa, G., & Madiéga, Y. G. (1995). La Haute-Volta coloniale: témoignages, recherches, regards. *KARTHALA Editions.*

Mberu, B., Béguy, D., & Ezeh, A. C. (2017). Internal Migration, Urbanization and Slums in Sub-Saharan Africa. In Africa's Population: In Search of a Demographic Dividend (pp. 315-332). *Springer, Cham.*

Mberu, B., Wamukoya, M., Oti, S., & Kyobutungi, C. (2015a). Trends in causes of adult deaths among the urban poor: evidence from Nairobi urban health and demographic surveillance system, 2003–2012. *Journal of Urban Health*, *92*(3), 422-445.

Mberu, B. U., & Mutua, M. (2015b). Internal migration and early life mortality in Kenya and Nigeria. Population, Space and Place, 21(8), 788-808.

McCartney, G., Collins, C., & Mackenzie, M. (2013). What (or who) causes health inequalities: theories, evidence and implications?. *Health Policy*, 113(3), 221-227.

Meslé, F., & Vallin, J. (2002). La transition sanitaire: tendances et perspectives. Démographie: analyse et synthèse III Les déterminants de la mortalité, *Paris, INED*, 439-461.

Mikkelsen, L., Phillips, D. E., AbouZahr, C., Setel, P. W., De Savigny, D., Lozano, R., & Lopez, A. D. (2015). A global assessment of civil registration and vital statistics systems: monitoring data quality and progress. *The Lancet*, 386(10001), 1395-1406.

Ministère de La Sante (2011). Plan National de Développement Sanitaire, Burkina Faso, 55 p.

Ministère de la santé, Direction génerale de l'information et des statistiques sanitaires (2010). Carographie de l'offre de santé, région du centre

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

Moultrie, T., Dorrington, R., Hill, A, et al. (2013). Tools for demographic estimation. International Union for the Scientific Study of Population. Retrieved on August 1, 2016 from http://demographicestimation.iussp.org.

Murray, C. J., Rajaratnam, J. K., Marcus, J., Laakso, T., & Lopez, A. D. (2010). What can we conclude from death registration? Improved methods for evaluating completeness. *PLoS medicine*, *7*(4), e1000262.

Nauman, E., VanLandingham, M., Anglewicz, P., Patthavanit, U., & Punpuing, S. (2015). Rural-to-urban migration and changes in health among young adults in Thailand. *Demography*, *52*(1), 233-257.

Neiderud, C. J. (2015). How urbanization affects the epidemiology of emerging infectious diseases. *Infection ecology & epidemiology*, *5*(1), 27060.

Niamba, L., Legrand, T., Gagnon, A., Sie, A., Zabre, P. (2016). Le double fardeau épidémiologique chez les personnes âgées en milieu rural africain : tendances de mortalité et causes de décès à Nouna (Burkina Faso). *Étude de la population africaine*, 30(1), p. 2122-2134.

Nolan, L. B. (2015). Slum definitions in urban India: implications for the measurement of health inequalities. *Population and development review*, 41(1), 59-84.

Norman, P., Boyle, P., & Rees, P. (2005). Selective migration, health and deprivation: a longitudinal analysis. *Social science & medicine*, *60*(12), 2755-2771.

Nunez, L., & Wheeler, B. (2012). Chronicles of death out of place: Management of migrant death in Johannesburg. *African Studies*, *71*(2), 212-233.

Nwakeze, N. M., & Kandala, N. B. (2011). The spatial distribution of health establishments in Nigeria. *African Population Studies*, 25(2).

Obermeyer, Z., Rajaratnam, J. K., Park, C. H., Gakidou, E., Hogan, M. C., Lopez, A. D., & Murray, C. J. (2010). Measuring adult mortality using sibling survival: a new analytical method and new results for 44 countries, 1974–2006. *PLoS medicine*, *7*(4), e1000260.

Peer, N. (2015). The converging burdens of infectious and non-communicable diseases in rural-to-urban migrant Sub-Saharan African populations: a focus on HIV/AIDS, tuberculosis and cardio-metabolic diseases. *Tropical Diseases, Travel Medicine and Vaccines*, 1(1), 6.

Phillips, K. A., Morrison, K. R., Andersen, R., & Aday, L. A. (1998). Understanding the context of healthcare utilization: assessing environmental and provider-related variables in the behavioral model of utilization. *Health services research*, *33*(3 Pt 1), 571.

Pison, G. (2005). Population observatories as sources of information on mortality in developing countries. *Demographic Research*, 13, 301-334.

Pison, G., Wade, A., Gabadinho A., et al. Population and Health in Developing Countries -Volume 1 (2002). Mlomp DSS, Senegal. Ottawa. *International development research centre*. pp. 271-278.

Poirier, J., Piché, V., Le Jeune, G., et al. (2001). Projet d'étude des stratégies de reproduction des populations sahéliennes à partir de l'enquête «Dynamique migratoire, insertion urbaine et environnement au Burkina Faso». *Cahiers québécois de démographie*, 30(2): 289–309.

Pullum, T. W., & Staveteig, S. (2017). An assessment of the quality and consistency of age and date reporting in DHS surveys, 2000-2015. ICF.

Rajaratnam, J. K., Tran, L. N., Lopez, A. D., & Murray, C. J. (2010). Measuring under-five mortality: validation of new low-cost methods. *PLoS Medicine*, *7*(4), e1000253.

Ramroth, H., Lorenz, E., Rankin, J. C., et al. (2012). Cause of death distribution with InterVA and physician coding in a rural area of Burkina Faso. *Tropical Medicine & International Health*, 17(7): 904–913.

Randall, S., & Coast, E. (2016). The quality of demographic data on older Africans. *Demographic Research*, *34*, 143.

Rao, C., Bradshaw, D., Mathers, C.D. (2004). Improving death registration and statistics in developing countries: Lessons from sub-Saharan Africa. *Southern African Journal of Demography*. 9(2): 81-99.

Remais, J. V., Zeng, G., Li, G., Tian, L., & Engelgau, M. M. (2012). Convergence of non-communicable and infectious diseases in low-and middle-income countries. *International journal of epidemiology*, 42(1), 221-227.

Reniers, G., Masquelier, B., & Gerland, P. (2011). Adult mortality in Africa. In Rogers R G and Crimmins E M (eds.), International Handbook of Adult Mortality. *Springer Netherlands*, 151–170.

Riley, J. C. (2005). The timing and pace of health transitions around the world. *Population and development review*, 31(4), 741-764.

Robertson, L., Gregson, S., Madanhire, C., Walker, N., Mushati, P., Garnett, G., & Nyamukapa, C. (2008). Discrepancies between UN models and DHS survey estimates of maternal orphan prevalence: insights from analyses of survey data from Zimbabwe. *Sexually transmitted infections*, *84*(Suppl 1), i57-i62.

Rossier, C., Soura, A. B., Duthé, G., & Findley, S. (2014a). Non-communicable disease mortality and risk factors in formal and informal neighborhoods, Ouagadougou, Burkina Faso: Evidence from a health and demographic surveillance system. *PloS one*, *9*(12), e113780.

Rossier, C., Soura, A., Duthé, G., Lankoande, B., & Millogo, R. (2014b). Are the urban poor always worse off? Socioeconomic differentials in adult cause specific mortality at the periphery of Ouagadougou, Burkina Faso. *Revue Quetelet*, *2*(2), 61-80.

Rossier, C., Soura, A., Lankoande, B. (2013). Migration et santé à la périphérie de Ouagadougou. Une première analyse exploratoire. *Revue Quetelet*, 1(1), p. 91-118.

Rossier, C., Ducarroz, L. (2012a). La pauvreté dans les quartiers de l'OPO : une approche qualitative. *ISSP, Université de Ouagadougou, rapport de recherche*, 76 p.

Rossier, C., Soura, A., Baya, B., Compaoré, G., Dabiré, B., Dos Santos, S., ... & Lankoandé, B. (2012b). Profile: the Ouagadougou health and demographic surveillance system. *International journal of epidemiology*, *41*(3), 658-666.

Rossier, C., Soura, A., Lankoande, B., Millogo, R. (2011). Observatoire de population de Ouagadougou. Données collectées au Round 0, Round 1 et au Round 2, Rapport descriptif. *ISSP, Ouagadougou*, 71 p.

Sankoh, O., Byass, P. (2012). The INDEPTH Network: Filling vital gaps in global epidemiology. *International Journal of Epidemiology*, 41(3), pp. 579-588.

Sauerborn, R., Berman, P., & Nougtara, A. (1996). Age bias, but no gender bias, in the intrahousehold resource allocation for health care in rural Burkina Faso. *Health Transition Review*, 131-145.

Serra, R. (2009). Child fostering in Africa: When labor and schooling motives may coexist. *Journal of Development Economics*, 88(1): 157–170.

Shapiro, D., & Gebreselassie, T. (2009). Fertility transition in sub-Saharan Africa: Falling and stalling. *African Population Studies*, 22(2): 3–23.

Sié, A., Soura, A., Derra, K., et al. (2015). Niveaux et tendances de la mortalité au Burkina Faso à partir des données des observatoires démographiques et de santé de: 2009–2011. *DSS Nouna, DSS Ouaga, DSS Nanoro, DSS Kaya.*

Sie, A., Louis, V., Gbangou, A., Müller, O., Niamba, L., Stieglbauer, G., ... & Becher, H. (2010). The health and demographic surveillance system (HDSS) in Nouna, Burkina Faso, 1993–2007. *Global health action*, *3*(1), 5284.

Silva, R. (2012). Child mortality estimation: consistency of under-five mortality rate estimates using full birth histories and summary birth histories. *PLoS Medicine*, *9*(8), e1001296.

Sobngwi, E., Mbanya, J. C., Unwin, N. C., Porcher, R., Kengne, A. P., Fezeu, L., ... & Alberti, K. G. M. M. (2004). Exposure over the life course to an urban environment and its relation with obesity, diabetes, and hypertension in rural and urban Cameroon. *International journal of epidemiology*, *33*(4), 769-776.

Sodjinou, R., Agueh, V., Fayomi, B., & Delisle, H. (2008). Obesity and cardio-metabolic risk factors in urban adults of Benin: relationship with socio-economic status, urbanisation, and lifestyle patterns. *BMC public health*, *8*(1), 84.

Soura, A. B., Mberu, B., Elungata, P., Lankoande, B., Millogo, R., Beguy, D., & Compaore, Y. (2015). Understanding inequities in child vaccination rates among the urban poor: Evidence from Nairobi and Ouagadougou health and demographic surveillance systems. *Journal of Urban Health*, *92*(1), 39-54.

Soura, A. B., Lankoande, B., Millogo, R., & Bangha, M. (2014). Comparing causes of death between formal and informal neighborhoods in urban Africa: evidence from Ouagadougou Health and Demographic Surveillance System. *Global health action*, *7*(1), 25523.

Soura, A., Pison, G., Senderowicz, L., & Rossier, C. (2013). Religious differences in child vaccination rates in urban Africa: Comparison of population surveillance data from Ouagadougou, Burkina Faso. *Etude de la Population Africaine*, *27*(2), 174.

Stanton, C., Abderrahim, N., & Hill, K. (2000). An assessment of DHS maternal mortality indicators. *Studies in family planning*, *31*(2), 111-123.

Streatfield, P. K., Khan, W. A., Bhuiya, A., Alam, N., Sié, A., Soura, A. B., ... & Oduro, A. (2014). Cause-specific mortality in Africa and Asia: evidence from INDEPTH health and demographic surveillance system sites. *Global health action*, *7*(1), 25362.

Tabutin, D., Masquelier, B. (2017). Mortality Inequalities and Trends in Low-and Middle-Income Countries, 1990–2015. *Population, English edition*, 72(2), 221-295.

Tadesse, S. (2013). Agreement between physicians and the InterVA-4 model in assigning causes ofdeath: the role of recall period and characteristics specific to the deceased and the respondent. *Archives of Public Health*, *71*(1), 28.

Timæus, I., & Jasseh, M. (2004). Adult mortality in sub-Saharan Africa: evidence from demographic and health surveys. *Demography*, 41(4): 757–772.

Timæus, I. M. (1992). Estimation of adult mortality from paternal orphanhood: a reassessment and a new approach. *Population Bulletin of the United Nations*, 33: 47–63.

Timaeus, I. M. (1991). Measurement of adult mortality in less developed countries: a comparative review. *Population Index*, 57(4): 552–568.

Ujoh, F., & Kwaghsende, F. (2014). Analysis of the Spatial Distribution of Health Facilities in Benue State, Nigeria. *Public Health Research*, *4*(5), 210-218.

UNAIDS (2016). aidsinfo.unaids.org, site consulté le 30 août 2016

UNDP (2016). Human Development Report 2016: Human Development for Everyone. *Washington DC, USA.*

United Nations human settlement program (UN-Habitat) (2013). State of the World's cities 2012/2013, new york, routledge, 185 p.

United Nations. (2017). The World Population Prospects: the 2017 Revision . Department of Economics and Social Affairs, Population Division.

United Nations. (2015). The World Population Prospects: the 2015 Revision . Department of Economics and Social Affairs, Population Division.

United Nations. (2014). World Urbanization Prospects, The 2014 Revision. Retrieved on July 31, 2016 from https://esa.un.org/unpd/wup/Publications/Files/WUP2014-Highlights.pdf.

United Nations. (2015). Transforming our world: the 2030 Agenda for Sustainable Development. Retrieved on August 4, 2016 from https://sustainabledevelopment.un.org/post2015/transformingourworld.

Unwin, N., James, P., McLarty, D., Machybia, H., Nkulila, P., Tamin, B., ... & McNally, R. (2010). Rural to urban migration and changes in cardiovascular risk factors in Tanzania: a prospective cohort study. *BMC Public Health*, 10(1), 272.

Urquia, M. L., & Gagnon, A. J. (2011). Glossary: migration and health. *Journal of Epidemiology & Community Health*, jech-2010.109405.

Vallin, J., & Meslé, F. (2010). De la transition épidémiologique à la transition sanitaire: l'improbable convergence générale. Ralentissements, Résistances et Ruptures dans les Transitions Démographiques (Coll. Actes de la Chaire Quetelet 2010). *Leuven, Belgium: Presses Universitaires de Louvain*, 257-290.

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

Van der Geest, S. (2004). Dying peacefully: considering good death and bad death in Kwahu-Tafo, Ghana. Social science & medicine, 58(5), 899-911.

Van Rooy, G., Mufune, P., & Amadhila, E. (2015). Experiences and perceptions of barriers to health services for elderly in rural Namibia: a qualitative study. *SAGE Open*, *5*(3), 2158244015596049.

Verhulst, A. (2016). Child mortality estimation: An assessment of summary birth history methods using microsimulation. *Demographic Research*, *34*, 1075-1128.

Vorster, H. H., Kruger, A., & Margetts, B. M. (2011). The nutrition transition in Africa: can it be steered into a more positive direction?. *Nutrients*, 3(4), 429-441.

Waziri, S. I., Nor, N. M., Abdullah, N. M. R., & Adamu, P. (2016). Effect of the Prevalence of HIV/AIDS and the Life Expectancy Rate on Economic Growth in SSA Countries: Difference GMM Approach. *Global journal of health science*, 8(4), 212.

WHO (2017). Global Health Observatory data repository, Birth registration coverage data by country. Retrieved on may 16th 2018 from http://apps.who.int/gho/data/view.main.HS09v

Wilson, D. M., Smith, S. L., Anderson, M. C., Northcott, H. C., Fainsinger, R. L., Stingl, M. J., & Truman, C. D. (2016). Twentieth-century social and health-care influences on location of death in Canada. *Canadian Journal of Nursing Research Archive*, *34*(3).

Zeba, A. N. (2012). Nutrition transition and the double burden of malnutrition among adults in Ouagadougou, Burkina Faso (West Africa), *PhD thesis, Université de Montréal, Montréal*. Retrieved on August 6, 2016 from http://hdl.handle.net/1866/8754.

Ziraba, A. K., Fotso, J. C., & Ochako, R. (2009). Overweight and obesity in urban Africa: a problem of the rich or the poor?. *BMC public health*, 9(1), 465.

Zongo, M. (2003). La diaspora burkinabé en Côte d'Ivoire: trajectoire historique, recomposition des dynamiques migratoires et rapport avec le pays d'origine. *African Sociological Review*, 7(2), 58-72.