THREE ESSAYS ON INTERNAL MIGRATION AND RISK FACTORS FOR NON-COMMUNICABLE DISEASES (NCDS) IN LOW- AND MIDDLE-INCOME COUNTRIES (LMICS)

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ABSTRACT

THREE ESSAYS ON INTERNAL MIGRATION AND RISK FACTORS FOR NON-COMMUNICABLE DISEASES (NCDS) IN LOW- AND MIDDLE-INCOME COUNTRIES (LMICS)

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Low- and middle-income countries (LMICs) have been experiencing extensive internal migration, which is closely associated with the increasing prevalence of risk factors for non-communicable diseases (NCDs). In this dissertation, I study the impact of internal migration on main NCD risk factors across three diverse LMIC contexts: China, Indonesia, and Malawi. In Chapter 1, I introduce the background, motivation, and research goals of this dissertation. In Chapter 2, I use data from the 2011 China Health and Retirement Longitudinal Study (CHARLS) to examine the associations between rural-urban migration and three main NCD risk factors, hypertension, obesity, and abdominal obesity, among older adults aged 45 or above. I find that rural-urban migrants have significantly higher chances of getting all three risk factors than rural non-migrants, suggesting a negative impact of rural-urban migration on health outcomes. Meanwhile, the number of years lived in cities significantly predicts being hypertensive, implying a "years since migration (YSM)" effect. In addition, health-related behaviors examined play a very limited role in mediating the association between migration and health. In Chapter 3, using data from the fourth and fifth waves of the Indonesia Family Life Survey (IFLS), I study the impact of rural-urban migration on overweight status in Indonesia. I find that rural-urban migration is significantly associated with being overweight, and the association is significantly stronger among women than men, demonstrating a gender disparity in health. Moreover, the number of years lived in cities does not predict overweight status, and health behavioral factors still explain little of the association between migration and health. In Chapter 4, I use data from the 2008 and 2019 waves of the Malawi Longitudinal Study of Families and Health (MLSFH) to investigate the impact of internal migration, not only rural-urban but also rural-rural, on weight status in Malawi. I find that rural-urban and rural-rural migration are both significantly associated with increased Body Mass Index (BMI) and that rural-rural migration significantly predicts being overweight. Meanwhile, the impact of rural-rural migration is significantly stronger among women than men, showing a gendered impact of migration on health. In Chapter 5, I summarize findings from the three main chapters and discuss their implications for policymaking and future research.

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CHAPTER 1

INTRODUCTION

Internal Migration and NCDs in LMICs

Tremendous advancements in modern transportation and communication technology lowered the financial costs of and physical constraints on human mobility. Migration, either within or across country borders, has been easier than ever. According to the United Nations, there are over one billion migrants globally, among whom 763 million are internal migrants (United Nations, 2013). In other words, every tenth person in the world is an internal migrant. The large and increasing number of internal migrants is contributed by both rural-urban migration and rural-rural migration in low- and middle-income countries (LMICs).

On one hand, with rapid urbanization, people in middle-income countries (MICs) and some low-income countries (LICs) move to cities for better economic opportunities and higher standards of living. There are about 4.2 billion people living in urban areas, accounting for 55% of the world population, and this number will reach 68% by 2050. Approximately 90% of the increase will occur in Asia and Africa (United Nations, 2018). On the other hand, rural-rural migration still dominates internal migration in the LICs of sub-Saharan Africa (SSA). Although widespread rural-urban migration is estimated to triple the urban population in SSA by 2030 (United Nations, 2014), most SSA populations will remain rural for the foreseeable future. The prevalent rural-rural migration in SSA mainly results from marriage/divorce or sometimes from climate-related reasons, and such migration normally occurs among women, as women in SSA primarily migrate for family-related reasons (Anglewicz, 2012; Reniers, 2003).

As a consequence, LMICs will be home to hundreds of millions of rural-urban and rural-rural migrants in the next few decades. The huge inflow of migrants from the countryside to cities and other rural areas poses challenges to public infrastructure and social systems in the receiving areas. In turn, exposure to new living environments shape all aspects of migrants' lives, and one of the most important aspects is health. The potential negative impact of internal migration on health which has been documented in many LMICs (e.g., Anglewicz et al., 2018; Anglewicz et al., 2019; Chen, 2011; Lu, 2010; Nauman et al., 2015), shows that migration is associated with higher adult mortality (Collinson et al. 2014; Ginsburg et al. 2016), lower self-rated physical health (Chen, 2011; Lu, 2010), deteriorated mental health (Chen, 2011; Nauman et al., 2015), worse child health (Anglewicz et al., 2019), and increased transmissions of infectious diseases (Anglewicz et al., 2018; Lagarde et al., 2003).

Nevertheless, how internal migration shapes non-communicable diseases (NCDs) and their risk factors (e.g., hypertension and overweight/obesity) is understudied. NCDs, such as cardiovascular diseases, diabetes, and cancers, are becoming increasingly prevalent in LMICs (Marshall, 2004). More than 36 million people die from NCDs annually, and 80% of the deaths occur in LMICs (World Health Organization, 2014). Even in SSA where infectious diseases remain to be the top health burden and the prevalence of NCDs is relatively low compared with high-income countries (HICs), NCDs are projected to surpass infectious diseases to be major causes of morbidity and mortality by 2030 and result in 28 million additional deaths (World Health Organization, 2014). For infectious diseases, LMIC governments developed health interventions promoting improved hygiene and treatments, which have achieved positive results. However, as NCDs are new in the LMIC context and are typically asymptomatic at early stages, relatively less has been done to curb their prevailing spread.

As migrants continue moving from the countryside to cities or other rural areas and NCDs take away increasing years of life in LMICs, it is of great importance to examine how internal migration is associated with NCD risk factors and understand the mechanism through which internal migration shapes health outcomes. The results will be useful to help governments develop preventive strategies for NCDs, improve the health and wellbeing of internal migrants, and augment their public health systems.

Empirical Findings on Internal Migration and NCD Risk Factors

Previous research in LMICs has mainly documented the impact of internal migration on two major NCD risk factors, hypertension and being overweight/obese, and almost exclusively focuses on rural-urban migration. For hypertension, prior studies showed that compared with rural non-migrants, rural-urban migrants had elevated blood pressure and significantly higher risks of being hypertensive in India (Ebrahim et al., 2010), Guatemala (Ramirez-Zea et al., 2005), and Kenya (Poulter et al., 1985). The patterns of being overweight/obese are less consistent. Some researchers reported significant associations between rural-urban migration and overweight/obesity in India (Ebrahim et al., 2010), Peru (Creber et al., 2010), China (Wang et al., 2021), and Malawi (Chilunga et al., 2019), while others found rural-urban migration did not predict weight status in Tanzania (Cockx et al., 2017) and Kenya (Peters et al., 2019).

In terms of the mechanisms that link migration and health outcomes, researchers found that migrants experienced significant changes in their health-related behaviors. For example, compared with rural men and women, both migrant men and women had more sedentary lifestyles with significantly lower levels of physical activity in India (Sullivan et al., 2011) and Guatemala (Ramirez-Zea et al. 2005), and Kenya (Poulter et al., 1985). Meanwhile, the consumption of westernized processed food as well as unbalanced diets was also considered as a factor that contributed to the differences in NCD risk factors by migration status in Iran (Aghasadeghi et al., 2008) and Kenya (Poulter et al., 1985).

Gaps in the Existing Literature

Given important findings from previous research, gaps in the literature on internal migration and NCD risk factors remain. First, most existing studies used cross-sectional data, failing to adjust for potential selection into migration. Migration is not a behavior that is randomly adopted by everyone but highly selective on individuals' sociodemographic factors and health conditions (Stark, 1984). Migrants typically have better health than those who remain, and this positive health selection has been documented in many LMICs (e.g., Anglewicz et al., 2018; Lu, 2008; Lu & Qin, 2014; Nauman et al., 2015; Riosmena et al., 2013). Cross-sectional data do not provide information on pre-migration health and socioeconomic status, and researchers cannot distinguish whether the differences in health between migrants and non-migrants are indeed driven by migration or due to migrant selectivity. Likewise, with cross-sectional data, unobserved factors associated with both migration and health could confound the relationship between the two and may cause spurious associations. Therefore, it is preferable to use longitudinal data to more accurately examine the impact of migration on health outcomes.

Second, previous studies paid little attention to rural-rural migration. It is particularly problematic for research in SSA because rural-rural migration will continue dominating internal migration in that region for the decades to come. Unlike rural-urban migrants who usually move for work, rural-rural migration in SSA typically results from marriage/divorce or climate-related reasons (Anglewicz, 2012). As a consequence, rural-rural migrants are very likely to represent a different group of people from rural-urban migrants in terms of sociodemographic factors and health behaviors. Therefore, the relationship between rural-urban migration and NCD risk factors may not apply to rural-rural migrants. In SSA, where rural-rural migration remains a critical form of internal migration, it is vital to understand its implications for health.

Third, previous studies mostly consider migrants as a single group and ignore the variations among individuals who migrate for different lengths of time and have exposure to environments at destinations. The concept of “accumulation of risk” from the life course theory points out that life course exposures or risks gradually accumulate through episodes of illness and injury, adverse environmental conditions, and health-damaging behaviors (Ben-Shlomo & Kuh, 2002). This concept is particularly suitable for studying NCDs. Their onsets do not immediately follow temporary exposure to risk factors, but rather result from a long-term and continuing accumulation of risks, such as negative changes in lifestyles and health behaviors. A similar concept in the current research on health and migration is the Years Since Migration (YSM) effect, which argues that the health advantages of migrants deteriorate with time in the destination. Research in China

(Chen, 2011), Indonesia (Lu, 2010), and South Africa (Ajaero et al., 2017) documented the YSM effect on self-rated physical health and mental conditions. However, little is known about whether the YSM effect exists for NCDs.

Fourth, the gender pattern of the impact of internal migration on NCD risk factors is understudied. While previous research has shown important gender differences in the prevalence of NCD risk factors, such as being overweight (Ebrahim et al., 2010; Varadharajan et al., 2013; Chilunga et al., 2019; Kanter & Caballero, 2012), it is unclear whether the impact of internal migration on developing NCD risk factors also varies by gender. The gender pattern is important because women constitute an increasing sharing of rural-urban migrants in many LMICs (Sukamdi, 2015) and continue outnumbering men in rural-rural migration in SSA (Anglewicz, 2012). Meanwhile, women are more vulnerable to chronic conditions related to NCD risk factors but are less likely to be diagnosed and treated than men in LMICs (Bonita & Beaglehole, 2014). Therefore, it is worth investigating whether their health is impacted differently by migration from men so that LMIC governments can implement more targeted health interventions.

Last but not least, although research in some LMICs attributes the association between internal migration and NCD risk factors to health-related behaviors, the mediating effect of these health behavioral factors, such as smoking, alcohol consumption, physical activity, and diet, has not been precisely quantified. Therefore, the puzzle of the underlying pathways through which migration shapes health is not fully solved. Nevertheless, understanding the mechanisms linking migration with NCD risk factors would contribute to more effective policymaking to curb the rising mortality and morbidity from NCDs in LMICs.

Research Goals

Motivated by the aforementioned gaps, this dissertation aims to answer the following research questions. First, how is rural-urban migration associated with NCD risk factors? For LICs in SSA, does rural-rural migration also impact the chances of developing NCD risk factors? Second, does the impact of internal migration on NCD risk factors accumulate over time, with a longer time since migration associated being with higher risks of having NCD risk factors? Third, does the impact of migration on NCD risk factors vary by gender? Fourth, how much of the associations between migration and NCD risk factors, if there are any, can be explained by changes in health-related behaviors? These questions will be covered by all three main chapters together while some of them are not examinable due to data limitations in the contexts of study, which will be explained in detail in the final section.

Contexts of Study

In order to answer the proposed research questions, I choose three LMICs as case studies: China, Indonesia, and Malawi. They share many similarities. Geographically, they are located in Asia/Africa where the urbanization process is the most rapid (United Nations, 2018). In China, the number of people living in urban areas will reach 1.1 billion in 2050, accounting for 80% of the Chinese population (United Nations, 2018). Approximately 80% of urban residents will be migrants from rural areas (Chan, 2013). Similar trends are also observed in Indonesia and Malawi. Indonesia is the fastest urbanizing country in Asia. It has had an annual growth of 4.4% in urban populations on average in the past four decades, and urban residents will constitute 68% of its total population within the next 10 years (Marta et al., 2020). Malawi is urbanizing at an annual average rate of 6.3%, with high rural-urban migration (World Health Organization, 2018).

Besides fast urbanization rates and large numbers of internal migrants, these countries all face a burgeoning health burden of NCDs. It is estimated that about 80% and 73% of annual deaths in China and Indonesia, respectively, are attributed to NCDs (World Health Organization, 2009; World Health Organization, 2018). The health challenge brought by NCDs is even greater in Malawi. Major NCD risk factors, including hypertension and being overweight/obese are becoming increasingly prevalent (Price et al., 2018). Two population-based nationwide surveys show that 33% of Malawian adults are hypertensive and 22% are overweight (Msyamboza et al., 2013; Msyamboza et al., 2012). Meanwhile, infectious diseases, such as HIV/AIDs and malaria, remain major death causes, creating a double burden of disease.

Given these similarities, the three countries nevertheless have their own unique aspects that provide a more detailed and complete picture of internal migration and NCDs in the LMIC context. China has the most aged population of the three countries and even among all LMICs. By 2050, there will be 366 million older adults in China, which is greater than the current U.S. population. The share of people above 65 years old in the total population will reach 26% (United Nations, 2019). Compared with younger people, older adults are more likely to suffer from NCDs. Therefore, a larger proportion of older adults corresponds to a greater health burden of NCDs.

Indonesia’s uniqueness lies in the feminization of internal migration. More specifically, there has been a rise in women’s rural-urban migration that was once dominated by men. In Indonesia, migrant women outnumber men among married, divorced, and widowed people, and these differences are especially obvious in younger groups (Sukamdi & Mujahid, 2015). The increasing number of female migrants has important implications on the risk profile of NCDs because females are more vulnerable to many NCDs while having less apparent symptoms to be diagnosed and treated (Bonita & Beaglehole, 2014).

Malawi is different from the other two countries as a representative of SSA, where little is known about the implications of migration for NCDs due to the lack of longitudinal data that contains migration histories and anthropometric indicators. In addition, like many other SSA countries, most Malawians reside in rural areas, and rural-rural migration will remain a critical form of internal migration (Anglewicz, 2012; Oucho & Gould, 1993), which provides an opportune setting to examine how rural-rural migration shapes weight.

The last difference among these countries is the development level. According to the 2019 Human Development Index (HDI), a comprehensive measure of development from life expectancy, education, and gross national income per capita, China is ranked the 85th out of 189 countries and regions, followed by Indonesia (111th), with Malawi (172th) towards the bottom of the list (United Nations Development Programme, 2019). The gradient of socioeconomic and health development, together with the aforementioned similarities and uniqueness in social systems and disease risk profiles, enable this dissertation to examine how internal migration influences NCD risk factors in a broad LMIC context from a more complete perspective.

Overview of Three Main Chapters

The rest of the dissertation is organized as follows. In each of the next three chapters, I examine how internal migration shapes major NCD risk factors in one chosen context of study. Chapter two focuses on China, and chapters three and four cover Indonesia and Malawi, respectively. The fifth chapter serves as a conclusion that summarizes the main findings of these three chapters, explores similarities and differences in analysis results across contexts, and reflects on the implications of the analysis results.

In chapter two, I use data from the China Health and Retirement Longitudinal Study (CHARLS), which is a nationally representative longitudinal survey. The research subject is Chinese aged 45 years or above and their spouses, and the survey assesses their socioeconomic and health circumstances (Zhao et al., 2013). The data capture respondents' migration histories, sociodemographic factors, measured anthropometric indicators, and health-related behaviors. Because the number of older respondents who migrated across waves is small, only the baseline survey is used to ensure a decent sample size and sufficient statistical power. Although the analysis is not longitudinal, as discussed in the Discussion section of chapter two, the special historical period in China during which older respondents migrated to cities makes the potential biases from migration health selection very unlikely and should not impact the main findings of the analysis. I use logistic regression models to examine the impact of rural-urban migration on three main NCD risk factors, hypertension, obesity, and abdominal obesity. I also explore whether the impact of rural-urban migration differs among respondents who moved to cities for different years. In addition, I use mediation analysis techniques to quantify the mediating effects of health-related behaviors, including smoking, drinking, and physical activity.

In chapter three, I examine how rural-urban migration shapes overweight status in Indonesia. The data come from the fourth (2007-2008) and fifth (2014-2015) waves of the Indonesia Family and Life Survey (IFLS), which is an ongoing longitudinal survey and contains a wealth of information collected at the individual and household levels, including multiple indicators of economic and non-economic well-being, such as migration histories and health outcomes. Fixed-effects (FE) models are used to adjust for potential migration selection as well as other biases from other time-invariant confounders. I also examine the gender pattern of the impact of rural-urban migration on being overweight and explore whether the chance of being overweight differs by lengths of time spent in cities. In addition, the survey contains valuable information on household consumption of cooking oil and sugar that is generally not available in other datasets, enabling me to more comprehensively understand the mediating effects of health-related behaviors on the association between rural-urban migration and overweight status.

In chapter four, I study the impact of both rural-urban and rural-rural migration on being overweight. The data come from the 2008 and 2019 waves of the Malawi Longitudinal Study of Families and Health (MLSFH), which is one of a few long-standing longitudinal cohort studies in SSA and provides information about demographic, socioeconomic, and health conditions in one of the poorest countries over two decades (Kohler et al., 2015). FE models are used to predict continuous BMI and overweight status. In addition, I also explore how the impact of two migration types on weight status varies by gender.

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CHAPTER 2

HOW URBAN LIFE EXPOSURE SHAPES RISK FACTORS OF NON-COMMUNICABLE DISEASES (NCDS): AN ANALYSIS OF OLDER RURAL-URBAN MIGRANTS IN CHINA

Abstract: Research in some low- and middle-income countries (LMICs) has documented that exposure to urban life negatively impacts health, especially in terms of non-communicable diseases (NCDs), and attributed the association to health-related behaviors. However, it is unclear if such patterns exist in China. Meanwhile, given the severe population aging trend, previous research lacks focus on rural-urban migrants of older age groups. In addition, different extents of urban life exposure among migrants are either ignored or indirectly measured, and the mediating effects of health behavioral factors have not been quantified. Using data from 2011 China Health and Retirement Longitudinal Study (CHARLS), this study examined three major NCD risk factors, hypertension, general obesity, and abdominal obesity, among older adults aged 45 or above (N = 11,126). Employing logistic regression models and mediation analysis, I find that rural-urban migrants have significantly higher odds of having three NCD risk factors than rural dwellers, and have similar risk profiles as urban residents. Among rural-urban migrants, years lived in cities significantly and cumulatively predict hypertension. However, health-related behaviors, including tobacco use, alcohol consumption, and physical activity, only account for a small proportion of the differences between rural-urban migrants and rural dwellers, implying other pathways through which urban settings shape older rural-urban migrants' health outcomes.

Introduction

The world has been experiencing rapid urbanization over the past few decades, with the number of urban residents rising from 751 million in 1950 to 4.2 billion in 2018 (United Nations, 2018). Currently 55% of the world population lives in cities and the share will reach 68% by the middle of the century (United Nations, 2018). The increasing number of rural-urban migrants, together with the overall growth of the world's population, will add another 2.5 billion people to urban areas by 2050, and 90% of the increase will take place in low- and middle-income countries (LMICs) in Asia and Africa, in which the rate of urbanization is greater than that in high-income countries (United Nations, 2018).

The debate on the health implications of urban life has been long-lasting in the context of LMICs. Some argue that living in cities has a positive influence on health outcomes because of better health care services, safer water supply, and greater access to health information (Eckert & Kohler, 2014; McDade & Adair, 2001). Others, however, hold that urbanization negatively impacts health outcomes (Bygbjerg, 2012; Montgomery et al., 2003), and one of the main arguments is that urban lifestyles result in the increasing prevalence of non-communicable diseases (NCDs) that have replaced infectious diseases to become a major health burden in many LMICs (Islam et al., 2014). Diets that are high in salt, sugar and fat, decreased physical activity with sedentary lifestyles, and increased use of tobacco and alcohol (Hancock et al., 2011) are closely associated with NCD risk factors, such as hypertension and obesity (Islam et al., 2014). Consequences of the epidemiological transition from infectious diseases to NCDs will be exacerbated by population aging in LMICs, as older adults in the developing world are more likely to suffer from NCDs than their counterparts in developed countries because of distressed and disadvantaged early life (WHO, 2018).

China, the biggest LMIC and home to 19% of the world population, is at the intersection of urbanization and population aging. It is projected that the number of people living in urban areas will reach 1.1 billion in 2050, accounting for 80% of the Chinese population (United Nations, 2018). Approximately 80% of urban residents will be migrants from rural areas (Chan, 2013). Meanwhile, the number of older people in China will increase to 402 million by 2040, and its proportion of the total population will reach 28% (United Nations, 2013). As a result, there will be more and more rural-urban migrants at older ages. On the one hand, they have access to many urban resources that are beneficial to their health outcomes, such as clean water, convenient transportation, and better health care services. On the other hand, they are also exposed to unhealthy lifestyles that are related to increasing risks of getting NCDs. Over 80% of annual deaths in China are caused by NCDs and the proportion among older adults is 69% (WHO, 2009). Research aimed at understanding the health implications of urban life exposure will be important for the Chinese government to develop prevention strategies for NCDs, optimize existing health care systems, and improve the wellbeing of older rural-urban migrants. Meanwhile, it will provide references for other LMICs that are faced with NCD challenges brought about by urbanization and population aging.

One aspect that sets China apart from other LMICs experiencing rapid urbanization is the continuing influence of the Hukou system, a national household registration system created in 1958 to fix population in place and limit internal migration (Cui & Cohen, 2015). The movement from the countryside to cities was enabled by the loosening of the strict Hukou system. The Hukou system divides the entire Chinese population into two groups based on their birth places: people who were born in urban areas have non-agricultural Hukou and those who were born in rural areas hold agricultural Hukou (Liu & McGuire, 2015; Wu & Wang, 2014). Before 1978, rural dwellers who were prohibited from moving to cities had no access to many resources that were only available in urban areas, such as high-quality education, sufficient working opportunities, satisfying housing conditions, and generous social welfare and health care benefits (Liu & McGuire, 2015; Wu & Wang, 2014). The Hukou system was reformed in 1978, allowing rural dwellers to migrate to urban areas if they could find jobs and secure their own accommodations. Some of the could even convert their Hukou status from agricultural to non-agricultural after working in cities for certain years (Cui & Cohen, 2015, Tao, 2008). During the past few decades, the Chinese government has continued to reform the Hukou system, and rural-urban migrants have more ways of changing their Hukou status, such as higher education, employment, and marriages with urban Hukou holders (Cui & Cohen, 2015, Tao, 2008). However, there are still many migrants who hold rural Hukou. On the one hand, urban Hukou allows migrants to access various resources that may benefit health. On the other hand, research shows that urban Hukou holders among migrants have stronger attachments to cities and better acculturation to urban life (Zhang, 2013), and thus may have similar lifestyles and health outcomes with urban residents. Therefore, Hukou status is an interesting context-specific factor that may have implications on rural-urban migrants' health.

On the global scale, previous studies that examined how exposure to urban life is associated with rural-urban migrants' health in LMICs typically focus on migrants of younger age groups and few choose older migrants as research subjects. Moreover, although much research attributes the influence of urban settings on health to lifestyles, the mediating role of health-related behaviors has not been quantified, obscuring the pathways between urban life and health outcomes. In the scope of China, studies on the health implications of urban settings often simply compare the health outcomes of rural and urban residents, and generally neglect rural-urban migrants. In recent years, researchers have begun to pay more attention to this group but have mainly examined how urban life predicts their self-rated health. Specific physical health outcomes, such as NCD risk factors, are rarely examined. More importantly, these studies mostly compare rural-urban migrants with their rural/urban counterparts, ignoring variations within the group of rural-urban migrants who have different degrees of urban life exposure.

In this study, I aim to answer three research questions. First, how do rural-urban migrants differ from urban residents and urban dwellers in terms of developing major NCD risk factors? Second, how much of these differences can be explained by health behavioral factors? Third, how are different lengths of urban life exposure associated with NCD risk factors among rural-urban migrants? To address these questions, I will use data from the 2011 China Health and Retirement Longitudinal Study (CHARLS), a nationally representative longitudinal survey. I will focus on respondents aged 45 or above, and examine three important NCD risk factors: hypertension, general obesity, and abdominal obesity. Meanwhile, I will examine the mediating effects of a set of health-related behaviors, including smoking, drinking, and physical activity. In order to capture the variation among rural-urban migrants, I will use the number of years lived in cities as a direct measure of urban life exposure. I will also include migrants' Hukou status in the analysis and explore how it may impact migrants' health outcomes.

Literature Review

Empirical Findings

Rural-urban migration represents more than mere changes in residential locations but also movements from agricultural to industrial settings, in which various resources that contribute to better health outcomes are more adequate. In China, all-cause death rates at all ages have been consistently lower in urban areas than in rural areas during the past three decades (National Bureau of Statistics of China, 2011). This urban health advantage is explained by more socioeconomic resources, greater access to health care services, and more completed infrastructure, such as clean water and convenient transportation (Chai et al., 2010; Zimmer et al., 2010). People living in the cities enjoy urban benefits that are not available in rural areas, but at the same time are exposed to unhealthy lifestyles, including longer sedentary time, less physical activity, and more fat and sugar in daily diets (Rosenthal, 2014). Research shows that Chinese urban residents have significantly lower physical activity than their rural counterparts (Du et al., 2013, Muntner et al., 2005), in terms of both work-related and leisure-time activities (Muntner et al., 2005). Urban residents are also more likely to consume excessive amounts of fried food are typically high-sodium and high-fat (Wang et al., 2008), whereas their rural counterparts eat more balanced diets rich in vegetables and whole grains (Campbell & Junshi, 1994). These unhealthy lifestyles are associated with the increasing prevalence of NCDs, which have replaced infectious diseases to become the number one health threat in China, accounting for over 80% of annual deaths and 69% of total health burden

(WHO, 2009). The risk factors of major NCDs, such as high blood pressure and obesity, are much more common among urban residents than in rural dwellers, and the high prevalence is attributed to high fat diets and physical inactivity (Popkin & Du, 2003; Zhu et al., 2016).

The mixed and inconclusive results of prior studies on the health implication of urban settings in China leave unanswered the question of whether rural-urban migrants will have lower chances of developing NCDs. One the one hand, migrants come from rural environments with high levels of physical activity and access to relatively healthy diets. After migrating, they also enjoy better access to urban healthcare resources, potentially leading to have better health outcomes. On the other hand, they may experience increasing risks of getting NCDs after gradually adapting unhealthy urban lifestyles. Studies conducted in other LMICs tried to address this question and find evidence that migrating to cities negatively impacts the prevalence of NCD risk factors among rural-urban migrants. For example, in India, a populous country where rural-urban migration is common, individuals who migrated from rural to urban areas have significantly higher blood pressure and a higher prevalence of obesity than those who remained in rural areas (Ebrahim et al., 2010). Compared with rural men and women, both migrant men and women have significantly lower levels of physical activity and their levels were similar to those of their urban-born counterparts (Sullivan et al., 2011). In Guatemala, rural-urban migrants have significantly lower physical activity and higher blood pressure than those remained in their native villages (Ramirez-Zea et al. 2005). In Iran, rural-urban migrants have a higher chance of getting coronary diseases compared with their rural counterparts, which is explained by westernization of the traditional

Iranian diet and a sedentary lifestyle (Aghasadeghiet al., 2008). Urban lifestyles have driven the increasing prevalence of NCD risk factors, even in the least developed countries. In Kenya, a longitudinal study shows that rural-urban migrants' blood pressure increases and tends to keep rising only six months after migration, which is also attributed to changes in diets and physical activity (Poulter et al., 1985).

In the context of China, although NCDs are rarely examined, a growing number of studies have recently stepped out of the traditional comparison of health outcomes between urban residents and rural dwellers, and started paying attention to the health status of rural-urban migrants. Most of the existing research on physical health uses self-rated health as a measure. Overall, they find support for a healthy migrant effect, which refers to the phenomenon that migrants have better health than their non-migrant counterparts (Abraido-Lanza et al., 1999). Using data from a national longitudinal survey data between 2003 and 2007, Lu and Qin (2014) finds that rural-urban migrants have better physical health outcomes than rural non-migrants. Similarly, Hou et al.(2019) demonstrate that rural-urban migrants report better physical health than both rural and urban non-migrants. Chen (2011) uses data from a household survey in Beijing in 2009 and shows that rural-urban migrants have advantage in physical health over urban non-migrants. Interestingly, the advantage diminishes over time. The declining health advantage of migrants is referred to as the years since migration (YSM) effect, which also gains support from some research on migrant workers showing that they experience deteriorating physical health over time after migration (Ma et al., 2020). However, it is unclear whether the healthy migrant effect and the YSM effect will still hold when specific physical diseases are analyzed. In terms of Hukou status, the patterns are not conclusive, with some showing that rural-urban migrants who do not hold urban Hukou reporting better physical health than those who obtained urban Hukou (Chen, 2011) while others suggesting that Hukou status is not significantly associated with physical health of migrants when other covariates are controlled (Hou et al., 2019). Still, it is unknown what the results will look like when it comes to NCDs.

Gaps in the Literature

Although increasing attention has been given to the health status of rural-urban migrants in LMICs, gaps in the literature remain. First, most studies conducted in other LMICs use the entire rural-urban migrant population or migrants of younger ages as research subjects. People in their middle and older ages have different risk profiles for physical diseases from their younger counterparts and typically face higher risks of developing NCDs. Given the magnitude of population aging in LMICs, it is of paramount importance to examine the link between rural-urban migration and health among older age groups. Meanwhile, focusing on older rural-urban migrants will provide more meaningful policy implications for governments to improve the health and wellbeing of this group.

Second, for existing research in China, it mainly examines self-rated health of rural-urban migrants. Few specific physical outcomes were examined, not to mention NCDs. However, as discussed above, urban lifestyles are closely associated with the prevalence of NCDs and studies in other LMICs have documented rural-urban migrants face increasing risks of developing NCD risk factors. Therefore, it is worth researching how migrating to cities is related to NCD risk factors among Chinese rural-urban migrants.

Third, previous studies mostly compare the general physical health of rural-urban migrants with that of their rural/urban counterparts, but ignore the variations within the group of rural-urban migrants who have been living in cities for different lengths of time and thus have different urban life exposure. The concept of “accumulation of risk” from the life course theory points out that life course exposures or insults gradually accumulate through episodes of illness and injury, adverse environmental conditions, and health damaging behaviors (Ben-Shlomo & Kuh, 2002). Therefore, it is reasonable to think that rural-urban migrants who reside in cities for longer durations face higher risks of getting NCDs. This hypothesis also echoes the YSM effect observed in some existing research that has been discussed above. Some studies do consider the changes in migrants’ health during their stay in cities (e.g. Chen, 2011), but they normally use a dummy variable indicating whether migrants experience deteriorating health. Such measures fail to show a detailed pattern of how migrants’ health changes with time. Gu et al. (2017) sheds light on this issue. It innovatively uses types of birth places and lifetime occupations as measures of urban life exposure, and divides migrants into subgroups with early, mid-late, and late-life urban exposure. However, both measures are indirect, and the categorization is too broad to capture nuanced variations within each exposure group.

Last but not least, although research in other LMICs attributes the association between rural-urban migration and NCD risk factors to lifestyle changes, the mediating role of related health behavioral factors, such as smoking, drinking and physical activity, has not been precisely quantified. Therefore, the puzzle of the underlying mechanism through which urban life shapes NCD risk factors is not fully solved.

Research Goals

My analysis aims to fill aforementioned gaps in the following aspects. In comparison to previous studies that mainly focus on self-rated physical health among rural-urban migrants, I will examine three important NCD risk factors that are prevalent in China, hypertension, general obesity, and abdominal obesity (WHO, 2009). I will not only compare the probability of getting these three NCD risk factors among rural-urban migrants with that among urban/rural residents, but also analyze the differences within rural-urban migrants due to different extents of urban life exposure. For this purpose, instead of relying on indirect measures, such as types of birth place and lifetime occupations, I will measure urban life exposure by calculating the number of years that migrants lived in cities. What is more, I will include health behavioral factors (i.e. tobacco use, alcohol consumption, and physical activity) in the analysis to test their mediating effects, which have been argued to exist in many LMICs yet have not been formally quantified. In addition, I will add migrants' Hukou status to the analysis and explore how NCD risk factors differ between migrants with rural and urban Hukou. Moreover, I will include whether a respondent is being depressed, a binary mental health indicator that is normally taken as a dependent variable in examining the effect of rural-urban migration, as a control variable. Many studies have shown that being depressed is closely associated with developing NCD risk factors. Other common sociodemographic factors will also be controlled. Finally, rather than study the entire rural-urban migrants or those at younger ages, I study individuals at age 45 or above, a population group who starts to face higher risks of NCD onset. Focusing on internal migrants at older ages groups provides more meaningful policy implications for rapidly aging China.

Data and Measures

Data

The data for this study come from the baseline survey of China Health and Retirement Longitudinal Study (CHARLS), a nationally representative longitudinal survey. It is intended to provide a high-quality public micro-database with a wide range of information serving the needs of scientific and policy research on aging-related issues. CHARLS included in its sample Chinese aged 45 years or above and their spouses (if married). The baseline survey was conducted between June 2011 and March 2012, using a four-stage, stratified, cluster sampling method. In total, 17,708 individuals from 28 provinces (150 county-level units) were interviewed (Zhao et at., 2012). The baseline survey assessed their socioeconomic and health circumstances (Zhao et al., 2013).

Analytic Sample

In all 17,708 respondents, 13,908 of them are measured for blood pressure, height, weight, and waist circumference, which will be used to construct dependent variables. Among the 13,908 respondents whose biomarkers are collected, 1180 observations were dropped due to missing values for age or other key variables of interest. Fifty eight respondents are urban-to-rural migrants and 1480 rural dwellers turn into urban residents without migrating (will be discussed in detail when introducing independent variables). Three respondents have missing values in “places mainly lived before age 16”. Within the group of rural-urban migrants, 40 respondents have missing values in “the year first moved to the current city”, and 21 respondents have longer urban life exposure than their ages because of reporting errors. All these observations are not qualified to be included in the sample and are dropped. The final sample size is 11,126 (*N* = 11,126).

Measures

Dependent Variables

There are three dependent variables: hypertension, general obesity, and abdominal obesity. All of them are major metabolic risk factors of many NCDs, including cardiovascular diseases and diabetes (WHO, 2009). The threshold of hypertension is based on the WHO standard: systolic blood pressure equal to or above 140 mm Hg and/or diastolic blood pressure equal to or above 90 mm Hg (WHO, 2013). General obesity is indicated by Body Mass Index (BMI), which is calculated by weight divided by the square of height. The international standard for general obesity is BMI greater than or equal to 30. However, because of Asians' smaller body figures, an adjusted Asian standard is used in this study, which defines general obesity as having a BMI greater than or equal to 27.5. This cut-off was found to have the best sensitivity and specificity for risk-factor identification and has been widely used in research on obesity of Chinese populations (Bei-Fan, 2002; Hsu et al.,2015). Abdominal obesity is measured by waist circumference. Compared with general obesity, it focuses more on the fat distribution on human bodies, and medical research has indicated that it sometimes better predicts risks and mortality of NCDs than general obesity (Recio-Rodriguez et al., 2012). Abdominal obesity is measured by an adjusted Asian standard as well. Males who have waist circumferences great than or equal to 90 cm and females who have waist circumferences greater than or equal to 80 cm are defined as being abdominal obese (International Diabetes Federation, 2006). All health indicators, blood pressure, height, weight, and waist circumference, were on-site measured by professional medical staff, which provides more accuracy than self-reported data.

Independent Variables

There are two key independent variables. The first one is a dummy variable indicating whether a respondent is a rural-urban migrant. It will be included in the first two sets of models, in which the chances of getting three NCD risk factors for rural-urban migrants will be compared with those of rural dwellers and urban residents respectively. The survey contains questions asking where respondents were born, where they mainly lived before 16 years old, where they were living when the survey was conducted in 2011, and the date during which they first moved to their current residential place city. In this study, rural-urban migrants are defined as people who mainly lived in rural areas before age 16 and were living in urban areas in 2011 when the survey was conducted. Similarly, urban/rural residents are those who mainly lived in cities/the countryside before age 16 and were still living in urban/rural areas in 2011. It is worth noting that some respondents also reported mainly living in rural areas before age 16, and were living in cities now, but had the same birth places as their current residential places. These respondents are rural residents who became urban residents through the reclassification of their communities. Because their residential types changed without migrating they are not considered rural-urban migrants. In addition, although they also experience the shift from rural to urban settings, it is difficult to determine when the shift took place. Therefore, they will not be included in the analysis. The second key independent variable is urban life exposure, which is measured by the number of years lived in cities. It will be used in the third set of models where rural-urban migrants with different extents of exposure to urban life are compared. It is calculated by using 2011 minus the year they moved to current cities.

Other covariates include a set of health-related behaviors, a psychological factor (i.e. being depressed), and respondents' sociodemographic characteristics. In terms of health-related behaviors, tobacco use, alcohol consumption, and physical activity are examined, all of which are closely associated with NCD risk factors. The survey has a series of questions asking about the history and the current status of respondents' smoking and drinking behaviors. Both smoking and drinking are measured by dummy variables indicating whether respondents were current smokers and current drinkers. Physical activity is generated from questions asking the frequency of respondents doing activities that require intense or moderate physical efforts in a usual week and respondents who reported a frequency that is greater than or equal to one is considered "Active". Whether a respondent is depressed is included as a psychological factor. The survey includes ten questions from the Center for Epidemiological Study of Depression Scale (CES-D), a widely-used measure for depression. Each question is scaled from 0 to 3, and a total score greater than or equal to ten indicates depression, as suggested by the international standard (Andresen et al., 1994). As for sociodemographics, I control respondents' age, gender, educational attainment, marital status and household income. For age, I divide the sample into two groups, 45–60 years old and 60 years old or above. As 60 is the cutoff for older adults (WHO, 2011), this categorization of age more straightforwardly demonstrates how older adults differ from their middle-age counterparts in developing NCD risk factors. For household income, it is a comprehensive measure that sums up respondents' financial earnings from wage/salary, agricultural activities, self-employment, and public transfers (e.g. pension/subsidy). The log form of household income is used.

Methods

Logistic regression models are employed, as three dependent variables are binary. I will run the first two sets of models to compare three NCD risk factors of rural-urban migrants with those of rural dwellers and urban residents respectively. More specifically, I made two comparisons: one is between rural-urban migrants and rural dwellers, and the other is between migrants and urban residents.

In terms of the mediation analysis, the KHB test is used to examine the magnitude of the mediating effects of health-related behaviors. Unlike nested linear probability models whose coefficients can be directly compared to decompose a total effect into direct effect and mediating effect, the comparison in nested nonlinear probability models (e.g. logistic regression models) is not as straightforward. The uncontrolled and controlled coefficients may differ not only because of mediation but also a rescaling of the model that appears as long as the mediator has an independent effect on the dependent variable (Kohler et al., 2011).

In my analysis, the coefficient of residential status may change only if health behavioral factors have independent effects on NCD risk factors, which is completely possible. For example, smoking shapes people's blood pressure regardless of residential status. The KHB method solves this problem by comparing the full model with a reduced model that substitutes mediators by the residuals from a regression of the mediators on the key independent variable (see Kohler et al., 2011 for mathematical details). It recovers the degree to which a mediator explains the relationship between the key independent variable and the dependent variable in nonlinear probability models (Kohler et al., 2011). In this case, the KHB test reveals how much of the association between residential status and NCD risk factors can be explained by health-behavioral factors in logistic regression models.

I will run the third set of models to predict three NCD risk factors with different lengths of urban life exposure among rural-urban migrants. These models are constructed in the same way as the first two sets of models. I add migrants' Hukou status when controlling for socioeconomic factors in model 2.

Results

Descriptive Statistics

Descriptive statistics of the analytic sample are displayed in Table 2.1. The prevalence of hypertension is 38.1%, and that of obesity and abdominal obesity is 13.6% and 50.7% respectively. In the sample, 40.8% of the respondents are depressed. In terms of health-related behaviors, 29.7% of them currently smoke, 26.9% are current drinkers, and 28.2% are physically active.

There are 2161 rural-urban migrants, accounting for 19.4% of the total sample. On average, they have lived in current cities for 28.9 years, and 41.9% of them have urban Hukou. The numbers of rural and urban residents are 7933 and 1032 respectively. I use Chi-squared/t-test to compare the prevalence rates of three NCD risk factors and health-related behaviors as well as other sociodemographic factors between rural/urban residents and rural-urban migrants. Compared with those among rural residents, the prevalence rates of hypertension, general obesity, and abdominal obesity are all significantly higher among rural-urban migrants. There are no significant differences between urban residents and rural-urban migrants in hypertension and general obesity but significantly more migrants are abdominal obese. As for health-related behaviors, the smoking rate of rural-urban migrants is significantly lower than that of rural and urban residents, with that of rural residents being the highest. The proportion of current drinkers among rural-urban migrants is also significantly lower than that of rural and urban residents. Rural-urban migrants are significantly more physically active than urban residents, but less so when compared with rural residents. To sum up, rural-urban migrants are healthier than urban and rural residents in terms of smoking and drinking, but fall below rural residents in physical activity.

For other covariates, there is no significant differences in age and marital status between rural-urban migrants and rural/urban residents. The proportion of women is significantly higher in migrants than the other two groups. Rural-urban migrants have significantly higher education than rural residents but lose this educational advantage to urban residents with significant difference. Similarly, the household income of migrants is significantly higher than that of rural residents while is significantly lower than that of urban residents. For depression, the proportion of being depressed among migrants is significantly higher than that among urban residents and significantly lower than that in rural residents.

Regression Results

The regression results of hypertension, general obesity, and abdominal obesity are shown in Table 2.2. I only present the results of full models due to the page limit, and complete nested model results can be found in supplementary tables. In model 1, I control respondents' residential status, age and gender. In model 2, I add marital status, education and log household income. In model 3, being depressed is added. In the full model (model 4), I further include the set of variables that measure health-related behaviors.

The comparison between rural-urban migrants and rural dwellers is presented in the top panel of Table 2.2. Compared with rural dwellers, rural-urban migrants are significantly more likely to develop all three NCD risk factors. More specifically, on average, rural-urban migrants have 33.2%, 63.1%, and 68.0% higher odds of having hypertension, general obesity, and abdominal obesity, respectively, holding other variables constant.

In terms of sociodemographic factors and the physiological factor, compared with their middle-age counterparts, on average, individuals aged 60 or above have 2.2 times higher odds of being hypertensive while 28.4% lower odds of being obese, ceteris paribus. Gender does not predict hypertension but being female is associated with 43.6% higher odds of being general obese and 4.8 times higher odds of having abdominal obesity. Marriage has a protective effect against hypertension but is associated with higher odds of being general obese and abdominal obese. Compared with people who are married, unmarried people on average have 45.0% higher odds of having hypertension, but 28.0% and 17.1% lower odds of having general obesity and abdominal obesity. Education is not significantly associated with hypertension but positively predicts two obesity-related risk factors. Compared with those who have primary school or below education, respondents who went to middle school or above on average have 19.0% and 34.5% higher odds of being general obese and abdominal obese, respectively. Household income is a significant negative predictor of hypertension but has no significant association with general obesity and abdominal obesity. For depression, it is not significantly associated with hypertension but depressed respondents on average have 21.4% and 21.5% lower odds of being general obese and abdominal obese respectively, *ceteris paribus*.

As for health-related behaviors, drinking seems to not be a predictor of three NCD risk factors but smoking does play a role. Compared with people who were not smoking, current smokers on average have 42.1% lower odds of being general obese and 38.6% lower odds of being abdominal obese, holding other variables constant. Being physically active has protective effects against three NCD risk factors. Compared with respondents who are physically inactive, on average, those who are active have 11.4% lower odds of having hypertension, 18.2% lower odds of developing general obesity, and 14.0% lower odds of having abdominal obesity, *ceteris paribus*.

The comparison between rural-urban migrants and urban residents is presented in the bottom panel of Table 2.2. The differences between rural-urban migrants and urban residents turn out to be not statistically significant for all three NCD factors. In other words, on average, there are no significant differences between rural-urban migrants and urban residents in the chances of having hypertension, general obese, and abdominal obesity, holding other variables constant.

In terms of other covariates, some of them show similar patterns with what we observed in the top panel, given fluctuations in odds ratios, while others no longer predict NCD risk factors. Age is still positively associated with hypertension. Compared with people aged between 45 and 60, those who are 60 or above on average have 2.3 times higher odds of being hypertensive, holding other variables constant. Age no longer predicts general obesity. Instead, it becomes significantly positively associated with abdominal obesity. Compared with people aged between 45 and 60, those who are 60 or above on average have 27.3% higher odds of being abdominal obese. Gender no longer predicts general obese but being female still significantly increases the odds of being abdominal obese (by 3.5times). Marriage has no significant association with any NCD risk factors, and neither does log household income. However, the negative associations between depression and general obesity as well as abdominal obesity remain. Similarly, smoking is still a negative predictor of these two NCD risk factors. Being physically active is also negatively associated with hypertension and abdominal obesity.

The results of models that predict NCD risk factors within rural-urban migrants who have different urban life exposure are shown in Table 2.3. Overall, years lived in cities are positively associated with hypertension among rural-urban migrants, and the association is statistically significant ($p < 0.01$). More specifically, on average, every one-year increase in the time lived in cities is associated with an 1.0% increase in the odds of having hypertension, *ceteris paribus*. However, the chances of being general obese and abdominal obese are both not significantly associated with years lived in cities. In terms of Hukou, compared with migrants who hold rural Hukou, those who have urban Hukou on average have 32.8% higher odds of being hypertensive and 42.4% higher odds of being abdominal obese, *ceteris paribus*. Therefore, Hukou status indeed impacts the health outcomes of rural-urban migrants. For other covariates, some of the patterns that observed above remain. Older adults are significantly more likely to have hypertension than their middle-aged counterparts while are less likely to be obese. Being female largely increases the odds of being abdominal obese (by 3.8 times). Current smokers and people who are depressed remain to be less likely to have general obesity or abdominal obesity. Being physically active protects migrants against abdominal obesity.

KHB Test Results for Mediation Analysis

The regression results comparing rural-urban migrants and rural dwellers show that health-related behaviors per se are predictors of NCD risk factors, and that the odds ratio of being rural-urban migrants in model 3 decreased after these behavioral factors were added in model 4 (see Supplementary Tables). The KHB test (Table 2.4) reveals how health-related behaviors mediate the association between NCDs risk factors with being rural-urban migrants as compared to rural dwellers. Being rural-urban migrants increases the log odds of being hypertensive, general obese, and abdominal obese by 0.299, 0.525, and 0.550, respectively. Controlling for the set of health-related behaviors, the increases in log odds are reduced to 0.287, 0.489, and 0.519, showing a mediating effect of 0.012, 0.036 and 0.031. The total influence of all covariates is only 4.0%, 6.9%, and 5.6% times higher than leaving out three health-related behaviors. In other words, only 4.0%, 6.9% and 5.6% of the association between three NCD risk factors (hypertension, general obesity, and abdominal obesity) and being rural-urban migrants as compared to rural dwellers is attributed to health-related behaviors, respectively.

Therefore, the health-related behaviors that I controlled for seem to do little to mediate the association between urban life exposure and NCD risk factors, indicating the possibilities of other mechanisms through which urban life exposure shapes rural-urban migrants' health outcomes.

Discussion

As migrants move from rural to urban areas, they gain access to important urban resources that are beneficial to their health. Relatively complete public health systems curb the prevalence of infectious diseases, and better health care facilities offer high-quality treatments. However, there are concerns that urban settings may also negatively impact their health, especially in terms of NCDs. Results of studies in other LMICs support these concerns and argue that health-related behaviors are mainly mediators between urban life and health for rural-urban migrants. However, existing literature lacks focus on older migrants, and the impact of the duration of urban life exposure is poorly understood. Meanwhile, the mediating effects of health-related behaviors have not been quantified. This paper weights in on this debate by examining three major NCD risk factors: hypertension, general obesity, and abdominal obesity. It focuses on Chinese migrants at older ages (45 +), uses a direct measure of urban life exposure, and tests the mediating effects of health behavioral factors.

My analysis shows that compared with rural dwellers, rural-urban migrants are significantly more likely to have all three NCD risk factors. This finding provides support for research in other LMICs, including India (Ebrahim et al., 2010), Guatemala (Ramirez-Zea et al. 2005), Iran (Aghasadeghi et al., 2008), and Kenya (Poulter et al., 1985), documenting a negative impact of urban life on NCD risk factors. Distinguishing from existing research that studies rural-urban migrants as a single group, the direct measure of urban life exposure enables me to further examine how the odds of having NCD risk factors vary among rural-urban migrants who spent different lengths of time in cities. I find that the odds of having hypertension is positively associated with the number of years lived in cities. More specifically, every one-year increase in years lived in cities on average raises the odds of being hypertensive by 1%. This result draws a detailed picture of the dynamic process in which urban life exposure shapes a major NCD risk factor among older rural-urban migrants.

Meanwhile, the results show evidence for the accumulation of risks and the YSM effect, which both imply that the health outcome of migrants varies by the time they stay at destinations. I also tried to control for the age at migration since migrants who move at different life stages may have different health trajectories. However, this variable does not impact analysis results. It is interesting to observe that years lived in cities significantly predict hypertension but not general/abdominal obesity. A plausible explanation is that, compared with general/abdominal obesity that have obvious manifestations on the body, such as gained weight or increased waist circumference, hypertension is normally asymptomatic and has a very long incubation period until it causes the onset of NCDs (Rose, 2005). Therefore, general/abdominal obesity is much easier to be noticed and corresponding actions are more likely to be taken to control them. In contrast, hypertension is less likely to be discovered, especially in LMICs. Without proper prevention and management strategies, elevated blood pressure will keep rising and increase the chances of developing into hypertension over time (Redwine et al., 2012).

Although the risks of developing general/abdominal obesity do not increase by the time spent in cities, rural-urban migrants still face significantly higher odds of being obese than rural non-migrants. This may be explained by the fact that rural individuals who decide to move to cities have stronger desires for urban lifestyles and cultures, part of which are embodied by a pursuit of westernized foods in many LMICs, such as oily fast food, packaged snacks and bottled drinks. Migrants are eager to change their consumption behaviors, abandoning healthy rural traditions (e.g. balanced diets with grains and vegetables) and imitating urban natives, to strengthen a sense of identity and integrate to the host society (Tang et al., 2020). Such a transition to urban lifestyles and cultures leads to a higher chance of being obese. What is more, the results show that having urban Hukou is positively associated with being hypertensive and abdominal obese among rural-urban migrants. It relates to the fact that rural-urban migrants who converted their rural Hukou to urban ones have stronger belongings to cities and are better acculturated to city life (Zhang, 2013), and adopt lifestyles and develop risk profiles for health that are more similar to urban residents.

The results also suggest that there are no significant differences between rural-urban migrants and urban residents for all three NCD risk factors. This finding resonates with research that shows rural-urban migrants gradually lose their health advantages and their health converges with that of urban residents in LMICs. For example, in China, research shows that rural-urban migrants experience deterioration in self-reported physical health with increasing length of residence (Chen, 2011), and that the association between self-reported health and migration diminishes over time (Tong & Piotrowski, 2012). In South Africa, rural-urban migrants lose their mental health advantage relative to urban residents with their longer stay in cities (Ajaero et al., 2017). My results contribute to the literature by providing evidence from the aspect of NCD risk factors.

In addition, I examine the role of health-related behaviors in predicting NCD risk factors, and the magnitude of their mediating effects on the significant differences between rural-urban migrants and rural dwellers. The associations between health-related behaviors and NCD risk factors are generally consistent with what has been shown in prior studies. However, these mediating health-related behaviors explain surprisingly little of the differences in NCD risk factors between rural-urban migrants and rural dwellers. KHB test results show tobacco use, alcohol consumption, and physical activity together explains less than 7% of the total association for three NCD risk factors. This finding indicates that, different from studies in other LMICs that attributed the negative impact of urban settings to health-related behaviors, there are other pathways through which urban settings shape NCD risk factors in the context of China.

This study unavoidably has some limitations. First, the estimation of the impact of urban life exposure on health may have selection bias, as CHARLS does not provide health information of rural-urban migrants before migration. However, it is well-documented in the literature that migrants are positively selected and have better health than rural dwellers who remain (Stark, 1984). This positive selection has also been demonstrated by previous research in China (Lu & Qin, 2014). Therefore, even if selection bias exists in the sample, it would only imply an estimation that is larger in magnitude and strengthen my results. Second, only the time when rural-urban migrants reside in current cities is known and the entire migration history is not available. It may cause two potential issues. On the one hand, migrants might have lived in other cities before. However, it will only result in a conservative estimation of urban life exposure and its association with NCD risk factors, and will not change the direction of the results. On the other hand, there could be former migrants who have returned to rural areas and were identified as rural dwellers. However, the “salmon bias” argues that return migrants normally have worse health than those who stay in cities and it has been shown in studies conducted in China (Lu & Qin, 2014). Therefore, the possible existence of return migrants would only make rural-urban migrants a healthier group that should have displayed better rather than worse health.

Third, the data does not provide information about migrants' purposes of moving, which may also shape health outcomes. Based on the demographics of the migrant sample, they are all older adults with a mean age of 60 and have on average lived in cities for nearly 30 years. Therefore, many of them moved to cities in the 1980s and the 1990s at working ages. The 1980s and the 1990s are periods when Chinese domestic economy just began to develop and many factories were established in cities and labor demands were high. Therefore, migrants in this analysis are very likely to be migrant workers. Yet specific information on the purpose of migration would be more desirable. In addition, the data does not allow me to examine the influence of diet, which is argued as a major factor that is closely associated with urban life exposure and related to NCD risk factors. However, all current available data only have either respondents' migration histories or daily diets. This fact calls for data collection on both migration trajectories and dietary patterns, and the influence of diets on health outcomes of rural-urban migrants should be a direction for future studies. Finally, all regression coefficients in this analysis indicate associations and casual interpretations should be made with caution. For example, the results show relationships between depression and NCD risk factors. These relationships could occur in both ways. More specifically, being depressed may predict NCD risk factors, while NCD risk factors may affect mental health as well.

In conclusion, this study provides new evidence that urban life exposure negatively shapes NCD risk factors in the context of LMICs. As an increasing number of people are moving from rural to urban areas, LMIC governments need to pay more attention to control the prevalence of NCDs with a special focus on rural-urban migrants. Their chances of having NCD risk factors are similar to those of native urban residents but normally have fewer social and financial resources to counter health challenges. Knowledge of symptoms and preventions of NCDs should be more widespread in migrants' communities, and health care systems need to be more affordable and accessible for rural-urban migrants. Further studies need to be conducted in other LMICs to determine whether the results of study persist. Moreover, since health-related behaviors that I examined are not main mediators between urban settings and NCD risk factors, future research should explore and discover alternative pathways.

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Table 2.1 Descriptive statistics (mean or percentage), China Health and Retirement Longitudinal Study (CHARLS), 2011

	All	Migration Status		
		Rural	Urban	Rural-urban
N	11126	7933	1032	2161
Health outcomes				
Hypertension [a]	38.1%	35.9%***	43.1%	43.6%
General obesity [b]	13.6%	11.2%***	18.5%	19.8%
Abdominal obesity [c]	50.7%	45.3%***	60.1%***	66.4%
Urban life exposure				
Years migrated to cities [d]	-	-	-	28.9
Socioeconomic and demographic factors				
Age	59.4	59.4	58.9	59.6
Age 60 or above	45.2%	45.2%	43.6%	45.8%
Female	55.2%	51.2%***	51.2%***	71.9%
Married	87.0%	87.2%	85.8%	87.0%
Educational attainment				
Middle school or above	31.0%	24.1%***	72.1%***	36.6%
Primary school or below	69.0%	75.9%***	27.9%***	63.4%
Household income last year [e]	18177.4	16573.2*	27630.3***	19552.1
Urban Hukou[f]	-	-	-	41.9%
Psychological factor				
Being depressed [g]	40.8%	44.2%***	23.6%***	36.5%
Health-related behaviors				
Current smoker	29.7%	33.2%***	26.8%***	17.9%
Current drinker	26.9%	29.0%***	29.0%***	18.3%
Physically active [h]	28.2%	30.4%***	20.5%**	23.9%

+ p<0.1, * p<0.05, ** p<0.01, *** p<0.001

Notes: [a] The t-test or Chi-squared test (depending on the variable) use rural-urban migrants as the reference group and compare them with rural dwellers and urban residents, respectively.

[b] Hypertension is defined as blood pressure ≥ 140/90 mm Hg and respondents who were on treatment are also considered as hypertensive even if they were measured normal blood pressure.

[c] General obesity is defined by BMI (Body Mass Index $= \frac{\text{Weight}}{(\text{Height})^2}$) ≥ 27.5, and the standard is adjusted for Asian body figures.

[d] Abdominal obesity is defined as waist circumference ≥ 90 for males and waist circumference ≥ 85 for females, and the standard is adjusted for Asian body figures.

[e] Years lived in cities is calculated by 2011 minus the year when the respondent firstly moved to the current city.

[f] Household income is calculated as the sum of all financial earnings from salary, agricultural activities, self-employment, and public transfers. The currency unit is CNY (Yuan), and 1 Yuan equals 0.15 USD.

[g] Hukou is a Chinese national household registration system based on individuals' birth places (urban/rural). Living in cities with rural Hukou will limit individuals' access to educational, health, and social welfare resources. Rural-urban migrants initially hold rural Hukou, which could be converted to urban through education, employment, and marriage with urban Hukou holders.

[h] Depression is measured by 10 questions from Center for Epidemiological Study of Depression Scale (CES-D). Each question is scaled from 0 to 4, and 30 is cutoff for depression.

[i] Physically active is defined by participating in any physical activities that require high or moderate efforts for at least once in a usual week.

Table 2.2 Odds ratios on hypertension, general obesity and abdominal obesity, China Health and Retirement Longitudinal Study (CHARLS), 2011

VARIABLES	Hypertension	General Obesity	Abdominal Obesity
Residential status			
Rural-urban migrants (ref. = rural dwellers)	1.332***	1.631***	1.680***
	(0.071)	(0.114)	(0.098)
Socioeconomic and demographic factors			
Age 60 or above (ref. = age 45-60)	2.170***	0.716***	0.982
	(0.101)	(0.048)	(0.049)
Female	1.075	1.436***	4.780***
	(0.060)	(0.123)	(0.274)
Not married	1.450***	0.720**	0.829**
	(0.094)	(0.039)	(0.057)
Middle school or above (ref. = primary school or below)	1.031	1.190*	1.345***
	(0.055)	(0.087)	(0.077)
Log household income	0.981*	0.992	0.985+
	(0.008)	(0.011)	(0.008)
Psychological factor			
Being depressed	0.971	0.786***	0.785***
	(0.043)	(0.050)	(0.037)
Health-related behaviors			
Current smokers	0.927	0.579***	0.614***
	(0.053)	(0.055)	(0.036)
Current drinkers	0.954	0.928	0.916
	(0.051)	(0.077)	(0.053)
Physically active	0.886*	0.818**	0.860**
	(0.043)	(0.057)	(0.044)
Observations	10094	10094	10094

Table 1.2 Odds ratios on hypertension, general obesity and abdominal obesity, China Health and Retirement Longitudinal Study (CHARLS), 2011 (Continued)

Residential status			
Rural-urban migrants (ref. = urban residents)	0.956	1.023	0.978
	(0.081)	(0.109)	(0.087)
Socioeconomic and demographic factors			
Age 60 or above (ref. = age 45-60)	2.252***	0.866	1.273**
	(0.177)	(0.086)	(0.108)
Female	0.956	1.057	3.497***
	(0.094)	(0.128)	(0.351)
Not married	1.190	0.882	0.805+
	(0.134)	(0.129)	(0.099)
Middle school or above (ref. = primary school or below)	0.796**	0.877	0.943
	(0.066)	(0.093)	(0.083)
Log household income	1.006	0.995	0.980+
	(0.011)	(0.014)	(0.011)
Psychological factor			
Being depressed	0.875	0.758**	0.818*
	(0.072)	(0.078)	(0.071)
Health-related behaviors			
Current smokers	0.953	0.583***	0.619***
	(0.101)	(0.082)	(0.066)
Current drinkers	1.003	1.054	1.119
	(0.099)	(0.131)	(0.121)
Physically active	0.831*	0.959	0.793*
	(0.076)	(0.105)	(0.077)
Observations	3193	3193	3193

Standard errors clustered by household in parentheses
+ p<0.1, * p<0.05, ** p<0.01, *** p<0.001

Table 2.3 Odds ratios on hypertension, general obesity and abdominal obesity of rural-urban migrants, China Health and Retirement Longitudinal Study (CHARLS), 2011

VARIABLES	Hypertension	General Obesity	Abdominal Obesity
Urban life exposure			
Years lived in cities	1.009**	1.002	1.000
	(0.003)	(0.004)	(0.003)
Socioeconomic and demographic factors			
Age 60 or above (ref. = age 45-60)	1.899***	0.750*	1.035
	(0.197)	(0.100)	(0.121)
Female	1.051	1.108	3.754***
	(0.132)	(0.175)	(0.484)
Not married	1.218	0.893	0.887
	(0.170)	(0.161)	(0.138)
Middle school or above (ref. = primary school or below)	0.867	0.936	0.915
	(0.091)	(0.125)	(0.104)
Log household income	1.005	0.997	0.964
	(0.014)	(0.017)	(0.014)
Urban Hukou	1.328**	1.164	1.424**
	(0.133)	(0.143)	(0.159)
Psychological factor			
Being depressed	0.903	0.781*	0.797*
	(0.086)	(0.093)	(0.082)
Health-related behaviors			
Current smokers	1.039	0.581**	0.543***
	(0.136)	(0.102)	(0.073)
Current drinkers	0.918	1.155	1.069
	(0.117)	(0.181)	(0.147)
Physically active	0.828^{+}	0.961	0.720**
	(0.091)	(0.124)	(0.085)
Observations	2161	2161	2161

Standard errors clustered by household in parentheses
+ p<0.1, * p<0.05, ** p<0.01, *** p<0.001

Table 2.4 KHB test results [a], China Health and Retirement Longitudinal Study (CHARLS), 2011

	Model 3	Model 4[c]	Difference	Mediation Effect [d]
Hypertension	0.299***[b] (0.052)	0.287*** (0.052)	0.012*** (0.004)	4.0%
General obesity	0.525*** (0.068)	0.489*** (0.068)	0.036*** (0.008)	6.9%
Abdominal obesity	0.550*** (0.056)	0.519*** (0.056)	0.031*** (0.007)	5.6%

+ p<0.1, * p<0.05, ** p<0.01, *** p<0.001

Notes: [a] Since the difference in three NCD risk factors are statistically significant between rural-urban migrants and rural dwellers, and not so between migrants and urban residents, the test is only conducted for the models that compare migrants with rural dwellers.

[b] Log odds of being rural-urban migrants are reported with standard deviation in parentheses.

[c] Compared with model 3, model 4 additionally controls health-related behaviors, including tobacco use, alcohol consumption, and physical activity.

[d] The mediation effect reports how much of the total association between being rural-urban migrants and each NCD risk factor is explained by the set of health-related behaviors added in model 4.

CHAPTER 3

RURAL-URBAN MIGRATION AND OVERWEIGHT STATUS IN LOW- AND MIDDLE-INCOME COUNTRIES: EVIDENCE FROM LONGITUDINAL DATA IN INDONESIA

Abstract: With rapid urbanization and extensive rural-urban migration, being overweight has become an increasingly common source of health risk in low- and middle-income countries (LMICs). Using data from the fourth and fifth waves of the Indonesia Family Life Survey (IFLS) and employing fixed-effects (FE) models (N = 7,267), this study provides new evidence on the impact of rural-urban migration on overweight status across time and gender. Findings suggest that rural-urban migration is significantly associated with increased chances of being overweight, and the association is significantly stronger among women than men. The results also show that the number of years lived in urban areas does not predict being overweight among migrants, and that mediating health-related behaviors do little to explain adverse weight outcomes of migrants. Intervention programs aiming for healthy weight status should be implemented among rural-urban migrant communities in LMICs, with special attention to women.

Introduction

The rising prevalence of overweight is a global health crisis, affecting 2.2 billion people worldwide (World Bank, 2020). However, research on the causes and consequences of being overweight has focused overwhelmingly on high-income countries, with relatively less attention to the rest of the world. This is problematic because over 70% of the 2.2 billion overweight population reside in low- and middle-income countries (LMICs), and overweight has become a leading risk factor for morbidity and mortality in these countries (World Bank, 2020). Specifically, it is one of the most prominent risk factors for various non-communicable diseases (NCDs), such as cardiovascular diseases and cancer, and causes 2.8 million deaths annually, most of which take place in LMICs (World Health Organization, 2020). Increasing rates of overweight and related NCDs also severely constrain the socioeconomic development of LMICs by reducing productivity and life expectancy while increasing disability and health care costs (World Bank, 2020). The financial costs of overweight and obesity are projected to exceed $7 trillion among LMICs in the next 15 years (World Bank, 2020). Therefore, it is of paramount significance to understand the patterns and driving forces of overweight in LMICs, to improve the health and wellbeing of their populations and facilitate their social and economic development.

The rising health burden of overweight in LMICs is closely associated with the rapid urbanization process and the increase in urban populations. LMICs are projected to have the highest urbanization rates in the next few decades and the proportion of the urban population is projected to reach 59% by 2050 (United Nations, 2018). Extensive rural-urban migration is one of the key driving forces of the fast urban population increase in LMCs (Brueckner & Lall, 2015; United Nations, 2018). It is estimated that the large-scale rural-urban migration, together with the natural increase of urban population, will add 2.5 billion people to cities by the middle of the century, 90% of whom will reside in LMICs (United Nations, 2018). The arrival of migrants from rural areas in cities not only gives them access to health-benefitting resources, such as clean water sources and quality health care services, but also exposes them to urban environments in which being overweight is more prevalent. With the continually increasing number of migrants arriving in cities from rural areas, it is critical to understand the impact of rural-urban migration on overweight in LMICs.

Still, existing research on overweight in LMICs focused more on socioeconomic status (SES) and demographic factors, finding a positive association among people in low-income countries as well as women in middle-income countries, with mixed results for men in middle-income countries (Dinsa et al., 2012). Compared with SES, relatively less attention was given to the impact of urban settings on overweight. Overall, existing research consistently documented that urban residence was associated with higher chances of being overweight in LMICs (Dinsa et al., 2012; Neuman et al., 2013; Mayen et al., 2014). Most of these studies draw comparisons between people with urban and rural residences, ignoring the potentially unique experience of rural-urban migrants by mixing them with urban residents. Rural-urban migrants share similar living habits with rural dwellers before migration and are exposed to the same urban settings as urban residents after migration. Therefore, they may differ from rural/urban non-migrants in overweight status and should be considered as a separate group in the analysis.

Researchers have recently started to pay more attention to rural-urban migrants and showed inconclusive patterns of the association between rural-urban migration and overweight in different LMICs. In India, some researchers reported an obesity gradient, with urban residents having the highest prevalence, rural dwellers the lowest, and rural-urban migrants in between (Ebrahim et al., 2010), while others found that the significantly higher odds of being overweight/obese among rural-urban migrants than rural dwellers was only observed among women (Varadharajan et al., 2013). In China, rural-urban migrants had a similar risk of being overweight to urban residents, which was significantly higher than that of rural dwellers (Li, 2022). A similar pattern was also observed in Peru (Creber et al., 2010). Another study in China compared rural-urban migrants with rural dwellers of the same minority ethnic group within a province, and showed that migrants were more than twice as likely to be overweight and obese than rural dwellers (Wang et al., 2021). The associations between rural-urban migration and overweight status were also mixed in the least developed countries in sub-Saharan Africa (SSA). For instance, rural-urban migration significantly predicted overweight and obesity in Malawi (Chilunga et al., 2019), whereas had no significant impact on overweight in Tanzania (Cockx et al., 2017) and Kenya (Peters et al., 2019).

Although previous studies have documented important links between rural-urban migration and being overweight, gaps in the literature remain. First and foremost, existing research largely relied on cross-sectional data and failed to adjust for the selection bias of migration. More specifically, moving from the countryside to cities is not a behavior that is randomly adopted. It is closely related to people's health status, as individuals who migrate normally have better health than those who remain. The migration health selection has been documented in many LMICs, such as China (Lu & Qin, 2014), Indonesia (Lu, 2008), Thailand (Nauman et al., 2015), and Malawi (Anglewicz et al., 2018). Cross-sectional data do not provide information on the health of rural-urban migrants before migration, and thus researchers cannot distinguish whether the observed differences between migrants and rural/urban non-migrants are indeed contributed by rural-urban migration or due to migrant selectivity. Likewise, with cross-sectional data, unobserved factors associated with both migration and health could confound the relationship between the two and may cause spurious associations. Therefore, it is preferable to use longitudinal data to more accurately examine the impact of migration on health.

Second, many previous studies compared rural-urban migrants with populations at destinations, i.e., urban residents. This comparison might conflate and overstate the negative impact of rural-urban migration while neglecting its potential benefits on health because of the socioeconomic and health disparities between sending and receiving areas (Benatar, 1998; Lu, 2010). A more appropriate approach is to compare individuals' health with and without migration, which can be approximated by comparing the health of rural-urban migrants with similar non-migrants in rural areas (Lu, 2010), especially when longitudinal data can be leveraged to account for selection into migration.

Third, while there are important gender differences in the prevalence of being overweight (e.g., Ebrahim et al., 2010; Varadharajan et al., 2013; Chilunga et al., 2019), it is unclear whether the impact of rural-urban migration on overweight also differs by gender. The gender pattern is important because women are more vulnerable to chronic conditions related to being overweight but are less likely to be diagnosed and treated than men in LMICs (Bonita & Beaglehole, 2014). As women constitute an increasing sharing of rural-urban migrants in many LMICs, it is worth investigating if their health is impacted differently by migration from men.

Fourth, research on how migrants' duration of urban residence impacts overweight is scarce in LMICs. Many researchers did not include this variable in analyses due to data limitations, and a few studies that examined the length of migrants' urban life exposure showed inconsistent results (Chilunga et al., 2019; Peters et al., 2019; Li, 2022; Wang et al., 2021). The reliance on cross-sectional data in these studies is another important limitation.

Finally, pathways through which urban settings shape overweight status are puzzling. The mediating effects of health-related behaviors, especially changes in diets and physical activity, have rarely been analyzed with longitudinal data. Some research showed that moving to urban areas was followed by more sedentary lifestyles with higher rates of smoking and alcohol consumption (e.g. Ebrahim et al., 2010; Chilunga et al., 2019). However, data on the subject is not commonly available, and even when it is, the extent to which these health-related behaviors mediate the link between migration and weight is rarely examined. Nevertheless, understanding the mechanisms through which urban settings shape weight would contribute to more effective policymaking to curb the rising trend of overweight in LMICs.

Driven by these gaps, this study aimed to provide new evidence on rural-urban migration and overweight status by drawing longitudinal data from the fourth and fifth waves of the Indonesia Family Life Survey (IFLS) and using fixed-effects (FE) models to adjust for migrant selectivity and unobserved time-invariant confounders at both individual and wave levels. Indonesia faces a high prevalence of overweight and has huge flows of rural-urban migrants, among whom women account for a considerable proportion, offering an appropriate context to explore how rural-urban migration shapes overweight by gender in addition to both sexes combined. I also used the number of years lived in urban areas to predict overweight among migrants and examined the mediating effects of health-related behaviors. The findings will help LMIC governments better understand how the association between rural-urban migration and overweight varies across time and gender as well as its mediators, and implement more targeted and efficacious intervention programs to limit rising overweight.

Context of Study

Indonesia is the fourth most populous country in the world and has had one of the highest urbanization rates in the world during the past few decades (United Nations, 2018); its urban population almost quadrupled from 32.8 million to 118.3 million between 1980 and 2010 (Mardiansjah et al., 2021). Fueled by extensive rural-urban migration, the Indonesian Central Bureau of Statistics estimated that the number of people residing in urban areas would increase by 3 million annually, and the urban population would reach 203 million by 2035, accounting for two-thirds of the Indonesian population (Mardiansjah et al., 2021). Meanwhile, the number of overweight adults has doubled during the past two decades, with prevalence rates increasing rapidly across all sociodemographic groups (World Health Organization, 2021). However, a thorough review revealed relatively little research on overweight and obesity in Indonesia (Rachmi et al., 2017). The dramatic increase in the urban population, the rising health burden of overweight, and the insufficient research on this issue all together make Indonesia a particularly appropriate context to study the impact of rural-urban migration on overweight in LMICs.

Another aspect that makes Indonesia an opportune setting for this analysis is the feminization of internal migration. Similar to many LMICs, the absolute number of men outweighs that of women among Indonesian internal migrants. However, the proportions of migrant women are higher in the age groups of 15-24 and 60 and above, and among married migrants (Sukamdi, 2015). The ample representation of migrant women in various sociodemographic categories in Indonesia provides an interesting context to explore the potential gendered impacts of urban residence on overweight status.

Data and Measures

Data

Data for this study were drawn from the fourth and fifth waves of the Indonesian Family Life Survey (IFLS). The IFLS is an ongoing longitudinal socioeconomic and health survey in Indonesia. It is based on a sample of households representing approximately 93% of the Indonesian population in 13 of the 27 provinces in 1993 when the first wave of data collection was conducted (Strauss et al., 2016). IFLS4 was fielded in late 2007 and early 2008 with the same households and their split-offs from the first wave, and IFLS5 was conducted in late 2014 and early 2015 with the same set of households and their split-offs interviewed in IFLS4 (Strauss et al., 2016). Both IFLS4 and IFLS5 provide detailed information on migration histories, health conditions, and sociodemographic characteristics at the individual level as well as economic status and consumption behaviors at the household level.

Analytical Sample

There were 8,212 respondents (from 4,982 households) consisting of rural-urban migrants and rural dwellers presented in both waves of data (merged using unique respondent and household numbers). Rural dwellers were defined as respondents who lived in rural areas in the previous wave, remained in rural areas in the last wave, and reported no movements between waves. Rural-urban migrants were people who lived in rural areas in the fourth wave and moved to urban areas before the fifth wave. The categorization of rural and urban areas was based on the assignment by the Indonesian Bureau of Statistics (BPS) for each wave. Among these, 346 individuals were not measured for height and/or weight, and 599 individuals had missing values in other covariates. These observations are dropped[1]. The size of the final analytical sample was 7,267 (from 4,500 households) (N=7,267).

Model Specification

The dependent variable was overweight status, which was defined as having a Body Mass Index (BMI, $\frac{weight(kg)}{height(m)^2}$) of 23 or higher. This cutoff was adopted by the World Health Organization for Asian body figures and had been shown to have the best sensitivity and specificity for risk-factor identification (World Health Organization Expert Consultation, 2004). It had been widely used in research on the overweight status of Asian populations (e.g., Zhou, 2002; Jih et al., 2014; Hsu et al., 2015). The IFLS measured respondents' height and weight in both the fourth and fifth waves. This variable was binary, with 1 for being overweight.

[1] Additional analyses show no significant differences between dropped cases and the analytical sample.

There were two main independent variables of interest. The first one was respondents' residential status, which was used in the set of models comparing rural-urban migrants with rural dwellers. A dummy variable was generated to indicate respondents' residential status. It was 0 for rural dwellers in both waves. For rural-urban migrants, it was 0 in the fourth wave and 1 in the fifth wave. The second main independent variable was the number of years lived in urban areas, which was used in the models restricted to rural-urban migrants. It was calculated by adding up all the time that rural-urban migrants spent in urban areas. The IFLS recorded detailed information about respondents' migration history, documenting the types of destination and the length of stay for each movement between the fourth and the fifth wave. The types of destinations included "Big cities", "Small towns", and "Villages". Considering the overall low socioeconomic development level in Indonesia, small towns were also coded as urban areas, as people who reside in small towns would have very different lifestyles and much more exposure to urban settings than those who lived in rural villages. A robustness check showed that excluding "Small towns" from urban areas when calculating the duration of urban residence did not impact analysis results. For respondents who moved back and forth between rural and urban areas, only the time lived in urban areas was counted. For the fifth wave, the maximum value was 8 for migrants who moved to cities right after the previous wave in 2007 and stayed in the same urban areas in the last wave in 2015. The minimum value was 0 for respondents who just moved to urban areas in the same year in which the fifth wave of the survey was conducted. For the fourth wave, the variable was coded as 0 for all migrants because the focus of this paper was migration between the fourth and fifth waves.

This analysis also included a number of sociodemographic and health controls, including age, gender, marital status, education, household per capita income, self-rated physical health, and depression. Education was coded as a dummy variable because of the generally low education level in the sample, with 0 for “Primary school or below” and 1 for “Secondary school or above”. Household income consisted of both salary/wage at the individual level as well as farm business profit, non-farm business profit, and non-labor income at the household level. The household income in the fourth wave was adjusted for inflation by using the World Bank’s Consumer Price Index (CPI) ratio for Indonesia in 2007 and 2014. The household income per capita was obtained by using household income divided by the number of household members. Self-reported physical health was a binary variable where 1 indicated “Healthy or somewhat healthy” and 0 indicated “Unhealthy or somewhat unhealthy”. Whether a respondent was depressed was included as a psychological factor. Both waves of the IFLS include 10 questions from the Center for Epidemiological Study of Depression Scale (CES-D), a widely-used screening tool for depression. Each question was scaled from 0 to 3, and a total score greater than or equal to 10 indicated depressive feelings (Andresen et al., 1994).

In addition, this study also included health behavioral factors: tobacco use, physical activity in the past week, and household per capita consumption of sugar and oil. They were associated with both urban lifestyles and weight changes. The IFLS asked about respondents’ current and history of smoking. A categorical variable was generated indicating whether a respondent was a current smoker, ever smoker, or never smoker. Physical activity was measured by whether respondents walked with moderate effort for more than 10 minutes during the past week. In terms of dietary patterns, the IFLS collected information on the amount of cooking oil (in liters) and sugar (in kgs) that a household last purchased in the past month. Monthly consumption provided a smoother estimate of diet than weekly expenditure data. Based on household size, I calculated per capita expenditures on oil and sugar, which were modeled as continuous.

Methods

I ran two sets of FE models with individual and wave FE to adjust for potential selection into migration and omitted variable bias (Allison, 2005). Adding individual FE essentially compared each individual at the fifth wave with him/herself at the fourth wave, and thus ruled out the impact of time-invariant factors, both observed and unobserved, at the individual level. Similarly, including wave FE in the models accounted for the fixed factors at the aggregate societal level between the two waves of the survey that were not captured in the data but might also affect people's migration decisions and overweight status.

The two most common FE models for estimating binary outcomes are conditional logit and linear probability models. The selection between the two models has been the subject of considerable debate in recent years, with advantages and disadvantages associated with each (e.g., Beck, 2020; Timoneda, 2021). The conditional logit model took into account the binary structure of the dependent variable but only keeps observations that had variation in the dependent variable across waves, dropping those that do not. In this study, only about 20% of the sample changed their overweight status across waves. Dropping those cases would not only dramatically reduce the analytic sample (and potentially introduce selection bias), but would also undermine the validity of point estimates because individuals with no changes in overweight status provide variations that could help identify parameters. Research showed that linear probability specification with fixed effects produced more accurate estimates and predicted probabilities than the logistic specification when less than 25% of the sample had variations in outcomes (Timoneda, 2021). Conditional logit models had additional disadvantages relating to the interpretation, especially when generating predicted probabilities at the lower end of the distribution of independent variables (Achen, 1982; Timoneda, 2021).

For these reasons, I estimated a linear probability model, which was superior in that it used information from all observations in the sample and provides coefficients that were easier to interpret. One potential disadvantage of linear probability models was that they may produce predicted probabilities that were out of the range of 0 and 1. However, the study aimed to assess the effect of rural-urban migration on overweight rather than predicting each individual's probability of being overweight. As such, the out-of-range predicted probabilities could be simply understood as close to 0 or 1. I also calculated predicted probabilities for observations in all models presented below and none had out-of-range predictions. Another disadvantage was that linear probability models violated the assumption of heteroscedasticity. To address this issue, I estimated robust standard errors clustered by households.

As a robustness check, I estimated logistic and linear specifications with the same dependent variable and independent variables, and found that they produce very similar average marginal effects (AME) (results are presented in Appendix A). Therefore, treating the binary outcome as linear would not affect the accuracy and efficiency of point estimates in this analysis. Moreover, since examining the mediating effects of health-behavioral factors was one of the research goals, linear probability models provided a much simpler and more straightforward way of comparing nested models by allowing us to compare coefficients directly.

The first set of models pooled rural-urban migrants and rural dwellers together and examined the impact of rural-urban migration on overweight status. I also added an interaction term between residential status and gender to study the potential gendered impact of rural-urban migration on overweight status. The second set was limited to rural-urban migrants with years lived in cities being the main independent variable. The two sets of models are elaborated in the equations below.

$$Overweight_{it} = \beta_1 Residential\_status_{it} + \sum_{k=2}^{10} \beta_k \left(Control_{kit}\right) + \alpha_i + \gamma_t + u_{it} \quad (1.1)$$

$$Overweight_{it} = \beta_2 Residential\_status_{it} + \beta_3 Residential\_status_{it} * Gender + \sum_{k=2}^{10} \beta_k \left(Control_{kit}\right) + \alpha_i + \gamma_t + u_{it} \quad (1.2)$$

$$Overweight_{it} = \beta_4\, Years\_in\_cities_{it} + \sum_{k=2}^{10} \beta_k \left(Control_{kit}\right) + \alpha_i + \gamma_t + u_{it} \quad (2)$$

In the first set of models, the independent variable of interest was the residential status for respondent *i* at time *t*, which was coded as 0 for all respondents in the previous wave and 1 for rural-urban migrants in the latest wave, and 0 was the reference group. In the second set of models, the key independent variable was the number of years lived in urban areas, which was 0 for all migrants in the previous wave. In both sets of models, the control variables included marital status, educational attainment, household income per capita, self-rated health, depression status, physical activity, tobacco use, and the household per capita consumption of cooking oil and sugar. The term α_i represented time-invariant factors at the individual level. The term γ_t represented wave fixed effects, which controlled for unobserved fixed factors at the aggregate societal level between the two waves of surveys. Robust standard errors clustered by household were used to account for potential correlations among individuals within each household.

Results

Descriptive Statistics

Sample descriptive statistics are shown in Table 3.1 by migration status and survey year. There were 681 rural-urban migrants, accounting for 9.4% of the sample. They spent on average 3.6 years in urban areas between the two survey waves. The number of rural dwellers was 6,586.

While internal migration in Indonesia had feminized in recent years, women's share of migrants was still significantly lower than that of rural dwellers. There was a strong selection into rural-urban migration. In 2007, compared with their rural counterparts who remained in the countryside, rural-urban migrants were significantly younger, more educated, and less likely to have been married. The proportion of current smokers and the household per capita consumption of sugar were both significantly lower among rural-urban migrants than in rural dwellers. Migrants also had marginally significantly ($p<0.1$) higher household per capita income than that of rural dwellers. Meanwhile, even though there were no significant differences in self-rated health between the two groups, the share of being overweight was significantly lower among rural-urban migrants than among rural dwellers. These results suggest that rural-urban migrants were positively selected by various sociodemographic and health behavioral factors. However, significantly more migrants were depressed, showing poorer mental health conditions.

In terms of the sample descriptive statistics in 2014, there was a considerable increase in the prevalence of overweight for both groups. The increase among rural-urban migrants was especially notable, as the proportion of overweight people in the fifth wave was about 1.8 times that in the previous wave. Besides the rates of overweight, the proportions with depressive symptoms also increased dramatically for both groups. Rural-urban migrants, the group that showed worse mental health in the previous wave, still had a higher proportion of depressed individuals, which was more than 3.5 times higher than the number in 2007.

Compared with rural residents, migrants' advantage in education persisted. Also, although the proportion of never-married among migrants was much lower than that in the previous wave, it was still significantly higher than that among rural dwellers. Moreover, the income gap between migrants and rural dwellers drastically widened with the former's household per capita income being almost two times that of the latter. Interestingly, despite the loss in health advantage of not being overweight over rural dwellers, significantly more rural-urban migrants rated themselves as healthy or somewhat healthy than rural dwellers. In addition, the proportion of rural-urban migrants who were physically active was significantly lower than that of rural dwellers, indicating the adoption of a more sedentary lifestyle over time. For diets, the significant difference between the two groups in the consumption of sugar disappeared, suggesting an increase in sugar consumption among migrants, and they also consumed significantly more cooking oil than rural dwellers.

Regression Results

The FE regression results comparing rural-urban migrants with rural dwellers are presented in Table 3.2. The numbers of observations were two times those in the descriptive statistics, as each respondent was compared with themselves in the previous wave and counted as two observations. Nested FE models were constructed. Model 1 included only the key independent variable and socioeconomic factors. Model 2 added controls for physical and mental health conditions. Model 3 further included health-related behaviors. In the full model (Model 4), an interaction term between residential status and gender was added.

When only controlling for sociodemographic factors, rural-urban migration was on average associated with a 7.3 percentage point increase in the chance of being overweight ($p<0.01$), holding other variables constant. Marriage was also associated with being overweight. Compared with people who were never married, individuals with marriage histories were on average 4.8 percentage points more likely to be overweight, *ceteris paribus*. Household per capita income was associated with being overweight as well: every one-dollar increase in per capita income was associated with a 1.2 percentage point increase in the probability of being overweight. Education, in contrast, did not predict overweight.

After adding physical and mental health to the model, all of the aforementioned patterns persisted, though they were slightly attenuated. Depression did not predict overweight but self-rated health did. Compared with those who rate their health as unhealthy or somewhat unhealthy, people who considered themselves to be healthy or somewhat healthy were on average 5.1 percentage points more likely to be overweight, *ceteris paribus*. In model 3, when health-related behaviors were included, all coefficients observed in model 2 remained the same, and none of the health behavioral factors were significant predictors of being overweight, suggesting that health-related behaviors examined explained little of the association between rural-urban migration and overweight status.

Results for Model 4 with the interaction term between residential status and gender are displayed in the final column, with non-migrant women being the reference group. Among women, rural-urban migration was on average significantly associated with an 11.7 percentage point increase in the chance of being overweight, holding other variables constant. The interaction term was also significant. More specifically, the impact of rural-urban migration on migrant men was on average 8.8 percent points lower than that of migrant women, *ceteris paribus*. It demonstrates that women's overweight status is more vulnerable to the negative influence of rural-urban migration.

The FE regression results comparing rural-urban migrants who spent different lengths of time in urban areas are presented in Table 3.3, with a similar structure as the previous table. Overall, years lived in urban areas did not significantly predict being overweight. The impact of marital status remained significant.

Discussion

Being overweight has been an emerging health burden that relates to millions of deaths in LMICs. It is closely associated with the rapid urbanization in these countries and will be exacerbated by the continuously increasing number of people who migrate to urban areas from the countryside. However, the impact of rural-urban migration on overweight status is understudied in the LMIC context. This study provided new evidence on the association between rural-urban migration and overweight status, and further contributed to the literature by exploring the underlying gender pattern of this association and examining the mediating effects of health-related behaviors, especially diets, which were often missed in the previous literature due to data limitations.

The descriptive results showed that, in Indonesia, rural-urban migrants represented a highly selected group who are younger, better educated, less likely to have marriage histories, and had higher per capita household income than rural dwellers. These patterns of socioeconomic and demographic factors among migrants as compared to rural dwellers are consistent with theories on migration selection (Stark, 1984; Lucas, 1997). Meanwhile, rural-urban migrants were positively selected on health outcomes and health-related behaviors, with a significantly lower prevalence of being overweight and smoking as well as low consumption of sugar than rural dwellers. The positive migration health selection, which was associated with overweight status after migration, would not have been observed in cross-sectional data.

Although rural-urban migrants achieved economic successes, as evidenced by substantially higher household incomes than their rural counterparts, they sacrificed their physical and mental health as well as adopted unhealthy urban lifestyles. They had a much greater increase in the prevalence of overweight over time compared with that of rural dwellers, which was about 1.8 times that before migration. Meanwhile, the proportion of individuals with depressive symptoms among migrants was more than triple that before moving to cities, which was also significantly higher than that among rural dwellers. In addition, rural-urban migrants became less physically active, and more of them became current smokers. They also consumed significantly more sugar and oil.

The results from FE models showed that rural-urban migration was associated with increased chances of being overweight relative to remaining in rural areas. This pattern resonates with previous research in LMICs (e.g. Ebrahim et al., 2010), and is even more striking given the positive selection into migration with respect to both self-rated health and health-related behaviors. Results also demonstrated intriguing departures from those on unhealthy weight in high-income countries. In general, compared with those who considered themselves as unhealthy or somewhat unhealthy, people who rated their health as healthy or somewhat healthy were more likely to be overweight. This finding relates to the traditional thoughts in many LMICs that heavier weight is a symbol of social status and wealth and is pursued by people in these countries (Kim et al., 2010).

In addition, my results revealed an interesting gender pattern in the link between rural-urban migration and overweight status. Overall, women's overweight status was more severely influenced by urban settings than men's, with the magnitude of the impact more than three times higher among migrant women than migrant men. This finding adds to the existing literature that documents a higher prevalence of overweight in women by showing women are also much more vulnerable to the negative impact of rural-urban migration on overweight status than men. The gender disparity may be closely related to reasons for migration. In LMICs, most migrants move for better employment opportunities. Among these migrant workers, there is a clear gender division of labor, with men being employed in labor-intensive industries, and women working mainly in the textile and manufacturing industries that are much more sedentary and require less physical activity (Zhang, 2014), which may result in being overweight. Nevertheless, the potential reason associated with the gender disparity and weight is not directly testable in this dissertation due to data limitations, and future research should continue exploring the driving forces of the gender pattern.

My analysis also showed that the chances of being overweight among rural-urban migrants did not vary by the duration of urban residence between the two waves of the survey. This finding is consistent with studies in some other LMICs, such as China (Li, 2022) and India (Chilunga et al., 2019). One plausible explanation is that compared with other NCD risk factors (e.g. hypertension) that are asymptomatic until the first attack of disease, overweight has obvious manifestations on the body, such as gained weight or increased waist circumference, and thus is more easily to be noticed and corresponding actions are more likely to be taken to control it. However, it is also likely that the insignificant result is caused by the short time interval between two waves of the survey, eight years, which may not be long enough for the accumulative effect of urban residence on overweight to emerge.

As for the mediating effects of health-related behaviors, although descriptive statistics show that rural-urban migrants did adopt less healthy urban lifestyles after moving to cities, neither these health-related behaviors *per se* significantly predict being overweight nor helped explain the association between urban residence and being overweight. The coefficients of models that control for health behavioral factors are very similar to those that do not. Therefore, the health-related behaviors examined in this study seem to not be the main drivers of the impact of urban residence on overweight, implying that there are other pathways through which urban settings shape weight. Similar findings are documented in a previous study in China (Li, 2022).

This study has some limitations. First, the classification of respondents' residential status was based on the latest two waves of surveys, and it is possible that individuals who were categorized as rural dwellers lived in urban areas before. However, the misclassification would only result in an underestimate of the impact of rural-urban migration on overweight status. Second, the time interval between two waves of surveys is eight years, which might be too short for the cumulative impact of urban residence on being overweight to emerge. However, some variables of interest in this analysis were not included in previous waves, and the residential status of respondents who moved back and forth between rural and urban areas across waves would be hard to define with more waves of data. Therefore, it is impractical for this analysis to use a longer time period. Future research should consider using longitudinal data with a longer follow-up interval to further examine any potential cumulative effect. Third, the health-related behaviors included in this analysis were not complete. The IFLS did not provide information on alcohol use, and its variables on dietary patterns and nutrient intake were also not comprehensive. Overall, longitudinal data that contain both migration history and complete health behavioral factors are rare. This calls for comprehensive data collections on respondents' health-related behaviors so that future studies can conduct more thorough mediation analyses. Finally, although fixed-effects models were used to adjust for migration selection bias and omitted variable bias at individual and wave levels, there were some other biases that cannot be completely ruled out, such as unobserved heterogeneity due to unmeasured characteristics that vary over time. Therefore, casual interpretations of the findings should be made with caution.

In conclusion, this study provided new evidence from longitudinal data that rural-urban migration negatively shapes overweight status in a LMIC context, and that women are more severely impacted than men. More longitudinal studies need to be conducted in other LMICs to see if the chance of being overweight by residential status as well as its gender pattern persist. As the rapid urbanization and extensive rural-urban migration in LMICs continue, governments in these countries should promote a scientific understanding of overweight and spread the knowledge of maintaining healthy weight status in urban communities among rural-urban migrants. Meanwhile, gender-specific intervention programs and policies targeting women should be considered. Women account for a considerable proportion of the migrant population in many LMICs and are more vulnerable to the negative influence of urban settings. In addition, since health-related behaviors examined in this analysis do not mediate between rural-urban migration and overweight, future research should continue to explore other health behavioral factors with more comprehensive data and also discover potential alternative pathways.

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Table 3.1 Descriptive statistics (mean or percentage), Indonesia Family Life Survey (IFLS), 2007 & 2014

	2007			2014		
	All	Rural-urban	Rural	All	Rural-urban	Rural
N	7267	681	6586	7267	681	6586
Health outcome						
Overweight	33.6%	26.9%	34.3%***	47.1%	48.6%	47.0%
Urban life exposure						
Years lived in cities	-	0	-	-	3.6	-
Socioeconomic and demographic factors						
Age	37.0	25.3	38.2***	43.9	32.4	45.1***
Female	55.1%	50.5%	55.6%**	55.1%	50.5%	55.6%**
Education						
Primary school or below	57.2%	23.2%	60.7%***	56.6%	22.3%	60.0%***
Secondary school or above	42.8%	76.8%	39.3%***	43.4%	77.7%	40.0%***
Marital status						
Never married	21.0%	55.5%	17.4%***	6.2%	21.7%	4.6%***
Ever married	79.0%	45.5%	82.6%***	93.8%	78.3%	95.4%***
HH income per capita ($)	629.3	688.8	622.8^{+}	831.5	1483.6	764.1***
Physical and mental health status						
Self-rated health						
Healthy or somewhat healthy	87.9%	88.8%	87.9%	75.8%	79.9%	75.4%*
Unhealthy or somewhat unhealthy	12.1%	11.2%	12.1%	24.2%	20.1%	24.6%*
Depressed	4.1%	7.3%	3.8%***	21.1%	25.8%	20.6%**
Health-related behaviors						
Walking with moderate efforts in the past week	89.6%	88.4%	90.8%	72.4%	62.6%	73.5%***
Current smoker	33.9%	29.2%	34.4%**	34.4%	34.1%	34.4%
Ever smoker	1.7%	1.2%	1.8%	6.6%	5.3%	6.8%
Never smoker	64.4%	69.6%	63.9%**	59.0%	60.6%	58.8%
HH last sugar purchase in the past month (kg)	0.249	0.213	0.253**	0.287	0.264	0.289
HH last cooking oil purchase in the past month(liter)	0.267	0.241	0.269^{+}	0.363	0.407	0.359*

$^{+}$ $p<0.1$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Notes**:** t-test/chi-squared test are conducted to compare rural dwellers/urban residents with rural-urban migrants in each wave.

Table 3.2 Coefficients from fixed-effects models on overweight status, Indonesia Family Life Survey (IFLS), 2007 & 2014

	Model 1	Model 2	Model 3	Model 4
Residential status				
Rural-urban migrants (ref. = rural dwellers)	0.073**	0.072**	0.073**	0.117***
	(0.023)	(0.023)	(0.023)	(0.032)
Interaction terms (ref. = rural dwellers×female)				
Rural-urban migrants×male				-0.088*
				(0.042)
Socioeconomic and demographic factors				
Ever married (ref. = never married)	0.048*	0.047*	0.048*	0.046*
	(0.019)	(0.019)	(0.019)	(0.019)
Secondary school or above	0.121	0.117	0.117	0.117
(ref. = primary school or below)	(0.087)	(0.087)	(0.086)	(0.086)
Log HH income per capita ($)	0.012**	0.011**	0.011**	0.011**
	(0.004)	(0.004)	(0.004)	(0.004)
Physical and mental health status				
Self-rated health				
Healthy or somewhat healthy		0.051***	0.051***	0.051***
(ref. = unhealthy or somewhat unhealthy)		(0.014)	(0.014)	(0.113)
Depressed		-0.000	-0.001	-0.000
		(0.016)	(0.016)	(0.015)
Health-related behaviors				
Walking with moderate efforts in the past week			0.007	0.006
			(0.014)	(0.014)
Current smoker (ref. = never smoker)			-0.031	-0.026
			(0.030)	(0.030)
Ever smoker			-0.049	-0.042
			(0.035)	(0.035)
HH last sugar purchase in the past month (kg)			0.003	0.003
			(0.012)	(0.012)
HH last cooking oil purchase in the past month(liter)			0.011	0.010
			(0.011)	(0.012)
Observations	14534	14534	14534	14534

Standard error clustered by household in parentheses
$^{+}$ $p<0.1$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 3.3 Coefficients from fixed-effects models on overweight status, rural-urban migrants, Indonesia Family Life Survey (IFLS), 2007 & 2014

	Model 1	Model 2	Model 3
Urban life exposure			
Years lived in cities	0.004	0.004	0.001
	(0.010)	(0.010)	(0.010)
Socioeconomic and demographic factors			
Ever married (ref. = never married)	0.107*	0.100*	0.093*
	(0.045)	(0.045)	(0.044)
Secondary school or above	0.093	0.102	0.074
(ref. = primary school or below)	(0.210)	(0.209)	(0.203)
Log HH income per capita ($)	0.008	0.007	0.006
	(0.008)	(0.008)	(0.008)
Physical and mental health status			
Self-rated health			
Healthy or somewhat healthy		0.054	0.048
(ref. = unhealthy or somewhat unhealthy)		(0.039)	(0.039)
Depressed		-0.020	-0.019
		(0.044)	(0.044)
Health-related behaviors			
Walking with moderate efforts in the past week			0.047
			(0.041)
Current smoker (ref. = never smoker)			-0.056
			(0.059)
Ever smoker			-0.043
			(0.120)
HH last sugar purchase in the past month (kg)			0.054
			(0.048)
HH last cooking oil purchase in the past month(liter)			0.022
			(0.038)
Observations	1362	1362	1362

Standard error clustered by household in parentheses
$^{+}$ $p<0.1$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Appendix A: The comparison of binary and continuous model specifications

Table A.1 Average marginal effects (AME) of rural-urban migration on overweight status

	LPM	Logit
AME	0.053^{**}	0.051^{**}
Standard error	(0.019)	(0.019)
95% Confidence interval	[0.016, 0.090]	[0.013, 0.089]

$^{+}$ p<0.1, * p<0.05, ** p<0.01, *** p<0.001

Table A.2 Average marginal effects (AME) of years lived in cities on overweight status among migrants

	LPM	Logit
AME	0.019^{**}	0.017^{**}
Standard error	(0.006)	(0.005)
95% Confidence interval	[0.008, 0.030]	[0.006, 0.027]

$^{+}$ p<0.1, * p<0.05, ** p<0.01, *** p<0.001

The purpose of the Table A.1 and A.2 is to show the comparison between modeling overweight status as binary in logit models and as continuous in linear probability models (LPMs) Therefore, individual and wave fixed effects are not added. As we can see, the two models produce very similar average marginal effects (AME). In other words, treating the binary outcome variable as continuous in this analysis does not impact the accuracy and efficiency of point estimates. The result is consistent with the findings of other empirical works that compare the two modeling strategies. For example, Beck (2020) replicates an article that used the linear probability model by comparing the original results with those generated from the conditional logit model and finds that the magnitudes of the effects and standard errors are almost the same (Beck, 2020).

It is worth noticing that the estimates of models without fixed effects are different from those in the main text from fix-effects models. For example, in Table A.2, “years lived in cities” significantly predicts overweight status among migrants. However, as shown in the main text, there is no significant association between “years lived in cities” and migrants' overweight status after adding individual and wave fixed effects. This contrast demonstrates the advantage of longitudinal data and fixed-effects models, which adjust for omitted variables that lead to spurious associations.

CHAPTER 4

INTERNAL MIGRATION AND WEIGHT STATUS IN SUB-SAHARAN AFRICA: A LONGITUDINAL ANALYSIS OF MALAWI

Abstract: Previous research on internal migration and health in sub-Saharan Africa (SSA) has paid relatively less attention to non-communicable diseases (NCDs) and their risk factors. Existing studies primarily used cross-sectional data, failing to adjust for potential migration health selection. Meanwhile, the health impact of rural-rural migration, the dominating pattern of internal migration in SSA, is understudied. Using data from the 2008 and 2019 waves of the Malawi Longitudinal Study of Families and Health (MLSFH) and employing fixed-effects (FE) models, this study examines how internal migration, both rural-urban and rural-rural, shapes a prominent NCD risk factor, being overweight. Results show that internal migration significantly and positively predicts Body Mass Index (BMI) and overweight status. Interestingly, even migrants who move to rural destinations have significantly elevated BMI and increased chances of being overweight. In addition, the significant differences between migrants and rural non-migrants are entirely driven by women, and the impacts of migration on BMI and being overweight among rural-rural migrants are significantly stronger for women than men. The significant associations between internal migration and weight status as well as its gender pattern call for effective policymaking and program implementation to curb the rising overweight crisis, with particular attention to migrant women.

Introduction

The negative impact of internal migration on both physical and psychological health has been documented in many low- and middle-income countries (LMICs) (e.g., Anglewicz et al., 2018; Chen, 2011; Lu, 2010; Nauman et al., 2015). In sub-Saharan Africa (SSA) where internal migration will continue being extensive for the decades to come (Oucho & Gould, 1993), research on this topic has linked internal migration with higher adult mortality (e.g., Collinson et al. 2014; Ginsburg et al. 2016), worse child health (Anglewicz et al., 2019), and increased transmissions of infectious diseases, such as HIV/AIDS (e.g., Lagarde et al., 2003), while relatively less attention was paid to non-communicable diseases (NCDs) and their risk factors. However, with rapid economic development and urbanization, NCDs have become emerging health burdens in this region. NCDs are projected to surpass infectious diseases to be leading causes of morbidity and mortality by 2030, resulting in 28 million additional deaths (WHO, 2014). The double burden of diseases proposes enormous challenges to constrained medical resources and public health systems in SSA. Therefore, it is critical to understand how internal migration shapes NCDs and their risk factors in these countries.

Being overweight, defined as having Body Mass Index (BMI) greater than or equal to 25, is one of the most prominent risk factors for various NCDs, such as cardiovascular diseases, diabetes, and cancers (WHO, 2020). Although the prevalence of overweight/obesity in SSA is still relatively low compared to that in high-income and middle-income countries, it increased by more than one-third between 1992 and 2005 and will keep rising at more rapid rates in the next few decades (Ziraba et al., 2009). Nevertheless, evidence on internal migration and overweight status in a low-income SSA context is scarce, and a small body of studies show mixed and inconsistent patterns. For instance, using data from a cross-sectional survey that interviewed 13,903 rural non-migrants and 9,903 rural-urban migrants in Malawi, Chilunga et al. found that rural-urban migration is associated with significantly higher chances of being overweight (Chilunga et al., 2019). In contrast, Peters et al. analyzed data from a nationally representative cross-sectional weighted sample of 6171 non-pregnant women in Kenya and found no significant association between rural-urban migration and weight status (Peters et al., 2019). Similar conflicting results are documented even in studies of the same country. In Tanzania, Unwin et al. found significant associations between rural-urban migration and weight gain (Unwin et al., 2010), while Cockx et al. found no such associations (Cockx et al., 2017).

Besides inconclusive findings, previous studies have three main limitations. First and foremost, they primarily used cross-sectional data, failing to adjust for potential selection into migration. Migration is not a behavior that is randomly adopted by everyone but highly selective on individuals' sociodemographic factors and health conditions (Stark, 1984). Migrants typically have better health than those who remain, and this positive health selection has been documented in many LMICs (e.g., Anglewicz et al., 2018; Lu, 2008; Lu & Qin, 2014; Nauman et al., 2015; Riosmena et al., 2013). Cross-sectional data cannot provide information on pre-migration health and other characteristics that might confound the relationship between migration and post-migration health, making it unclear whether the observed health outcomes by migration status are indeed impacted by migration or just a result of migration health selection. Longitudinal data is preferable to control for pre-migration health and adjust for biases from potential migration health selection and other unobserved confounders. However, longitudinal data in SSA that contains detailed migration histories and anthropometric measures are rare.

Another limitation of existing literature is the almost exclusive focus on rural-urban migration with little attention to rural-rural migration. Although widespread rural-urban migration is estimated to triple the urban population in SSA by 2030 (United Nations, 2014), rural-rural migration still dominates internal migration in this region (Oucho & Gould, 1993), as most SSA areas will remain rural in the foreseeable future. The link between rural-urban migration and overweight status is straightforward. As people move from the countryside to cities, they have higher incomes that enable them to afford unhealthy processed food and are exposed to more sedentary lifestyles (Rosenthal, 2014), both leading to overweight. However, how rural-rural migration shapes weight remains unclear. Unlike rural-urban migrants who usually move for work, rural-rural migration in SSA typically results from marriage/divorce or climate-related reasons (Anglewicz, 2012). As a consequence, rural-rural migrants may represent a different group of people from rural-urban migrants in terms of sociodemographic factors and health behaviors. Therefore, the relationship between rural-urban migration and weight status may not apply to rural-rural migrants. In SSA, where rural-rural migration continues dominating internal migration, it is vital to understand its implications for a prominent NCD risk factor.

Finally, the gender pattern of the impact of internal migration on weight status remains understudied. Although some prior research (e.g., Chilunga et al., 2019) and a comprehensive review of literature on overweight status in SSA (Steyn & Mchiza, 2014) have shown that the prevalence of overweight/obesity is significantly higher among women than men, little is known about whether the influence of migration on weight status also differs by gender. This issue is worth investigating for two reasons. On one hand, most of the rural-rural migration in SSA relates to marriage or marital dissolution (Anglewicz, 2012). Individuals move with their spouses for marriage and return to their places of origin after divorce/widowhood. Research has shown that such migration typically occurs among women, as women in SSA primarily migrate for marriage-related reasons (Anglewicz, 2012; Reniers, 2003). In other words, women account for a considerable proportion of rural-rural migration, a dominating migration pattern in SSA. Therefore, as rural-rural migration continues to be prevalent in the next few decades, it is essential to examine how women's internal migration experiences uniquely shape their health outcomes. On the other hand, women are more vulnerable to chronic conditions related to being overweight but are less likely to be diagnosed and treated than men in LMICs (Bonita & Beaglehole, 2014). For example, a longitudinal analysis in Malawi shows that women are more likely to have an onset of hypertension than men (Kohler et al., 2022). Exploring the gender pattern of the associations between internal migration and weight status will help policymakers better understand the health needs of women and implement gender-specific interventions to improve their health and wellbeing.

This paper aims to contribute to the literature on internal migration and health outcomes in SSA by examining how internal migration, not only rural-urban but also rural-rural, shapes overweight status, a prominent NCD risk factor. Using two waves of longitudinal data spanning over a decade from the Malawi Longitudinal Study of Families and Health (MLSFH) and employing fixed-effects (FE) models, this study efficiently adjusts for migration health selection as well as other biases from time-invariant confounders that are not captured in the data. The study also provides new evidence on the gender pattern of the impact of internal migration on health. The findings will help SSA governments better understand the rising overweight crisis and its association with two main population mobility patterns so that corresponding public health policies can be made to curb the morbidity and mortality from overweight-related NCDs.

Study Context

This study is set in Malawi, a country with a population of 18 million in Southeast Africa. Malawi fits the study perfectly for two main reasons. First, internal migration is common in this country. Malawi has been experiencing high urbanization rates, and its urban population will continue growing for the decades to come, primarily contributed by extensive rural-urban migration (Anglewicz et al., 2018). More importantly, most Malawians still reside in rural areas, and rural-rural migration will remain a critical form of internal migration (Anglewicz, 2012; Oucho & Gould, 1993), which provides an opportune setting to examine how rural-rural migration shapes weight. Second, being overweight has been a rising health burden in Malawi (Price et al., 2018). A population-based nationwide survey using the World Health Organization (WHO) STEPwise approach has shown that more than one out of every five Malawian adults is overweight (Msyamboza et al., 2013), and the percentage will continue increasing in the next few decades. The high prevalence of overweight in Malawi ensures an ample number of overweight adults when malnutrition and underweight are also common in SSA countries.

Data and Measures

MLSFH

The data comes from the Malawi Longitudinal Study of Families and Health (MLSFH), one of the few long-standing longitudinal cohort studies that contain information about demographic, socioeconomic, and health conditions in a lower-income SSA context over two decades (Kohler et al., 2015). The MLSFH was established in 1998, initially targeting a population-based representative sample of approximately 1500 ever-married women and 1000 husbands in three rural sites of Malawi (Kohler et al., 2015). Following a household enumeration in the three designated survey sites in 1998, a random sample of approximately 500 ever-married women aged 15–49 was selected in each site, along with all of their spouses. Follow-up surveys took place in 2001, 2004, 2006, 2008, 2010, and 2019, and the sample was supplemented with young adults, parents of existing MSLFH respondents, and new spouses for those who married between waves (Kohler et al., 2015). The MLSFH study population closely matches the characteristics of nationally-representative surveys, including the Malawi Demographic and Health Survey (MDHS) and the Integrated Household Survey (IHS) (Kohler et al., 2015).

The study utilizes data from the 2008 and 2019 waves of the survey. The 2008 wave is the first follow-up in MLSFH that collects measured anthropometric indicators. It also provides information on respondents' pre-migration health and sociodemographic factors that can be used to adjust for migration selection. The 2019 wave contains detailed information on individuals' migration trajectories since 2008, measured anthropometric indicators, and socioeconomic status.

Measures of Migration Status

In 2019, the MLSFH collected detailed information on respondents' migration histories by asking about types of current and previous residences since 2008. The answers include "Urban area", "Town/District", and "Rural area". "The definitions of urban and rural areas are based on the latest Malawi census (Malawi National Statistical Office, 2018). Urban area" refers to four major cities in Malawi: Lilongwe, Blantyre, Mzuzu, and Zomba. "Town/District" includes towns around the four major cities as well as trading centers where many small businesses are located in. "Rural area" contains rural villages and rural market places. "Town/District" is combined with "Urban area" because very few respondents fall into that category.

Based on this categorization, respondents' migration status can be identified. Individuals who lived and remained in the same rural villages and had no migration history between the two waves are rural non-migrants. Rural-rural migrants are those who lived in rural villages in 2008 and moved to different villages in 2019. Similarly, rural-urban migrants are individuals who lived in rural areas in 2008 and moved to urban areas/towns in 2019.

Analytical Sample

There are 932 individuals consisting of rural non-migrants, rural-urban migrants, and rural-rural migrants presented in two waves of data (merged using unique respondent numbers). Among the 932 individuals, 34 respondents have missing values in height and weight measures, and 42 have missing values in other covariates. These observations are excluded from the analytical sample[2]. The final sample size is 856 (*N*=856).

[2] Additional analyses show no significant differences between dropped cases and the analytical sample.

Dependent Variables

There are two dependent variables. One is BMI, calculated as $\frac{weight}{height^2}$ (kg/m^2). The other is overweight status, defined as having BMI greater than or equal to 25 (WHO, 2020), which is a binary measure. Obesity (BMI ≥ 30) is combined with the category of being overweight due to its low prevalence. Weight and height are measured onsite by professional health staff, following the protocol developed by the Health and Retirement Study (HRS) (Kohler et al., 2015). The continuous BMI shows the overall trend of how internal migration shapes respondents' weights, while the binary overweight variable reveals how migration status is associated with BMI above a threshold that is detrimental to health.

Covariates

The main independent variable is migration status. This variable is categorical, with rural non-migrants being the reference group. The other two groups are rural-urban migrants and rural-rural migrants. The definition and identification of each group have been discussed above. Other covariates are sociodemographic factors, which are collected in both the 2008 and 2019 waves, including age, gender, education, and marital status. Education is a binary measure, with primary school or below in one group and secondary school or above in the other. Marital status is also binary, indicating whether the respondent is married or living together with a partner. I also control household economic wellbeing, an important factor that relates to migration decisions and weight status, by household wealth and household saving. Household wealth is measured by a continuous wealth index calculated through principal component analysis (PCA) of common household assets ownership, including radio, television, bicycle, etc. Household saving is a binary variable, indicating whether the household had any savings.

Methods

Fixed-effects (FE) models with individual and wave FE are employed to adjust for potential selection into migration and omitted variable bias (Allison, 2005). Adding individual FE essentially compares each individual at the 2019 wave with him/herself at the 2008 wave, and thus rules out the impact of time-invariant factors, both observed and unobserved, at the individual level. Similarly, including wave FE in the models account for the fixed factors at the aggregate societal level between the two waves of surveys that are not captured in the data but may also affect people's migration decisions and overweight status. The selection between conditional logit models with FE and linear probability models (LPM) with FE has been discussed in detail in the Method section of Chapter 2, and will be skipped here for brevity. I still choose to use LPM with FE in this analysis because of the more consistent point estimates and easier interpretations.

This study estimates two sets of FE models with the continuous BMI being the dependent variable in the first set and binary overweight status in the second.

$$BMI_{it} = \beta_1 Migration\_status_{it} + \sum_{k=2}^{4} \beta_k \left(Control_{kit}\right) + \alpha_i + \gamma_t + u_{it} \quad (1.1)$$

$$BMI_{it} = \beta_2 Migration\_status_{it} + \beta_3 Migration\_status_{it} * Gender + \sum_{k=2}^{4} \beta_k \left(Control_{kit}\right) + \alpha_i + \gamma_t + u_{it} \quad (1.2)$$

$$Overweight_{it} = \beta_4 Migration\_status_{it} + \sum_{k=2}^{4} \beta_k \left(Control_{kit}\right) + \alpha_i + \gamma_t + u_{it} \quad (2.1)$$

$$Overweight_{it} = \beta_5 Migration_{status_{it}} + \beta_6 Migration_{status_{it}} * Gender + \sum_{k=2}^{4} \beta_k \left(Control_{kit}\right) + \alpha_i + \gamma_t + u_{it} \quad (2.2)$$

In both sets of models, the main independent variable is migration status. Covariates include marital status, education, household wealth, and household saving. The term α_i represents time-invariant individual FE, which controls unobserved fixed characteristics at the individual level. The term γ_t represents wave FE, controlling for unobserved fixed factors at the aggregate level between the two waves of surveys.

Nested FE models are constructed. In Model 1, I only control for migration status. Model 2 adds control for time-varying covariates that are captured in the data. In order to explore potential gender patterns of the associations between migration and weight status, I add interaction terms between migration status and gender in Model 3 to determine whether the differences in effect sizes of internal migration are significant between the two sexes. It is worth noticing that the number of rural-urban migrant men in the analytical sample is very small (only 3), which makes adding an interaction term between rural-urban migration and gender unpractical. Therefore, Model 3 is restricted to rural non-migrants and rural-rural migrants.

Results

Descriptive Statistics

The sample descriptive statistics are displayed in Table 4.1 by gender and survey year. T-tests/chi-squared tests are conducted to compare 1) men and women within each survey wave and 2) the pooled sample across two survey waves. Among the 856 respondents, 260 are men and 596 are women. In 2019, the average age for men was 41.4, and that for women was 38.8, with women being significantly younger. There are 580 rural non-migrants, and the numbers for rural-urban migrants and rural-rural migrants are 21 and 255, respectively. These numbers are consistent with rural-rural migration dominating internal migration in SSA. The average BMI significantly increased from 22.2 in 2008 to 23.3 in 2019. Strikingly, the proportion of overweight individuals more than doubled between the two waves, rising from 12.0% to 26.8%. What is worse, the prevalence of overweight among women was as high as 33.2% in 2019, suggesting that more than one out of every three women is overweight. This number is almost three times that for men in the same year, 11.9%, which also doubled from only 6.1% in 2008.

The proportion of women who have completed secondary school is significantly lower than that of men in both waves. For marital status, a significantly higher proportion of women were married/cohabitating than that of men in 2008 while the pattern reversed in 2019, with the proportion of married/cohabitating men being significantly higher than that of women. In both survey years, women have significantly less household asset ownership. As for household savings, overall, the proportion of respondents from households with savings significantly increased across the two waves. In 2008, 29.0% of women were from households with savings, which was significantly lower than the 37.7% for men. However, women caught up over time, increasing to 41.6% and showing no significant gender differences in household savings in 2019.

Regression Results

The regression results from FE models for BMI are shown in Table 4.2. The numbers of observations are two times those in the descriptive statistics, as each respondent was compared with themselves in the previous wave and counted as two observations. The first column displays results for Model 1 that only control for migration status. On average, rural-urban migration is associated with a 2.071-unit increase in BMI value (p = 0.008), and the increase associated with rural-rural migration is 0.962-unit (p <0.001), holding other covariates constant. In Model 2, after controlling for covariates, both coefficients are slightly attenuated but the patterns remain statistically significant. Among the covariates, household savings positively predict BMI. More specifically, on average, coming from households with savings is associated with a 0.522-unit increase in BMI, *ceteris paribus*. Other covariates are not significant predictors of BMI.

Results for Model 3 with the interaction term between internal migration and gender are displayed in the third column, with rural non-migrant women being the reference group. As mentioned before, this model excludes rural-urban migrants due to the small number of men in that group. Compared with rural non-migrant women, rural-rural migrant women on average have a 1.331-unit increase in BMI, holding other variables constant. The interaction term also shows significant results. More specifically, compared with that of rural-rural migrant women, the BMI of rural-rural migrant men is on average 1.402 units lower, *ceteris paribus*, suggesting that women's BMI is more severely impacted by rural-rural migration than men. In terms of other covariates, household saving still positively predicts BMI. Meanwhile, marital status also becomes a significant predictor of BMI. Compared with respondents who are not married, those who are married/cohabitating on average have 0.545 units higher BMI, holding other variables constant.

The regression results from FE models for overweight are shown in Table 4.3. The first column displays results for Model 1 that only controls for migration status. Compared with rural non-migrants, rural-urban migrants are on average 20.0% more likely to be overweight, and rural-rural migrants are 13.7% more likely to be overweight (p<0.001), holding other variables constant. In Model 2, after controlling for covariates, both coefficients are slightly attenuated and the association between rural-urban migration and overweight status is only marginally significant. Among the covariates, the household wealth marginally predicts overweight. More specifically, on average, every 1-unit increase in the household wealth index is associated with a 0.017-increase in the chance of being overweight, *ceteris paribus*. Other covariates turn out not to significantly predict overweight.

Results for Model 3 with the interaction term between internal migration and gender are displayed in the third column, with rural non-migrant women being the reference group. Compared with rural non-migrant women, rural-urban migrant women are on average 18.0% more likely to be overweight, holding other variables constant. The interaction term between internal migration and gender gives significant results again, suggesting that the impact of rural-rural migration on overweight status also varies by gender. More specifically, compared with rural-rural migrant women, rural-rural migrant men are on average 15.1% less likely to be overweight, *ceteris paribus*. As for covariates, household wealth still marginally and positively predicts overweight status, and other covariates are not significant predictors of being overweight.

Discussion

This study contributes to a small but growing body of literature on the impact of internal migration on NCDs in a low-income SSA context by documenting significant associations between internal migration and being overweight, one of the most prominent and increasingly prevalent NCD risk factors in Malawi. The findings suggest that, from

2008 to 2019, the average BMI increased by 1.1 units. The increase is not necessarily detrimental because more than 2.8 million Malawians still face the risks of malnutrition and being underweight (United Nations, 2015). However, at the same time, the prevalence rate of overweight doubled among men and reached more than a third among women within just 11 years. The drastic increase in the overweight population in Malawi manifests the rising overweight crisis in the entire SSA region.

The study demonstrates significant associations between internal migration and weight status, regardless of destination types. Both rural-urban and rural-rural migrants have significantly higher BMI and greater chances of being overweight than rural non-migrants. These findings support previous studies that document positive associations between rural-urban migration and weight status in SSA countries, such as Malawi (Chilunga et al., 2019) and Tanzania (Unwin et al., 2010). More importantly, they show the critical role of rural-rural migration in shaping migrants' health. It is always neglected in the existing literature but has particularly profound implications for understanding the rising overweight trend in SSA, where people who move among villages continue outnumbering those who migrate to urban areas.

In addition, this study breaks down the impact of internal migration on weight status by gender. The significant associations between internal migration and weight status seem to be entirely driven by women, as the BMI and the chance of being overweight for migrant men are not significantly different from those for their non-migrant counterparts. In contrast, among women, migrating from the countryside to either rural or urban areas significantly increases the chance of being overweight by approximately 20%. Meanwhile, the significant interaction term between rural-rural migration and gender suggests that compared with men, women are more severely impacted by migration for having elevated BMI and increased chances of being overweight. Previous research shows that women in LMICs are more likely to suffer from but are less likely to be diagnosed and get treated for NCDs, including those related to being overweight (Bonita & Beaglehole, 2014), such as hypertension (Kohler et al., 2022). The findings of this study further prove that women are more vulnerable to the influence of rural-rural migration, of which they account for a greater proportion than men, clearly demonstrating a gender disparity in health outcomes among migrants that urgently needs the attention of policymakers. A plausible explanation for the observed gender pattern is that men and women migrate for different reasons. Compared with men, women in SSA consistently move for marriage, especially in rural-rural migration (Anglewicz, 2012). In the analytical sample, at least more than a third of rural-rural migrant women move to join their spouses for marriage. Many longitudinal studies following respondents over decades have documented significant associations between marriage and weight gain (e.g. Averett et al., 2008; Cobb et al., 2016) because of increased meal portions and decreased levels of physical activity.

This study has some strengths. On one hand, it overcomes the limitations of cross-sectional study designs, which usually fail to control for migration selection and other factors that may confound the relationship between migration and health outcome, yielding biased estimates. As shown in Table B.1 (in Appendix B), using only the 2019 wave of MLFSH that does not provide information on pre-migration health and other sociodemographic factors before migration, the significant associations between internal migration and BMI as well as overweight status documented in this study would not have been observed. On the other hand, the study expands the almost exclusive focus on rural-urban migration in previous research in LMIC contexts. Meanwhile, it examines the gender pattern of the impact of migration on health outcomes, which is also understudied in prior research. In the next few decades, SSA will continue being the region with the most active population mobility compared to the rest of the world. While rural-urban migration will grow with rapid urbanization rates, rural-rural migration will remain the dominating migration pattern in the foreseeable future, of which women constitute a great share. Future studies should continue exploring whether the impact of rural-rural migration as well as the gender disparity in health outcomes exist in other SSA countries.

This study also has some limitations. First, compared with rural-rural migrants, the number of rural-urban migrants is relatively small, which may constrain the statistical power of the analytical models for this group. Meanwhile, the small number of men in rural-urban migrants makes examining the gender pattern of rural-urban migration on BMI and overweight status impractical. However, the relative numbers of rural-rural and rural-urban migrants are consistent with the fact that migrating from one rural area to another dominates internal migration in SSA. Future research may use other datasets that include more rural-urban migrants in the sample to see if the results remain and explore the gendered impact of rural-urban migration on weight status. Second, the identification of migration status is based on the respondents' types of residence in 2008 and 2019, and it is possible that individuals had multiple moves between the two time points. However, considering more than one move will make the categorization of rural-urban/rural migration unfeasible, and the number of respondents who moved more than once is very small. Therefore, it should not impact the main findings of the analysis. Third, health-related behaviors, such as tobacco use, alcohol consumption, physical activity, and dietary patterns, are not available in the 2008 wave of the survey, and thus could not be incorporated into the model design. These behavioral factors may change after individuals migrate and shape their health outcomes. However, longitudinal data that records these health-related behaviors together with migration history is rare, and points to the need for more data collection in SSA. Another related limitation is that, although the study documents significant associations between migration and weight status, the mechanisms through which migration shapes weight remain unclear. Future researchers may consider examining the main mediators that link migration and health outcomes. Finally, fixed-effects models adjust for unbiases from time-invariant confounders, but the potential impacts of time-varying factors that may confound the relationship between migration and weight status are not controlled for. Casual interpretations should be made with caution.

In conclusion, taking advantage of longitudinal data, this study provides new evidence on the associations between internal migration and NCD risk factors in SSA, and sheds light on the impact of rural-rural migration on health outcomes as well as its gender pattern. Besides continuing to deal with infectious diseases and poverty and malnutrition, SSA governments need to allocate more resources to tackle the rising overweight crisis and realize its close association with internal migration. Effective public health policies and intervention programs that increase people's awareness of overweight and help prevent overweight as well as maintain healthy weight status should be implemented, with particular attention to migrant women.

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Table 4.1 Descriptive statistics (mean or percentage), Malawi Longitudinal Study of Families and Health (MLFSH), 2008 & 2019

	2008			2019		
	Men	Women	Total	Men	Women	Total
N	260	596	856	260	596	856
Migration status						
Rural non-migrants	260	596	856	179	401	580
Rural-urban migrants	-	-	-	3	18	21
Rural-rural migrants	-	-	-	78	177	255
Health outcome						
Body Mass Index (BMI) [b]	21.7	22.3**	22.2	21.9	23.8***	23.3***
Overweight [b]	6.1%	14.6%**	12.0%	11.9%	33.2%***	26.8%***
Socioeconomic and demographic factors						
Age	30.4	27.8*	28.6	41.4	38.8*	39.6
Education						
Primary school or below	69.2%	90.1%***	83.8%	65.8%	86.4%***	80.1%+
Secondary school or above	30.8%	9.9%***	16.2%	34.2%	13.6%***	19.9%+
Marital status						
Married/living together	71.2%	88.6%***	83.3%	89.2%	79.0%***	82.1%
Not married	28.8%	11.4%***	16.7%	10.8%	21.0%***	17.9%
Household wealth index quintile [c]	3.19	2.88**	2.98	3.31	2.85***	2.99
Household with savings	37.7%	29.0%*	31.7%	46.2%	41.6%	43.0%***

$^{+}$ $p<0.1$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Notes: [a] T-tests/chi-squared tests are conducted to compare: 1) sample characteristics between men and women within each wave, 2) the pooled sample across two waves.

[b] BMI is calculated as $\frac{weight}{height^2}$ (kg/m^2), and having BMI ≥ 25 indicates overweight.

[c] Household wealth index is a continuous measure that indicates household economic wellbeing, which is calculated through principle component analysis (PCA) of common household assets ownership, including radio, television, bicycle, etc. The statistics for the quintiles of this index are presented in the table.

Table 4.2 Coefficients from fixed-effects model for BMI, Malawi Longitudinal Study of Families and Health (MLFSH), 2008 & 2019

BMI	Model 1	Model 2	Model 3[a]
Migration status (ref.= rural non-migrants)			
Rural-urban migrants	2.071**	1.925*	-
	(0.774)	(0.774)	-
Rural-rural migrants	0.962***	0.903***	1.331***
	(0.216)	(0.218)	(0.261)
Interaction terms (ref. = rural non-migrants×female)			
Rural-rural migrants×male			-1.402**
			(0.471)
Covariates			
Education (ref. = primary school or below)			
Secondary school or above		0.542	0.529
		(0.429)	(0.431)
Marital status (ref. = not married)			
Married/living together		0.350	0.545*
		(0.243)	(0.249)
Household wealth index		0.081	0.066
		(0.069)	(0.070)
Whether the household have any saving (ref. = no)			
Yes		0.522**	0.541**
		(0.184)	(0.186)
N	1712	1712	1672

Standard error in parentheses
$^{+}$ $p<0.1$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Notes: [a] Model 3 excludes rural-urban migrants because of the small number of migrant men in that group.

Table 4.3 Coefficients from fixed-effects model for overweight status, Malawi Longitudinal Study of Families and Health (MLFSH), 2008 & 2019

Overweight	Model 1	Model 2	Model 3
Migration status (ref. = rural non-migrants)			
Rural-urban migrants	0.200*	0.173^{+}	-
	(0.099)	(0.100)	-
Rural-rural migrants	0.137***	0.133***	0.180***
	(0.028)	(0.028)	(0.340)
Interaction terms (ref. = rural non-migrants×female)			
Rural-rural migrants×male			-0.151*
			(0.061)
Covariates			
Education (ref. = primary school or below)			
Secondary school or above		0.089	0.086
		(0.055)	(0.056)
Marital status (ref. = not married)			
Married/living together		0.026	0.047
		(0.031)	(0.032)
Household wealth index		0.017^{+}	0.015^{+}
		(0.009)	(0.009)
Whether the household have any savings (ref. = no)			
Yes		0.027	0.025
		(0.024)	(0.024)
N	1712	1712	1672

Standard error in parentheses
$^{+}$ $p<0.1$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Notes: [a] Model 3 excludes rural-urban migrants because of the small number of migrant men in that group.

Appendix B: Predicting BMI and overweight status with cross-sectional data

Table B.1 Coefficients from OLS model for BMI and odds Ratios from logistic model for overweight, Malawi Longitudinal Study of Families and Health (MLFSH), 2019

	BMI	Overweight
Migration status (ref.= rural non-migrants)		
Rural-urban migrants	0.299	0.738
	(0.837)	(0.380)
Rural-rural migrants	-0.129	1.025
	(0.279)	(0.192)
Covariates		
Age	-0.024^{+}	1.002
	(0.012)	(0.009)
Female	2.203^{***}	5.14^{***}
	(0.288)	(1.194)
Education (ref. = primary school or below)		
Secondary school or above	-0.399	0.971
	(0.353)	(0.229)
Marital status (ref. = not married)		
Married/living together	0.574	1.435
	(0.337)	(0.337)
Religious Affiliation (ref. = no religion)[a]		
Catholic	0.751	3.341
	(1.108)	(3.892)
Muslim	0.078	1.708
	(1.098)	(1.992)
Other	0.562	2.487
	(1.072)	(2.866)
Household wealth index	0.494^{***}	1.341^{***}
	(0.079)	(0.070)
Whether the household have any savings (ref. = no)		
Yes	-0.165	0.795
	(0.274)	(0.143)
N	856	856

Standard error in parentheses
$^{+}$ $p<0.1$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Notes: [a] Religious affiliation is not included in the fixed-effects models because it remains stable over time, and thus is considered as time-invariant and has been controlled by individual fixed-effects.

CHAPTER 5

CONCLUSION

In the next few decades, low- and middle-income countries (LMICs) will continue urbanizing rapidly, largely via massive rural-urban migration. Meanwhile, rural-rural migration will remain a critical form of internal migration in countries of sub-Saharan Africa (SSA) for the foreseeable future. The impact of internal migration on non-communicable diseases (NCDs), a fast-rising health burden taking away millions of lives annually in LMICs, is understudied. This dissertation contributes to the literature on migration and health by documenting significant associations between internal migration and major NCD risk factors in three LMICs: China, Indonesia, and Malawi. These countries represent LMICs at different socioeconomic development levels, giving the dissertation findings profound policy implications for a broad LMIC context.

Associations between Internal Migration and NCD Risk Factors

Significant associations between internal migration and major NCD risk factors are found in all three contexts of study. Chinese rural-urban migrants have similar risks of being hypertensive, obese, and abdominal obese to urban non-migrants, which are significantly higher than those among rural non-migrants. In Indonesia, rural-urban migration is significantly associated with increased risks of being overweight. Similar patterns are also observed in Malawi, where both rural-urban and rural-rural migration significantly and positively predict Body Mass Index (BMI) and overweight status. The consistent findings across diverse contexts further validate the existence of the negative impact of internal migration on NCD risk factors and lend support to previous research that documented such a negative impact in the LMIC context, such as India (Ebrahim et al., 2010), Guatemala (Ramirez-Zea et al. 2005), Kenya (Poulter et al., 1985), Peru (Creber et al., 2010), China (Wang et al., 2021), and Malawi (Chilunga et al., 2019).

The demonstrated differences in health outcomes by migration status have important implications. On one hand, many governments and individuals in LMICs only see the positive sides of urbanization, such as more employment opportunities, the modernization of public infrastructure, increased access to education, health care, and social services (Eckert & Kohler, 2014) but ignore its negative effects on health. The purpose of this dissertation is not to deny the important benefits of urbanization in LMICs, but rather to draw attention from health policymakers and urge them to think about, when enjoying the benefits of urbanization, how to improve the health and wellbeing of the increasing number of rural-urban migrants who fare worse in health than rural non-migrants. On the other hand, the impact of rural-rural migration on health has been largely ignored in the previous literature. The results from chapter four in Malawi alert governments in SSA where most of their populations reside in and migrate among rural areas that the risks of NCDs are also rising in a low-income rural context and are closely associated with their active population mobility. Besides continuing dealing with infectious diseases, more financial and medical resources may be allocated to tackle NCDs.

Impacts of Migration on NCD Risk Factors by Gender

The dissertation documents important gender patterns of the impact of internal migration on NCD risk factors. In China, compared with men, women are significantly more likely to be obese. This finding is consistent with previous literature showing that the prevalence rates of overweight/obesity are higher among women in LMICs (Kanter & Caballero, 2012). Furthermore, the impact of internal migration is significantly stronger among migrant women than migrant men in Indonesia and Malawi. The results clearly demonstrate a gender disparity that women's health outcomes are more severely impacted by migration experiences. This gender disparity calls for effective health policymaking targeting women for two reasons. First, population aging has been a huge challenge, especially in middle-income countries like China. It is well documented that women outlive men and that older adults are more likely to develop NCD risk factors than their younger counterparts. Second, women account for a greater share of internal migrants than men in many LMICs. For example, in Indonesia, there has been a feminization of its internal migration over the past few decades (Sukamdi, 2015). In SSA countries like Malawi, women continue outnumbering men in rural-rural migration (Anglewicz, 2012). Therefore, as women's weight status is more vulnerable to migration experiences, health interventions that aim to increase awareness of overweight risks and help prevent and control overweight/obesity need to be implemented among migrant women in LMICs.

The gender disparity may be closely related to reasons for migration. In terms of rural-urban migration, most migrants move for better employment opportunities. Among these migrant workers, there is a clear gender division of labor, with men being employed in labor-intensive industries, and women working mainly in the textile and manufacturing industries that are much more sedentary and require less physical activity (Zhang, 2014), which may result in overweight/obesity. As for rural-rural migration in SSA, women have always been the main force, and many move to join their spouses after marriages.

Many longitudinal studies following respondents over decades have documented significant associations between marriage and weight gain because of increased meal portions and decreased physical activity (Averett et al., 2008; Cobb et al., 2016). Nevertheless, these potential reasons associated with the gender disparity and weight are not directly testable in this dissertation due to data limitations, and future research should continue exploring the driving forces of the gender pattern.

Mediating Effects of Health-related Behaviors

The dissertation quantifies the mediating effects of health behavioral factors, which were not tested in previous studies that documented changes in individual health behaviors after migration and considered them as the main contributors to the associations between internal migration and NCD risk factors. Consistent results from China and Indonesia show that health behavioral factors controlled in the studies play a very limited role in mediating the impact of internal migration on health. More specially, in China, health behaviors including smoking, alcohol consumption, and physical activity only explain about 5% of the associations between rural-urban migration and hypertension, obesity, and abdominal obesity. In the chapter on Indonesia, I additionally control for the household consumption of oil and sugar, two important cooking ingredients that relate to weight. However, together with smoking and physical activity, they still explain little of the variations in overweight status by migration histories.

The finding suggests other alternative pathways through which internal migration shapes health. For example, compared with urban residents, rural-urban migrants have restricted access to health care services because of the high costs of medical treatments and poor coverage of their social insurance in urban hospitals. Their health knowledge and awareness of NCDs are also relatively limited. The lacks of health services and knowledge both have negative impacts on health outcomes. In addition, the separation from families, adaptation to new environments, and stigmatization and discrimination of migrants (Li et al., 2006; Lu, 2010; Mou, 2013) are critical stressors that closely relate to higher chances of having NCD risk factors. All these factors can be important mechanisms that link internal migration and health that are worth investigating in future research. Meanwhile, it has to be kept in mind that the examination of health-related behaviors in this dissertation is far from comprehensive, and researchers on this topic should continue exploring a more complete list of health behavioral factors if the data allows.

Accumulative Effects of Migration on NCD Risk Factors

Another important goal of this dissertation is to test the Years Since Migration (YSM) effect or accumulative effect of internal migration on NCD risk factors. The findings suggest that its existence may depend on the type of NCD risk factors. More specifically, in China, the risks of having hypertension increase with the length of time spent in cities whereas no such an effect is found in general/abdominal obesity. Similar results are found in Indonesia where the number of years spent in cities does not predict the chance of being overweight. A plausible explanation is that, compared with general/abdominal obesity that has obvious manifestations on the body, such as gained weight or increased waist circumference, hypertension is normally asymptomatic and has a very long incubation period until it causes the onset of NCDs (Rose, 2005). Therefore, general/abdominal obesity is much easier to be noticed and corresponding actions are more likely to be taken to control them. One caveat is that the insignificant results may result from the short time interval between survey waves (e.g. eight years in IFLS), which may not be long enough for the accumulative effect of urban residence on some NCD risk factors to emerge. Therefore, future research should consider using longitudinal data that has a longer follow-up time interval to further estimate the YSM effect.

Conclusion

In sum, this dissertation documented the negative impact of internal migration, both rural-urban and rural-urban, on major NCD risk factors across three LMICs with different socioeconomic conditions and development levels. As extensive internal migration continues in the coming decades and NCDs are become the leading health burden in the LMIC context, effective policymaking that aims to counter the health challenge of NCDs is urgently needed among migrant communities, with special attention to women, whose health outcomes are more severely impacted by migration experiences than men. Although this dissertation has chosen three very different LMICs that represent a considerable amount of variations in a broad LMIC context, future research should examine additional LMIC contexts to see if the documented patterns persist. In addition, the dissertation also points to the need for more comprehensive longitudinal data collection in terms of health-related behaviors so that their mediating effects can be better examined.

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