ASSOCIATION OF SOCIOECONOMIC STATUS WITH INCIDENCE AND MORTALITY OF HEART DISEASE AND STROKE IN OLDER PEOPLE IN CHINA

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A thesis submitted in partial fulfilment of the requirements of the University of Wolverhampton for the degree of Doctor of Philosophy

August 2020

DECLARATION

I certify that this work or any part thereof has not previously been presented in any form to the University or to any other body whether for the purposes of assessment, publication or for any other purpose (unless otherwise indicated). Save for any express acknowledgements, references and/or bibliographies cited in the work, I confirm that the intellectual content of the work is the result of my own efforts, with supervisory assistance from Professor Ruoling Chen, Dr Alex Hopkins and Dr Angela Clifford and of no other person.

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Date: August 2020

ABSTRACT

Introduction: Over the past four decades, China has experienced increasing gap between the rich and poor, along with rapid economic development, and increased the numbers of heart disease and stroke. The population in Chins is ageing. It is unclear whether socioeconomic inequalities are associated with increased risk of heart disease and stroke in older people and their surviving in China. This PhD study aimed to investigate the associations of multiple measurements of socioeconomic status (SES) with incidence of heart disease and stroke in older Chinese people and all-cause mortality in those patients.

Methods: Two prospective community-based cohort studies were conducted in Anhui province and in four other provinces in China. The Anhui cohort consisted of a random sample of 3,336 older adults, of whom 1,736 aged ≥65 years recruited from urban areas in 2001 and 1,600 aged ≥60 years from rural areas in 2003. In a standard questionnaire interview, they were recorded for sociodemographic, behaviours/lifestyles, social networks and supports, cardiovascular diseases and other related risk factors. SES was measured by urban-rural living, educational level, occupational class, satisfactory income, and any serious financial problems occurred in the past two years. Heart disease and stroke were documented based on self-reported doctor-diagnosis. The cohort members were followed up until 2011 to monitor vital status and causes of mortality, during which three waves of re-interviews were taken for survivors to further document incident heart disease and stroke. Following the same protocol as that in the last two surveys in the Anhui cohort study, the Four-province cohort study completed a baseline survey in 2008-2009 for 4,314 participants who were aged ≥60 years, who were randomly recruited from Guangdong, Shanghai, Heilongjiang, and Shanxi. The Four-province cohort study was followed up until 2012 to monitor the vital status and with re-interviewing survivors. The data of the Anhui cohort and the Four-province cohort studies were analysed in multivariate Cox regression models to examine the associations of SES with incidence and mortality of heart disease and stroke, respectively.

Results: The data from the two cohort studies showed that low SES was generally associated with increased incidence of heart disease and stroke and all-cause mortality in older adults with these diseases, although the association varied with SES indicators. Pooled data demonstrated that while rural versus urban living was associated with reduced incidence of heart disease (multivariate adjusted hazard ratio 0.56, 95% CI 0.44-0.71), it increased mortality in participants with heart disease (3.57, 2.01-6.34). Rural living was associated with increased incidence of stroke (1.66, 1.08-2.57) and non-significantly all-cause mortality in participants with stroke (1.98, 0.70-5.59). While high occupational class was associated with increased incidence of stroke (1.56, 1.01-2.38), low level of education was significantly associated with mortality in participants with heart disease (1.59, 1.05-2.39). Low income or having financial problems was associated with increased incidence of heart disease (1.42, 1.00-2.00 in low family income) and all-cause mortality in people with heart disease (2.68, 1.08-6.65 in low personal income).

Conclusions: In China older people with low SES had increased risks of heart disease (except for rural living) and stroke (except for occupational class). Impact of low SES on increased mortality in older people with heart disease and stroke appeared stronger. Strategies targeting different SES groups involving comprehensive approaches are needed to reduce incidence of heart disease and stroke and improve surviving in older people with heart disease and stroke.

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LIST OF ABBREVIATIONS

ADL: Activities of Daily Living

AGECAT: Automated Geriatric Examination for Computer Assisted Taxonomy

AIS: Acute Ischemic Stroke

AMI: Acute Myocardial Infarction

BMI: Body Mass Index

BP: Blood Pressure

CABG: Coronary Artery Bypass Grafting

CAD: Coronary Artery Disease

CBM-disk: China Biological Medicine Database

CCHD: Complex Congenital Heart Disease

CHD: Coronary Heart Disease

CI: Confidence Interval

CIA: Central Intelligence Agency

CNKI: China National Knowledge Infrastructure

CNSR II: China National Stroke Registry II

CT: Computed Tomography

CTA: Computed Tomographic Angiography

CVD: Cardiovascular Disease

CVDRFs: Cardiovascular Disease Risk Factors

DALYs: Disability-Adjusted Life-Years

DBP: Diastolic Blood Pressure

DSM-III: The Diagnostic and Statistical Manual of Mental Disorders, Third Edition

GCC: Gulf Cooperation Council

GDP: Gross Domestic Product

GMS: Geriatric Mental State

GNI: Gross National Income

HD: Heart Disease

HDL: High Density Lipoprotein

HICs: High Income Countries

HR: Hazard Ratio

ICD: International Classification of Disease

mRS: Modified Rankin Scale

ICH: Intracerebral Haemorrhage

IMD: Index of Multiple Deprivation

IMF: International Monetary Fund

IRSD: Index of Relative Socio-economic Disadvantage

LACI: Lacunar Cerebral Infarct

LDL: Low Density Lipoprotein

LMICs: Low- and Middle-Income Countries

MDS: Minimum Data Set

MI: Myocardial Infarction

MRI: Magnetic Resonance Imaging

MS: Murray Score

NIHSS: National Institutes of Health Stroke Scale

NZDep: New Zealand Index of Deprivation

OCSP: the Oxfordshire Community Stroke Project

OR: Odds Ratio

PACI: Partial Anterior Circulation Infarcts

PEO: Population, Exposure and Outcome

POCI: Posterior Circulation Infarcts

PRISMA: Preferred Reporting Items for Systematic reviews and Meta-analyses

RCT: Randomized Controlled Trial

RR: Relative Risk

SAH: Subarachnoid Haemorrhage

SBP: Systolic Blood Pressure

SC: Social Class

SD: Standard Deviation

SES: Socioeconomic Status

SOA: Super Output Area

TACI: Total Anterior Circulation Infarcts

TC: Total Cholesterol

TG: Triacylglycerol

TIA: Transient Ischaemic Attack

WHO: World Health Organisation

WHR: Waist-Hip Ratio

WS: Womersley Score

WTO: World Trade Organisation

ACKNOWLEDGEMENT

This study was conducted at the Faculty of Education, Health, and Wellbeing (FEHW), University of Wolverhampton, UK. I would like to thank the faculty and its staff for providing an excellent environment and services to complete all the research work and the thesis.

I am in deep appreciation and gratitude to my director of studies, Professor Ruoling Chen, for providing me with such a great opportunity to study this PhD, including the available databases of the Chinese cohort studies, and offering valuable supervision throughout the doctoral study, including large data analysis skills. I am also deeply grateful for the support from co-supervisors Dr Alex Hopkins and Dr Angela Clifford, who supplied valuable suggestions for my PhD research. I appreciated Drs Yuyou Yao and Yuhui Wan, who were visiting scholars at FEHW from the Anhui Medical University, China, for the Chinese cohort data management and data analysis support.

I would like to thank staff and PhD students in the Research Group of Population Health, led by Professor Ruoling Chen, for supporting my PhD study activities, particularly my PhD mates (Aishat Taiwo Bakre, Isaac Moses Danat, and Rizwan Nadim) for sharing their research experience, and an EU MSCA research fellow (Dr James Jie Tang) for the data analysis discussion and advice. I wish to sincerely thank Dr Martin Partridge and Amanda Rodney in the group for proofreading the thesis chapters 1, 2, 3, 5, 10 and 11. Anna Nottrodt, an independent academic proofreading person, has provided her proofreading of my PhD thesis chapters 4, 6, 7 and 9.

Finally, I express my gratitude to my friends and all others for their company and help here in the UK. I want to express my deep gratitude to my parents and my family for their caring, support and encouragement. I am grateful for all their efforts and love.

Funding: I obtained the QR travel grants and the QR GCRF funding from the Faculty and the University to support my attending of international conferences to give oral presentations about my research work and learning. The conferences were (1) the 6th International Conference on Epidemiology and Public Health, Paris, France, 23-25 October 2017, (2) the 24th Annual Cardiologists Conference, Barcelona, Spain, 11-13 June 2018, and (3) the joint European Stroke Organisation and World Stroke Organization Conference (ESO-WSO Virtual Conference 2020), Vienna, Austria, 7-9 November 2020.

CONFERENCE PRESENTATIONS AND JOURNAL PUBLICATIONS DURING PHD STUDY

Presentations at International and National Conferences

1. **Zhou, W.,** Hopkins, A., and Chen, R. Association between socioeconomic status and incident stroke in China. Oral presentation at the joint European Stroke Organisation and World Stroke Organization Conference (ESO-WSO Virtual Conference 2020), Vienna, Austria, 7-9 November 2020.
2. **Zhou, W.,** Chen, R., Hopkins, A., Tang, J., and Brunner, E. Different measurements of socioeconomic status and the risk of stroke in older men and women in China. Poster presentation at the 25th Annual Conference of Chinese Life Scientists Society in the UK (CLSS-UK), London, University College London United Kingdom, 14 September 2019.
3. **Zhou, W.,** and Chen R. Socioeconomic status and incident risk of stroke in older Chinese: the Anhui cohort study. Oral presentation at the Global epidemiology and Public Health Conference, Telford, University of Wolverhampton United Kingdom, 20-23 August 2018.
4. **Zhou, W.,** and Chen R. All-cause mortality in older people having heart disease with depression: a rural community-based cohort study in China. Oral presentation at the 24th Annual Cardiologists Conference, Barcelona, Spain, 11-13 June 2018.
5. **Zhou, W.,** Hopkins, A., and Chen R. Socioeconomic deprivation and survival in older adults with angina: a community-based cohort study in China. Oral presentation at the 6th International Conference on Epidemiology and Public Health, Paris, France, 23-25 October 2017.

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2. **Zhou, W.**, Hopkins, A., Zaman, M. J., Tao, X., Rodney, A., Yao, Y., Cao, Z., Ma, Y., Hu, Z., Copeland, J., & Chen, R. (2020). Impacts of heart disease, depression

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CHAPTER ONE: INTRODUCTION

1.1 Introduction

This chapter presents an overview and background of the thesis. It includes the definition and development history of socioeconomic status, its measurements, and the global overview of the association of socioeconomic status with health. This chapter also presents a brief outline of the overall structure of the thesis.

1.2 Background

1.2.1 SES definition and development history

Socioeconomic status (SES) is one of the most widely used constructs in epidemiological, economic, and social science research. It is a composite measure of an individual's or family's social and economic position in relation to others (Kawachi and Berkman, 2000, Oakes and Rossi, 2003). SES can be broadly defined as one's access to financial, social, cultural, and human capital resources (Statistics, 2012).

The term SES is used to describe one's resources access and position within the social structure. There are two components in SES including the actual resources and status (Krieger et al., 1997). Actual resources are ones an individual already has, such as education, material wealth, and social support. Status, on the other hand, concerns potential availability of resources when needs arise. The higher the social status, the more access to potential resources. In general, an individual's SES is traditionally defined as the educational level, occupational class and income level (Statistics, 2012). Status can be reflected in income and achieved through education and occupation.

The importance of social conditions for health has been recognised for centuries. Ever since the number of deaths was counted by John Graunt in England in the 17th century, the impact of social variations on morbidity and mortality have been observed

(Graunt, 1977). In the 19th century, physicians such as Villerme (Villermé, 2008) and Virchow (Virchow and Rather, 1985) also identified social class and work conditions as important determinants of health and disease through observations (Rose, 1992). However, early studies often concentrated on the adverse effects of health from poverty, poor housing conditions, and work environments.

By the 20th century, the term of SES was gradually established, although the hierarchical conceptions of society can be traced back to a long time ago. In the 1920s, Pitirim Sorokin promoted a view of stratification in society, where each person or group had a position or "status" in that hierarchy (Pitirim, 1927). Max Weber (Weber et al., 1946) further depicted the multidimensional qualities of position, such as economic arrangements leading to "class," social arrangements to "status," and political arrangements to "power." Since concepts were put forward by Sorokin, there have come to a long way to develop an objective, factual, behaviouristic, and quantitative sociology. Starting from Counts' scale in 1925, a sociologist reviewed the literature in 1953 and counted about 333 publications on the topic of SES to that year (Coover, 2016). However, this field has since grown exponentially with almost 2.5 million papers on this topic being published.

1.2.2 Measurement of SES

SES is frequently implicated as one of the major determinants to population health. Different measurements of SES in populations could have different health research findings and conclusions, as well as implications for practice and policy (Braveman et al., 2005). Each SES measurement will emphasise a particular aspect of social stratification, which may be more or less relevant to different health outcomes and at different stages in the life course (Havranek et al., 2015). On the other hand, most SES measurements are, to different degrees, correlated with each other, because they all measure aspects of the underlying socioeconomic stratification (Galobardes et al., 2007).

Choosing the variables or approaches that are relevant to the populations and outcomes under study are important for SES measuring. SES is typically measured using either individual variables of educational level, occupational class, income, or a composite SES variable. A brief explanation of the main indicators used to measure SES in health research will now be presented.

1.2.2.1 Educational level

Education as a main socioeconomic indicator has been widely used in epidemiological studies. The level of education is a strong determinant of SES as it shapes potential occupational class and income expectation. Within the life course framework, education measures the transition from childhood SES to one that will be the individual's own. Educational level is considered as the most basic and reliable variable; it allows classification of individuals who do not work such as housewives and retired older adults (Smith et al., 1998).

Education can be measured usually as a continuous variable meaning the total number of years spent on full time schooling, or as categorical measuring by the levels achieved, which might be specified experience or completing a specified number of years (Galobardes et al., 2006). For example, in China, educational level can be classified as Primary School (1-6 years of schooling), Junior (Lower) Secondary School (7-9 years of schooling), Senior (Upper) Secondary School (10-12 years of schooling), Bachelor's Degree (13-16 years of schooling) or Short Cycle (Zhuanke, 13-14 years schooling), Master's Degree (17-18 years of schooling), and Doctoral Degrees (19-21 years of schooling).

Educational achievement, to a large extent, is acquired during childhood and youth, which generally stabilises in the adult years. Thus it could be more likely to avoid being affected by health impairments that may emerge in adulthood (Kawachi and Berkman, 2000). The main advantages of studying associations between education and health are that educational level is easily recorded and kept in most of national datasets (Ferrario et al., 2017). It is relatively easy to measure self-administered questionnaires and response rates to educational questions tend to be high.

1.2.2.2 Occupational class

Occupation is one of the most frequently used indicators for SES in health research (Galobardes et al., 2006). To some extent, it determines individuals' income and health benefit provisions (MacDonald et al., 2009) and it also reflects their educational level, skills, and social standing (Fujishiro et al., 2010).

Occupation has been used, mainly in European countries, as a marker of social stratification (Krieger et al., 1997). For example, in the UK social stratification has traditionally been conceptualised in terms of someone's occupation and is recorded systematically on all death certificates. There is a six-level categorisation in the British Registrar General's Social Classes (SC), including (I) Professional occupations, (II) Managerial and technical occupations, (III) Skilled non-manual occupations, (IV) Skilled manual occupations, (V) Partly-skilled occupations, and (VI) Unskilled occupations, which were introduced in 1913 and used to show association of health gradients (Marmot et al., 1991).

Approaches for examining occupation as a measure of SES in health studies include occupational class, occupational prestige, work content, and access to health coverage and sick leave. A number of occupational schemes measure particular aspects of SES, but they all include the generic mechanisms that associate SES with health (Galobardes et al., 2007). In addition, occupation-based indicators will capture more specific job-related factors, such as exposure to certain toxic or physical working conditions. Occupation (parental or individual adult) is strongly related to income and therefore any association between occupation-based SES and health may indicate a direct relationship between material resources and health. Occupations also reflect social standing or status and may be related to health outcomes because of certain privileges – such as easier access to and better quality of health care, access to education and more salubrious residential facilities that are more easily achieved for those of higher standing (Galobardes et al., 2007).

1.2.2.3 Income

Income is a SES measure of material circumstances in most socioeconomic studies. Although the possession of money *per se* is unlikely to directly affect most health outcomes, the ways in which money is used to provide health-promoting environments (work, residential), allow consumption of health-enhancing commodities (food, exercise) and facilitate access to health services, have an important effect on health (Galobardes et al., 2007).

Assessing SES by income may raise the question of how to measure income appropriately. Usually, income is measured by selection of a predefined range of income based on monthly or yearly, or by self-reported satisfaction of income; also, income can be measured either for the individual or according to the family average income (Galobardes et al., 2006). Annual household income represented total income received by all family members sharing the same household in the previous calendar year (Wu et al., 2008). The income range can be straight forward to assign based on individuals' monetary value, if a person's income is all derived from wages, salaries, bonuses, government payments, pensions, investment, and social financial assistance. Family members were all same house residents conjoined through blood, marriage, or adoption. Per capital household income was computed by dividing total household income by number of individuals in the same household.

Income is likely to be a more 'sensitive' indicator than educational level and occupational class with respect to participants' willingness to disclose this information accurately. There is evidence that participants may be reluctant to reveal information about their actual earning when data collecting with face-to-face questionnaire (Galobardes et al., 2006). Therefore, researchers consider the subjective opinion of self-reported 'satisfaction of income' as also an important objective SES measure (Demakakos et al., 2008), although this may be subject to nonresponse or reporting bias. In addition, even if numerical values can be categorised as different income level accordingly, its relation to SES can only be appreciated when it is relative to the cost of living. Income usually varies in different countries, regions, birth cohorts, or by gender, thus special caution should be taken in the analysis of multinational comparisons.

1.2.2.4 Area-based SES

Area-based measures of SES are employed when the object of analysis is a geographical area SES rather than the individual (Galobardes et al., 2007). Previous studies from geography, epidemiology, and public health showed significant association of living location with health outcomes. A whole body of research conceptualises place as the unit of analysis to assess the geographical inequalities of SES in health (Tunstall et al., 2004). It is a way to evaluate health policies and provision of health services which are specifically implemented and delivered through places.

Similar to area-based SES, urban-rural living is a widely used indicator in epidemiological sociology, particularly in low and middle income countries such as China (Mangal et al., 2015). In China it is more preferable to use urban-rurality as respondents' area-based SES (Mangal et al., 2015). Current urban-rural structure is a dual social status where urban and rural have their own characteristics due to the unique household registration system (*hukou* system). There were wide inequalities between urban and rural areas in education, employment opportunities, income, political rights, social welfare, and healthcare services access (Cao et al., 2009). The health-related strategies such as medical insurance mainly depend on the policies issued in *hukou* registered locations rather than a geographically location where the individual is currently living (Yan et al., 2017).

Area-based SES is specifically needed when the goal of research is to investigate whether socioeconomic aspects of the place where a person lives, over and above individual socioeconomic circumstances, affect that person's health. A broader view of place provides a much richer potential to understanding disease processes. Studying place as a unit of analysis will describe and account for all the people that live in it, their class, the accumulation of capital in the place, and all factors that will ultimately shape health. Area-based SES can also be used as proxies for individual-level SES when individual measures are not available and different groups in terms of areas are compared.

1.2.2.5 Composite SES

Composite SES can be measured by aggregating individual-level SES (e.g., proportion with higher education, proportion of unemployed, blue-collar, or manual occupations, average income) in an appropriate area level. It is also possible to create a composite variable or index with weights for several individual-level indicators. For example, ‘deprivation indices’ have been widely used in the UK to characterize areas on a continuum from deprived to affluent. In the UK, geographical variations in deprivation have important policy implications, as they serve to allocate public resources to areas. There are some well-known deprivation indices used commonly such as Index of Multiple Deprivation (IMD) in England and Carstairs Index (Carstairs and Morris, 1989) in Scotland. IMD quantifies relative deprivation across seven domains including income, employment, education and skills, health and disability, crime, barriers to housing and services, and living environment (McLennan et al., 2019), which is calculated at the super output area (SOA) level, with average population sizes of approximately 1,500 persons, while the Carstairs index is based on four census variables including low social class, lack of car ownership, overcrowding and male unemployment and the overall index reflects the material deprivation of an area, in relation to the rest of Scotland, which is calculated at the postcode sector level, with average population sizes of approximately 5,000 persons. Other similar indices are the Jarman Score (Jarman, 1991) and Townsend deprivation index (Townsend et al., 1988) in the UK, the Index of Relative Socio-economic Disadvantage (IRSD) in Australia (Walker and Hiller, 2005), and the New Zealand Index of Deprivation (NZDep) in New Zealand (Atkinson et al., 2014).

1.3 SES measured worldwide and in countries

1.3.1 SES in world

The World Bank has historically classified every economy as low, middle, or high income countries. It now further specifies countries as having low-, lower-middle-, upper-middle-, or high-income economy. The World Bank uses gross national income (GNI) per capita, in current U.S. dollars converted by the Atlas method of a three-year moving average of exchange rates, as the basis for this classification. GNI is viewed as a broad measure and the single best indicator of economic capacity and progress, which can change with economic growth, inflation, exchange rates, and population.

1.3.1.1 High income countries

High income countries are defined by the World Bank as a country with a GNI per capita of US $12,376 or more in 2019; there are 81 countries and territories classified as HICs accordingly. Several institutions, such as the Central Intelligence Agency (CIA) or International Monetary Fund (IMF), take factors other than high per capita income into account when classifying countries as "developed" or "advanced economies". According to the United Nations, for example, some high-income countries may also be developing countries. The Gulf Cooperation Council (GCC) countries, for example, are classified as developing high income countries. Thus, both developed and developing countries may be classified as high income countries.

1.3.1.2. Middle income countries

Middle income countries are broken up into lower-middle income and upper-middle income economies. Lower-middle-income economies have per capita GNIs between $1,026 and $3,995 in 2019, while upper-middle economies have per capita GNIs between $3,996 and $12,375. There are 53 lower-middle income economies and 56 upper-middle economies worldwide according to the World Bank in 2019. Middle income countries are a very diverse group by region, size, population, and income level, ranging from tiny nations with small populations, such as Belize and the Marshall Islands, to all four of the BRIC giants—Brazil, Russia, India, and China. China and India together account for nearly one-third of the world's population and are increasingly influential players in the global economy.

The diverse nature of these 109 middle income countries means that the challenges facing many of them are quite different. For nations in the lower-middle-income category, the biggest issue might be providing its citizens with essential services, such as water and electricity, while for the economies in the upper-middle-income category, the greatest challenges could be reducing socioeconomic inequalities between poor and rich.

1.3.1.3 low income countries

Low-income countries are defined as nations that have a per capita GNI of less than $1,026 in 2019. Low income countries are often synonymous with underdeveloped countries, also known as developing countries, emerging markets, or newly industrialized countries. These countries receive development aid, which is financial aid given by governments or agencies from other countries to boost and support the economic, political, social, and environmental development.

There are currently 32 countries in the low-income country's category. Somalia is at the bottom of the low-income countries list, with a GNI per capita of $130. Low income countries face struggles relating to a poor economy. Issues related to poor economic health include below average life expectancy, high infant mortality rates, poor educational outcomes, degrading infrastructure, environmental and climate conditions, and poor health outcomes.

1.3.2 SES in China

1.3.2.1 China's economic story over the past four decades

The economy of China has transitioned from a state dominated planned socialist economy to a mixed economy over the past four decades. In December 1978, China started to undertake a programme of gradual but fundamental reform of the economic system. The economic reform in China, which is known in the West as the Opening of China, refers to the programme of economic reforms termed “Socialism with Chinese characteristics” and “socialist market economy”. The reform has introduced market principles with two stages. The first stage, in the late 1970s and early 1980s, involved the de-collectivisation of agriculture, the opening up of the country to foreign investment, and permission for entrepreneurs to start businesses. The second stage of reform, in the late1980s and 1990s, involved the privatisation and contracting out of much state-owned industry and the lifting of price controls, protectionist policies, and regulations, although state monopolies in sectors such as banking and petroleum remained. The two-stage reforms significantly raised willingness to work hard and produce a greater yield. Meanwhile Chinese authorities established a series of special economic zones (Shenzhen, Guangdong in 1980) and new areas (Pudong, Shanghai in 1992) for foreign investment in coastal regions that were relatively tariff reduction and free of the bureaucratic interventions that hampered economic growth. These new economic districts that supported by central government became engines of growth for the national economy (Brandt and Rawski, 2008). With deeper integration into the world economy, China further opened its economic and joined the World Trade organisation (WTO) in 2001. The domestic private sector grew remarkably, accounting for as much as 60% of China’s GDP by 2018. Unprecedented growth has occurred in China since economic reform in 1978, with the economy GDP increasing by average 9.5% per year. The processes of reforms with marketisation, decentralisation and globalisation have greatly reduced poverty. However, income inequalities have being increased between coastal and inland regions in China, and also between urban and rural areas.

1.3.2.2 Income gap between urban and rural residents

Since the opening up of China, rapid economic growth has brought huge improvement in people's living standards and lifted millions out of extreme poverty. In China, many people have experienced rising real incomes since reform in the late 1970s. During the period of 1978-2015, the real income of the bottom 50% of Chinese households has been increased by about five times on average (Piketty et al., 2019). Meanwhile rapid economic growth brought about large income gap between the rich and the poor, urban and rural areas, and southeast coastal and northwest inland regions. Recent studies showed that the poorest quarter of Chinese households owned less than 2% of the national total wealth, while the richest 1% owned more than one third (Xie and Jin, 2015). This rapid growth at the top end of the income distributions has transformed China into one of the world's most unequal countries. Gini coefficient for income in China, a widely used measured of inequality, was 0.73, higher than the US 0.41 and Germany 0.32, while the World Bank considers a coefficient above 0.40 representing dangerous levels of inequality (Xie and Jin, 2015). Previous studies demonstrated that urban-rural discrepancy and regional differences (southeast coastal vs northwest inland regions) are two major factors accounting for overall income inequality; both have widened substantially in recent years. In China the biggest income gap is from differences between urban and rural areas, which has become more serious in recent years. Rural poverty persists as urban wealth growing rapidly. The gap is often attributed to policies of household registration (hukou system). Although the government has carried out reforms of the hukou system so as to have greater mobility in recent years, substantial barriers aiming to protect the welfare of registered urban residents (e.g., schooling and health insurance) remain. Wan et al (Wan, 2007) reported that China's income gap between rural and urban areas accounted for 70-80% of the overall regional inequality. Emerged data has shown that on average, the per capita disposable income of rural households (US$1818) remained 2.72 times lower than that in urban areas (US$4944) in 2016 (Chinese National Statistics Bureau, 2019).

1.3.2.3 Population ageing in China

China has experienced rapid economic growth since the market-economy reforms and opening-up policy in the early 1980s. As a middle-income country it has shown rapid improvement in health conditions and undergone epidemiological transitions in the decades following the founding of the People's Republic of China in 1949. Data from the Chinese Disease Surveillance Point system from 2004 to 2016 showed that the mortality and infant-mortality rates have decreased continuously and significantly (Zhu et al., 2019). However, health disparities also exist alongside the rapid economic growth. There is a clear gradient linking life expectancy and GDP in different provinces: life expectancy was 80.26 years in Shanghai compared with 71.10 years in the poorest province of Guizhou, for example (Chinese National Statistics Bureau, 2019).

China is currently the most highly populated country in the world in terms of both total population and the number of elderly people. The total population in 2018 was more than 1.39 billion (Chinese National Statistics Bureau, 2019). The demographic structure has changed since the implementation of the one-child policy in urban areas in 1979, and the rapid economic and societal development of recent decades. China has become an ageing society as a result of declining fertility and increasing life expectancy (Luo and Xie, 2014). In 2018, the proportion of Chinese citizens above 60 years old reached 17.9%, approximately over 249 million (Chinese National Statistics Bureau, 2019). In addition, according to the National Statistics Bureau of 2015, the life expectancy of Chinese people was 76.34 years (73.64 years for males and 79.43 years for females). More importantly, while adults aged 65 and over accounted for 10.5% of the total population in the year 2015, this proportion is estimated to increase to approximately 17.2% by 2030 and 27.5% by 2050, respectively.

1.4 Association between SES and health

SES as comprehensive measures of the social standing is a widely used concept in health studies. It is strongly associated with the health conditions and outcomes of an individual or a family (Sharma, 2013) and the association has been found to cross cultural and geographic boundaries (Zimmer and Kwong, 2004). Evidence showed that SES disparities were correlated with health inequalities; generally speaking, lower SES is associated with worse health (Yu et al., 2019) and higher mortality (Signorello et al., 2014). The effects of SES on health can be expressed by differences in lifestyles, exposure to occupational hazards and environmental pathogens, low levels of social support and social capital, access to health services, poor social policy, the cumulative effects of stress and differences in health risk behaviours (Kagamimori et al., 2009). Although there is some evidence of a diminishing influence in the association of SES with health at old ages, it appears that older adults of low SES are not completely immune to its deleterious health effects (Zimmer and Kwong, 2004).

1.4.1 Association of low SES with poor health

Low SES is significantly associated with a wide range of health problems that carry a heavy burden of morbidity and premature mortality in a majority of modern societies. This particularly occurs among older adults, on chronic and preventable disease such as cardiovascular disease (CVD) (de Mestral and Stringhini, 2017), metabolic syndrome (Montez et al., 2016), arthritis (Brennan-Olsen et al., 2017), tuberculosis chronic respiratory disease (Gupta et al., 2011), gastrointestinal disease (Haag et al., 2011), and psychological stress (Santiago et al., 2011).

SES is considered as a fundamental cause of health inequalities in social epidemiology. Link and Phelan (Link and Phelan, 1995) argued that regardless of the mechanisms between SES and diseases, those with high SES have more resources access to protect health, such as money, knowledge, prestige and beneficial social support. Socioeconomic inequalities in health are apparent at almost every stage in the life course, from birth (neonatal outcomes, infant mortality) to working age (e.g., CVD, accidents) and old age (functional disability). Exposure to low SES during a specific developmental period have reverberating consequences years later that cannot ever be fully ameliorated. For example, in early childhood low SES could influence developmental process (particular brain and body development needed adequate nutrition intake during period of great plasticity but low SES family could not provide it) (Power and Hertzman, 1997), and these low SES in early life stages would then make the individual aplasia or suffer from various diseases in adulthood. Adults with low SES are more likely to have unhealthy behaviours such as smoking and alcohol drinking, which cause many chronic diseases. Moreover, adverse impact on health can be from early exposure and adult exposures simultaneously across the life course, and these cumulative exposures take a toll at older ages. Inadequate nutrition intake in childhood and financial difficulty in adulthood both would have an accumulated risk of all-cause mortality in older ages.

1.4.2 Association of poor health with low SES

The bidirectional pathways between SES and health have been emphasised by epidemiologists (Smith, 2007). For example, income affects health as individuals with more income can afford healthier foods and better healthcare, while health can also affect income as healthier individuals are able to work more productively (Svedberg et al., 2019) and have higher income (Muennig, 2008). Similar reverse causality also can be found in the association of health with education; ill-health in childhood may limit educational attendance and/or attainment and predispose to adult disease, suggesting that childhood health influences SES throughout adulthood (Case and Paxson, 2010).

Health selection theory demonstrates that poor health would result in low SES as the process by which differences in health status lead to differences in socioeconomic position (Goldman, 1994). Healthier individuals could achieve favourable position in society, but not in those with poor health. Ill health prevents someone from undertaking high paid employment, and thus reduces income and wealth accumulation (Galama and Van Kippersluis, 2013). Furthermore, long-term ill health in childhood, reduces educational outcomes, and therefore affects employment opportunities and earning potential later in life (Benzeval et al., 2014). There are also more subtle mechanisms. For example, people's health, in particular obesity, height and physical appearance, can influence economic outcomes such as employment opportunities or wages. Previous studies showed that shorter stature and higher BMI were associated with lower SES; women with higher BMI had lower annual household income and higher deprivation, while men with shorter stature had lower education, annual household income and job class (Tyrrell et al., 2016).

Bidirectionality of causation between health and SES is an especial characteristic of adult populations. People who are unable to work due to health reasons may have reduced their occupational class and income due to their health impairments. There is evident showing that two years after the sudden illness, the employment probability lowers by 7% and personal income by 5% (García-Gómez et al., 2013).

1.5 Overview of the research topic

Heart disease is the number one killer and stroke is the number two (Lozano et al., 2012), and both are the main health problems in the world. The existence of socioeconomic differences in the incidence and mortality of heart disease and stroke has been well documented in most west countries. Despite improvements in health inequalities in many countries, disparities in the incidence and mortality of heart disease and stroke between socioeconomically disadvantaged groups and their relatively prosperous counterparts continue to exist, and possibly to widen. Effective strategies and preventive interventions of health promotion, through reducing socioeconomic inequalities, need to be implemented to reduce health inequalities in heart disease and stroke, particularly in older people.

Heart disease and stroke are ageing-related diseases (Mattiuzzi and Lippi, 2020), approximately 70% of heart disease and stroke occurring in persons aged over 65 years (Odden et al., 2011, Yousufuddin and Young, 2019). The incidence of heart disease and stroke continue to increase worldwide and especially in low- and middle-income countries (LMICs), including China, where population is ageing and income gap between rich and poor is widening. However, fewer studies have been done to investigate the association of SES with heart disease and stroke, and evidence linking SES to these two conditions remains limited in LMICs. Most of the available evidence from LMICs originates from hospital-based studies with varying quality and from middle-aged populations (de Mestral and Stringhini, 2017). There remains a need for more research to better understand the association of SES with the incidence and mortality of heart disease and stroke in older adults in LMICs. Therefore, the focus of this thesis is to examine their associations in older people in China.

1.6 Outline of the Thesis

This thesis examines the association of SES with heart disease and stroke in older people in China. It employs two large-scale community-based cohort studies to explore the association of different measurements of SES with the risk and mortality of heart disease and stroke. The thesis includes and presents systematic literatures and meta-analysis to strengthen the evidence of the associations in older people in China.

The thesis is divided into six distinct studies with an overarching theme that reflect the association of SES with incidence and mortality of heart disease and stroke in older Chinese adults. The first chapter sets the context. This chapter provides an overview of the research topic, the SES definition development history, its measurements and the global overview of the association of SES with health. The second chapter presents a critical review of the literature on the associations of incidence and mortality of heart disease and stroke worldwide and includes a summary of the main gaps and rationale for the PhD study, research question and objectives as well as the conceptual model for the research. The third chapter describes the methodology adopted throughout the thesis. It highlights the rationale for the quantitative research methods including data collection and analysis of the study. The fourth chapter reviews systematically and performs meta-analysis for the existing studies in the impacts of low SES on the incidence and mortality of heart disease and stroke in China. The fifth chapter examines prevalence and demographic characteristics related to SES among older adults in China. The sixth chapter investigates associations between different measurements of SES and incidence of heart disease in older Chinese. The seventh chapter assesses the associations between different measurements of SES and all-cause mortality in old adults with heart disease. The eighth chapter investigates the associations between different measurements of SES and incidence of stroke in older adults. The ninth chapter assesses the associations between different measurements of SES and all-cause mortality in older adults with stroke. The tenth chapter examines the impacts of SES on all-cause mortality in those with either heart disease or stroke and those with neither. The eleventh chapter presents the overall discussion by presenting the summary of key findings and relationships of different measurements of SES with incidence and mortality of heart disease and stroke. This chapter also presents the strengths, limitations, implication, and suggestions for future research, followed by conclusions.

CHAPTER TWO: OVERALL LITERATURE REVIEW FOR ASSOCIATION OF SOCIOECONOMIC STATUS WITH HEART DISEASE AND STROKE

2.1 Introduction

This chapter reviews the literature on association of socioeconomic status (SES) with incidence and mortality of heart disease and stroke. Its first part covers literature on the association of SES with incidence and mortality of heart disease, and the second part reviews the association with incidence and mortality of stroke. The gaps of knowledge on the topic along with the rationale, the aim and the objectives for the study are presented.

2.2 Social determinants of health inequalities

The gross inequalities in health present a challenge to the world. The gap was almost up to 20 years in life expectancy within countries and 50 years between countries, respectively (Marmot, 2005). Many studies showed that these inequalities in health could be largely explained by social factors. In a social determinants perspective, relative deprivation (e.g., income distribution) is an important focus in the health gradient, showing relation to both material or physical needs and capability, spiritual, or psychosocial needs (Marmot, 2005).

In the current thesis, the widely cited Dahlgren and Whitehead rainbow model of the main determinants of health was employed as a framework to help identify the choice of socioeconomic indicators (Dahlgren and Whitehead, 2006). The indicators of SES selected in the thesis were based on the second outer layer (Figure 2-1), which included living and working conditions, specifically education, work environment, unemployment, housing, health care services, and essential goods and services. The housing and health care services substantially differ between region and area, while the availability of essential goods including agriculture and food products are associated with income and financial status. Therefore, in the thesis, I used four SES indicators, including educational level, occupational class, income, and area-based SES, to assess their associations with health inequalities.

Figure 2-1. Dahlgren and Whitehead's model of the social determinants of health

2.3 Association of SES with heart disease

Heart disease is a leading cause of death and accounts for about one-fifth of deaths worldwide (Lozano et al., 2012). The term "heart disease" covers any disorder of the heart, and denotes various types of heart conditions including coronary heart disease (CHD), hypertensive heart disease, cardiomyopathy and myocarditis, rheumatic heart disease, atrial fibrillation and flutter, or any other heart diseases. CHD is one of the most common types of heart disease worldwide, accounting for over 70% of heart disease (Lozano et al., 2012).

2.3.1 SES and incidence of heart disease

The research on SES associated with heart disease has been extremely dynamic over the last half century. There is marked variation in their associations among different regions of the world - both between nations and even regions within a country. Over the past 3 decades, CHD mortality rates have decreased significantly in high income countries (HICs), while the incidence of CHD has still increased in low- and middle-income countries (LMICs) (Roth et al., 2015, Roth et al., 2017). In the coming decades, the number of heart disease patients is estimated to increase substantially in LMICs (Yusuf et al., 2014).

Previous studies showed that low SES was associated with increased risk of heart disease (Lewis et al., 2015, Veronesi et al., 2016, Wang et al., 2017a). However, most of the knowledge on the association comes from studies performed in HICs (de Mestral and Stringhini, 2017). Few studies have investigated the impact of SES on the risk of heart disease in LMICs (Wang et al., 2017a). The potentially causal association between SES and the risk of CHD was unclear in LMICs.

2.3.1.1 Educational level and incidence of heart disease

Education remains the predominant SES indicator in epidemiologic studies. In a 2017 meta-analysis of 17 cohort studies (participants aged 38.85-67.34 years) undertaken in Europe, North America, and East Asia (all were HICs), Khaing et al. reported that pooled relative risk (RR) of CHD in people with low versus high educational level was 1.36 (95% CI 1.11-1.66), and the corresponding RR for medium versus high education was 1.21 (1.06-1.40) (Khaing et al., 2017). Lewis et al. (Lewis et al., 2015) found that increased incidence of CHD associated with low educational level was more evident among older adults; when compared to those with higher educational level, participants at age ≥65 years with lower educational level had increased risk of incident CHD (HR

1.82, 1.02-3.25), but at age <65 years the corresponding risk was not increased (HR 0.96, 0.31-3.02).

The findings of the association of educational level with incidence of heart disease are inconsistent in HICs outside Europe and North American, and in some middle income countries, while the data in low income countries is scarce. In a 2015 meta-analysis of 24 studies from Australasia, China, Japan, Taiwan, Thailand, and Singapore, Woodward et al. (Woodward et al., 2015) found no associations between education and incidence of all coronary disease (fatal or non-fatal) in Australasian and in Asian countries; the pooled HRs for primary or below vs tertiary education in relation to all coronary disease incidence were 1.15 (0.98-1.35) and 1.18 (0.83-1.67) respectively.

Recent large nationwide cohort studies from HICs showed that educational disparities in the incidence of heart disease varied by diagnosis (Christensen et al., 2016). Data of all Danish residents aged 35-84 years between 1985 and 2009 showed that there were significant differences between low and high educational level in the incidence of CHD, acute myocardial infarction (AMI), heart failure, while inequality in atrial fibrillation and in valvular heart disease was small and insignificant (Christensen et al., 2016).

Several studies have also assessed secular trends in educational inequalities in heart disease. In a 2014 study with 141,332 individuals in Norway, Igland et al. showed that relative inequalities in the incidence of AMI decreased between 2001 and 2009, although mortality remained constant (Igland et al., 2014). Similar decreasing trend for incidence of acute coronary events among persons with lower educational level can be found in previous cohort studies from Sweden (Yang et al., 2012a) and Finland (Lammintausta et al., 2012).

Studies also examined gender differences in the association of educational level with incident CHD. A 2017 meta-analysis of 116 cohort studies from 17 countries with over 22 million individuals showed that the relative risk for CHD for low versus high education was 1.66 (1.46-1.88) for women and 1.30 (1.15-1.48) for men (Backholer et al., 2017). The MORGAM (MOnica Risk, Genetics, Archiving and Monograph) study, which included 49 European cohorts of 110,928 participants with 12 years follow-up, reported that compared to the most educated participants, the risk of developing CHD in the least educated women was more evident (pooled HR 2.0, 1.7-2.4) than men (pooled HR 1.6, 1.4-1.8) (Veronesi et al., 2016).

2.3.1.2 Occupational class and incidence of heart disease

Much attention has been paid about the impact of occupational class on the risk of heart disease in HICs. Studies in HICs showed that people with low occupational class had increased risk of heart disease (Tenkanen et al., 1997, Ramsay et al., 2009, Manrique-Garcia et al., 2011). However, less investigation has been done on the association of occupational class with the risk of heart disease in LMICs.

The association of occupational class with incident heart disease has been well studied in HICs. A 2011 meta-analysis of 30 cohort and case-control studies from HICs, including almost four million participants, showed that a pooled RR for incident AMI in those with low occupational class was 1.41 (1.25-1.70) compared to those highest occupational class (Manrique-Garcia et al., 2011). Another meta-analysis of 15 cohort studies in 2016 showed that a pooled RR for CHD for manual versus non-manual occupational class was 1.59 (1.28-1.97) in women and 1.50 (1.25-1.80) in men (Backholer et al., 2017). A similar association can be found in the older population of which most of have already retired. A population-based cohort study, which followed up 3,761 British men aged 60-79 years for 6.5 years showed that adjusted hazard ratio

(HR) for incident CHD was 2.14 (1.06-4.33) in those of unskilled workers compared to those professionals (Ramsay et al., 2009). Literature on the association of occupational class with incident heart disease remains scare in LMICs, probably because a large proportion of their populations work in the informal sector (Galobardes et al., 2006).

2.3.1.3 Income and incidence of heart disease

Income and wealth are often thought to be associated with the risk of incident heart disease. Most studies in HICs showed that individuals with low income had an increased risk to develop heart disease. The meta-analysis of 28 studies from Europe, 4 from USA, and 4 from Asia showed that a pooled RR for CHD was 1.49 (1.16-1.91) in low income groups and 1.27 (1.10-1.47) in medium income groups when compared to high income groups (Khaing et al., 2017).

The impact of low income on the risk of heart disease in men is the same as that in women. A study of 6,913 US participants with a longer follow-up of over 22 years showed that low household income was associated with increased risk for developing CHD in men (adjusted HR 1.35, 1.06-1.71) and in women (HR 1.40, 1.10-1.79) (Thurston et al., 2005). Similarly, a multilevel study of 2.6 million participants with 3 years follow-up in Sweden showed that women and men with low income had a 70% and 62% increased risk for developing CHD respectively, compared to their counterparts with high income (Sundquist et al., 2004a).

Literature on the association of income with incident heart disease remains scare in LMICs. A 12-year follow-up study of 2,704 participants aged ≥20 years in Turkey showed that compared to the high family income, the RR for people in the low family income was 1.75 (1.17-2.61) in CHD events after adjustment for age, sex, and other major risk factors (Keleş et al., 2003).

Economic difficulties in terms of financial crisis or financial problems were associated with increased risk of CHD. A recent cohort study of 3,937 participants aged 23-35 years with over 30 years follow-up in USA showed that the risk of incident CHD was higher among those with higher income volatility (high vs low volatility: HR 2.07, 1.10-3.90) and income drops (≥2 vs 0 income drops: HR 2.54, 1.24-5.19) after adjustment for sociodemographic, behavioural, and CVD risk factors (Elfassy et al., 2019). However, there has been no study to assess such association in older adults.

2.3.1.4 Area-based SES and incidence of heart disease

Literature on the association between place of residence and incidence of heart disease is growing, mostly from HICs. Areas where people live is usually thought of as an important predictor of his or her health. Socioeconomic environment of living location (e.g., neighbourhood education and neighbourhood income) may differ in many aspects, such as dietary habits and health care access (Sundquist et al., 2004b).

The association of area-based SES with incident HD has been well established in HICs. Data from the Atherosclerosis Risk in Communities Study with 9.1 years follow-up among 13,009 US participants showed that people living in disadvantaged areas, which was defined by a summary score for the socioeconomic environment, had higher risk of incident CHD than people living in advantaged areas, in particular among those with low income living in disadvantage areas (Roux et al., 2001). The HR for incident CHD among those living in the most disadvantaged areas was 1.6 (1.1-2.2) in Whites and 1.5 (1.0-2.3) in Blacks after adjusted for individual SES indicators of education, occupation, and income (Roux et al., 2001). A recent cohort study of almost one million participants aged 40-50 with a mean follow-up time of 5.5 years in Sweden showed that the fully-adjusted HR for incident myocardial infarction for low versus middle neighbourhood SES was 1.24 (1.13-1.36) in men, and 1.17 (1.00-1.38) in women

(Carlsson et al., 2016). The match figures for incident CHD were 1.23 (1.14-1.32) and 1.24 (1.10-1.40) (Carlsson et al., 2016). Another Swedish study of 2.6 million participants with 3-year follow-up showed the risk of CHD in relation to the area-based SES, which was measured by the use of Care Need Index (Sundquist et al., 2004a). The study found that after full adjustment for confounders including personal income, the risk of incident CHD was 87% increased for women and 42% increased for men in the most deprived areas compared to the most affluent areas (Sundquist et al., 2004a).

The evidence of area-based SES associated with incidence of heart disease remained scarce in LMICs. Few studies have investigated the association of area-SES with the risk of heart disease in LMICs, which might be due to lack of area-based SES data. Even in China and India where exist large inequalities between urban and rural areas, no study has assessed the impact of rural-urban disparity on incidence of heart disease. More studies are needed to analyse their associations in LMICs.

2.3.2 SES and mortality of heart disease

Heart disease is the single largest cause of death in the world (Lozano et al., 2012), in which CHD alone accounts for around 9 million deaths every year according to the WHO estimates (Nowbar et al., 2019). While the CHD mortality has fallen by more than half in HICs over the past 25 years, it has been increased rapidly in LMICs, accounting for more than 80% of global deaths from CHD (Finegold et al., 2013). The increased deaths from CHD might be due to socioeconomic changes, increase in life span and acquisition of lifestyle related risk factors (Gaziano et al., 2010). Economic development worldwide in the past few decades has contributed the overall increases in SES for people, regions and countries, but the impact of SES differences on mortality of CHD has varied in HICs vs LMICs (Rosengren et al., 2019).

2.3.2.1 Educational level and mortality of heart disease

Previous studies in the general population without baseline CHD have showed an association between low educational level and adverse cardiovascular outcomes (Bucher and Ragland, 1995). A US study of 3,154 middle aged men with 22 years follow-up showed that compared with college graduates, nongraduates had increased risk of CHD mortality (adjusted HR 1.54, 1.13-2.09) (Bucher and Ragland, 1995).

The association of low educational level with increased mortality in heart disease patients has also been established in HICs. A recent US study of 6,318 CHD patients with 4.2 years follow-up showed that compared to patients with graduate education, adjusted HR of all-cause mortality in patients with educational level of elementary/middle school was 1.52 (1.11-2.09), in high school 1.43 (1.17-1.73) and in college education 1.26 (1.03-1.53), and the corresponding HRs for cardiovascular death were 1.46 (1.02-2.11), 1.38 (1.10-1.73) and 1.24 (0.99-1.56) respectively (Kelli et al., 2019).

The inverse association of educational level with CHD mortality remained significant in subgroup by age. A longitudinal study of 10 European populations with 95 million person years showed that at ages over 60 years, compared to those with upper secondary education or higher, rate ratio of CHD mortality for men with lower secondary education or less was 1.22 (1.21-1.24) and for women 1.36 (1.33-1.38), while at ages 30-59 years, the corresponding figures were 1.55 (1.51-1.60) and 2.13 (1.98-2.29) (Avendano et al., 2006b). Similarly, in the analysis of patients with CHD from the Emory Cardiovascular Biobank, Kelli et al. (Kelli et al., 2019) found no significant difference between age <65 and ≥65 years in the association of educational level with all-cause mortality; the HRs for graduate vs others were 1.58 (1.14-2.19) and 1.20 (0.96-1.50), respectively.

There have been an increased number of studies of examining the impact of educational inequality on CVD mortality in LMICs, but few assessing association with heart diseases (Vathesatogkit et al., 2014, Woodward et al., 2015). Nevertheless, a recent cohort study of 3,369 patients with AMI in China showed that in patients who were illiterate vs college education, adjusted HR of 1-year mortality was 2.37 (1.13-6.83) (Huo et al., 2019).

2.3.2.2 Occupational class and mortality of heart disease

The impact of occupational class on mortality of heart disease has been extensively studied in HICs, particularly in Western Europe and the USA (Hemingway et al., 2000, Lostao et al., 2001, Emberson et al., 2004). The association of occupational class with mortality in heart disease patients remains small in either HICs or LMICs. But studies in HICs showed that in general populations heart disease mortality was higher in those with low occupational class than those with high occupational class. A prospective study of 5,628 middle-aged British men with 20 years follow-up showed that compared to those non-manual, the HR of CHD mortality in manual men was 1.50 (1.25-1.79) after adjustment for imprecision of social class measurement (Emberson et al., 2004). The estimated HR remained significant (HR 1.28, 1.06-1.54), after further adjustment for CHD risk factors including blood cholesterol, blood pressure, BMI, smoking, drinking, physical activities, and lung function (Emberson et al., 2004). A cohort study of 17,907 male civil servants aged 40-69 years with 25-year follow-up in London demonstrated that the lowest employment grade was associated with increased CHD mortality (HR 1.56, 1.2-2.1) compared to the highest employment grade (Hemingway et al., 2000).

A comparative study from the USA and 11 high-income European countries, including over 163,000 individuals aged 30-64 years, showed that CHD mortality associated with occupational class was varied by countries and age (Kunst et al., 1999, Mackenbach et al., 2000). The rate ratios comparing manual classes with non-manual classes for mortality were clearly above 1.00 in Northern and Western European countries, but below 1.00 in Southern European countries (Mackenbach et al., 2000). The study found that occupational differences in CHD mortality generally decreased with age, although they persisted at all ages; the association was stronger at age 30-44 years and attenuated 35%-65% at age 60-64 (Kunst et al., 1999).

In a 2016 study, Mackenbach et al. assessed changes in mortality inequalities in European countries from 1990 to 2010. Register based data of 12 countries, including Finland, Norway, Sweden, Scotland, England and Wales, France, Switzerland, Spain (Barcelona), Italy (Turin), Slovenia, and Lithuania showed that inequalities in manual vs non-manual occupations in mortality narrowed by up to 35% in most countries, which was driven mostly by decreasing CHD and smoking related causes (Mackenbach et al., 2016).

Most of these studies of examining the association between occupational class and mortality were carried out in HICs, and mainly in population aged <65 years old, and in men (Mackenbach et al., 2000, Lostao et al., 2001, Emberson et al., 2004). Few studies have investigated the impact of occupational class on mortality in older adults with heart disease. The data of occupational class associated with heart disease mortality remains scarce in LMICs. However, previous studies from the Seychelles (Stringhini et al., 2014), Bosnia and Herzegovina (Janković et al., 2015), India and Pakistan (Ali et al., 2016) suggested that compared to those with high occupational class, people with low occupational class had higher prevalence of CVD risk factors and increased CVD mortality. The impact of occupational class on mortality in heart disease patients in LMICs needs to be studied further.

2.3.2.3 Income and mortality of heart disease

Compared to other indicators of SES, income is less commonly used as an SES indicator to assess its association with mortality of heart disease, partly due to its sensitivity (Galobardes et al., 2006). There were a number of studies undertaken in HICs, suggesting that income was associated with all-cause and CHD mortality (Salonen, 1982, Bucher and Ragland, 1995). Data from the Western Collaborative Group Study of 3,154 employed middle-aged men with over 22 years follow-up showed that the RR of low income was 1.21 (1.03-1.43) for all-cause mortality and 1.27 (0.97-1.66) for CHD mortality (Bucher and Ragland, 1995). A longitudinal study of 3,644 men aged 30-59 in Finland showed that low income was associated with an excessive risk of death from any causes (RR 1.8, 1.2-2.6) and from CHD (RR 1.7, 1.0-2.9) (Salonen, 1982). Most of published studies were in middle age populations. There have been few studies undertaken in LMICs, although more evidence exists regarding the association between income and CVD mortality (Hoang et al., 2006) and risk factors (Bardach et al., 2016). No study has assessed inequalities in heart disease mortality related to income among older adults in LMICs. Previous studies in HICs suggested that social disparities in CHD mortality was six-fold between the most deprived and the most affluent individuals among those aged 35-44 years, although the inequality diminished with increasing age and reach equal level at ages above 85 years (O'Flaherty et al., 2009). Nevertheless, it is still an important issue to assess the impact of income on heart disease mortality in older people, particularly in LMICs, where there is an ageing population who may not have fixed pension after retirement.

2.3.2.4 Area-based SES and mortality of heart disease

Area-based SES was considered as one of the SES indicators associated with heart disease mortality. Hospital data studies showed that CHD patients with the highest versus lowest area-based SES (which was based on regional purchasing index (Moissl et al., 2019) or residential postcode (Jones et al., 2015)), had 70-90% increased risk of death. Data of 4,286 women from the British Women's Heart Study with 12-year follow-up showed that one standard deviation increase in Index of Multiple deprivation (IMD) score, had HRs of 1.25 (1.18-1.33) and 1.34 (1.15-1.55) for all-cause mortality and for CHD mortality, respectively (Sánchez-Santos et al., 2013).

Apart from area-based SES, studies in HICs assessed the difference of mortality of heart disease between urban and rural areas, showing that people living in rural or remoted areas had a higher risk of death due to CHD (Kulshreshtha et al., 2014, Australian Institute of Health Welfare, 2014). In the US, data from the National Centre for Health Statistics showed that age-adjusted CHD mortality was higher in rural (173/ per 100,000) than in urban areas (164 per 100,000) in 2014 (Kulshreshtha et al., 2014). In Australia, data from the Institute of Health and Welfare 2009-2010 showed that death rate from CHD for men and women aged 55-69 living in remote and very remote areas was 3.0 and 1.5 times, compared to their counterparts living in urban areas (Australian Institute of Health Welfare, 2014).

The evidence of area-based SES associated with mortality of heart disease in LMICs remains scarce. In contrast to studies in HICs, studies in LMICs showed a higher risk of CHD mortality in urban areas. In China, the Report on Cardiovascular Disease (Wei-Wei et al., 2017) showed that CHD mortality was slightly higher among residents of urban areas than rural, with the mortality rate of 107.50 versus 105.37 per 100,000 , which was crude data analysis. Data from the Disease Surveillance Point (Wan et al., 2018) suggested that although the mortality rates of CHD between urban and rural areas in China had an increase in the past decades, the rate increased more rapidly in rural areas. However, most studies showed that differences in the mortality rates of CHD between urban and rural were not adjusted for any confounders to remove the residual effects. It remains unclear whether there were significant urban-rural differences in mortality among patients with HD. This therefore requires further research.

2.4 Association of SES with stroke

The burden of stroke has increased across the world, with the disability-adjusted life years ranked at 3rd up from 5th since 1990 (Kyu et al., 2018). The global burden of disease study demonstrated that people in LMICs have a higher risk of stroke than in HICs (Johnson et al., 2019). Evidence showed that most of burden of stroke is in LMICs, which bear more than 70% of the incidence, mortality and DALYs (Hankey, 2013).

2.4.1 SES and incidence of stroke

Previous studies showed that low SES was associated with increased risk of stroke in the general population (Cox et al., 2006, McFadden et al., 2009, Addo et al., 2012, Marshall et al., 2015). Current knowledge of the impact of SES on incident stroke has been predominantly derived from studies undertaken in HICs. It may not be applied to those in LMICs. There is little research on the association between SES and the risk of stroke in LMICs.

2.4.1.1 Educational level and incidence of stroke

The impact of educational level on incidence of stroke has been well studied in previous studies (McHutchison et al., 2017), confirming that the lower educational level is associated with higher risk of stroke. In rural China, a cohort study of 14,936 participants aged ≥18 with 27 years follow-up showed that compared to those with schooling years of >9, the multivariate adjusted HR was 2.9 (1.3-6.5) in participant of

0 years, 3.1 (1.4-7.0) in those of 1-6 yeas, and 2.2 (1.0-5.1) in those of 7-9 years (Wu et al., 2019). McHutchison et al. (McHutchison et al., 2017) carried out a meta-analysis of 79 studies with 141,788 stroke patients and found that the risk of stroke was significantly increased in people with low versus high education (HR 1.33, 1.17-1.53). There is evidence of an educational gradient in the risk of stroke. In a meta-analysis of 72 cohort studies, Khaing et al. reported that compared to those with high educational level, pooled risk ratio of incident stroke was 1.23 (1.06-1.43) in those low educational level, and 1.17 (1.01-1.35) in those middle educational level (Khaing et al., 2017).

However, in older population studies there were some inconsistent findings in the association between educational level and incidence of stroke. A population-based cohort from the Health and Retirement Study in USA (n=19,565, aged above 50 years) with 8.5 years follow-up showed inverse association of educational level with stroke incidence at ages 50-64 years (HR 1.4, 1.1-1.7), but the increased incidence of stroke was not significant at ages 65-74 years (1.1, 0.9-1.4) and ages 75+ (1.2, 0.9-1.4) (Avendano and Glymour, 2008). The data of the New Haven cohort of 2,812 American participants with 12 years follow-up showed that compared to those with the highest education, people aged 65-74 with the lowest education had increased risk of incident stroke (HR 2.07, 1.04-4.13), while the corresponding HR in those aged ≥75 with was 0.42 (0.22-0.79) (Avendano et al., 2006a). The Three-City Study (3C study) in France, which included 9,294 non-institutionalised participants aged ≥65 years with 6 years follow up, also showed non-significant association between education and ischaemic stroke; HR was 0.92 (0.52-1.62) for intermediate educational level and 1.00 (0.52-1.89) for high education when compared to those with low education (Grimaud et al., 2010).

However, fewer studies have been done to assess the impact of educational level on risk of incident stroke in old people in LIMCs.

2.4.1.2 Occupational class and incidence of stroke

The association between occupational class and incidence of stroke has been well studied, but the findings have been inconsistent. In the UK, a prospective community-based study of 22,488 adults aged 39-79 years with over 10 years follow up showed that social class, indicated by occupational class, was inversely associated with stroke incidence; the HR for the lowest versus the highest social class was 2.55 (1.34-4.85) after full adjustment including educational level, and in those aged >65 years, the inverse association of low occupational class with increased stroke incidence remained (results not shown) (McFadden et al., 2009). In Sweden, a population-based sample of 6,994 men aged 47-56 years with over 35 years follow-up showed that participants with unskilled manual occupations had a significantly lower risk of incident stroke than those with high occupation of officials, and lower risk of ischemic stroke remained significant after accounting for competing risk of death (HR 0.62, 0.46-0.84) (Novak et al., 2013). Some studies showed weak association of occupational class with incidence of stroke. In a meta-analysis of 3 cohort studies, Backholer et al. reported a relative risk of incident stroke for manual versus non-manual occupations of 1.81 (0.91 to 3.62) in women and 1.50 (0.96 to 2.36) in men (Backholer et al., 2017).

Most of existing cohort studies were carried out in HICs (McFadden et al., 2009, Novak et al., 2013, Backholer et al., 2017), while few studies have been carried out in LMICs. To assess the association of occupational class with stroke incidence in LMICs is of importance, in particular those countries having higher risk of stroke such as China.

2.4.1.3 Income and risk of stroke

The association between income and incidence of stroke parallels that seen in education and occupational class above. In a meta-analysis including 4 cohort studies from Asia, 28 from Europe, and 4 from the USA, Khaing et al. reported that a pooled risk ratio of stroke incidence was 1.30 (0.99-1.72) in people with low versus high income groups, and 1.24 (1.00-1.53) in people with middle versus high income groups (Khaing et al., 2017).

Previous studies in HICs showed some inconsistent findings of the association between income and stroke incidence at old age (Avendano et al., 2006a, Avendano and Glymour, 2008, Grimaud et al., 2010). In USA, the Health and Retirement Study showed that the lowest 10% decile vs top 10% of income was strongly associated with increased risk of stroke at ages 50 to 64 years after adjustment for wealth and education (HR 1.8, 1.3-2.6), but the statistical significance was decreased with age (1.7, 1.0-2.8 at ages 65-74 and 1.1, 0.6-2.0) at ages 75+) (Avendano and Glymour, 2008). In the New Haven cohort study, lower income was associated with higher stroke incidence at ages 65 to 74 (2.08, 1.01-4.27), but the incidence of stroke was higher among those with the highest income at ages 75+ (2.33, 1.16-4.54) (Avendano et al., 2006a). In France, the Three-City Study showed a similar result that higher income group had 80% increased risk of stroke in those aged over 65 years when compared to lower income group (HR 1.77, 1.20-2.61) (Grimaud et al., 2010).

The association of income with the incidence of stroke was predominantly derived from HICs, which may not be applicable to those in LMICs, particularly among older adults who have experienced economic transitions. There have been few studies undertaken in LMICs to examine the impact of income on incident stroke (Cox et al., 2006, Addo et al., 2012, Marshall et al., 2015).

2.4.1.4 Area-based SES and risk of stroke

The association of area-based SES with incident stroke has been well studied in HICs. In the US, a 11.5-year follow-up cohort of 3,834 white participants aged ≥65 years who had no stroke at baseline showed that the fully adjusted HR of incident stroke was 1.32 (1.01-1.73) in those living in the lowest vs highest neighbourhood SES (Yan et al., 2013). In Japan, data of 90,843 individuals aged 40-69 with mean follow-up of 16.4 years showed a clear neighbourhood SES gradient in the incidence of stroke; the fully adjusted HR of stroke incidence, in order of increasing depression with reference to the least deprived areas, were 1.16 (1.04-1.29), 1.12 (1.00-1.26), 1.18 (1.02-1.35), and 1.19 (1.01-1.41) (Honjo et al., 2015). Pooling data of 3,077 patients with incident stroke from three population-based studies in Perth, Melbourne, and Auckland between 1995 and 2003 Heeley et al. reported that compared to those in the least deprived areas, the rate ratio of incident stroke was 1.70 (1.47-1.95) in those living in the most deprived areas (Heeley et al., 2011), but the result was not adjusted for confounders.

In addition, some studies assessed urban-rural disparity in the risk of stroke. A prospective community-based study conducted in Northern Portugal showed that the crude annual incidence rate of stroke was higher in rural (3.05 per 1000, 95% CI 2.65-3.44) than in urban (2.69 per 1000, 2.44-2.93) and the difference was significant in those aged 75 to 84 years (Correia et al., 2004). In China, a national population-based survey that was conducted in 155 urban and rural centres in 31 provinces with 480,687 adults aged ≥20 years reported that stroke incidence in rural areas (298.2/100 000) appeared to be significantly greater than that of their urban counterparts (203.6/100 000) (Wang et al., 2017b). However, other studies showed that people living in the urban areas could have increased risk of stroke. In sub-Saharan Africa, the Tanzania Stroke Incidence Project enrolled eligible stroke patients occurring within 3 years and showed that there was higher incidence in urban compared with rural areas, which was most notably in the 65-84 years age group (Walker et al., 2010). In spite of these differences between rural and urban in the risk of stroke, all these studies did not adjust for confounders to assess the rural-urban disparities in the risk of stroke, and the residual effects could not be removed. There is need to do more research on urban-rural disparity in the risk of stroke.

2.4.2 SES and mortality of stroke

Stroke is the second most common cause of death and the third most common cause of disability worldwide (Feigin et al., 2017). The number of stroke-related deaths has increased by 26% and disability-adjusted life-years (DALYs) by 19% over the past 30 years (Lozano et al., 2012). There are over six million deaths due to stroke annually (Johnson et al., 2019), and about 87% of them occurred in LMICs (Strong et al., 2007, Feigin et al., 2009, Feigin et al., 2014).

2.4.2.1 Educational level and mortality of stroke

The association of educational level with mortality after stroke has been well studied previously. In a meta-analysis of 12 prospective cohort studies from mostly HICs in Europe, Oceania, North America, and East Asia, Wang et al. (Wang et al., 2020) found that an overall pooled RR of the risk of stroke mortality in patients with the lowest versus highest education was 1.21 (1.11-1.33), and in subgroup analysis by study location the RR was 1.18 (1.06-1.31) in Europe and 2.12 (1.27-3.54) in America, but not in Asia (1.28, 0.94-1.75). However, in an early meta-analysis of cohort studies from Asian countries, Woodward et al. (Woodward et al., 2015) reported an inverse association of education with stroke mortality. The authors pooled data of 24 cohort studies, including over 216,000 individuals from the general population from China, Japan, Taiwan, Thailand, and Singapore, and found that the HR of stroke mortality (fatal or non-fatal) in participants with low vs high education was 1.54 (1.17-2.04) (Woodward et al., 2015).

Analysing and pooling data of 10 European cohort studies, namely Finland, Norway, Denmark, England/Wales, Belgium, Switzerland, Austria, Italy, Barcelona (Spain), and Madrid (Spain), Avendano et al. (Avendano et al., 2004) examined gender differences in the associaiton between educaitonal level and stroke mortlaity. The RR for stroke mortality for low versus high educaiton was 1.27 (1.24-1.30) in men and 1.29 (1.27-1.32) in women (Avendano et al., 2004). The impact of educational level on stroke mortality was the same between men and women. Few studies have been undertaken in LMICs to examine gender differences in the impact of educational level on stroke mortality.

There were some inconsistent findings of the association between educational level and stroke mortality in old people; some studies found a significant association of education with mortality (Avendano et al., 2004, Chen et al., 2015b), and other did not (Andersen et al., 2014). In above meta-analysis of 10 European populations, Avendano et al. reported pool RRs for stroke mortality in low compared to middle/high education groups were 1.52 (1.45-1.59) among those aged 30 to 59 years, 1.37 (1.33-1.41) among those aged 60 to 74 years, and 1.19 (1.17-1.21) among those aged ≥75 years (Avendano et al., 2004). Similarly, in the Anhui cohort study of 2,978 participants aged ≥60 years in China, Chen et al. analysed 5-year follow-up data and found that stroke patients with education level of ≤primary school had a multivariate adjusted HR of 1.88 (1.05-3.36) (Chen et al., 2015b). However, data from the Danish Stroke Register of 56,581 Danes patients aged >40 years with 3.1 years follow-up showed that those aged <65 years with basic education had a 15% increased risk of mortality compared to those with higher education (HR 1.15, 1.02-1.30), while for patients aged >65 years, there was no difference by educational level (data not shown) (Andersen et al., 2014).

2.4.2.2 Occupational class and mortality of stroke

Occupational class was thought as an important predictor for death after stroke. In a recent meta-analysis including 5 cohorts from Europe, 1 from the USA, 1 from Australia, and 3 from China, Wang et al. reported a pooled RR for low versus high occupational class of 1.54 (1.35-1.75) for stroke mortality (Wang et al., 2020). A comparative study between the USA and European countries, including over 163,000 individuals, showed that mortality of stroke was higher among people with lower occupational class, with rate ratios ranging between 1.96 and 1.25 (Mackenbach et al., 2000).

The association of occupational class with mortality after stroke may decrease with age. In Austria, a hospital-based cohort study of 2,606 stroke patients (mean age 67 years) with 2.5 years follow-up showed that after adjusted for risk factors of stroke, unskilled workers had a HR of 1.61 (1.08-2.41) of mortality after stroke and skilled workers had a HR of 1.66 (1.22-2.26) when compared to white-collar workers, but the study further showed that patients in retired situation had a HR of 1.45 (0.79-2.67) compared to those still in employed (Arrich et al., 2005). Data of China National Stroke Registry (participants mean aged 65.5 years) showed that the risk of mortality after stroke was not significant in those who were retired compared to those who were non-manual workers (HR 1.09, 0.87-1.36) (Pan et al., 2016). In China, the 5-year follow-up community-based cohort of stroke patients aged ≥60 years also showed a non-significant association between occupational class and mortality after stroke; the HR was 1.28 (0.75-2.19) in manual workers when compared to non-manual workers (Chen et al., 2015b).

2.4.2.3 Income and mortality of stroke

Income was significantly associated with mortality after stroke. In a recent meta-analysis including 9 cohorts studies from Europe, 2 from North America, and 3 from China, Wang et al. (Wang et al., 2020) reported a pooled RR of 1.54 (1.30-1.82) of stroke mortality in people with low vs high income and in the subgroup analysis by study location, the corresponding RR was 1.58 (1.25-1.99) in Europe, 1.22 (0.85-1.74) in North America, and 2.11 (0.85-5.25) in China (Wang et al., 2020).

Evidence of the association between income and mortality after stroke remains limited in LMICs, apart from China (de Mestral and Stringhini, 2017, Wang et al., 2020). In China, previous studies examined the association of income with mortality at 1, 3 and 5 years after stroke (Pan et al., 2016, Zhou et al., 2006, Chen et al., 2015b) follow-up cohort studies, but showed inconsistent findings [1.15 (0.99-1.33), 2.22 (1.36-3.63), and 1.64 (0.97-2.78)] respectively. One study showed a significant association between income and mortality after stroke (Zhou et al., 2006), one study closely approaching to a statistical significance (Pan et al., 2016), and one study non-significant association (Chen et al., 2015b). Their details will have been included for a systematic review in the Chapter 4.5.

There is also a dearth of evidence regarding the association of income with mortality after stroke at old age. In the limited research, the findings have been inconsistent. Data from the Danish Stroke Register of 56,581 stroke patients aged >40 years with 3.1 years follow-up showed that patients with lowest quintile income had 40% increased risk for death than those with the highest quintile income (HR 1.43, 1.35-1.54), and the corresponding risk was similar in patients below and above the age of 65 years (Andersen et al., 2014). However, data from the 5-year follow-up cohort in China showed that the risk of death after stroke associated with low income was not significant among those aged ≥60 years; fully adjusted HR was 1.64 (0.97-2.78) among stroke patients with low vs high income (Chen et al., 2015b). Large-scale cohort studies are required to examine the impact of income on mortality after in LMICs.

2.4.2.4 Area-based SES and mortality of stroke

Area-based SES was considered as one of the most important factors of mortality after stroke. The evidence is growing regarding the association of area-based SES with mortality after stroke, mostly from the USA and a few other HICs. In 2013, data from the Cardiovascular Health Study of American adults aged ≥65 years with a mean 11.5 years of follow-up showed that living in a disadvantaged neighbourhood was associated with higher 1-year mortality after stroke (HR 1.77, 1.17-2.68) (Brown et al., 2013). However, some of earlier studies from European countries reported either weak or no association of area-based SES with mortality after stroke. Aslanyan et al. (Aslanyan et al., 2003) followed up 2,026 ischemic stroke patients for at least 2 years in the UK, and used the Womersley score (WS) and Murray score (MS) to assess area-based SES. The authors found that the HR for all-cause mortality was 1.03 (1.00-1.06) in WS (per additional point) measure and 1.09 (0.99-1.19) in MS (per increase by 1) measure after adjustment for age, sex, stroke severity, blood pressure, stroke subtype, medical history, and smoking. An Italian study showed no association of area-based SES with short term (30 days) and first year mortality after either ischemic or haemorrhagic stroke; the HRs of lowest vs highest area-based SES were from 0.72 to 1.59 with all p-values of >0.05 (Cesaroni et al., 2009).

Some other HICs outside Europe have also shown insignificant association of area-based SES with mortality after stroke. Pooled data from studies undertaken in Australia and New Zealand, which used Index of Relative Socio-Economic Disadvantage [IRSD] and New Zealand index of deprivation [NZDep] respectively, showed no association of area-based SES with 12-month case fatality rates for stroke in the multivariate adjusted model (Heeley et al., 2011). Similarly, a cohort study from Japan with a mean follow-up of 16.4 years also found no association between neighbourhood SES and stroke mortality after adjustment for behavioural, psychosocial and CVD biological risk factors; the fully adjusted HR of most deprived vs least deprived area-based SES was 1.02 (0.76-1.38) (Honjo et al., 2015).

In LMICs there have been few cohort studies examining association between area-based SES and mortality after stroke. It may be partially due to lack of relative index or data to assess area-based SES. However, there are several studies of indirectly examining the association using different measurements. In Brazil, during a period of 1996 to 2011 stroke mortality decreased across all levels of neighbourhood SES, based on income, but greater declines were observed in the more privileged neighbourhoods of Sao Paulo and thus relative inequalities in stroke mortality increased (Fernandes et al., 2015). Some studies in LMICs used urban-rural disparity to assess the impact of area-based SES. For example, a meta-analysis study in China showed that the pooled RR of mortality in stroke patients living in rural areas was 1.47 (1.37-1.58) when compared to those living in urban areas (Chen et al., 2015b).

2.5 Rationale for the PhD study

Heart disease is the number one killer and stroke is the number two in the world (Lozano et al., 2012). Their incidence and prevalence have been increasing in LMICs, forming a great proportion of burden to society. However, little is known whether SES plays an important role in the increased risk of heart disease and stroke in the LMICs. Firstly, knowledge of the associations of SES with heart disease and stroke were predominantly derived from studies undertaken in HICs, and it may be difficult to generalise in LMICs.

Secondly, most findings from previous studies were based on middle-aged populations, which may not apply to older populations. Compared to middle aged population, older people are vulnerable for lowering SES and have different risk factors and lifestyles profiles. The literature suggested that the incidence and morality of heart disease and stroke increase with age, and people aged ≥65 years older had over five times higher risk of heart diseases and stroke than young people aged 44-54. Thirdly, the impact of SES assessed in different measurements in older age on heart disease and stroke are poorly understood. Investigating the associations of SES with the risk and mortality of heart disease and stroke in older population in LMICs would help construct balanced policies to reduce the burden of heart disease and stroke.

Most of published studies from HICs suggested that low SES was associated with increased incidence of heart disease and stroke. However, data of studies from LMICs are limited, although most of LMICs like China has experienced an epidemiological transition, where the evolving change in lifestyle and health behaviours - including tobacco use, decreased physical activity and obesity - are contributing to increased incidence of heart disease and stroke. Few studies used multiple measures of SES to assess the association with the incidence of heart disease and stroke. The literature on SES inequalities, still remains unclear on how different SES indicators measured in old age relates to the incidence of heart disease and stroke. The indicators of SES captured by various measures and the pathways through which they may affect health are likely to be slightly overlapping but different. Evidence show that indicators of SES represented a hypothetical latent social dimension associated with different phenomena and tap into different causal mechanisms. Furthermore, populations with different levels of SES may also present unique risk factors such as the levels of chronic disease treatment and CVD risk factors controlling. To enhance understanding of and update existing research on the impacts of SES would help reduce the incidence of heart disease and stroke and improve survival in people with these health conditions.

Literature continues to expand, including systematic literature and meta-analyses of large longitudinal cohort studies consistently confirming the significant association of low SES with increased mortality of heart disease and stroke. However, most studies were conducted from HICs, and even the meta-analysis results could not help with increasing data in LMICs. Nevertheless, available literature, even though limited, from LMICs suggested that socioeconomically deprived population in LMICs generally have poorer health than their better-off counterparts; they have lower coverage of health insurance, inadequate healthcare access, lower life expectancy, and poorer nutritional status. Besides, most studies from LMICs used hospital data to examine association of SES with heart disease and stroke, having missed the impact of SES on incidence of these diseases, and the findings cannot be applied in older population in the community. Therefore, the associations between SES and mortality after heart disease and stroke need to be further studied in community dwelling older adults.

China is the largest LMIC and has the world’s largest population. Heart disease and stroke are the two leading causes of deaths in China, accounting for about half of the deaths in the Chinese population. Over the past four decades, China has experienced a rapid economic growth, along with increasing gap in income between rich and poor. Evidence shows that the major changes in China’s society, including a dramatic shift from a traditional to a more western lifestyle and rapid urbanization, may have contributed to the increase in the incidence and mortality of heart disease and stroke. In light of the projected further growth of the population of older adults in near future, the societal burden attributable to heart disease and stroke will continue to rise in China. However, the knowledge of the impact of SES on the incidence and mortality of heart disease and stroke are limited in older Chinese. Investigating the association of SES with the incidence and mortality of heart diseases and stroke in China would help broaden the findings from previous studies and guide public health strategies, which will decrease socioeconomic inequalities, targeting socioeconomically deprived older people and reduce burden of heart diseases and stroke. Particularly the findings of the proposed PhD study could be applied in other LMICs.

2.5.1 Aim of the PhD study

The aim of the PhD research project is to assess the impact of socioeconomic status on the incidence and mortality of heart disease and stroke in older Chinese people.

2.5.2 Objectives of the PhD study

The objectives of this study are as follows:

1. To examine distributions of demographic characteristics and disease risk factors associated with SES among older people in China,
2. To examine the associations between different measurements of SES and incidence of heart disease in older Chinese people,
3. To assess the associations between different measurements of SES and all-cause mortality in older Chinese people with heart disease,
4. To investigate the associations between different measurements of SES and incidence of stroke in older Chinese people,
5. To assess the associations between different measurements of SES and all-cause mortality in older Chinese people with stroke,
6. To examine the impacts of SES on all-cause mortality in older Chinese people with either heart disease or stroke and those with neither.

2.6 Conclusions

This chapter has completed an overall literature review for SES, measured by educational level, occupational class, income, and area-based SES (urban-rurality), and their associations with incidence and mortality of heart disease and stroke. Most of the published studies were from HICs, and suggested that low SES was associated with increased incidence and mortality of heart disease and stroke. Fewer studies have been done to assess these associations in China (the largest LMIC) where there have been increased CVD and gaps in SES. To better understand the association of SES with heart disease and stroke and help advance knowledge of the topic, I will examine data of two large-scale cohort studies from China in my PhD study to assess the impact of SES on the incidence and mortality of heart disease and stroke in older people.

CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter covers the methods used for this PhD research study. It presents the quantitative research method in population health research from study design, data collection, data analysis and data interpretation. The quantitative method of the overall design in terms of the prospective cohort studies employed and the rationales for the choices made are explained. The Anhui cohort and Four-province cohort studies, including participants' recruitment, data collection and follow-up, are presented in detail. The chapter concludes the brief statistical methods that will be used in the following chapters.

3.2 Quantitative methods

The PhD research study used quantitative methods to investigate the impact of socioeconomic status (SES) in older age on incidence of heart disease and stroke and on all-cause mortality in older people with heart disease and stroke. The quantitative method emphasises objective measurements and the statistical, mathematical, or numerical analysis of data using computational techniques (Muijs, 2010, Creswell and Creswell, 2017). The process of measurement is central to quantitative research and the quantitative data is any data collected through polls, questionnaires, and surveys, or by examining pre-existing statistical data. Based on numerical data analysis, quantitative research can generalise results to some larger population or to explain a particular phenomenon (Saks and Allsop, 2012).

Quantitative research is widely used to investigate a health problem and it is concerned with generating and testing hypotheses by examining association between the exposure (e.g., rural vs urban living) and the outcome of interest (e.g., incident heart disease or stroke) within a population (Curtis and Drennan, 2013). One of the specific strengths of using quantitative methods in health research is the generation of data that are highly consistent, precise and reliable (Apuke, 2017). Personal bias can be avoided or minimised by keeping a 'distance' from participating subjects and using accepted computational techniques. Another main strength is that due to applying well established standards, quantitative research can be replicated and then analysed and compared with similar studies (Choy, 2014). In addition, the quantitative approach allows for a broader study, involving a greater number of subjects and enhancing the generalisation of the results (Queirós et al., 2017). According to my PhD study research topic, I have employed the quantitative methods to achieve the research objectives.

3.3 Quantitative research design: cohort study

Quantitative study designs have been widely used in population health research and social epidemiology (Berkman et al., 2014). There are several quantitative approaches including ecological, cross-sectional, case-control, cohort and experimental trial study designs (Hoare and Hoe, 2013). While randomised controlled trials are considered the gold standard in establishing causal relations, cohort studies offer the huge benefit to study incidence and mortality of disease (Hoe and Hoare, 2012). It is considered the best non-randomized control study design to distinguish between cause and effect since they measure events in chronological order, particularly in prospective cohort study design (Mann, 2003). Therefore, in this research study prospective cohort studies were used to examine the impacts of socioeconomic status on incidence and mortality of heart disease and stroke in older adults in China.

3.3.1 The prospective cohort study design

The prospective cohort study design is an observational study used to investigate the causes of disease and to establish links between risk factors and health outcomes over a future period of time.

3.3.1.1 Strengths of cohort studies

The prospective cohort study is the well-established non-randomized control study design to investigate causal relationship in social epidemiology (Caruana et al., 2015). As cohort studies measure potential causes before the outcome has occurred, the study can demonstrate that these cause (exposure) preceded the disease (outcome), which could ascertain causal relationship (Mann, 2003). It is also a perfect fit for hypothesis testing and generation, while the incidence and natural disease history can be determined and described (Bhopal, 2016). A further advantage is that cohorts permit calculating the effect of each variable on the outcome of interest using the term of relative risk or hazard ratio (Mann, 2003, Caruana et al., 2015).

3.3.1.2 Limitations of cohort studies

Prospective cohort studies are expensive in terms of financial and human resources and are often time-consuming since chronic diseases could take a long time to develop (Bailey and Handu, 2013). Another problem with prospective cohort studies is where a certain outcome is rare disease or rare health event then the number of subjects in cohort studies that need to be studied is often so large (since there is a majority likely not show the disease), as to make cohort study impractical or unfeasible (Mann, 2003). The loss of some cohort members to follow up is also a challenge in prospective cohort study, which can significantly affect the outcome (Caruana et al., 2015).

3.3.1.3 Confounding

For prospective studies, it is difficult to recruit and screen for participants with the same background (e.g., age, lifestyle, health status). Confounding is a particular challenge due to unable to control for variability of participants and human studies. In statistical analysis, a confounder (also called confounding variable or confounding factor) is a variable existing as a third factor that influences both the outcome of interest and the exposure, causing a spurious association (VanderWeele and Shpitser, 2013). It is argued that confounders could either strengthen association between the exposure and the outcome of interest or attenuate or even negate their association (Szklo and Nieto, 2014). Therefore, identifying and selecting appropriate confounders for adjustments is crucial in establishing a statistically valid association between exposure and outcome of interest.

3.3.2 Rationale for using prospective cohort study data in the thesis

Prospective cohort study design and data analysis were employed in this PhD research study. It was suggested that the selection of a research design should be based on the objective of the research problem or issue being addressed (Mann, 2003). The decision for using data from prospective cohort study was informed by the overall objective of the research work which is concerned with assessing causal relationship. Therefore, cohort study design is the most appropriate to demonstrate causal relationships between SES and incidence of heart disease and stroke and all-cause mortality in patients with heart disease and stroke in my PhD research.

It was argued that a major concern in investigating causal relationship is the challenge of demonstrating the sequence of events or that exposure preceded the outcome (Mann, 2003, Caruana et al., 2015). However, unlike case-control studies that compare groups retrospectively, prospective cohort studies are able to demonstrate temporality of order clearly, and thus the causal relationships are relatively more reliable (Caruana et al., 2015). Although the randomised control trial is a gold standard, it is highly expensive and beyond the reach of the researcher. It is argued that prospective cohort studies are also expensive and could be time-consuming (Bailey and Handu, 2013). Therefore, the research work in this thesis is based on analysis of secondary data from already completed prospective Anhui cohort and the Four-province cohort studies of older adults in China. The approval for use and access to cohort data have been granted for the research project thereby reducing the burden in terms of cost and time in collecting fresh data.

One concern for the use of cohort data to investigate the incidence and mortality of heart disease and stroke in the cohort study is that it could take time for the health effects to manifest thereby requiring large cohort members and longer follow-up. However, cohort members in the prospective Anhui cohort and the Four-province cohort studies for the PhD research are 3,336 and 4,314, respectively, and followed up over 10 years and 4 years, which was similar to those in some studies undertaken in Western countries and was considered adequate to detect health effect of heart disease and stroke in older adults (Bailey and Handu, 2013). This is based on the sample sizes and follow-up years of our Chinese cohort studies, which would have given enough numbers of incident HD and stroke cases to test the hypotheses in my PhD research. Another concern for the use of cohort study data is dealing with confounding factors (Caruana et al., 2015). In the case of evaluating the magnitude and nature of SES to population health, it is important to adjust for confounding factors to isolate the effect of other risk factors such as lifestyle and CVD risk factors. However, many important covariates as potential confounders have been collected at baseline investigation of the two cohort studies, while appropriate and strict statistical methods were employed in the analysis to minimise bias**.**

3.3.3 Systematic literature review and meta-analysis

Systematic literature review and meta-analysis provide an overview of the evidence relating to a specific research question by combining data from existing or primary research (Dewey and Drahota, 2016). They are widely used in research of health care, public health, and public policy (Bakre et al., 2018, Danat et al., 2019).

The systematic reviews are a type of literature review that strives to comprehensively identify, appraise, and synthesise all the relevant literature on a given topic (Petticrew and Roberts, 2008). They formulate research questions that is clearly stated before the review, and identify and synthesise studies that directly relate to the systematic review question. Comprehensive and transparent searches will conduct over multiple databases and grey literature and the process can be replicated and reproduced by other researchers. Systematic reviews are designed to provide a complete, exhaustive summary of current evidence, published and unpublished, that is "methodical, comprehensive, transparent, and replicable (Siddaway et al., 2019)."

The quality of the studies included in the review is assessed systematically and critically. Where possible a meta-analysis is carried out in which numerical data from two or more identified studies is pooled and a weighted average calculated. Meta-analysis is a subset of systematic review, which is a quantitative, formal, epidemiological study design used to systematically assess previous studies to derive conclusions from the large body of research (Haidich, 2010). The results from a meta-analysis can improve precision of estimates of the effect of risk factors for disease or other outcomes, answer questions not posed by the individual studies, and settle controversies arising from apparently conflicting studies. In particular, the examination of heterogeneity is vital to generate a new hypothesis. While systematic reviews and meta-analysis are often applied in RCTs, observational studies such as cohort and case-control studies also can be included when outcomes are measured at specific points in the study (Hoe and Hoare, 2012).

Clearly, unpublished studies may not be found by searching the literature in database. It is possible that published studies are systemically different from unpublished studies; for example, positive findings may be more likely to be published (Haidich, 2010). Therefore, a meta-analysis based on literature search results alone may lead to publication bias. Efforts are needed to minimise this potential bias, including reviewing the references in published studies, searching computerised databases of unpublished material, and investigating other sources of information including conference proceedings, graduate dissertations and clinical trial registers.

3.4 Prospective cohort studies

In the thesis, the Anhui cohort and the Four-province cohort studies were used to investigate the associations of socioeconomic status with incidence and mortality of heart disease and stroke in China. The method for the cohort studies are described in the following sections.

3.4.1 Anhui cohort study

The Anhui cohort study was conducted in the Anhui province, China. Anhui is one of 34 provinces in China and is located in the mid-eastern region of China. The geographical area of the Anhui cohort study was Hefei City (the capital of Anhui) and Yinshang County, in Anhui (see Figure Map 3-1).

Figure Map 3-1 showing the location of Anhui province

3.4.1.1 Study population and setting

The targeted population was those aged ≥65 years from urban areas and those >60 years who had lived for at least 5 years in the rural of the Anhui province. The study population was 3,336 older adults residing in urban and rural communities. The Yiming district from Hefei City was used as the collaborative base for the teams facilitating the collection of data.

3.4.1.2 Sampling strategy and participants' recruitment

In 2001, the study opted to investigate up to 2,000 subjects in the urban community on the basic of the sample sizes in the previous studies (Chen et al., 1999) and the practical resources and working experience (Chen et al., 2004). The required sample was selected by stratified random technique drawing six from ten subdistrict residency committee lists of older adults. The targeted population consisted of those subjects aged ≥65 years who had lived for at least five years in the district. Of 1,810 eligible older people, 1,736 participated in the study (response rate of 95.9%). In 2001, the participants were interviewed at home by a trained survey team from the School of Health Administration, Anhui Medical University.

In 2003, the investigators carried out a similar study of health survey in the rural communities in Anhui (Chen et al., 2005). They selected all 16 villages in the Tangdian district of Yingshang County as the study field, representing a typical rural community. Two subvillages were randomly selected from each village for the survey. The target population included persons aged ≥60 years who had lived in the villages for more than 5 years. Based on the sample size of above urban samples, 1,709 eligible older persons were selected and 1,600 participants were successfully interviewed at home, with the response rate of 93.6% (1600/1709). The survey team completed all data collection by 30th April, 2003.

As a whole, the baseline health survey of the Anhui cohort study consisted of 3,336 participants who were from urban (n=1,736) and rural communities participated, with a response rate of 94.8%.

3.4.1.3 Data collection for baseline health in the cohort

The General Health and Risk factors Questionnaires (Chen et al., 2004), the Geriatric Mental State Questionnaires (GMS) and the Automated Geriatric Examination for Computer Assisted Taxonomy (AGECAT) (Chen et al., 2005) were used to interview each of participants to collect necessary data for health survey at baseline. These are described below.

3.4.1.3.1 The General Health and Risk Factors Questionnaires

The main interview materials during baseline investigations were from an already validated Chinese version of the general health and risk factors questionnaires and the GMS (3^{rd} edition) questionnaires. The general health record which was derived partly from the Minimum Data Set (MDS) of the MRC-ALPHA study including a number of relevant risk factors (Saunders et al., 1991) and the Scottish MONICA surveys (Chen et al., 2003). The General Health and Risk Factors Questionnaire and the GMS questionnaires including the following: (1) demographic and socioeconomic information, (2) lifestyle and behaviours, (3) social support and relationships, (4) psychosocial aspects, (5) doctor-diagnosed cardiovascular diseases and medications and self-assessed physical health, (6) adverse life events occurring in the last two years, (7) hobbies and activities of daily living (ADL).

Socioeconomic status

Socioeconomic status (SES) was measured from long-term living location of urban and rural areas and from individual records of educational level, occupational class, satisfactory income, and financial problems.

Educational level for each participant was recorded at his/her actual schooling level (either primary school, secondary school, high secondary school, or university/college). Those without any school attainment would be grouped as "illiterate" (Chen et al., 2015b).

Occupational class of participants was classified as 'non-manual' or 'manual' based on their current or last main job titles (including officer/teacher, businessman, manual worker, peasant, housewife or other).

Satisfactory income for each participant was asked to answer the question of 'Are you satisfied with your income?' (with answers either at "very satisfied", "satisfied", "average" or "poor").

Financial problems for each participant was asked whether they had any financial problems in the past two years (with answers either "yes" or "no").

The Anhui cohort study consisted of urban and rural communities' participants, which could be used for urban-rural living in SES measurement (Chen et al., 2014a).

Heart disease and stroke diagnosis

Heart disease was documented in the questionnaire from participant's self-report during the interview. Each participant was asked whether he or she had heart disease diagnosed by doctors (with answers either "yes" "no" "unknown" or "unwilling to reply").

Stroke was documented from participants' self-report of having been diagnosed by a doctor. Each participant was asked whether he/she had a doctor diagnosed stroke or paralysis (with answers either "yes" "no" "unknown" or "unwilling to reply").

Other variables

<u>Disease risk factors recorded in the questionnaire interview</u>

Behaviour/lifestyle was assessed by collecting information on smoking ('never', 'ex-', 'current-', and 'unknown') and alcohol drinking ('never', 'daily', 'often', and 'occasionally'). Social network regarding their marital status ('married', 'never married', 'divorced', and 'widow'), living status ('alone', 'spouse only', 'children and/or grand/children only', 'spouse and/or grand/children and/or parents', and 'others'), frequency of visiting children or other relatives ('never', 'at least monthly or less often', 'at least weekly', and 'daily'), contacting friends in the community ('never', 'at least monthly or less often', 'at least weekly', and 'daily'), contacting neighbours ('never', 'at least monthly or less often', 'at least weekly', and 'daily'), and help available when needed ('no' and 'yes') was enquired. The researchers also asked whether the participants had the ability to take care of themselves in daily life and what sorts of common hobbies (exercising, walking and group travel, participating in senior community activity) they had. For each participant, history of having one or more chronic diseases and other health status such as hypertension, hypercholesterolemia, angina, diabetes was documented through self-report in the questionnaire.

Physical measurements

According to standard procedures (Chen et al., 2003), all participants at baseline interview were measured systolic blood pressure (SBP) and diastolic blood pressure (DBP) for the diagnosis of hypertension, weight and height for BMI calculation, and waist circumferences.

Systolic BP (SBP) and *diastolic BP (DBP)* was recorded in mm Hg by Hawksley random-zero sphygmomanometers at the first and fifth Korotkoff sounds. Resting BP was measured three times at 1 min intervals. The cuff size was selected according to the size of participant's mid-upper arm circumference. Blood pressure measurements were assessed twice at the first visit and seated after five minutes rest. The mean of the two readings was used. *Hypertension* was defined as SBP ≥140 or DBP ≥90 mm Hg or being treated with antihypertensive agents.

Weight (kg), height (cm) and *waist circumference (cm)* in light clothes were measured using standard methods (Han and Lean, 2001) to assess overweight and obesity based on BMI and central fat distributions based on waist circumference action levels (Lean et al., 1995). The cut-off points for BMI variable used in this study were based on the

BMI classification recommended for Asian Chinese population by the Chinese government (Chen, 2008).

Mental statement measurements

The GMS Schedule with the AGECAT were used to diagnose depression and dementia (Copeland et al., 2002). The GMS is a standardised, semi-structured interview that has become as one of the most commonly used technique for assessing psychopathology for patients aged over 60 years (Copeland et al., 2002) and the AGECAT is a computer assisted programme validated against clinical psychiatric interviews. The information from the GMS data were assessed by means of the computer-assisted system of the AGECAT to identify depression and dementia in the participants (Copeland et al., 1990), which has been compared with psychiatrists' diagnoses and DSM-III criteria and applied with good levels of agreement in a variety of settings, including older adults in China.

The GMS-AGECAT dementia and depression diagnosis in the Anhui cohort showed good reliability (Chen et al., 2005). GMS symptoms are coalesced into a 150 'symptom components'. In stage I, the symptom components are brought together into groups which typify the major symptom areas of each diagnostic syndrome. The scores on these individual groups determine the final syndromal level of 'confidence of diagnosis'. Thus, the system uses both quantitative and qualitative measures when allotting subjects to the levels of confidence; required for its construction are many hundreds of clinical decisions on the placement of groups of symptom components on the syndrome levels. Individual participants are allocated to levels of confidence of diagnosis (0-5) on each of the eight diagnostic syndromes: organic disorder, depression, mania, schizophrenia and paranoia, obsessional, phobic, hypochondriacal, and general anxiety (Chen et al., 2009). In stage II, the various syndrome levels are compared with one another to derive a final differential diagnosis and a level of confidence of diagnosis from 0-5. A level of 3 to 5, in most circumstances designates a ‘case level’ which corresponds to a level of severity that psychiatrists usually recognise as a case for clinical intervention. Levels 1 and 2 are designated as ‘subcases’ that those having the principal mental disorder but not severe enough to qualify as ‘case’, whereas level 0 (no confidence level on any syndrome) is classified as “well” (Chen et al., 2008, Chen et al., 2009). The diagnostic agreement between the research psychiatrists and AGECAT was good, with generalised the scores of 0.87 for depressive disorders and 0.73 for organic brain syndrome (Chong et al., 2001).

3.4.1.4 Follow-up of cohort

In one year after the baseline survey, the Anhui cohort had 2,608 participants (wave 2) re-interviewed, for example, the urban cohort members in 2002 and the rural cohort member in 2004, with a response rate of 78.2%. The interview materials were the same as those at baseline. From 2007 to 2009, 1,757 cohort members in total (wave 3) (67.4%) were successfully re-examined (Chen et al., 2011). In 2010-2011, wave 4 survey was carried out on surviving cohort members and 944 participants (53.7%) were re-interviewed. At each wave of the follow-up the same questionnaires were used as the baseline for re-interview. In particular at Wave 3 and Wave 4 re-interview, actual income (including personal income and average annual income per person in the family) for data validation and the 10/66 algorithms research package for dementia diagnosis were further added in as supplement (Prince et al., 2008, Chen et al., 2013a).

Vital status of the cohort members was monitored until December 2011. At each wave survey home visits were conducted to obtain information about participants’ survival status through multiple sources including resident committees, family members, neighbours, and friends. For the urban cohort, electronic registration databases from the local Centre for Disease Control and Police Registration centralised in Hefei city were also reviewed to identify mortality and causes of deaths. In the total 671 deaths were identified during the follow up of cohort. Using a standard Verbal Autopsy questionnaire (Chen et al., 2013a) the next of kin responsible for the deceased were interviewed or the death certificates were reviewed to ascertain causes of death, including diagnosis of heart disease and stroke.

3.4.2 Four-province cohort study

The Four-province cohort study was carried out across Guangdong, Shanghai, Heilongjiang, and Shanxi provinces, which are located in the South, East, North, and West regions of China (see Figure Map 3-2).

Figure Map 3-2 showing the locations of Guangdong, Shanghai, Heilongjiang, and Shanxi provinces

3.4.2.1 Study population and setting

In 2008-2009, one rural and one urban community from each of four provinces were selected as the study fields. Following the Anhui cohort 3rd wave interview protocol, no fewer than 500 participants aged ≥60 years were recruited in each community. A cluster randomised sampling method was employed to select residential communities from each of the four provinces; in Guangdong, Jitang subdistrict Huangpu district in Guangzhou city and Lianfeng village in Zhongshan county; in Shanghai, a subdistrict (Xietu Road) in Xuhui district and two villages in Xingta township; in Heilongjiang, Dayou subdistrict in Daowai district in Harbin and four villages in Xianfeng township in Suihua; and in Shanxi, a subdistrict in Jinzhong and five villages in Zhuanzi township.

The target population consisted of residents aged ≥60 years living in the area for at least 5 years. A total of 4,314 participants were recruited based on the residency list of the committees of the village and the district. The participants were interviewed by trained medical survey teams in each centre (province) and there was an overall response rate of 93.8%. Two researchers from each centre team were trained at the Anhui Medical University and then they cascaded skills to local research teams and trained the interviewers. The local survey team from Guangzhou, Harbin and Shanxi Medical Universities and the School of Public Health of Fudan University interviewed the participants at home.

3.4.2.2 Data collection for baseline health in the cohort

Using the same protocol as those at the Anhui cohort wave 3 interview, the main interview included a general health and risk factors record, the GMS questionnaire, actual income, and the 10/66 algorithm dementia research package (Prince et al., 2008, Chen et al., 2013a). In the general health and risk-factors components we recorded details relating to sociodemographic information, social networks and support, and cardiovascular and other risk factors. Furthermore, personal income and family income were added to improve SES information. Participants (or their carers if the participants was unable to answer) were asked whether they had received a doctor's diagnosis of heart disease (further identify either coronary heart disease, valve heart disease, or other), stroke, hypertension, hypercholesterolemia, angina, diabetes, dementia, depression, etc. Systolic and diastolic blood pressure, height, weight and waist circumference were measured for all participants during the interview according to standard procedures as those at the Anhui cohort study (Chen and Tunstall-Pedoe, 2005). Depression was diagnosed using the GMS-AGECAT and dementia was diagnosed using the 10/66 algorithm dementia research package.

3.4.2.3 Follow-up cohort

Using the same protocol as that in the Anhui cohort follow up study, the cohort was followed up to 2012; 259 deaths were documented and 2,892 surviving cohort members were re-interviewed in 2010-2012 using the same questionnaires as those at baseline (Chen et al., 2016).

3.5 Data management and statistical methods

The PhD research used data of the prospective Anhui cohort and Four-province cohort studies that were already completed as described above. The datasets were cleaned by the research team in China and ready for statistical analysis to address the research questions. After access was granted, I studied the dataset carefully using their data dictionaries and identified and explored the variables of interests. The baseline and follow-up data of the Anhui cohort and the Four-province cohort studies were checked, coded, and cleaned before it was analysed to address the research questions. Data linkages were required for linking datasets in preparation for analysis (e.g., in Chapter nine, the Anhui cohort wave 3 survey was merged into the Four-province cohort baseline investigation). There was also the merging of categories of some variables for further analysis, (e.g., five education levels were grouped into low, middle, and high educational groups, and four main occupations grouped into manual and non-manual occupation).

In the two community-based cohort studies, there are a number of variables with missing data. Missing data (or missing values) is defined as the data value that is not stored for a variable in the observation of interest (Graham, 2009). The problem of missing data is relatively common in almost all studies and may have a significant effect on the conclusions that can be drawn from the data (Graham, 2009). In the Anhui cohort study, 19 covariates were taken in the analysis for adjustment; 15 variables (78.9%) had no missing data, three variables (e.g., diabetes) had 0.2-0.4% of missing data and one variable had 17.1% of missing data (e.g., smoking) (see the Chapter Eight Table 8-1). In the Four-province cohort study, 20 covariates were included for adjustment; 6 (30.0%) variables had no missing data and others had 0.1-3.0% of missing data (see the Chapter Eight Table 8-5). In the current thesis, the missing data that occurred in covariates was treated as a special group for analysis. This is because those participants who missed information on a variable may have a special reason for not answering the survey question.

Data were explored using descriptive statistics and multivariate regression analysis. Missing data was treated as a special group for analysis. In multivariate regression analysis, Cox regression models were used to examine associations of exposures (e.g., rural living, illiterate, manual occupation, poor satisfactory income) with outcomes (e.g., incident heart disease and stroke, all-cause mortality). All analyses were performed using SPSS version 24.0 (SPSS Inc, Chicago, USA) while meta-analysis involved the use of Stata IC version 14.0 (Stata Corp, College Station, Texas, USA). Records of syntax for the completed analysis were kept (Appendix 1).

3.5.1 Descriptive statistics

Descriptive statistics was used to examine the mean (standard deviation, SD) of continuous variables and percentage (%) for categorical variables. Distributions of baseline characteristics and health conditions of participants were examined using one-way analysis of variance (ANOVA) for continuous variables and χ^2 test for categorical variables.

3.5.2 Cox regression analysis

Cox proportional hazards regression model was the main inferential statistical test for the impacts of SES on incidence and mortality of heart disease (or stroke) (Chapters 6, 7, 8, 9, and 10). Person-years at risk (PYARs) for cohort members were computed to the end of follow up, date of incident heart disease (or stroke), death or loss at follow up. Annual incidence (or mortality) rate was expressed as cases per 1,000 person-years. Hazard ratios (HRs), 95% confidence intervals (CIs) and p-values were calculated from the multivariate models, controlling for socio-demographic variables, social network and support, and chronic disease risk factors (see appendix 1 for syntax for data analysis in Chapters 6-10).

3.5.2.1 Basic of the Cox proportional hazards regression model

Cox proportional hazards regression model (Cox, 1972) is one of the most commonly used statistical methods for analysis of censored survival data in health research. The purpose of the model is to assess simultaneously the association of several factors or exposures with survival time (Sullivan, 2013). In other words, it could be used to evaluate how specified factors influence the rate of a particular event happening (e.g., incidence, death) at a particular point in time. This rate is usually referred as the hazard rate, while predictor variables (or factors) are commonly termed covariates in epidemiology.

The Cox regression model is usually written as follows:

$$h(t) = h_0(t)\,\mathbf{exp}(b_1X_1 + b_2X_2 + \ldots + b_pX_p)$$

where $h(t)$ is the predicted hazard at time t, $h_0(t)$ is the baseline hazard and corresponds to the value of the hazard when all of the predictors (or independent variables) X_1, X_2, X_p are equal to zero. The predicted hazard (i.e., $h(t)$) is the result of the baseline hazard ($h_0(t)$) and the exponential function of the linear combination of the predictors. Thus, the predictors have a multiplicative or proportional effect on the predicted hazard.

The quantities exp(bi) are called hazard ratios (HR). If the HR for a predictor is above 1, then the predictor is associated with increased risk (i.e., decreased survival) and if it is below 1, then the predictor is protective (i.e., prolonged survival). If the HR is close to 1 then that predictor does not affect survival. In summary, that is

- HR = 1: No effect
- HR > 1: Increase in the hazard
- HR < 1: Reduction in the hazard

In a statistically significant predictor, its 95% confidence intervals (CIs) for the HRs should not include 1 (the null value). In contrast, the 95% CIs for the non-significant predictors include the null value.

3.5.2.2 Diagnostics for the Cox regression model

The Cox regression model is a proportional-hazards model that makes several key assumptions. These assumptions should be tested routinely prior to application of Cox regression model (Sullivan, 2013). A violation of these assumptions can produce misleading conclusions. The assumptions of Cox regression model include:

a. independence of survival times between different individuals in the sample,
b. a log-linear relationship between the predictors and the hazard,
c. a constant hazard ratio over time.

In the current thesis, the proportional hazard assumptions for the Cox regression models analysis in the two cohorts were tested for a number of variables. Thus the Cox regression model is appropriate to be used to examine the associations of SES with the incidence of HD and stroke and with all-cause mortality in patients with HD and stroke.

3.5.3 Meta-analysis

Meta-analysis was further performed by pooling all the data that included the odds ratios, rate ratios or hazard ratios and their 95% CIs from identified studies and the new community-based cohort studies together. A random effect model was employed if the heterogeneity of the within and between studies variation were significant; otherwise a fixed effect model was used (Haidich, 2010). The presence of heterogeneity across the studies was assessed by the I^2 statistics (Higgins and Thompson, 2002). An I^2 statistic of less than 25% indicates a small degree of inconsistency, and more than 50% indicates a large degree of inconsistency (Ioannidis et al., 2007). A funnel plot was used for exploring publication bias, and Egger's regression test was used for examining funnel plot asymmetry (Egger et al., 1997).

CHAPTER FOUR: SYSTEMATIC LITERATURE REVIEW AND META-ANALYSIS FOR THE IMPACTS OF SOCIOECONOMIC STATUS ON RISK AND MORTALITY OF HEART DISEASE AND STROKE IN CHINA

4.1 Introduction

In this chapter, systematic literature reviews and meta-analysis were performed regarding the associations of SES with incidence and mortality of heart disease and stroke in China. The overall impacts of SES were pooled from all published studies and then in terms of urban-rurality, educational level, occupational class, and income, on incidence and mortality, separately.

4.2 Impact of SES on risk of heart disease

4.2.1 Introduction

Heart disease (HD) is the first leading cause of death and the second leading cause of disability-adjusted life-years worldwide (Naghavi et al., 2017, Kyu et al., 2018). Existing evidence in epidemiological studies showed that the risk of incident HD was significantly increased in the general population with low vs high socioeconomic status (SES) (de Mestral and Stringhini, 2017, Backholer et al., 2017). Current knowledge about the impact of SES on incident HD is predominantly derived from studies undertaken in high income countries (HICs) (de Mestral and Stringhini, 2017), which may not be applicable to those in low and middle income countries (LMICs). In LMICs there are more and more people being affected by HD due to socioeconomic changes, increase in lifespan, and acquisition of lifestyle-related risk factors (Gaziano et al., 2010).

China is the largest LMIC and the most populous in the world. Over the past four decades, China has had a wider gap in income between rich and poor along with its economic development (Xie and Zhou, 2014). Previous studies showed that the age-adjusted incidence rate of coronary heart disease (CHD) in the year 2010-2011 had significantly increased by 83.04% compared to that in the year 1991-2001 (Deng et al., 2014). It has been predicted that the incidence of CHD in China will rise to more than 2.5 million per year by 2030 (Moran et al., 2010). The burden of CHD has been increasing and has become more marked due to socioeconomic progress, population ageing, and epidemiological transition in China (Zhao et al., 2018). However, there is a dearth of evidence regarding the association between SES and risk of incident HD in China, and the findings have been inconsistent. There was substantial heterogeneity in study population, types of HD, and SES measurements among these studies (Lee et al., 2000, Guo et al., 2012, Liu and Yan, 2016, Wang et al., 2017a). No systematic literature review has been done to examine the association between SES and risk of incident HD in China. Therefore, we carried out a systematic literature review and a meta-analysis to assess the association of SES with risk of HD in China.

4.2.2 Methods

4.2.2.1 Systematic literature review

Data sources and studies selection process

We carried out a systematic review according to the Preferred Reporting Items for Systematic reviews and Meta-analyses (PRISMA) guidelines (Liberati et al., 2009). We [Weiju Zhou, James Jie Tang] searched literature from PubMed, Medline, and Web of Science to identify those eligible for inclusion in this review. The strategy for the database search was developed using the Population, Exposure and Outcome (PEO) framework (Khan et al., 2003, Bettany-Saltikov, 2012). The search terms were ["heart disease" OR "coronary heart disease, ischaemic heart disease, hypertensive heart disease, cardiomyopathy and myocarditis, rheumatic heart disease, atrial fibrillation and flutter"] AND ["incidence" OR "incident, morbidity"] AND ["socioeconomic status" OR "poverty, education, income, occupation, rural"] AND ["China" OR "Chinese"] for all fields, including MeSH terms, abstract, title, or text words. We extensively searched Chinese literature electronic databases, including China National Knowledge Infrastructure (CNKI), China Biological Medicine Database (CBM-disk), WANFANG and Chongqing VIP to identify any publications in Chinese on this topic. The literature was covered from the earliest year in those datasets to 31st December 2019. The search for relevant articles included all studies with no language restriction. We screened the titles and abstracts for potentially relevant studies relating to the association of SES with risk of any type of HD. Alongside the electronic database searches, a manual reference search was conducted to find additional articles missed by the online search. The studies selected were appropriate for this review if they quantified the relationship between any measure of SES and risk of incident HD in the Chinese population.

Study selection flow is shown in Figure 4.2-1. The present study included only cohort and case-control studies. Cross-sectional studies and those studies which just gave numbers of cases/participants in different SES groups were excluded. We included studies that reported the hazard ratio (HR), relative risk (RR), or odds ratio (OR) and 95% confidence intervals (CIs) of incident HD associated with SES. Seven studies were identified for systematic review.

Data extraction and quality assessment

Each of the articles were reviewed by two reviewers and assessed independently using a predesigned data extraction form to extract the necessary information from the chosen studies. The information extracted included the first author's name, publication year, study location, recruitment strategy, baseline HD diagnosis criteria, sample size and characteristics, follow-up duration and rate, data analysis method, confounders adjustment, number of HD incident cases, and relevant statistical findings.

Differences in reviewing literature and extracting data between the two reviewers were resolved through face-to-face discussion, and where differences remained, these were discussed with the third reviewer to reach an agreement. These articles were reviewed for quality using a modified version of the Newcastle-Ottawa criteria (Wells et al., 2015). Based on specific criteria, a total awarded score of between 0-6 was classified as a low-quality study, while score of 7-9 was classified as a high-quality study.

4.2.2.2 Meta-analysis

The available data from these studies, including HR and OR and their 95% CIs were pooled together as a RR, with the assumption of achieving a common unit of comparison. From each study, we abstracted maximally adjusted risk estimates for the exposures and outcomes of interest. In case-control studies, the OR was used as a surrogate measure of the corresponding RR, since the ORs approximate the RRs when the absolute risk of HD is low (Hogue et al., 1983, Wang et al., 2012).

A random effect model was used if the heterogeneity of within-study and between-study variation in the identified studies was significant; otherwise, a fixed effect model was used. A funnel plot was used for exploring publication bias, and Egger's regression test was used for examining funnel plot asymmetry (Egger et al., 1997). First, we assessed an overall RR and 95% CI of incident HD for low versus high SES. Each eligible study was selected one figure for pooling data; if the study measured two or more indicators of SES, we selected one of their results, according to the order of SES composite score, urban-rurality, educational level, income, and occupational class. If the article only provided the RRs in different levels of SES, we took the figure from the lowest SES group for pooling the data. If the article gave the figures for only high vs low SES, we included them in the meta-analysis. If the article reported outcomes that were stratified by subtypes, we considered the overall effect size across the subgroups in the meta-analysis. Second, we stratified the identified studies for meta-analysis in terms of different measurement of SES.

4.2.3 Results

4.2.3.1 Literature review

In the seven identified articles, we found two cohort studies (Lee et al., 2000, Wang et al., 2017a) and five case-control studies (Donnan et al., 1994, Teo et al., 2009, Guo et al., 2012, Hu et al., 2012, Liu and Yan, 2016). They were all published between 1994 and 2017. All studies were reported in English journals. The five case-control studies were from hospital data and the two cohort studies from community data. Their sample sizes varied from 240 to 18,551, with a total of 11,460 incident HD cases. The mean age in the participants from these studies varied from 5.8 to 62.8 years. Of the seven studies, two measured only educational level as SES (Hu et al., 2012, Wang et al., 2017a), two measured educational level and occupational class (Donnan et al., 1994, Lee et al., 2000), one measured educational level and income (Teo et al., 2009), and two studies examined multiple SES indicators (Liu and Yan, 2016, Wang et al., 2017a). Of the seven studies, five showed an inverse association of SES with risk of incident stroke (Teo et al., 2009, Guo et al., 2012, Hu et al., 2012, Liu and Yan, 2016, Wang et al., 2017a) and two showed a non-significant association (Donnan et al., 1994, Lee et al., 2000).

The qualities of these studies were generally good (Table 4.2-3). The qualitative reviews of each study are as follows. Tables 4.2-1 and 4.2-2 document the details of the studies' characteristics and outcomes.

Case-control study

Donnan et al. (1994)

Donnan et al. (1994) conducted a case-control study of acute myocardial infarction (AMI) for 532 cases and 565 age- and sex-matched controls in four Hong Kong hospitals between July 1987 and December 1990. At ages <65 years, the univariate analysis showed that the OR of risk of AMI for formal vs non-formal education and for white vs blue collar occupations were 1.2 (0.7-2.0) and 0.7 (0.3-1.7) in men, respectively. The corresponding ORs were 0.7 (0.3-1.7) and 1.5 (0.4-6.1) in women. At ages ≥65 years, the matched figures were 0.9 (0.5-1.5) and 1.0 (0.5-1.7) in men and 1.0 (0.5-2.0) and 0.3 (0.1-1.0) in women. Due to their insignificance levels, the variables of education and occupation were not selected for the multivariate analysis.

Teo et al. (2009)

Teo et al. (2009) examined the INTERHEART China study of 3030 first acute myocardial infarction (AMI) cases and 3056 age- and sex-matched controls who were enrolled from 26 regional hospitals from February 1999 to March 2003. After adjusting for a number of co-variables, the ORs of incident AMI in those with ≤8 years schooling and 9-12 years schooling were 1.47 (1.28-1.68) and 1.05 (0.91-1.22), respectively, when compared to those with tertiary education. Compared to those with incomes in

Quintiles 4 and 5, the fully adjusted ORs were 1.25 (1.10-1.41) for those in Quintiles 1 and 2 and 1.19 (1.05-1.36) in those with an income in Quintile 3.

Guo et al. (2012)

Guo et al. (2012) examined a hospital-based case-control study, which was part of the INTERHEART China study, including 2909 first AMI cases and 2947 controls who were admitted to hospitals between February 1999 and March 2003 in 27 cities. After adjusted for a number of co-variables, the ORs of incident AMI in those with ≤8 years schooling and 9-12 years schooling were 1.33 (1.12-1.59) and 1.04 (0.88-1.23), respectively, when compared to those with trade school/college/university education. Compared to those with income of ≥¥10,000 per year, the fully adjusted ORs were 1.04 (0.90-1.21) in those with income of >¥6000-<¥10,000 and 0.97 (0.82-1.14) in those with income of ≤¥6000. In full adjustment analysis, ORs for incident AMI were not significant in skilled labour (0.92, 0.75-1.15) and in general labour (0.85,0.69-1.05) when compared to those who were professionals. There was no association between assets and risk of AMI.

Hu et al. (2012)

Hu et al. (2012) also examined the INTERHEART China case-control study with 2909 first AMI cases and 2947 controls who had no history of heart disease. After adjustment for age, sex, BMI, psychosocial factors, lifestyle, and other risk factors, the OR for the risk of AMI was 1.45 (1.26-1.67) in those with ≤8 years schooling vs those with >8 years schooling. The corresponding OR in men was 1.29 (1,09-1.52) and 1.55 (1.16-2.08) in women.

Liu et al. (2016)

Liu et al. (2016) carried out a hospital-based case-control study of 80 congenital heart disease cases and 160 controls between March 2014 and February 2015 in Changsha city, Hunan province. In the multivariate logistic regression analysis, the risk of congenital heart disease was significantly increased in those with rural vs urban registered permanent residence (OR 2.83, 1.16-6.88), in those whose father's occupation was a farmer vs a non-farmer (5.30, 1.94-14.47) and in those with low vs high family income (2.47, 1.00-6.07).

Cohort study

<u>Lee et al. (2000)</u>

Lee et al. (2000) examined the Chin-Shan Community Cardiovascular Cohort of 3,602 participants aged ≥35 years in Taipei city, Taiwan. The cohort was conducted in 1990 and was followed up in 1993 (wave 2) and in 1995 (wave 3). During the follow-up period, 99 incident coronary artery disease (CAD) occurred, of whom 51 were men and 48 were women. In the multivariate logistic regression analyses, the OR of risk of CAD was 1.5 (0.9-2.7) in those with white collar vs blue collar occupations and 0.8 (0.6-1.2) in those with ≥6 vs <6 years of schooling attainment.

<u>Wang et al. (2017)</u>

Wang et al. (2017) examined the Dongfeng-Tongji cohort study of 18,551 participants with a mean age 62.8 years who had no histories of CHD at baseline. The cohort was conducted between September 2008 and June 2010 and were followed up until October 2013. During the follow-up years, there were 1323 (10.79%) new CHD cases from low education background (≤8 years) and 578 (9.19) from high education background (≥9 years). After adjustment for age, BMI, waist circumference, smoking, drinking, physical activity, marital status, stress, fruit intake, vegetable intake, hypertension, hyperlipidaemia, diabetes, and family history of CHD, the HR of incident CHD was significantly increased in those with low education (1.12, 1.02-1.25). Data analysis for those aged ≥60 and <60 years old showed that the HR of incident CHD was 1.15 (1.03-1.30) and 0.95 (0.76-1.20) in those with low vs high education, respectively.

4.2.3.2 Meta-analysis

Among the seven studies, four studies examined the data of the INTERHEART China study to assess the association of SES with risk of HD, in which the study by Guo et al was selected for meta-analysis due to its detailed data and specific subject in the impacts of SES. Therefore, there were four studies eligible to be pooled for the overall association of SES with the risk of incident HD (Lee et al., 2000, Guo et al., 2012, Liu and Yan, 2016, Wang et al., 2017a) (Figure 4.2-2). The random effect model analysis showed that the RR of incident HD in people with low versus high SES was 1.25 (1.05-1.49), p=0.012. The analysis of publication bias from these four studies did not suggest any evidence of significant publication bias, with an Egger's test result of p=0.144 (Figure 4.2-3).

Data analysis for different indicators associated with risk of HD was run as follows.

Low and High Education level

Three studies reported the association between educational level and risk of incident HD, which included 4,909 HD cases (Lee et al., 2000, Guo et al., 2012, Wang et al., 2017a). Pooling data of the RR of incident HD in participants with low vs high educational level was 1.17 (1.08-1.28), p<0.001 (Figure 4.2-4).

Low and High Occupational class

Three studies reported the association of occupational class with risk of incident HD, comprising 3,088 HD cases (Lee et al., 2000, Guo et al., 2012, Liu and Yan, 2016). In the pooled data, participants with low occupational class had a higher risk of HD than their counterparts with high occupational class (pooled RR 1.24, 0.56-2.73; p=0.601) (Figure 4.2-5).

Low and High Income

There are two studies which reported the association of income with risk of incident HD, comprising 2,989 HD cases (Guo et al., 2012, Liu and Yan, 2016). In the pooled data, participants with low income had a higher risk of HD than their counterparts with high income (pooled RR 1.39, 0.57-3.38; p=0.471) (Figure 4.2-6).

Rural vs urban living

There was only one figure available for rural vs urban living, and thus it could not be included for meta-analysis.

4.2.4 Discussion

In this section of Chapter 4, we carried out a comprehensive systematic literature review and meta-analysis to assess the association of SES with the risk of incident HD in the Chinese population. We identified seven appropriate studies undertaken in China for the review and four studies were available for meta-analysis. The pooled data suggested that there was significant association of low SES with increased risk of HD in China, which was mainly from low educational level, but not from other three SES indicators (occupational class, income, urban-rurality).

Our review and pooled data showed that low education was significantly associated with increased risk of HD, which was consistent with previous studies in

HICs (Khaing et al., 2017). However, the impacts of low levels of occupation and income did not show an inverse association with increased risk of HD in our pooled data, which was not consistent with previous studies (Backholer et al., 2017, Khaing et al., 2017). In their meta-analysis, low occupational class and low income showed around a 50% increased risk of HD, respectively. Insignificant associations between low levels of occupation and income and the risk of HD might be due to limited studies available to be pooled in China, where only three studies reported occupational class (Lee et al., 2000, Guo et al., 2012, Liu and Yan, 2016) and two studies reported income (Guo et al., 2012, Liu and Yan, 2016). More studies are needed to assess the associations of occupational class and income with risk of incident HD in China.

There were large differences between rural and urban areas in terms of lifestyle, healthcare access, and social welfare in China. However, few studies have assessed the impact of rural and urban disparities on the risk of incident HD. Most studies regarding the association of SES with incident HD did not adjust for any confounders (Wu et al., 2015) and thus their residual effects might not be removed. More studies are needed to assess the impact of rural-urban disparity on the risk of incident HD with multivariate adjustments.

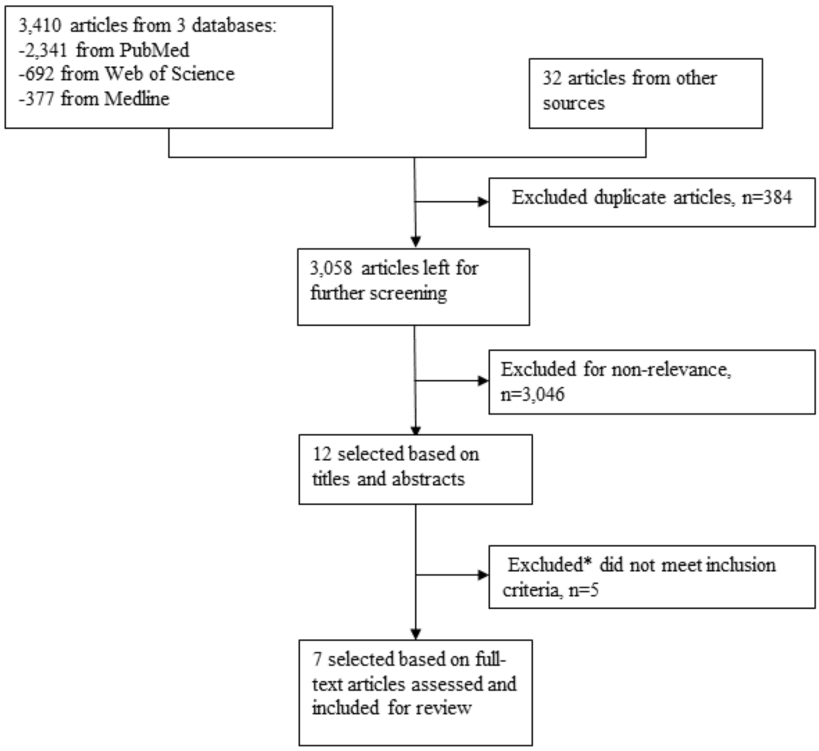
Existing studies showed some inconsistent findings of the association between SES and risk of incident HD in old age. Some studies showed that low educational level was significantly associated with increased risk of HD (Wang et al., 2017a), while others did not show such association (Donnan et al., 1994). In addition, evidence of other SES indicators associated with the risk of HD, such as occupational class, income, and rural-urban living, remains scarce for older adults. Previous studies showed that the risk of HD increased with age; compared to those aged 35-54, participants aged 55-64 and aged 65+ had 2.4 and 2.7 times increased risk of HD, respectively (Lee et al., 2000, Wu et al., 2015). More studies are needed to investigate their associations with old age, particularly in China and in LMICs where population is ageing.

Evidence of association between SES and the incidence of HD remains scarce in China. Most studies were derived using a case-control study design to assess the risk of HD associated with SES, while few studies were carried out using a prospective cohort study design. Therefore, causal associations between SES and the risk of incident HD could not be identified. There is an urgent need for prospective cohort studies to assess the impact of different indicators of SES on the incidence of HD, particularly among older adults.

4.2.5 Conclusions

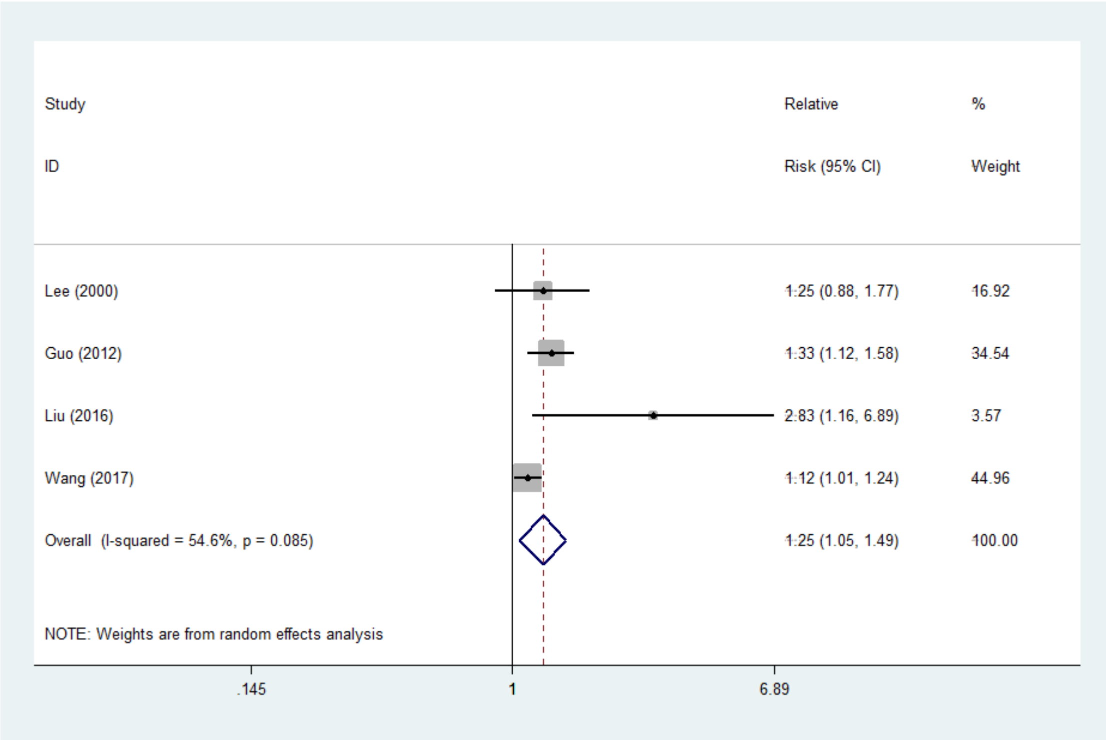
The current systematic literature review and meta-analysis have shown that there was significant association of SES inequality with risk of incident HD in the Chinese population. Low education levels showed a significantly increased risk of HD while there was no such association in low occupational class and income. Evidence of the association between SES and risk of incident HD at old age remains scarce in China. The need to assess the risk of incident HD in relation to different SES variables is urgent in China, particularly using population-based cohort studies.

Figure 4.2-1. Flowchart for literature search, and inclusion of studies for the research



*Reasons included: study design (such as cross-sectional study), did not assess the SES indicator(s), other outcome variables such as prevalence, prognosis and mortality, etc.

Figure 4.2-2. Forest plot for the pooled relative risk (RR) of SES with risk of incident heart disease



The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

Figure 4.2-3. Funnel plot assessing publication bias

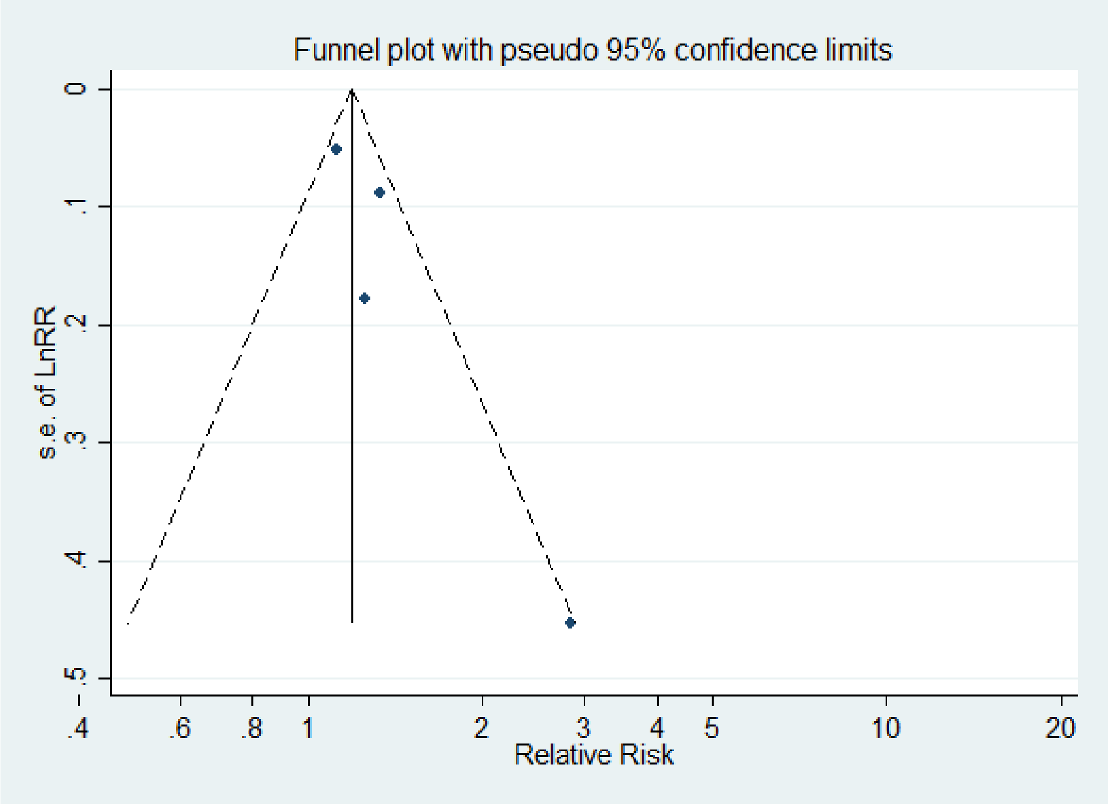
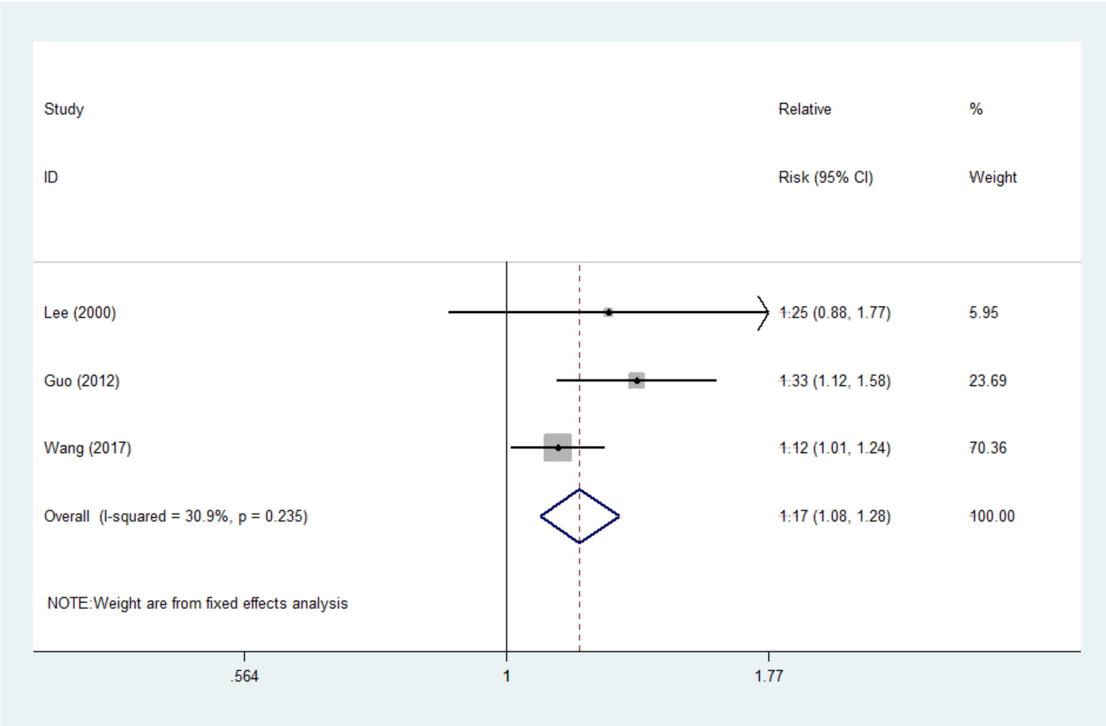
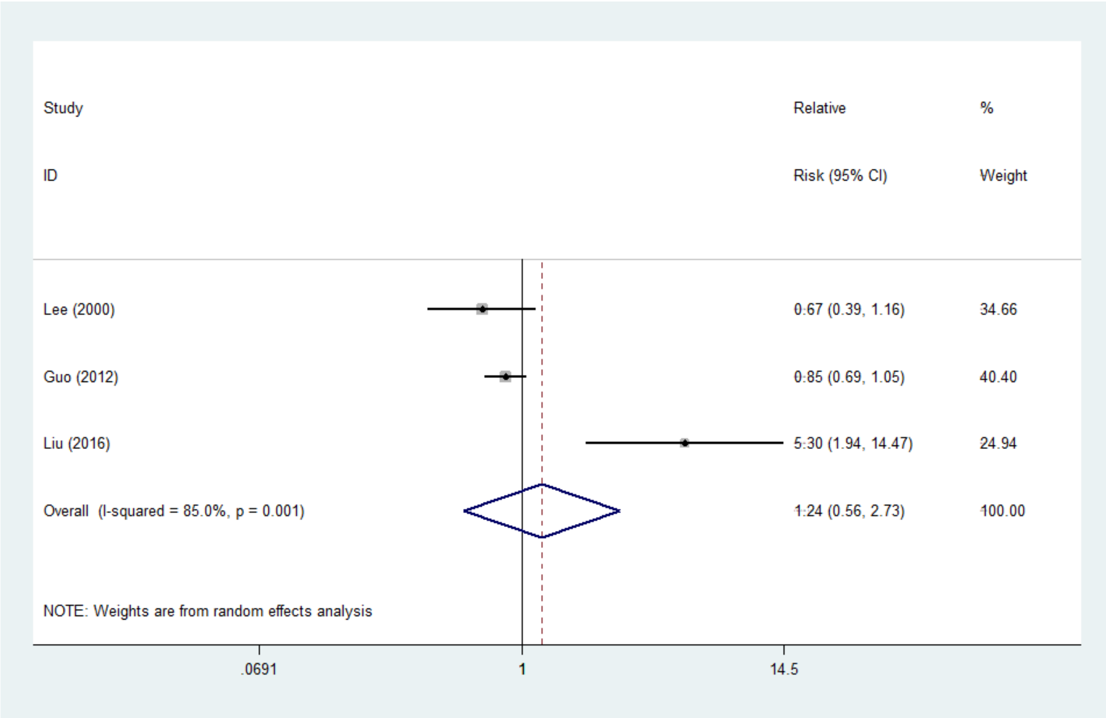


Figure 4.2-4. Forest plot for the pooled relative risk (RR) of low educational level with risk of incident heart disease



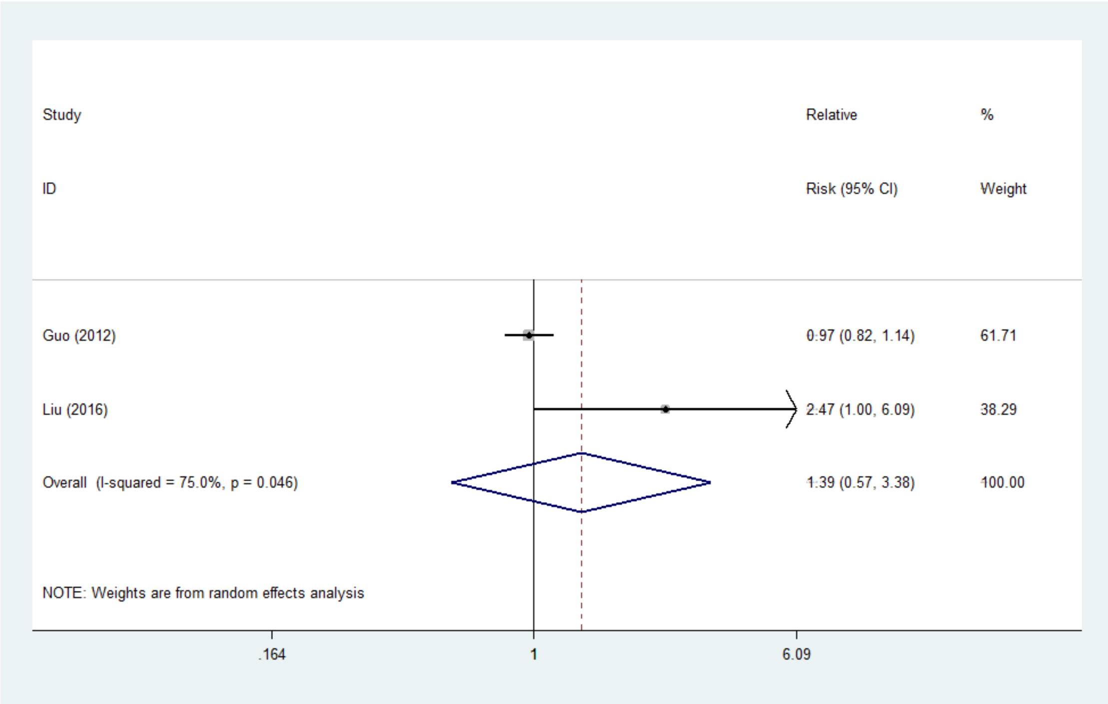
The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

Figure 4.2-5. Forest plot for the pooled relative risk (RR) of low occupational class with risk of incident heart disease



The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

Figure 4.2-6. Forest plot for the pooled relative risk (RR) of low income with risk of incident heart disease



The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

Table 4.2-1. Characteristics and findings of case-control studies identified for the systematic literature review of the association of SES with incident heart disease in China

First author, (publication year): study place	Participants' recruitment	Cases and controls selection and characteristics	Baseline HD diagnosis	Data analysis and adjustment for confounders	Findings
Donnan et al. (1994): Hong Kong	Incident case patients who were newly diagnosed and confirmed as having AMI from four of the major hospitals between July 1987 and December 1990 were recruited.	532 AMI cases and age- (±5 years) and sex-matched 565 controls (no history of MI, ischemic heart disease, or other forms of heart disease) were recruited.	AMI was diagnosed based on definite electrocardiographic (ECG) evidence.	AMI risk estimated using logistic regression analysis. Adjusted covariates were smoking status, moderate activity, triceps skinfold thickness, hypertension, and diabetes.	Unadjusted OR for risk of AMI was presented as follows: Aged <65 Education Male (M) No formal OR 1.0 Formal 1.2 (0.7-2.0) Female (F) No formal 1.0 Formal 0.7 (0.3-1.7) Occupation Male Blue collar OR 1.00 White collar 1.4 (0.8-2.3) Female Blue collar OR 1.00 White collar 1.5 (0.4-6.1) Aged ≥65 Education M No formal OR 1.00 Formal 0.9 (0.5-1.5) F No formal 1.00 Formal 1.0 (0.5-2.0) Occupation M Blue collar OR 1.00 White collar 1.0 (0.5-1.7) F Blue collar OR 1.00 White collar 0.3 (0.1-1.0)

					In the multivariate modelling, the educational and occupational variables were not selected for the analysis due to their significance level.
Teo et al. (2009): the INTER-HEART China study	Patients who admitted to the coronary care unit or cardiology ward between February 1999 and March 2003 from 26 centres were recruited.	3030 AMI cases and 3056 age- (±5 years) and sex-matched controls (without a history of CVD) at the same centres were enrolled.	AMI was diagnosed based on electrocardiogram changes.	AMI risk estimated using logistic regression analysis. Adjusted covariates were age, sex, ApoB/ApoA ratio, smoking, drinking, hypertension, diabetes, waist to hip ratio, depression, global stress, exercise, fruits and vegetables intake, and SES variables for education (or income).	Multivariate analysis was presented as follows: 1. Education Tert education: OR 1.00 9-12 years: 1.05 (0.91-1.22) ≤8 years: 1.47 (1.28-1.68) 2. Income Quantile 4 and 5: OR 1.00 Q 3: 1.19 (1.05-1.36) Q1 and 2: 1.25 (1.10-1.41)
Guo et al. (2012): the INTER-HEART China study	Patients who admitted to the coronary care unit or cardiology ward between February 1999 and March 2003 from 27 regions were recruited.	2909 AMI cases and 2947 age- and sex-matched controls (without a history of CVD) who were hospitalised in the same period were selected. The average age of cases was 62.1±11.7 years and of controls 60.3±11.4 years.	AMI was diagnosed based on electrocardiogram changes.	AMI risk estimated using logistic regression analysis. Adjusted covariates were age, sex, WHR, BMI, smoking, drinking, consumption of vegetables and fruits, exercise, marital status, stress, stressful life events, depression, hypertension, diabetes, stroke, family history of MI, and all SES variables for one another.	Multivariate analysis was presented as follows: 1. Education Trade school/college/university: OR 1.00 9-12 years: 1.04 (0.88-1.23) ≤8 years: 1.33 (1.12-1.59) 2. Income ≥¥10 000/year: OR 1.00 >¥6000-<¥10 000: 1.04 (0.90-1.21) ≤¥6000: 0.97 (0.82-1.14) 3. Occupation

					Professional: OR 1.00 Skilled labor: 0.92 (0.75-1.15) General labor: 0.85 (0.69-1.05) 4. Possessions ≤2: OR 1.00 3: 1.07 (0.92-1.24) 4: 1.04 (0.86-1.25) ≥5: 0.81 (0.62-1.06)
Hu et al. (2012): the INTER-HEART study	Patients who hospitalised to the coronary care unite or cardiology ward of participating centres in 17 cities between 1999 and 2002 were recruited.	2909 AMI cases and 2947 age- and sex-matched controls (without a history of CVD) who hospitalised in the same period were selected. The average age of cases was 62.1±11.7 years and of controls 60.3±11.4 years. Of 2857 participants, 1557 (53.5%) cases and 1300 (44.2%) controls has a low educational level.	AMI was diagnosed based on electrocardiogram changes.	AMI risk estimated using logistic regression analysis. Adjusted covariates were age, sex, BMI, smoking, drinking, lipids, self-reported hypertension and diabetes, obesity, diet, physical activity, and psychosocial factors.	Multivariate analysis for education was presented as follows: Total >8 years schooling OR 1.00 ≤8 years schooling 1.45 (1.26-1.67) Sex-specific The corresponding ORs were Men 1.29 (1.09-1.52) Women 1.55 (1.16-2.08)
Liu et al. (2016): Changsha, Hunan province	Patients who hospitalised to the Hunan Provincial People's Hospital between March 2014 and February 2015 were recruited.	80 congenital heart disease cases and 160 sex- and birth region-matched controls (without genetic disease and birth defects) who were underwent health check-ups at the same hospital during	CHD was diagnosed using echocardiography, CTA, cardiac catheterisation, or surgeries by senior paediatric cardiologists.	CHD risk estimated using multivariate conditional stepwise logistic regression analysis with the significant variables. Adjusted covariates were rural registered permanent	Multivariate analysis was presented as follows: 1.Children's registered permanent residence Urban OR 1.00 Rural 2.83 (1.16-6.88) 2.Father's occupation

		the same period were selected. The age range of cases was 0.25-11 years and the average age 5.8 years.		residence, father's occupation, parents' income, fathers' smoking status, maternal cold and fever, and maternal intake more eggs.	Non-farmer OR 1.00 Farmer 5.30 (1.94-14.47) 3.Parents' income ≥2000 CNY/M OR 1.00 <2000 2.47 (1.00-6.07)

AMI, acute myocardial infarction; CVD, cardiovascular disease; WHR, waist-hip ratio; BMI, body mass index; CTA, computed tomographic angiography.

Table 4.2-2. Characteristics and findings of cohort studies identified for the systematic literature review of the association of SES with incident heart disease

First author, (publication year): study place SES measured	Participants' recruitment	Sample size and characteristics	Methods of follow-up	Endpoint outcomes: HD cases and diagnosis criteria	Data analysis and adjustment for confounders	Findings
Lee et al. (2000): the Chin-Shan Community Cardiovascular Cohort (CCCC), Taipei, Taiwan	Recruited 4,349 individuals who lived in the Chin-Shan area and aged ≥35 years were recruited in 1990.	3,602 (response rate 82.8%) individuals were selected in the baseline survey, of whom 47.3% were men and 52.7% were women.	The cohort was followed up in September 1993 (wave 2) and in October 1995 (wave 3). The total rate of lost to follow-up was 11.3%.	99 incident coronary artery disease (CAD) cases, including 51 men and 48 women. Incident CAD cases were confirmed by review of questionnaires, medical records, laboratory reports, and government vital registry.	Logistic regression analyses were constructed with adjustment for age, sex, marital status, occupation, education, and insurance.	In multivariate analysis, the OR of incident CAD was presented as follows: Education <6 years OR: 1.0 ≥6 years schooling 0.8 (0.6-1.2) Occupation Blue collar: OR 1.0 White collar 1.5 (0.9-2.7)
Wang et al. (2017): the Dongfeng-Tongji Cohort study, Wuhan city	Recruited 27,009 retired employees of the Dongfeng Motor Corporation.	18,551 individuals were selected at baseline (men 8,164 and women 10,387); mean age 62.8 years.	The cohort was carried out between September 2008 and June 2010 and was followed up in 2013.	1901 incident CHD cases, including 1323 (10.79%) low education and 578 (9.19%) high education.	Cox proportional hazard regression models were used with adjustment for age, BMI, waist circumference, smoking, drinking, physical activity, marital status, stress,	In multivariate analysis, the HR of incident CHD for low vs high education was presented as follows: ≥9 years schooling HR 1.00 ≤8 years schooling HR 1.12 (1.02-1.25) The matched figures were <60 years HR 0.95 (0.76-1.20) ≥60 years HR 1.15 (1.03-1.30)

			The lost follow-up rate was 3.8%.	Incident CHD cases were confirmed by review of medical insurance documentation, hospital records and death certificates.	fruit intake, vegetable intake, hypertension, hyperlipidemia, diabetes, and family history of CHD.	

Table 4.2-3. Quality assessment for the seven articles identified that studied the association of SES with incident heart disease in China

Study	1	2	3	4	5	6	7	8	9	10
Hu *et al*. 2012	★	★	★	★	★	★	★	★	★	★
Donnan *et al*. 1994	★	★	★	★	★			★	★	★
Teo *et al*. 2009	★	★	★	★	★	★	★	★	★	★
Guo *et al*. 2012	★	★	★	★	★	★	★	★	★	★
Liu *et al*. 2016	★	★	★	★	★		★	★	★	★
Wang *et al*. 2017	★	★	★	★	★	★	★	★	★	★
Lee *et al*. 2000	★	★	★	★	★	★		★	★	★

Case-Control Study

1 – Is the case definition adequate? (Yes, with independent validation)
2 – Representativeness of the cases
3 – Selection of controls (hospital or community matched controls)
4 – Definition of controls (No history of the HD)
5 – Clear measurement of SES indicators (clear records or structured interview and with same for both cases/controls)
6 – Data analysis controlled for age and sex
7 – Data analysis controlled for other confounders
8 – Findings interpreted well
9 – Weakness mentioned and explained clearly
10 – Paper written well

Cohort Study

1 – Cohort truly representative
2 – Controls derived from the same cohort

3 – Clear measurement of socioeconomic status at baseline
4 – Adequacy Follow-up duration (≥12 months)
5 – Reliable methods of HD (ie, Medical insurance documentation, hospital records or death certificates)
6 – Cohort data analysis controlled for age and sex
7 – Cohort data analysis controlled for other confounders (ie, CVDs and risk factors)
8 – Findings interpreted well
9 – Weakness mentioned and explained clearly
10 – Paper written well
N/A = Not applicable

4.3 Impact of SES on mortality in people with heart disease

4.3.1 Introduction

Heart disease (HD) is the leading cause of death and accounts for about twenty percent of deaths in the world (Lozano et al., 2012). Previous studies showed that low socioeconomic status (SES) was strongly associated with increased mortality in HD patients (Kelli et al., 2019). Most studies on this topic come from HICs, with little available evidence from LMICs (de Mestral and Stringhini, 2017).

China is the largest LMIC. Over the past four decades, China has experienced rapid economic development. At the same time, socioeconomic disparities are widening. The proportion of total deaths due to HD has increased significantly (from 16% to 24% between 1999 and 2008) in China (Jiang et al., 2012). Previous studies found that HD patients with low SES in China had increased risk of HD mortality compared to their counterparts with high SES (Huo et al., 2019). However, other studies did not show such an association (He et al., 1994). In this chapter section, we carried out a systematic literature review and meta-analysis of current literature to assess the association of SES with mortality of HD in China.

4.3.2 Methods

4.3.2.1 Systematic literature review

Data sources and studies selection process

The method of systematic literature review was the same as that in the section 4.2.2 and has been fully described before. Briefly, we [Weiju Zhou, Yuyou Yao] searched PubMed, Medline, and Web of Science from database inception to 31st December 2019 to identify eligible articles for this review. The primary search terms included variations on the nomenclature of (1) 'heart disease' (or 'coronary heart disease', 'ischaemic heart disease', 'hypertensive heart disease', 'cardiomyopathy and myocarditis', 'rheumatic heart disease', 'atrial fibrillation and flutter'), (2) 'survival' (or 'mortality'), (3) 'socioeconomic status' (or 'poverty', 'education', 'income', or 'occupation', 'rural') and (4) 'China' (or 'Chinese') for all fields, including MeSH terms, abstract, title, or text words. The aspects on language restriction, Chinese literature electronic databases search and manual reference search were the same as those in the section 4.2.2 and have been fully described before. We read the titles and abstracts and screened for potentially relevant studies relating to the association of SES with mortality in people with HD. The studies selected were appropriate for this review if they quantified the relationship between any measure of SES and mortality in Chinese people with HD. Study selection flow is shown in Figure 4.3-1. The study in this Chapter section included cohort design studies only.

Data extraction and quality assessment

The methods of data extraction and quality assessment were the same as those described in Chapter 4.2.2, section 1.

4.3.2.2 Meta-analysis

The methods of meta-analysis for the available data from these studies were the same as those in Chapter 4.2.2, section 2 and have been described before.

4.3.3 Results

4.3.3.1 Literature review

There were 2687 hits in our literature search. Once duplicates had been removed, 2218 titles and abstracts were screened, and 14 studies were selected for a full-text review. This process yielded four original studies for review (Figure 4.3-1) (Weng et al., 1990, He et al., 1994, Xiang et al., 2018, Huo et al., 2019). They were published between

1990 and 2019; the paper published the earliest was in Chinese (Weng et al., 1990) and the other three were in English (He et al., 1994, Xiang et al., 2018). All of them were hospital-based studies. Their sample sizes varied from 740 to 3369, with a total of 7339 HD patients, and the average age of participants at the baseline in these studies varied from 0.89 years to 63.4 years. Of the four studies identified, one study measured educational level only (Huo et al., 2019), two studies measured occupational class only (Weng et al., 1990, He et al., 1994), and one study measured the effects of urban-rural living and SES composite scores (Xiang et al., 2018). Three studies reported a reverse association of SES with mortality in patients with HD (Weng et al., 1990, Xiang et al., 2018, Huo et al., 2019), while one reported a positive association (He et al., 1994). Details of the studies' characteristics and outcomes can be seen in Table 4.3-1. The quality of the studies was generally good (Table 4.3-2). The descriptive account and the findings of each of these studies are as follows.

Educational level only

Huo et al (2019)

In 2019, Huo et al. examined data of 3369 patients with acute myocardial infarction (AMI) from 53 hospitals across 21 provinces of China between 2012 and 2015. The patients were followed up at 1, 6 and 12 months after discharge and their vital status were documented. In total, 84 (2.5%) patients died over one-year follow-up. After adjustment for sociodemographic factors, lifestyles, co-morbidities, family histories, severity of CHD disease, time from symptom onset to hospital arrival, and in-hospital treatment, the HR of 1-year mortality was 1.36 (0.45-4.08) in patients with senior high school education, 2.08 (0.79-5.49) in patients with junior high school education, 1.43

(0.53 -3.87) in patients with primary school education, and 2.37 (1.13-6.83) in illiterate patients when compared to those with college education.

Occupational class only

He et al. (1994)

In 1994, He et al. examined 895 patients with MI, who were admitted to Chaoyang Hospital, Beijing, China between January 1974 and December 1986. Of these patients, 745 (98.8%) of the 754 survivors of the initial hospitalisation were followed up in 1988. During the average follow-up of 4.4 years, there were 205 deaths. The crude HR of long-term total mortality was 2.59 (1.63-4.11) for non-manual occupations compared to manual occupations; in men it was 2.68 (1.61-4.47) and in women 0.92 (0.29-2.92). However, in the multivariate adjusted model the occupation variable was not entered for analysis since other variables in the model were more strongly associated with mortality than occupational class.

Weng et al. (1990)

In 1990, Weng et al. conducted a similar study on AMI patients who were hospitalised in Chaoyang Hospital from June 1970 to December 1986. After excluding 139 in-hospital deaths and 14 lost to follow-up, the authors examined the data of 740 patients who were followed up to 14 years. There were 226 deaths in the follow up, of which 178 died due to cardiomyopathy. After adjustment for smoking, medical histories of stroke, heart failure, and arrhythmia, the HR of all-cause mortality was 2.38 (1.64-3.45) in patients with manual versus non-manual occupations. The corresponding HR of death due to cardiomyopathy was 2.32 (1.52-3.53). However, the multivariate regression analysis did not include age and sex for adjustment in the study.

Urban-rurality and SES composite score

Xiang et al. (2018)

In 2018, Xiang et al. carried out a cohort study of 2,485 patients (aged <7 years) with complex congenital heart disease (CCHD) who were hospitalised to Fuwai Hospital in Beijing, China for cardiac surgery between May 2012 and December 2015. Baseline family SES was established using a composite score of the household income, occupation, and education level of each parent in the family. After a median follow-up of 32.1 months, 180 patients died. After adjustment for age at operation, weight, sex, operation type, category of diagnosis, rural residence, residence in a poverty-stricken area, length of intensive care unit stay, length of total postoperative hospital stay, and surgical care cost, the HR of all-cause mortality was 2.66 (1.62-4.35) in patients with low SES (score 5-7) and 2.16 (1.33-4.49) in patients with middle SES (score 8-10) in comparison to those with high SES (score 11-17). In the analysis of urban-rural disparity, the adjusted HR was 1.23 (0.81-1.35) in patients who lived in rural versus urban areas.

4.3.3.2 Meta-analysis

Of the four studies that were reviewed, one study (He et al., 1994) did not give an adjusted HR (its results were biased due to confounding factors) and was excluded from the meta-analysis. Thus, there were three studies left for the pooled data analysis, comprising 6,594 HD patients and 560 deaths. The fixed effect model analysis showed that the pooled RR of mortality in HD patients was 2.47 (1.86-3.27), $p<0.001$ in those with low versus high SES (Figure 4.3-2). The analysis of all three studies did not show evidence of publication bias, with an Egger's test result of $p=0.927$ (Figure 4.3-3). The meta-analysis could not be performed each SES indicator due to limited data.

4.3.4 Discussion

In this systematic review study, only four studies have been identified for examining the association between SES and mortality in patients with HD in China. Most studies showed that low SES was associated with increased mortality in patients with HD, although there was one study which showed a positive association in the SES indicator of occupational class (He et al., 1994). Pooled data from the available studies showed a significant association of low SES with increased mortality in patients with HD.

Coronary heart disease is the second leading cause of death in China. It has been predicted to replace stroke as the leading cause of death nationally in the near future (Zhou et al., 2016), which is due to population ageing and lifestyle changing toward a western risk factor profile (Zhang et al., 2017). However, there have been only four studies published over the past 30 years to examine the impact of SES on mortality in patients with HD. The association of SES with mortality after HD has been not well studied in China; samples in previous studies were mainly either myocardial infarction (Weng et al., 1990, He et al., 1994, Huo et al., 2019) or congenital heart disease (Xiang et al., 2018). There are no population-based studies examining the association.

The pooled data showed an inverse association of SES with mortality in HD patients, which was consistent with studies from HICs (Jones et al., 2015, Moissl et al., 2019). In Germany, Moissl et al. reported a HR of 1.32 (1.13-1.54) for all-cause mortality in CHD patients with low versus high socioeconomic deprivation (Moissl et al., 2019). In the UK, Jones et al. examined patients after percutaneous coronary intervention and found that patients with the lowest SES had a 90% increased risk of all-cause mortality when compared to those with the highest SES, (HR 1.93, 1.38-2.69) (Jones et al., 2015).

In this review, the two studies that were published in the early 1990s showed inconsistent results in the association of occupational class with mortality after HD, despite analysing similar datasets; He's study reported that white collar occupations had increased mortality after AMI (He et al., 1994), but Weng's study showed an inverse association of occupation with mortality (Weng et al., 1990). One of the reasons for this might be because He's study did not adjust for any confounders, and thus the residual effects could not be removed (He et al., 1994). In the meta-analysis, the unadjusted HR data was not used from He's study.

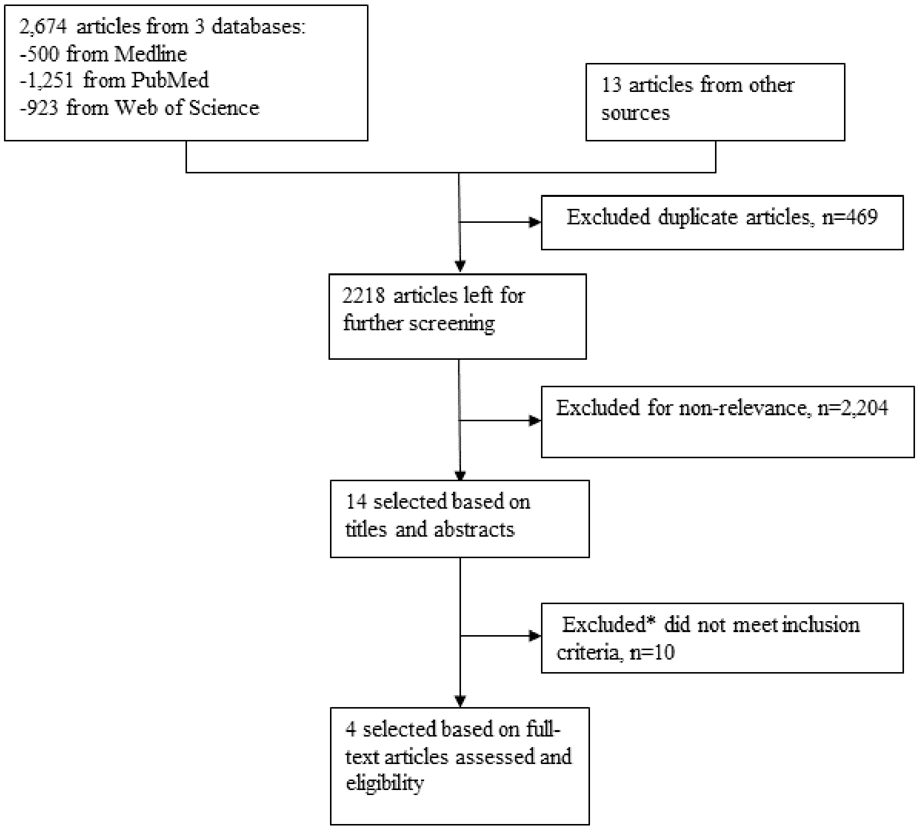
In China, there are large inequalities between rural and urban areas in terms of education, job opportunities, income and healthcare access. Only one study assessed the impact of rural-urban living on mortality of HD. Previous studies showed that increased mortality from HD in China was largely driven in rural areas (Zhang et al., 2017). However, most studies regarding the impact of rural living reported crude or age-standard mortality rate only, which did not adjust for any confounders to remove the residual effects (Liu et al., 2014, Gong et al., 2016, Ma et al., 2020); these studies were not eligible to be included in our study. More studies are needed to analyse such associations to identify whether socioeconomic inequalities, including rural-urban differences, are associated with increased mortality of HD, particularly in survival at older ages.

Income as a composite SES indicator is frequently used in most socioeconomic studies, and is a significant predictor of the incidence and the mortality of CVDs (Khaing et al., 2017, Wang et al., 2020). However, no study has assessed the association of income with mortality in patients with HD in China, so there is a need to do so.

4.3.5 Conclusions

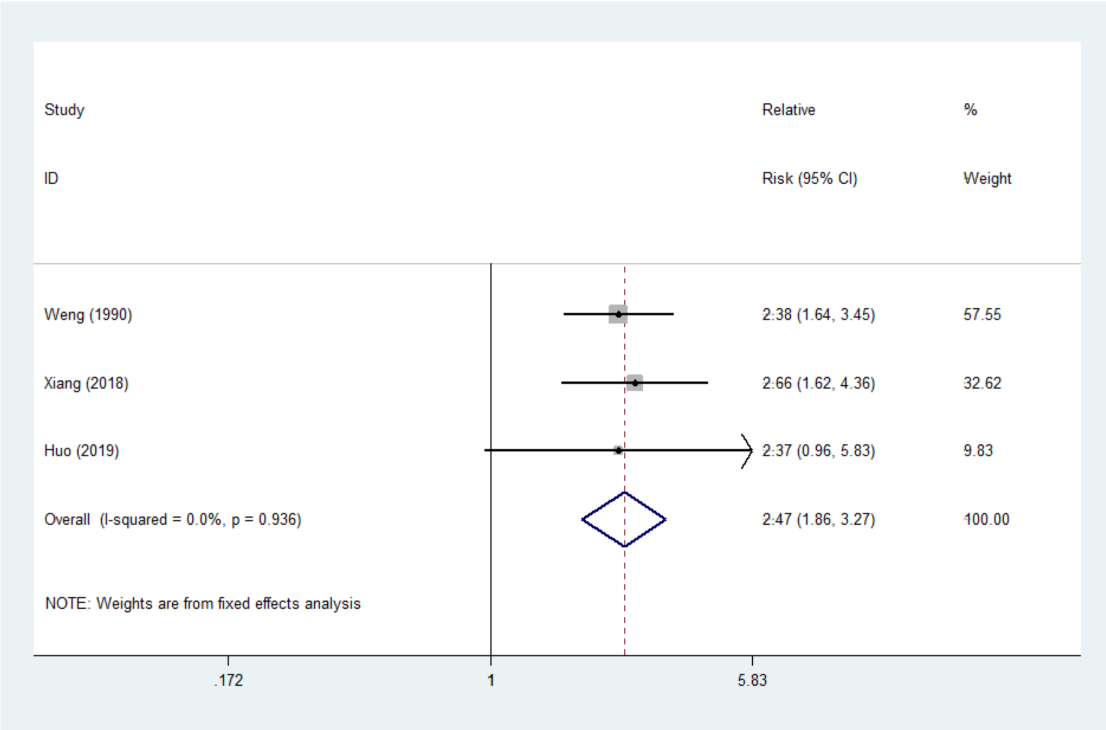
In summary, this systematic literature review suggests that there has been less investigation on the association between SES and mortality in patients with HD in China, and little attention has been paid to SES inequalities in survival in Chinese patients with HD. There is an urgent requirement to carry out studies in the population to assess the impact of SES on mortality in patients with HD and reduce survival inequalities.

Figure 4.3-1. Flowchart for literature search, and inclusion of studies for the research



*Reasons included: other outcome variables such as prognosis and study design (such as cross-sectional or case control), etc.

Figure 4.3-2. Forest plot for the pooled relative risk (RR) of SES with all-cause mortality after heart disease



The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

Figure 4.3-3. Funnel plot assessing publication bias

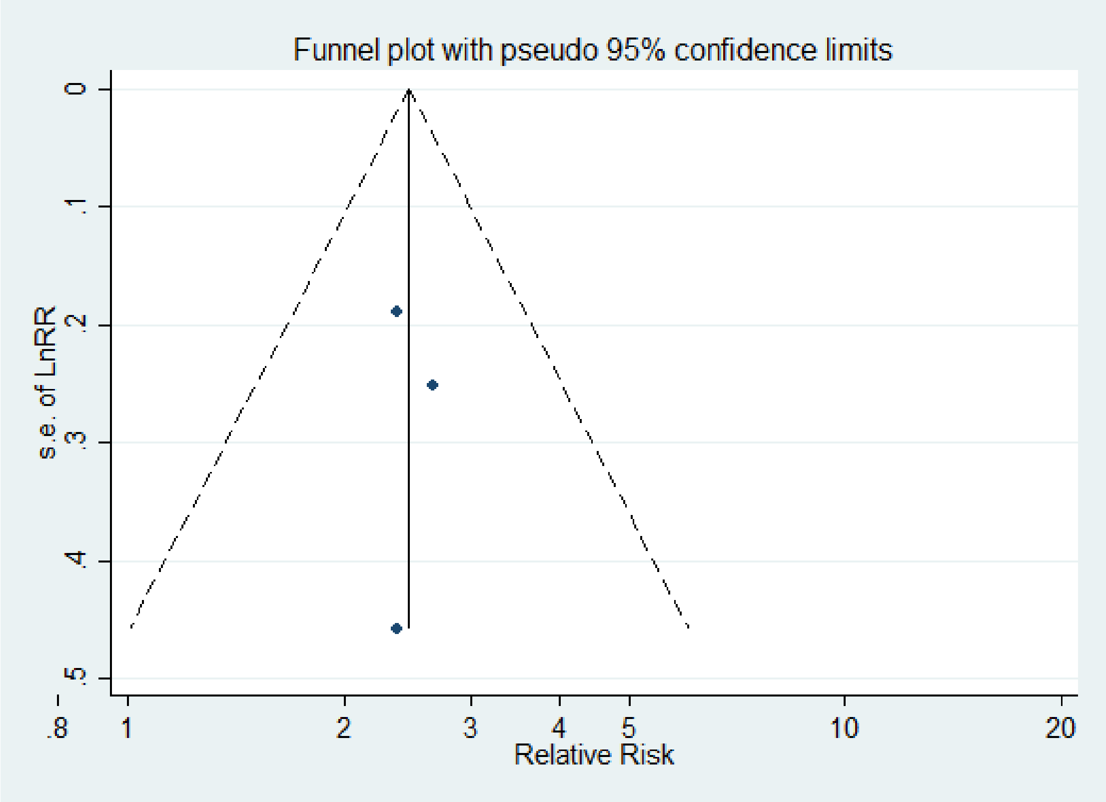


Table 4.3-1. Characteristics and outcomes of cohort studies for the systematic literature review of mortality among patients with heart disease in China

First author, (study years and place)	**Recruit and select patients**	**Heart disease diagnosis criterial**	**Characteristics of patients**	**Methods of follow-up**	**Data analysis**	**Findings**
<u>Educational level only</u>						
Huo (2019) (2012 to 2015, the China Patient-centred Evaluative Assessment of Cardiac Events-Prospective AMI Study, China)	Patients were recruited from 53 hospitals (35 tertiary and 18 secondary hospitals) if they met the criteria including (1) age ≥18 years; (2) hospitalised for AMI and presented within 24 hours of onset of symptoms. 3,369 AMI patients were included.	AMI was diagnosed according to the third universal definition.	The median age was 61 years (rang, 52-69), and 781 (23.2%) were women. 1123 (33.3%) had high, 1092 (32.4%) intermediate and 1154 (34.3%) had low educational attainment.	Followed up by trained research personnel at 1, 6 and 12 months post discharge. 25 patients were lost to follow up.	Cox models were used with adjustment for age, sex, diabetes, hypertension, hyperlipidaemia, smoking status, SBP at admission, heart rate at admission, AMI, mini-GRACE risk score, time from symptom to hospital arrival, inhospital coronary angiography, inhospital revascularisation and inhospital thrombolytic therapy.	84 (2.5%) deaths Fully adjusted HRs for 1-year mortality were presented as follows: High education HR 1.00 Intermediate education 1.71 (0.89-3.30) Low education 1.41 (0.74-2.69) High education HR 1.00 Low and intermediate education level HR 1.54 (0.85-2.81) College HR 1.00 Senior high HR 1.36 (0.45-4.08) Junior high HR 2.08 (0.79-5.49) Primary HR 1.43 (0.53-3.87) Illiterate HR 2.37 (1.13-6.83)

Occupational class only						
Weng (1990) (June 1970 to December 1986, Chaoyang Hospital, China)	Patients were recruited if they had chest pain, characteristic electrocardiographic changes, and serum enzyme level elevations. A total of 740 AMI survivors were left to analyse.	Myocardial infarction was diagnosed using WHO criteria.	518 were men and 222 were women. 156 patients were non-manual occupations, while 584 were manual occupations.	Followed up by researchers at home visit between January and October 1988. Vital status and cause of death were documented. The lost follow-up rate was 1.86%.	Cox models were used for long-term mortality with adjustment for smoking, medical histories of stroke, heart failure, and arrhythmia.	226 (30.5%) died due to any causes and 178 (24.1%) due to cardiomyopathy In multivariate adjusted analysis, the HR of all-cause mortality was 2.38 (1.64-3.45) in patients with manual versus non-manual occupations. The corresponding HR of death due to cardiomyopathy was 3.32 (1.52-3.53).
He (1994) (January 1974 to December 1986, Chaoyang Hospital, Beijing, China)	Patients were recruited in the study if they had 1) central anterior chest pain lasting for more than 15 mins; 2) characteristic electrocardiographic changes; 3) serum enzyme level elevations.	Myocardial infarction was diagnosed using WHO criteria.	523 men and 222 women who were survived and included to analyse. There was no data reported their age, but among 895 selected patients, 601 were men and	Followed up by two physicians at home visit. The vital status was documented and confirmed by a review of a city vital statistics records.	Cox models were used for long-term mortality.	205 (27.5%) deaths In univariate analysis, compared to those with manual occupations, the HR of long-term total mortality was 2.59 (1.63-4.11) in patients with non-manual occupations. The corresponding HRs were 2.68 (1.61-4.47) in men and 0.92 (0.29-2.92) in women.

	745 MI patients were followed up successfully and analysed in the study.		294 were women. The average age of the cohort was 60 years; 58.1 years old in men and 63.4 years old in women.	The lost follow-up rate was 1.2%.		
Xiang (2018) (May 1, 2012 to December 31, 2015, Fuwai Hospital, Beijing, China)	Patients aged <7 years who hospitalised for CCHD surgery were enrolled in this study. 2555 patients were included for analysis.	CCHD was confirmed by the surgeon from the medical record and coded using the International Classification of Disease, 10th revision.	The median age of patients at operation was 0.88 years, and 1548 (62%) were boys. 919 patients with low SES, 845 with middle SES, and 791 with high SES.	Followed up by trained interviewers At 1, 6, and 12 months after the date of discharge, and annually thereafter. The median follow-up was 32.1 months. 199 patients (7.8%) were lost to follow-up.	Cox models were used with adjustment for age at operation, weight, sex, operation type, category of diagnosis, rural residence, residence in a poverty-stricken area, length of intensive care unit stay, length of total postoperative hospital stay, and surgical care cost.	250 deaths Multivariate adjusted HRs for all-cause mortality were presented as follows: 1. Urban-rural Urban HR 1.00 Rural HR 1.23 (0.81-1.35) 2. SES score High SES HR 1.00 Middle HR 1.95 (1.18-3.22) Low HR 2.66 (1.62-4.35)

HR, hazard ratio; AMI, actual myocardial infarction; CVD, cardiovascular disease; SBP, systolic blood pressure; WHO, World Health Organisation; CCHD, complex congenital heart disease.

Table 4.3-2. Quality assessment for the four articles identified that studied the association of SES with mortality of heart disease in China

Study	1	2	3	4	5	6	7	8	9	10
Huo et al. 2019	★	★	★	★	★	★	★	★	★	★
Weng et al. 1990	★	★	★	★	★		★	★		
He et al. 1994	★	★	★	★	★			★	★	★
Xiang et al. 2018	★	★	★	★	★	★	★	★	★	★

Cohort Study

1 – Cohort truly representative

2 – Controls derived from the same cohort

3 – Clear measurement of socioeconomic status at baseline

4 – Adequacy Follow-up duration (≥12 months)

5 – Reliable methods of heart disease (ie, doctor diagnosis)

6 – Cohort data analysis controlled for age and sex

7 – Cohort data analysis controlled for other confounders (ie, CVDs and risk factors)

8 – Findings interpreted well

9 – Weakness mentioned and explained clearly

10 – Paper written well

4.4 Impact of SES on risk of stroke

4.4.1 Introduction

The burden of stroke has increased across the world, with the disability-adjusted life years ranked at 3rd up from 5th over the past decades (Kyu et al., 2018). There is increasing evidence in epidemiological studies showing that low socioeconomic status (SES) was associated with increased incidence of stroke in the general population (Cox et al., 2006, McFadden et al., 2009, Addo et al., 2012, Marshall et al., 2015). The global burden of disease study demonstrated that people in low- and middle-income countries (LMICs) have a higher risk of stroke than in high income countries (HICs) (Johnson et al., 2019).

China, the largest LMIC has the highest estimated lifetime risk of stroke worldwide (39.3%, 95% CI 37.5 to 41.1) (Feigin et al., 2018). Every year, around 5.5 million new stroke cases occur in China (Johnson et al., 2019). Over the past 40 years, China has experienced rapid economic growth, along with an increasing gap in income between rich and poor (Xie and Zhou, 2014). In recent years, there has been increasing interest in examining the association of SES with the incidence of stroke in China. A number of papers have been published (Wang et al., 2015); some studies showed that low SES was associated with increased risk of stroke (Li et al., 2019, Wu et al., 2019), while others did not (Wu et al., 2011, Wang et al., 2019). There are variations in the methods of studies and the SES measurements among these studies, including educational level, occupational class, income, and urban-rural disparity associated with increased risk of stroke. The overall picture of the impact of SES on incident stroke is unclear. No systematic literature review has been done to examine the association between SES and incidence of stroke in China. Therefore, we carried out a systematic literature review and a meta-analysis to assess the association of SES with incidence of stroke in China.

4.4.2 Methods

4.4.2.1 Systematic literature review

Data sources and studies selection process

The method of systematic literature review was the same as that in the section 4.2.2 and has been fully described before. Briefly, we [Weiju Zhou, James Jie Tang] searched literature from Medline, PubMed, and Web of Science to identify studies eligible for inclusion in this review. The search terms were [“stroke” OR “cerebrovascular accident, cerebrovascular disorders, cerebral haemorrhage, subarachnoid haemorrhage, intracranial haemorrhage”] AND [“incidence” OR “incident, morbidity”] AND [“socioeconomic status” OR “poverty, education, income, occupation, rural”] AND [“China” OR “Chinese”] for all fields, including MeSH terms, abstract, title, or text words. The literature was covered from the earliest year in those datasets to 31st December 2019. The aspects on language restriction, Chinese literature electronic databases search and manual reference search were the same as those in the section 4.2.2 and have been fully described before. We read the titles and abstracts and screened for potentially relevant studies relating to the association of SES with incident stroke. The studies selected were appropriate for this review if they quantified the relationship between any measure of SES and incidence of stroke in the Chinese population. Study selection flow is shown in Figure 4.4-1. The present study included only cohort and case-control studies. Cross-sectional studies and those studies which just gave numbers of cases/participants in different SES groups were excluded.

Data extraction and quality assessment

The methods of data extraction and quality assessment were the same as those described in Chapter 4.2.2, section 1.

4.4.2.2 Meta-analysis

The methods of meta-analysis for the available data from these studies were the same as in Chapter 4.2.2, section 2 and have been described before.

4.4.3 Results

4.4.3.1 Literature review

In the seven identified articles, we found one cohort study (Wu et al., 2019) and six case-control studies (Wang et al., 2005, Wu et al., 2011, Zhang et al., 2013, Song et al., 2014, Li et al., 2019, Wang et al., 2019). They were published between 2005 and 2019. Five studies reported in English, and two studies were published in Chinese Journals (Wang et al., 2005, Song et al., 2014). Three studies were from hospital data (Wang et al., 2005, Song et al., 2014, Wang et al., 2019) and four studies from community data. Their sample sizes varied from 281 to 11,078, with a total of 8,278 incident stroke cases. The mean age in the participants from these studies varied from 47.14 to 70.60 years. Of the seven studies, five measured only educational level as an indicator of SES (Wang et al., 2005, Wu et al., 2011, Song et al., 2014, Li et al., 2019, Wu et al., 2019), one measured educational level and income (Zhang et al., 2013), and one study examined multiple SES indicators (Wang et al., 2019). Of the seven studies, four (Zhang et al., 2013, Song et al., 2014, Li et al., 2019, Wu et al., 2019) showed an inverse association of SES with risk of incident stroke, one (Wang et al., 2005) showed a non-significant association, and two (Wu et al., 2011, Wang et al., 2019) showed a positive association.

The qualities of these studies were generally good (Table 4.4-3). The qualitative reviews of each study are as follows. Tables 4.4-1 and 4.4-2 document the details of the studies' characteristics and outcomes.

Case-control study

Wang et al. (2005)

Wang et al. (2005) carried out a case-control study on 358 haemorrhagic stroke patients and 358 non-stroke controls in six hospitals in Guangzhou city in 2004. Wang and Colleagues (2005) found that in univariate logistic regression analysis, the OR of incident stroke was 1.54 (0.85-2.78) in those with education level of ≤junior high school. There was no adjusted OR for the risk of stroke at different educational levels since in the multivariate analysis including BMI, lifestyle, cardiovascular risk factors, family medical histories, and other chronic clinical and biological indicators, it was not selected for the analysis due to its significance level. In addition, the study did not analyse occupational class variable, although each patient's occupation was recorded during the interview.

Wu et al. (2011)

Wu et al. (2011) carried out a 1:2 matched case-control study on 1,034 stroke cases and 2,068 non-stroke controls from five communities in Chongqing between 2004 and 2005. They found gender difference in the risk of stroke in relation to education. For men, the risk of stroke was significantly increased in those who were undergraduates and above (multivariate adjusted OR 1.97, 1.19-3.24) compared to those who were illiterate or only received primary school education, but the risk was not significant in those who completed middle school (1.17, 0.74-1.83) and high school or secondary education (1.27, 0.79-2.06). For women, the positive association of educational level with incident stroke was found in those who had middle school education (1.72, 1.16-2.56) and in those who were undergraduates and above (2.55, 1.54-4.22) when compared to those who were illiterate or primary school educated, but the risk was not significant in those with high school or secondary educations (1.46, 0.96-2.23).

Zhang et al. (2013)

Zhang et al. (2013) carried out a community-based case-control study of 226 subarachnoid haemorrhage (SAH) stroke cases and 434 SAH-free controls in Baotou city, Inner Mongolia from May 2009 to May 2011. In the univariate analysis, educational level of <university was not associated with risk of SAH (RR 1.12, 0.67-1.89) when compared to educational level of university or above, as did after stratified by gender (in men 1.16, 0.54-2.44; in women 1.09, 0.54-2.22). Due to its insignificance level, the variable of education was not selected for the multivariate analysis. In the univariate analysis of income <70,000 RMB versus ≥70,000 RMB, low annual income was significantly associated with increased risk of SAH (2.44, 1.43-4.17) and there was gender difference between men (4.76, 1.61-14.29) and women (1.56, 0.81-2.94). After further adjustment for marital status, overweight, hypertension, previous stroke, antithrombotic use, current alcohol intake, and current smoking, low annual income remained significant in the risk of SAH (2.91, 1.54-5.53), but the gender difference in the association of income with incident SAH was not significant (in men 3.58, 1.10-11.71; in women 2.51, 1.10-5.73).

Song et al. (2014)

Song et al. (2014) carried out a hospital-based case-control study in the Fengrun District People's Hospital, Tangshan, Hebei province, involving 136 ischemic stroke cases and

145 non-stroke controls between September 2009 and October 2012. Adjustment for smoking, hypertension, diabetes, triglyceride, total cholesterol, high-density lipoprotein, and low-density lipoprotein in the logistic regression model showed an OR of 0.66 (0.45-0.96) for the continuous variable of educational level with the risk of stroke. However, the study did not use the categorial variable of education to assess the association with incident stroke.

<u>Li et al. (2019)</u>

The 1:1 matched community-based case-control study by Li et al. (2019) examined the data of the High-risk Population Screening and Intervention Project for Stroke that was collected from 12 areas of northern China. In the study, 5,539 patients who had previous history of ischemic stroke were selected as cases. Compared to patients living in rural areas, stroke patients living in urban areas were more likely to have high levels of education and income. After adjustment for smoking, lack of exercise, family history of stroke, hypertension, dyslipidaemia, diabetes, and obvious overweight and obesity, low education was associated with increased risk of incident stroke in urban areas (OR 1.19, 1.02-1.39), but with reduced risk of stroke in rural areas (0.69, 0.54-0.88). In the analysis of exposed stroke risk factors in urban and rural areas, low levels of education and income were the more common risk factors for stroke in rural areas; the odds of ORs of low education and low income in rural versus urban areas were 3.15 (2.64-3.75) for low education and 3.80 (3.35-4.32) for low income.

<u>Wang et al. (2019)</u>

Wang et al. (2019) carried out a hospital-based case-control study of 347 ischaemic stroke cases and 347 non-stroke controls between September 2016 and October 2017 in Guangzhou city, Guangdong province. After adjustment for a number of co-variables, the ORs of incident stroke in those with 6-9 years schooling, 10-12 years schooling, and >12 years schooling were 2.63 (1.45-4.75), 1.56 (0.82-2.98), and 2.18 (1.25-3.82), respectively, when compared to those with ≤6 years schooling. Compared to those with income of ≤ ¥1000 per month, the fully adjusted ORs were 1.96 (1.21-3.15) for those with income of ¥1001-3000, 4.16 (2.39-7.22) for those of ¥3001-5000, and 2.83 (1.25-6.39) for those of >¥5001. In the full adjustment analysis, ORs for incident stroke were significantly increased in manual workers (1.95, 1.23-3.07) and in non-manual workers (1.87, 1.05-3.33), but not in those who were retired (1.05, 0.47-2.37).

Cohort study

<u>Wu et al. (2019)</u>

Wu et al. (2019) examined a population-based cohort study of 14,936 participants aged ≥18 years old who had no histories of ischaemic heart disease or stroke in the rural district of Tianjin city. The cohort has been conducted since 1991. During the 27 years follow-up, 638 new stroke cases were documented, including 404 ischemic strokes (63.3%), 121 haemorrhagic strokes (19.0%), and 113 undefined strokes (17.7%). After adjusted for age, sex, hypertension, diabetes, BMI, hypertension types, current smoking and alcohol consumption status, the HR of incident stroke was significantly increased in those with no schooling (2.9, 1.3-6.5), in those with 1-6 years of schooling (3.1, 1.4-7.0), and in those with 7-9 years of schooling (2.2, 1.0-5.1) when compared to those with >9 years schooling. Data analysis within those with ischemic stroke showed that the HR of incident stroke was 2.2 (0.9-5.4) in those with no schooling, 2.6 (1.0-6.3) in those with 1-6 years of schooling, and 2.1 (0.9-5.2) in those with 7-9 years of schooling, while within those with haemorrhagic stroke the corresponding figures were 4.6 (0.6-

33.8), 5.0 (0.7-36.7), and 1.6 (0.2-12.7), respectively, the insignificance of which would be due to the smaller number of patients with haemorrhagic stroke.

4.4.3.2 Meta-analysis

Among the seven studies, there were nine studied populations, which were pooled for the overall association of SES with the risk of stroke (Figure 4.4-2). The random effect model analysis showed that the RR of incident stroke in people with low versus high SES was 1.00 (0.68-1.46), p=0.989. The reason for no association of low SES with increased risk of stroke from these studied populations was that data of five studied populations showed a positive association, while the data of four others showed inverse association. The analysis of publication bias from these seven studies did not suggest any evidence of significant publication bias, with Egger's test giving a result of p=0.852 (Figure 4.4-3).

Data analysis for different indicators associated with stroke risk was run as follows.

Low and High Educational level

All studies reported the association between educational level and risk of incident stroke (Wang et al., 2005, Wu et al., 2011, Zhang et al., 2013, Song et al., 2014, Li et al., 2019, Wang et al., 2019, Wu et al., 2019), which included 8,278 stroke cases. Pooling data of the RR of incident stroke in participants with low educational level vs high educational level was 0.91 (0.65-1.28), p=0.596 (Figure 4.4-4).

Low and High income

There are two studies which reported the association of income with risk of incident stroke, comprising of 573 stroke cases. In the pooled data, participants with low income had a higher risk of stroke than their counterparts with high income (pooled RR 1.02, 0.13-8.16; p=0.982) (Figure 4.4-5).

Low and High levels of other SES

There were no rural-urban data and only one figure available for occupational class, and they could not be used for meta-analysis.

4.4.4 Discussion

In this section of Chapter four, we carried out a systematic review and meta-analysis to assess the association of SES with the risk of stroke in the Chinese population. We identified all seven studies undertaken in China for the review. Of these studies, six were case-control studies and only one was a cohort study. Two showed a positive association of SES with risk of incident stroke, and four showed an inverse association, although some of the SES indicators were not statistically significant. The pooled data suggested that there was no association between SES and incident stroke in China. The picture on the association of low SES with increased risk of stroke in the Chinese population was unclear, probably due to the small number of published studies. In spite of this, I would like to discuss more about SES.

Nine years ago, Kerr et al. (Kerr et al., 2011) reviewed twelve papers from world literature and carried out a meta-analysis. In their analysis, which included three studies from USA, eight from Europe, and one from LMICs, they found that the pooled HR for incident stroke was 1.67 (1.46-1.91) in people with low SES compared to those with high SES, and the increased risk of stroke in low SES would be reduced but not eliminated when classic vascular risk factors were adjusted for (1.31, 1.16-1.48). SES as a comprehensive measure of social standing encompasses educational level, occupational class, income, and urban-rural disparity. Lower SES may be attributed to obtaining an unhealthy lifestyle (e.g., physical inactivity and bad dietary habits), worse physical and psychosocial working conditions, and lower healthcare utilisation and access to primary care and medical care (Brännlund et al., 2013, Ravesteijn et al., 2013, Kim et al., 2013).

Most of existing studies in China have investigated the association of educational level with incident stroke, but the impacts of other SES indicators on the risk of stroke, including occupational class, income, and urban-rural disparity, are rarely understood. Previous studies suggested that educational level, occupational class, and income cannot be used interchangeably as indicators of a hypothetical latent social dimension (Geyer et al., 2006). Using only one indicator of SES may yield misleading results or provide less information than using multiple measures. It is of importance to explore the impacts of SES on the risk of stroke using multiple SES indicators in China.

Educational level associated with incident stroke has been reported in most existing studies, but there were some inconsistent findings in their associations in China. Some studies reported that low educational level was associated with increased risk of stroke (Song et al., 2014, Li et al., 2019), whereas other studies demonstrated inverse (Wu et al., 2011, Wang et al., 2019) or nonsignificant associations (Wang et al., 2005) with incident stroke. The heterogeneity in the associations could be due to the inconsistency in adjusting for potential confounders in the included studies. Some of the included studies did not adjust for any covariates due to its significance level (Wang et al., 2005), while other studies additionally adjusted for demographic and health variables that could confound the result or affect the association (e.g., age, sex, BMI, diabetes, and hypertension) (Wu et al., 2011, Li et al., 2019, Wang et al., 2019). These may develop biases in the meta-analysis (Felson, 1992). Therefore, more research is needed to assess the association of educational level with risk of incident stroke in China.

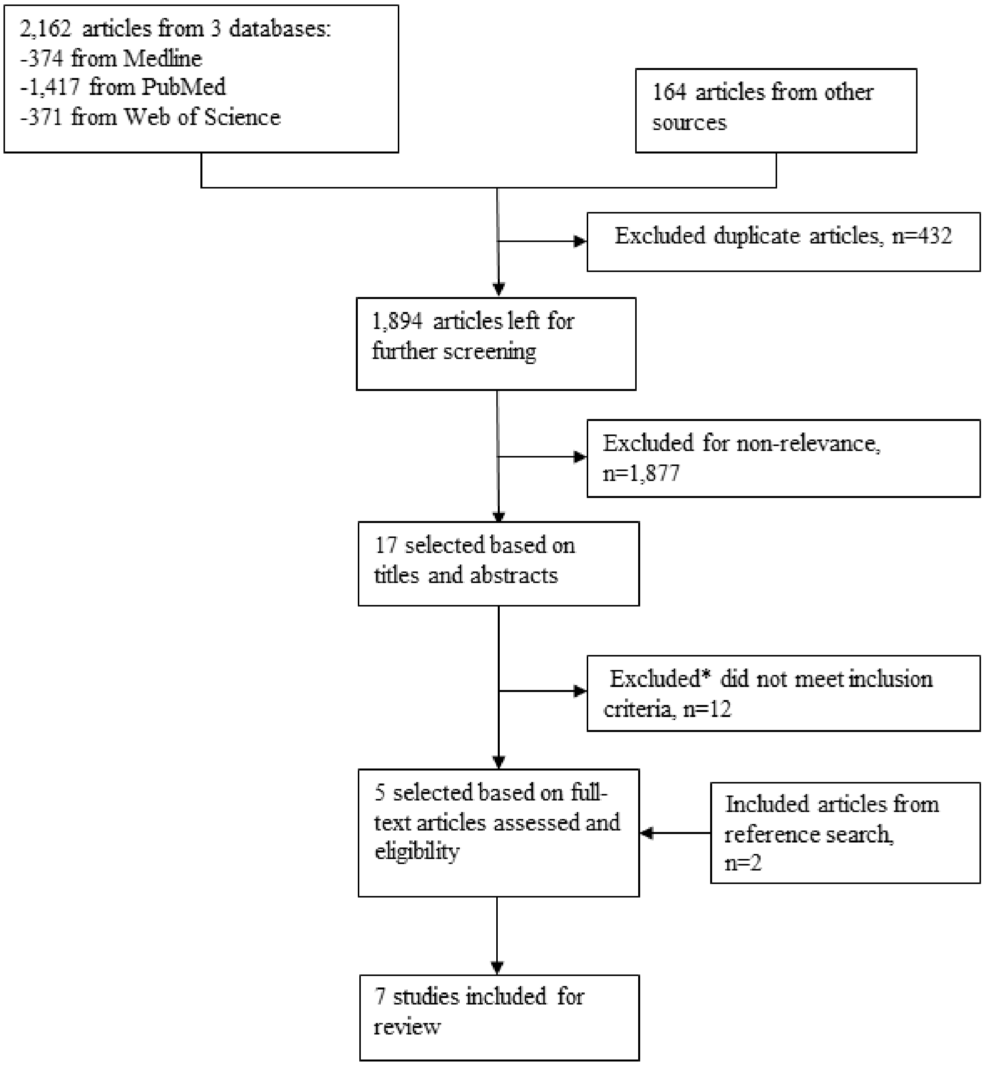
Occupational class and income are two other common indicators of SES in health research. However, few studies have assessed their impacts on the risk of stroke in China and thus limited data are available to perform a meta-analysis. Generally, people with higher job position and income are more likely to have better social and psychological factors and a better material environment. However, a recent study by Wang et al. (2019) showed that the risk of stroke was higher in those with higher levels of occupational class and income. These inconsistent findings were also seen in western literature and other HICs (Avendano and Glymour, 2008, McFadden et al., 2009). In the UK, McFadden et al. reported that lower occupational class was associated with higher stroke incidence (HR 2.55, 1.34-4.85) (McFadden et al., 2009), while in the US, Avendano et al. found that the incidence of stroke was higher among those with high income at ages 75+ (HR 2.32, 1.16-4.55) (Avendano et al., 2006a). One of the reasons for the inconsistent findings could be explained by studied sample variations, different countries' social systems, and epidemiological transition in the early stages that those with higher SES may have an unhealthy diet and lifestyle.

In this review, it was found that most studies on the association of SES with incident stroke were from case-control study design. This may or may not represent their causal relationships if the study design and conduct were not appropriate. The study design is by definition retrospective, which makes it hard to determine whether SES inequality is a cause or a consequence of incident stroke (Mann, 2003). Therefore, it cannot measure the incidence of stroke but just a relative risk (OR) in relation to SES. More studies of long-term follow-up cohorts are needed to lay particular emphasis upon the true temporality of the association of SES with incidence of stroke in China.

4.4.5 Conclusions

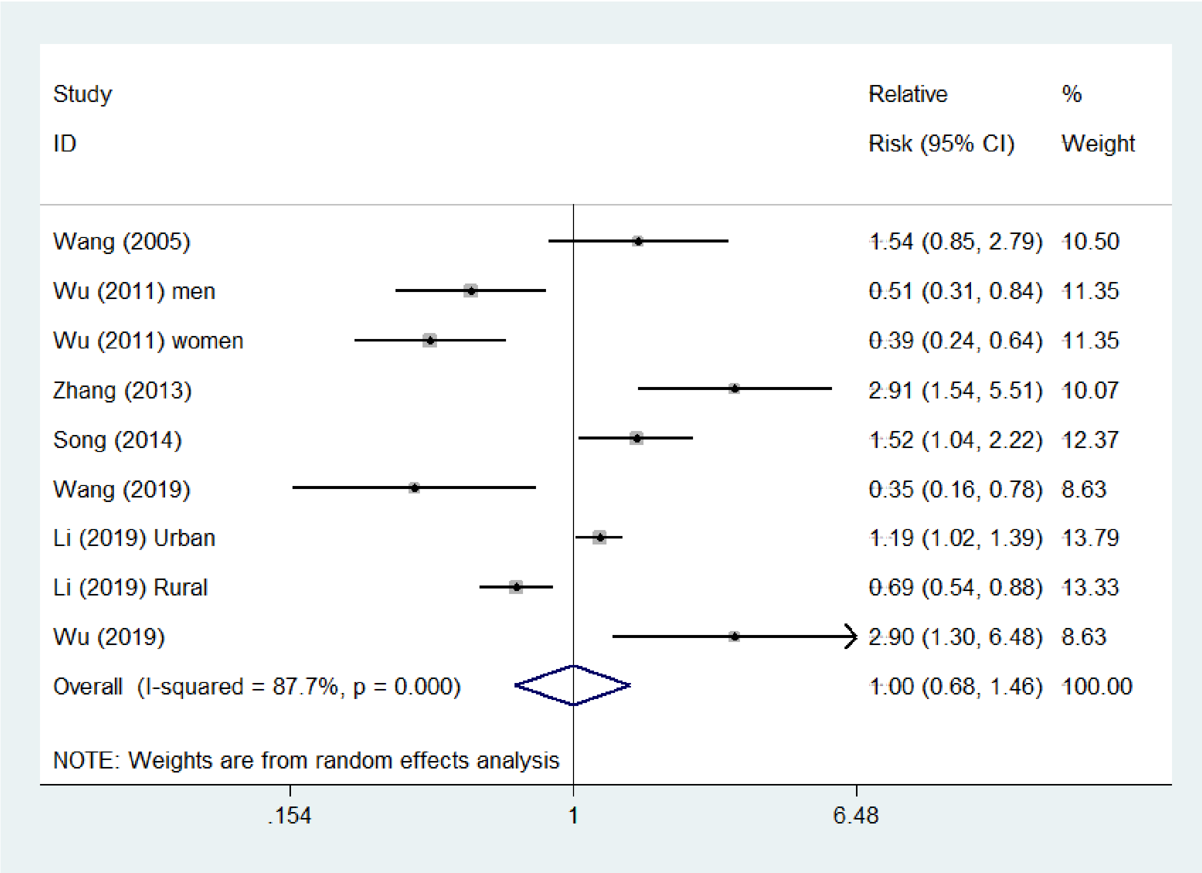
The current systematic literature review and meta-analysis have shown that there was no association of SES inequalities with increased risk of stroke in Chinese population, and the full picture of the impact of SES on incidence of stroke in China was still unclear. These results are probably because only a couple of studies have been published and most of them were case-control studies. There are knowledge gaps between China and HICs in the association of SES with incident stroke, which remains to be resolved in future. There is an urgent need to undertake more population-based studies, particularly cohort studies, to examine the impact of SES on the risk of stroke in China.

Figure 4.4-1. Flowchart for literature search, and inclusion of studies for the research



*Reasons included: study design (such as cross-sectional study), did not assess the SES indicator(s), other outcome variables such as prognosis and mortality, etc.

Figure 4.4-2. Forest plot for the pooled relative risk (RR) of SES with risk of incident stroke



The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

Figure 4.4-3. Funnel plot assessing publication bias

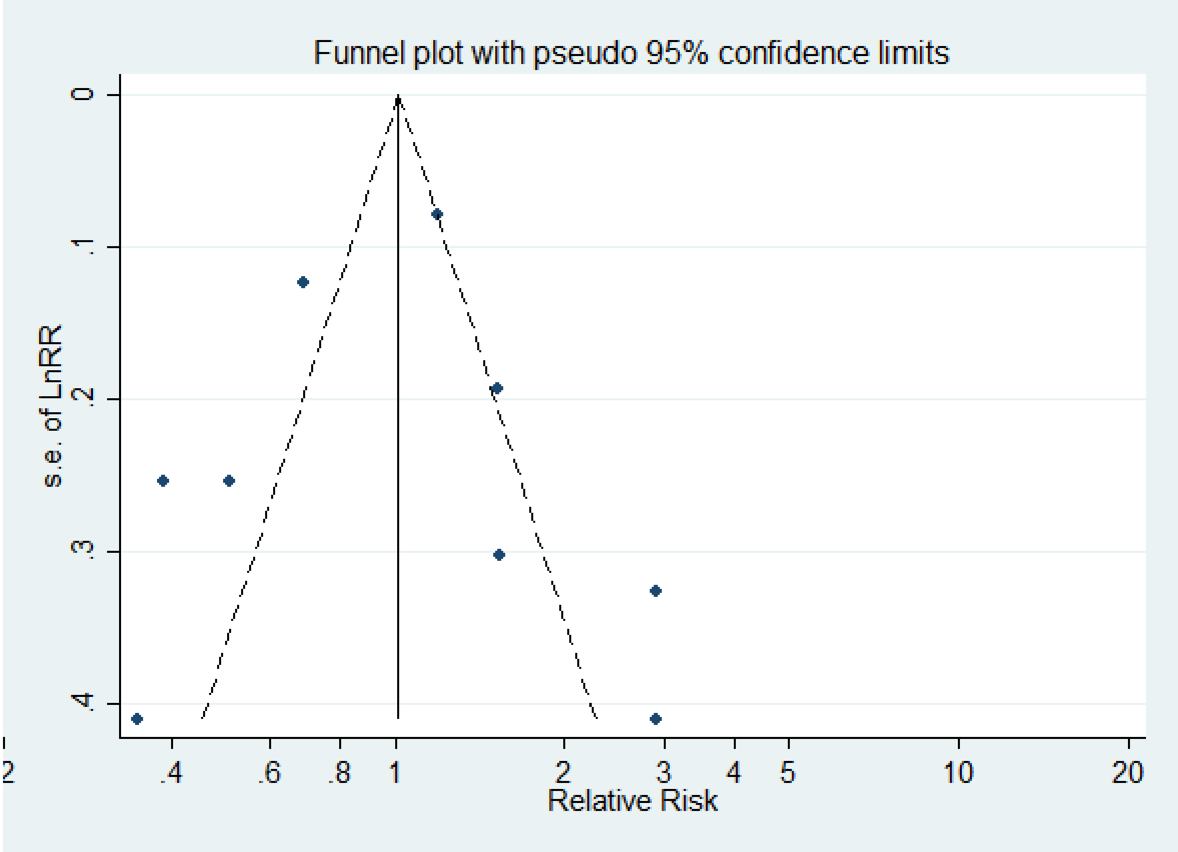
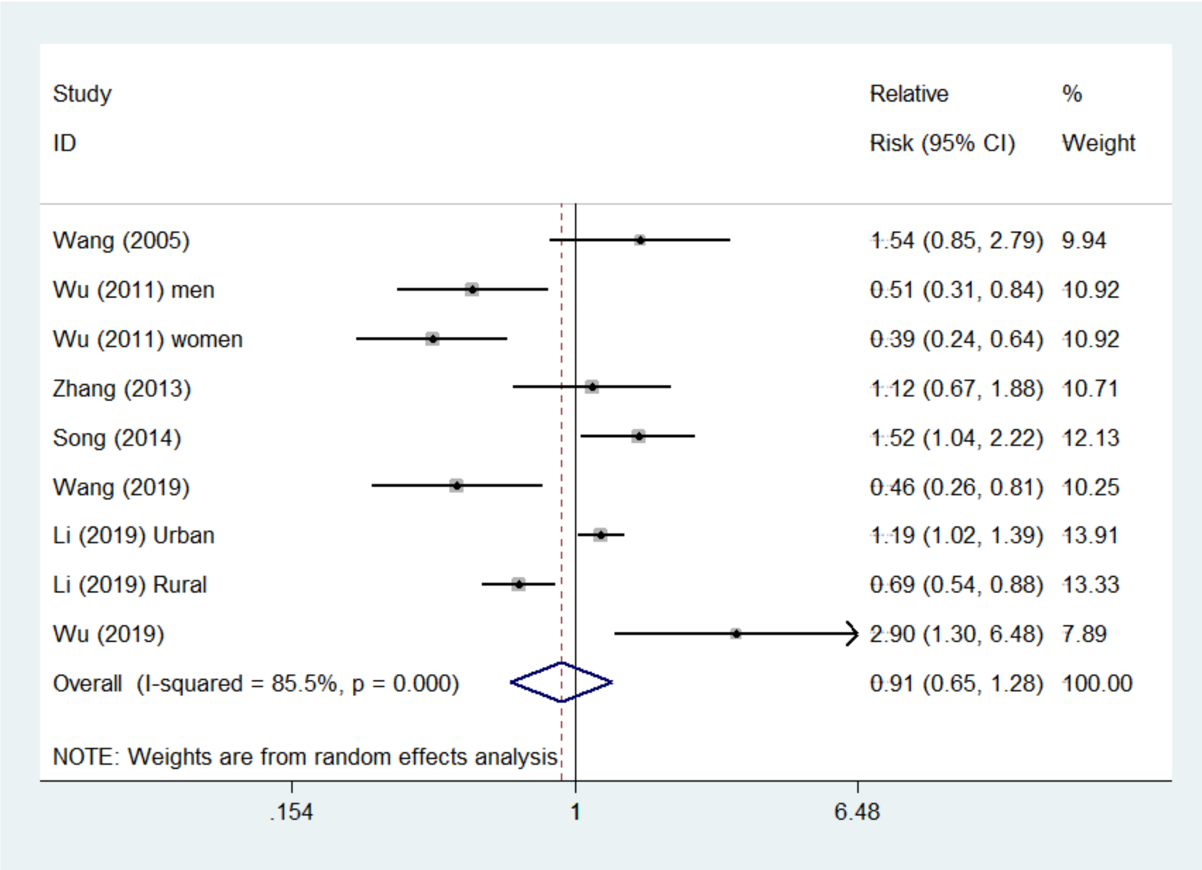
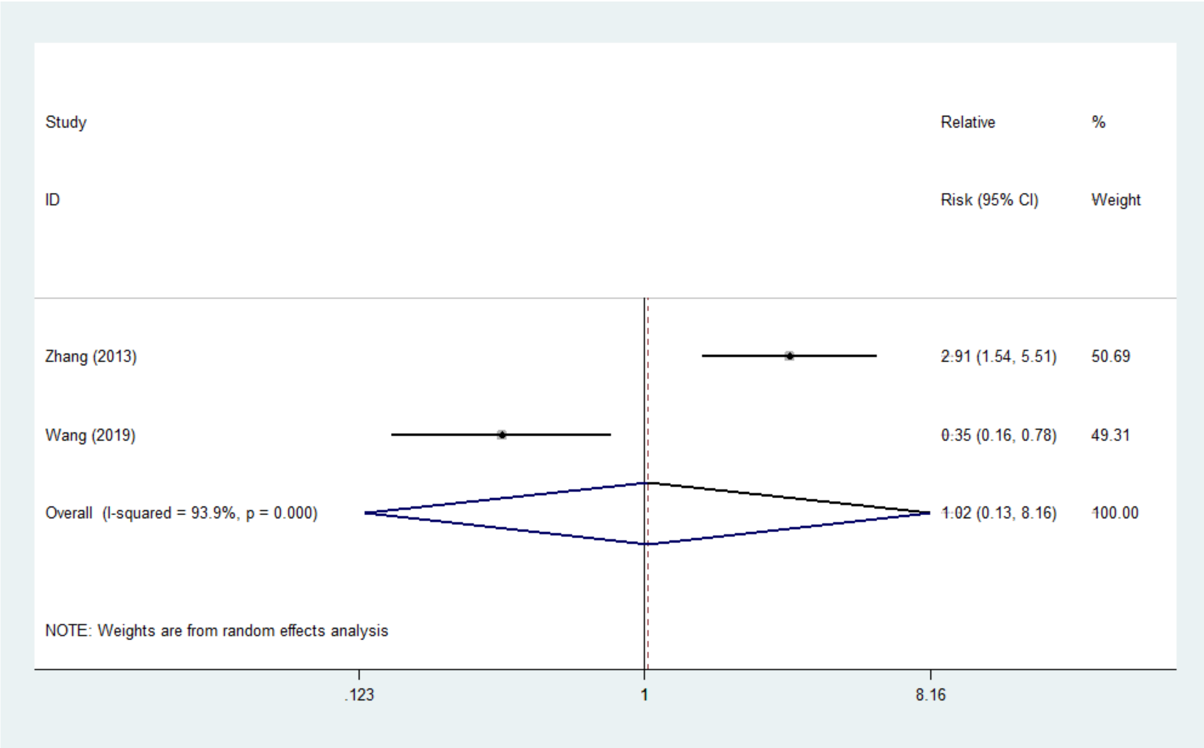


Figure 4.4-4. Forest plot for the pooled relative risk (RR) of low educational level with risk of incident stroke



The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

Figure 4.4-5. Forest plot for the pooled relative risk (RR) of low income with risk of incident stroke



The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

Table 4.4-1. Characteristics and outcomes of case-control studies identified for the systematic literature review of the association of SES with incident stroke in China

First author, (publication year): study place SES measured	**Participants' recruitment**	**Cases and controls selection and characteristics**	**Baseline stroke diagnosis**	**Data analysis and adjustment for confounders**	**Findings**
Educational variable only					
Wang et al. (2005): Guangzhou city, Guangdong province	Patients who were hospitalised in the five hospitals from January to December 2004 were recruited.	358 cases with a diagnosis of haemorrhagic stroke and 358 matched non-stroke controls who were hospitalised in the same period were selected. The average age of cases was 68.3±2.9 years and of controls 67.8±3.4 years.	Bleeding stroke was diagnosed based on national standard and confirmed by CT or MRI.	Stroke risk estimated using logistic regression analysis. Adjusted covariates were BMI, medical histories, family medical histories, smoking, salt consumption, and other chronic and biological indicators	Unadjusted OR for stroke patients with educational level of junior high school and below was 1.54 (0.85-2.78), p=0.153. In the multivariate modelling, the educational variable was not selected for the analysis due to its significance level.
Wu et al. (2011): Chongqing city	Those who aged ≥26 years and were hospitalised in five communities (Shapingba, Xiaolongkan, Tianxingqaio, Yu Bei Road and Ciqikou) were recruited.	1034 cases with a diagnosis of stroke and 2068 matched controls who lived in the same communities were selected. The study did not show the average age of cases and controls.	Stroke was diagnosed according to the Fourth National Academic of Cerebrovascular Disease in China in 1995, which was the same as the WHO standard.	Stroke risk estimated using logistic regression analysis. Adjusted covariates were age, drinking, excessive salt consumption, physical exercise, BMI, diastolic blood pressure, family history of hypertension, family history of stroke, hypertension, coronary	Multivariate analysis was presented as follows: 1. For men: Illiterate or primary school OR=1.00 Middle school OR=1.17 (0.74-1.83) High school or secondary OR=1.27 (0.79-2.06) Undergraduate and above OR=1.97 (1.19-3.24)

				heart disease, diabetes and hyperlipidaemia.	2. For women: The matched figures were OR=1.72 (1.16-2.56) OR=1.46 (0.96-2.23) OR=2.55 (1.54-4.22)
Song et al. (2014): Tangshan city, Hebei province	Those who were hospitalised in the Fengrun District Hospital between September 2009 and October 2012 were recruited.	136 cases with ischemic stroke and 145 non-stroke controls who were hospitalised in the same period were selected. The average age of cases was 67.7±7.2 years and of controls 67.4±6.1 years.	Stroke was diagnosed by CT or MRI.	Stroke risk estimated using logistic regression analysis. Adjusted covariates were smoking, hypertension, diabetes, TG, TC, HDL-C, and LDL-C.	Multivariate analysis showed a OR of 0.66 (95% CI 0.45-0.96) for a continuous variable of educational level*. * Educational level was treated as continuable variable according to schooling year.
Li et al. (2019): 12 areas of northern China	Those who aged ≥40 years living in the areas for at least 6 months (born before 1st January 1977) were recruited in the High-risk Population Screening and Intervention Project.	5,539 stroke cases and 5,539 matched controls were selected. Among stroke cases, 2,280 were from urban, with mean age 66.19±9.09 years, 50.83% male, while 3,259 from rural areas, mean age 65.47±8.95, 49.16% male. No detail characteristics of controls.	Stroke was confirmed by laboratory, physical, and carotid ultrasound examinations.	Stroke risk estimated using logistic regression analysis. Adjusted covariates were hypertension, diabetes, dyslipidaemia, physical exercise, smoking, atrial fibrillation, overweight or obesity, alcoholism, and family history of stroke.	Multivariate analysis was presented as follows: 1. In the urban areas Secondary school and above OR=1.00 Junior high school and below OR=1.19 (1.02-1.39) 2. In the rural areas The matched figure was OR=0.69 (0.54-0.88) 3. Ratio of ORs (rural versus urban) *Junior high school and below* ROR=3.15 (2.64-3.75) *<10,000 Yuan/year* ROR=3.80 (3.35-4.32)

Multiple SES indicators					
Zhang et al. (2013): Baotou city, Inner Mongolia	Those aged ≥15 years and hospitalised during a 2-year period from 8 May 2009 were recruited in the CHERISH study.	226 cases with SAH and 434 matched SAH-free controls were selected. The average age of cases was 58.5±13.2 years and of controls 56.8±15.8 years.	SAH was defined by standard criteria which was confirmed by CT, necropsy, or lumbar puncture.	Stroke risk estimated using logistic regression analysis. Adjusted covariates were marital status, BMI, hypertension, previous stroke, antithrombotic use, current alcohol intake, current smoking.	Univariate analysis for education was presented as follows: Total SAH Education ≥university RR=1.00 Education <university RR=1.12 (0.67-1.89) The match figures were For men RR=1.16 (0.54-2.44) For women RR=1.09 (0.54-2.22) The educational variable was not selected into multivariate adjusted regression model due to its significance level. Multivariate analysis for income was presented as follows: Total SAH Income ≥¥70,000 RR=1.00 Income <¥70,000 RR=2.91 (1.54-5.53) The match figures were For men RR=3.58 (1.10-11.71) For women RR=2.51 (1.10-5.73)
Wang et al. (2019): Guangzhou city,	Those who were hospitalised to the First Affiliated Hospital of	347 ischemic stroke cases and 347 age and sex matched non-stroke controls were selected.	Stroke was diagnosed according to the WHO criteria, confirmed by CT or MRI.	Stroke risk estimated using logistic regression analysis. Adjusted covariates were	Multivariate analysis was presented as follows: 2. Education ≤6 years: OR 1.00

Guangdong province	Guangdong Pharmaceutical University between September 2016 and October 2017 were recruited.	The average age of cases was 60.5±13.1 years and of controls 60.6±13.1.		sex, age, smoking, alcohol consumption, physical activity, meat consumption, vegetable consumption, fruit consumption, whole-grain consumption, hypertension, diabetes, coronary heart disease, hypercholesterolemia, atrial fibrillation.	6-9: OR 2.63 (1.45-4.75) 10-12: OR 1.56 (0.82-2.98) >12: OR 2.18 (1.25-3.82) 2. Income ≤¥1000/month: OR 1.00 ¥1001-¥3000: 1.96 (1.21-3.15) ¥3001-¥5000: 4.16 (2.39-7.22) >¥5001: 2.83 (1.25-6.39) 3. Occupation No job: OR 1.00 Manual workers: 1.95 (1.23-3.07) Non-manual: 1.87 (1.05-3.33) Retired: 1.05 (0.47-2.37)

"¥" refers to Renminbi (CNY, Yuan), the official currency of China. Currency exchange rate in 2020: China currency ¥10=US$1.43.
RR, relative risk; HR, hazard ratio; OR, odds ratio; CVD, cardiovascular disease; TIA, transient ischaemic attack; ICH, intracerebral haemorrhage; SAH, subarachnoid haemorrhage; AIS, acute ischemic stroke; WHO, World Health Organisation; CT, computed tomography; MRI, magnetic resonance confirmation; TG, total triacylglycerol; TC, total cholesterol; HDL-C, high density lipoprotein; LDL-C, low density lipoprotein.

Table 4.4-2. Characteristics and outcomes of cohort studies identified for the systematic literature review of the association of SES with incident stroke

First author, (publication year): study place SES measured	**Participants' recruitment**	**Sample size and characteristics**	**Methods of follow-up**	**Endpoint outcomes: Stroke cases and diagnosis criteria**	**Data analysis and adjustment for confounders**	**Findings**
Educational variable only						
Wu et al. (2019): Tianjin city	Recruited 14,936 people who were lived in 18 rural villages in Tianjin.	3,906 individuals were selected at baseline (men 1834 and women 2072); mean age 41.7±16.6 years. 47% participants (men 42.5% and women 57.5%) have never received any formal education.	The mean following-up time of 23.16 years, with a total of 85,346.5 person-years. No data was available for lost follow-up rate.	638 stroke cases (379 [59.4%] males), including 404 ischemic strokes, 121 hemorrhagic strokes, 113 undefined strokes. Stroke was diagnosed based on CT or MRI.	Cox proportional hazard regression models were used with adjustment for age, sex, hypertension, diabetes, BMI, hypertension types, current smoking and alcohol consumption status.	In multivariate analysis, the HR of incident stroke was presented as follows: *Total stroke:* >9 years HR 1.00 0 years 2.9 (1.3-6.5) 1-6 years 3.1 (1.4-7.0) 7-9 years 2.2 (1.0-5.1) The matched figures were *For Ischemic stroke:* 2.2 (0.9-5.4) 2.6 (1.0-6.3) 2.1 (0.9-5.2) *For Hemorrhagic stroke:* 5.0 (0.7-36.7) 4.6 (0.6-33.8) 1.6 (0.2-12.7)

CVDs, cardiovascular diseases; CT, computed tomography; MRI, magnetic resonance confirmation.

Table 4.4-3. Quality assessment for the 7 articles identified that studied the association of SES with incident stroke in China

Study	1	2	3	4	5	6	7	8	9	10
Wang et al. 2005	★	★	★	★	★			★	★	
Wu et al. 2011	★	★	★	★	★	★	★	★	★	★
Zhang et al. 2013	★	★	★	★	★		★	★	★	★
Song et al. 2014	★	★	★	★	★		★	★		★
Li et al. 2019	★	★	★	★	★	★	★	★	★	★
Wu et al. 2019	★	★	★	★	★	★	★	★	★	★
Wang et al. 2019	★	★	★	★	★	★	★	★	★	★

Case-Control Study

1 – Is the case definition adequate? (Yes, with independent validation)
2 – Representativeness of the cases
3 – Selection of controls (hospital or community matched controls)
4 – Definition of controls (No history of the stroke)
5 – Clear measurement of SES indicators (clear records or structured interview and with same for both cases/controls)
6 – Data analysis controlled for age and sex
7 – Data analysis controlled for other confounders
8 – Findings interpreted well
9 – Weakness mentioned and explained clearly
10 – Paper written well

Cohort Study

1 – Cohort truly representative
2 – Controls derived from the same cohort

3 – Clear measurement of socioeconomic status at baseline
4 – Adequacy Follow-up duration (≥12 months)
5 – Reliable methods of stroke (ie, CT/MRI scan)
6 – Cohort data analysis controlled for age and sex
7 – Cohort data analysis controlled for other confounders (ie, CVDs and risk factors)
8 – Findings interpreted well
9 – Weakness mentioned and explained clearly
10 – Paper written well
N/A = Not applicable

4.5 Impact of SES on mortality in people with stroke

4.5.1 Introduction

Stroke is the second leading cause of death worldwide. Increasing evidence from epidemiological studies suggested that there was a significant association of socioeconomic status (SES) with mortality after stroke (Cox et al., 2006, Addo et al., 2012, Marshall et al., 2015). SES as a comprehensive measure of social standing is strongly associated with the health conditions and outcomes of an individual or a family (Zimmer and Kwong, 2004, Sharma, 2013). Previous studies suggested that stroke patients with low SES had a significantly increased risk of mortality (Cox et al., 2006, Addo et al., 2012, Marshall et al., 2015, Chen et al., 2015b). Knowledge about the association of SES with mortality after stroke has been predominately derived from studies undertaken in high income countries (HICs) (Cox et al., 2006, Addo et al., 2012, Marshall et al., 2015), which may not be applicable to those in low- and middle-income countries (LMICs).

China is the largest LMIC and reports more patients with stroke than anywhere else in the world (Feigin et al., 2018). Over the past decades, China has experienced rapid economic development, along with an increasing gap in income between the rich and poor (Sicular et al., 2007). Alongside this, existing studies have shown an association between SES and mortality in people with stroke (Zhou et al., 2006, Liu et al., 2007b, Wu et al., 2014, Chen et al., 2015b, Pan et al., 2016), but the findings are inconsistent. Some studies suggested that high SES was associated with a low risk of mortality after stroke (Liu et al., 2007b, Wu et al., 2014, Chen et al., 2015b, Pan et al., 2016), while others did not show such an association (Zhou et al., 2006). In this section, we carried out a systematic literature review and meta-analysis to update the current knowledge on the association of SES with mortality in Chinese people with stroke.

4.5.2 Methods

4.5.2.1 Systematic literature review

Data sources and studies selection process

The method of systematic literature review was the same as that in the section 4.2.2 and has been fully described before. Briefly, we [Weiju Zhou, Yuyou Yao] searched literature from Medline, PubMed, and Web of Science to identify eligible studies for inclusion in this review. The search terms were [“stroke” OR “cerebrovascular accident, cerebrovascular disorders, cerebral haemorrhage, subarachnoid haemorrhage, intracranial haemorrhage”] AND [“survival” OR “mortality, death”] AND [“socioeconomic status” OR “poverty, education, income, occupation, rural”] and [“China” OR “Chinese”] for all fields, including MeSH terms, abstract, title, or text words. In the current review, the literature was searched from 1st September 2013 in each database to 31st December 2019, because a systematic review published by Chen et al. searched the database covering from 1966 (the earliest year in those datasets) to 30th August 2013 (Chen et al., 2015b). The aspects on language restriction, Chinese literature electronic databases search and manual reference search were the same as those in the section 4.2.2 and have been fully described before. We read the titles and abstracts and screened for original studies relating to the association of SES with mortality after stroke. The studies selected were appropriate for this review if they quantified the association between any measure of SES and mortality after stroke in the Chinese population. Study selection flow is shown in Figure 4.5-1. The study in this Chapter section included cohort design studies only.

Data extraction and quality assessment

The methods of data extraction and quality assessment were the same as those described in Chapter 4.2.2, section 1.

4.5.2.2 Meta-analysis

The methods of meta-analysis for the available data from these studies were the same as in Chapter 4.2.2, section 2 and have been described before.

4.5.3 Results

4.5.3.1 Literature review

Our search strategy found 1,242 records. Once duplicates had been removed, 917 titles and abstracts were screened, and 29 studies were selected for full-text review. This process yielded nine original studies after adding in three articles from the previous systematic review by Chen et al. (Figure 4.5-1).

In the nine eligible studies, we found that eight studies were from hospital-based studies (Zhou et al., 2006, Liu et al., 2007b, Sheng et al., 2010, Wu et al., 2014, Pan et al., 2016, Yan et al., 2017, Gu et al., 2018, Gu et al., 2019) and one study was from a community-based study (Chen et al., 2015b). They were published between 2006 and 2019. Their sample size varied from 143 to 78,189, with a total of 123,155 stroke patients, and the minimum age in these studies' populations varied from 18 to 60 years. Of the nine eligible studies, two studies only used the SES indicator of urban-rurality (Gu et al., 2018, Gu et al., 2019), two studies only used educational level (Liu et al., 2007b, Wu et al., 2014), one study only used income (Sheng et al., 2010), and four studies used multiple SES indicators (Zhou et al., 2006, Chen et al., 2015b, Pan et al., 2016, Yan et al., 2017). The qualities of these studies were examined (see Table 4.5-2), and in general they were good.

Table 4.5-1 shows the details of the characteristics and outcomes of each of the studies. The descriptive account and the findings of each of the included studies are as follows.

Urban-rurality only

Gu et al. (2018)

Gu et al. (2018) examined data from the China National Stroke Registry II (CNSR II) that were collected from 219 secondary or tertiary public hospitals between June 2012 and January 2013. A total of 24,941 patients were included for analysis after the exclusion of 77 patients with commercial insurance. Of the 24,941, 12,445 (49.9%) were covered by urban insurance, 10,283 (41.2%) were covered by rural insurance and 2,213 (8.9%) were self-paid. During the one-year follow-up period after stroke onset, 259 patients died. Compared to patients covered by urban insurance, those covered by rural insurance had an increased risk of all-cause mortality (HR 1.32, 1.17-1.48). However, the association of self-payment with mortality was not significant (1.18, 0.99-1.42).

Gu et al. (2019)

Gu et al. (2019) further examined the same data of the CNSR II of 5,707 female stroke patients, in which 2,880 (50.5%) were covered by urban insurance and 2,827 (49.5%) covered by rural insurance. Over a one-year follow-up, 249 stroke patients had died among those with urban insurance (8.7%) and 309 had died among those with rural insurance (10.9%). The fully adjusted HR of mortality was increased 40% in female stroke patients with rural insurance compared to those with urban insurance (1.40, 1.06-1.84).

Educational level

Liu et al. (2007)

Liu et al. (2007) examined a retrospective cohort study of 485 elderly ischemic stroke patients who were hospitalised in Xijing Hospital of the Fourth Military Medical University from January 2002 to June 2005. In the 4 years follow-up (min 1 day – max 47 months), there were 250 poor prognosis patients (including 76 deaths and others with mRS scores of 3-5) and 235 good prognosis patients who had mRS score of 0-2. The regression analysis, including age, National Institutes of Health Stroke Scale (NIHSS) score, history of stroke and educational level showed a coefficient of -0.042 (SE 0.018), p=0.019 for a continuous variable of educational level associated with poor prognosis. However, the mortality risk in relation to educational level could not be identified because the deaths and the poor prognosis patients were categorised into a group to analyse in this study.

Wu et al. (2014)

Wu et al. (2014) analysed the data from the "Zhejiang provincial information system for NCDs' surveillance and management" of 78,189 stroke patients who were recruited from January to December 2009 in Zhejiang province. During 30.6 (±23.31) months follow up, 33,265 deaths occurred. In multivariate adjustment analysis, HRs of all-cause mortality were significantly increased in patients who were illiterate and semiliterate (1.93, 1.67-2.23), and with primary school education (1.29, 1.11-1.49), but not those with middle school education (0.92, 0.79-1.07), compared to those with university degree or higher.

Income

Sheng et al. (2010)

Sheng et al. (2010) examined a prospective cohort of 143 stroke patients who were hospitalised in Suipin Country Hospital, Henan province during January 2001 to December 2003. 131 patients were followed up to 60 months, with 8.4% lost to follow-up, of which 71 died. Univariate analysis showed an increased HR of 1.57 (1.50-1.65) for patients with income of <1000 yuan/month compared to those of ≥1000 yuan/month. In stepwise multivariate modelling, including age, injure brain tissues, shift, recurrence, discharge status and social support, the income variable was not selected into the regression model due to its significance level and thus there was no data available.

Multiple SES indicators

Zhou et al. (2006)

Zhou et al. (2006) examined data from the Nanjing Stroke Registry Programme of 806 patients with ischemic stroke based on Jinling Hospital, Nanjing City, who were enrolled from August 1999 to August 2002. During the 3 years follow up, 166 stroke patients died (20.6%). The adjusted HR of mortality was 5.18 (2.84-9.44) in patients with manual occupations and 5.77 (2.67-12.46) in unemployed patients when compared with those in non-manual occupations. The adjusted HR was 5.45 (3.18-9.34) in patients with income of “0 yuan” and 2.22 (1.34-3.66) in patients with income of “>0-<1000 yuan” compared to those with income of “≥1000 yuan”. The housing space variable was significantly associated with mortality; adjusted HR in the lowest level of housing space was 2.13 (1.23-3.70), in the lower-middle level 1.17 (0.77-1.77), and in the upper-middle level 1.52 (1.01-2.28) compared with those in the highest level of housing space. There was no association of educational level with mortality; the adjusted HRs in patients with illiteracy, primary school, junior high school, senior high school and technical training vs those with university degree were 0.79 (0.31-2.01), 0.97 (0.39-2.40), 0.70 (0.28-1.77), 0.96 (0.33-2.78) and 1.81 (0.62-5.28) respectively.

Chen et al. (2015)

In 2015, Chen et al. examined the Anhui cohort study of the first to third wave surveys between 2001 and 2009. In the studied cohort, 2978 participants were followed up (89.3%). Of these participants, 167 patients with stroke were documented at baseline (42 from the wave 2 survey). During the follow-up, 505 cohort members died, in which 64 deaths occurred in patients with stroke (38.3%) and 501 in participants without stroke (17.8%). HR was significantly increased in stroke patients with educational level of ≤primary school vs >primary school (1.88, 1.05-3.36), but not in patients with <1000 Yuan/month vs ≥1000 Yuan/month (1.64, 0.97-2.78), in those with manual occupations vs non-manual occupations (1.28, 0.75-2.19), or in patients with rural vs urban living (1.51, 0.88-2.57).

Pan et al. (2016)

Pan et al. (2016) examined data from the China National Stroke Registry (CNSR) of 12,246 stroke patients who were recruited from 132 hospitals between September 2007 and August 2008. Over one-year follow-up, 1640 (13.4%) patients died. In multivariate analysis, OR of all-cause mortality was 1.26 (1.06-1.51) in patients with educational level of <6 years vs educational level of >9 years, 1.40 (1.11-1.77) in manual workers and 1.17 (0.89-1.54) in people with no job vs non-manual workers, and 1.15 (0.99-1.33) in patients with income of ≤¥1000 per month vs >¥1000 per month.

Yan et al. (2017)

Yan et al. (2017) carried out a retrospective cohort study of 471 ischemic stroke patients who were hospitalized at Shanghai Tenth People's Hospital, Tongji University School of Medicine. Each SES indicator, including education, occupation, annual income, and medical insurance, was categorised into five levels from the lowest to the highest, using scores of 0-4. Their scores were summed into a final score as a composite indicate of SES. The study population were divided into three groups according to the tertiles of the total score distribution: low (≤7), middle (8-9), and high (≥10). Over 31.6 (±10.4) months follow-up, 39 patients died. Compared to the 3rd tertile SES score, HR of all-cause mortality in the lowest SES groups was 2.13 (1.22-3.71) and in the middle SES group was 1.41 (0.80-2.51). Compared to those living in urban areas, HR of mortality in stroke patients living in county areas was 1.57 (0.85-2.91) and in stroke patients living in rural areas it was 3.05 (1.62-5.76).

In summary, all studies showed inverse associations of SES with increased mortality, although some SES indicators did not show significant associations. Overall, the current literature review suggested that increased SES was associated with reduced risk of mortality in China.

4.5.3.2 Meta-analysis

In the above nine published articles that were reviewed, two studies were excluded from the meta-analysis as one study's outcomes combined mortality with disability (Liu et al., 2007b) and the other partially duplicated with a report already included in the review (Gu et al., 2019). Thus, there were seven studies left for the pooled data analysis, comprising 116,963 stroke patients and 37,504 deaths. Data from these studied populations showed little variability in the associated effects between studies, with only one study showing an increased mortality after stroke (albeit not statistically significant) associated with high educational level. The random effect model analysis showed that stroke patients with low SES had increased mortality (pooled RR 1.71, 1.41-2.08, p<0.001) (Figure 4.5-2). The analysis of all seven studied populations did not show evidence of publication bias, with an Egger's test p-value of 0.526 (Figure 4.5-3).

The meta-analysis was performed in terms of the different measurements of SES available in studies.

Rural and Urban areas

In the seven published studies that were reviewed, three published studies reported the association of urban-rural disparity with mortality after stroke (Chen et al., 2015b, Yan et al., 2017, Gu et al., 2018), which included 25,579 stroke patients and 2,362 deaths in total. Pooling data of the RR of mortality after stroke in patients living in rural vs urban areas was 1.68 (1.08-2.63) (Figure 4.5-4). The corresponding figure for ischaemic stroke was 1.36 (1.21-1.52), using data from two studies (Yan et al., 2017, Gu et al., 2018).

Low and High Educational level

There were four studies which reported the association of educational level with mortality after stroke (Zhou et al., 2006, Wu et al., 2014, Chen et al., 2015b, Pan et al., 2016), comprising 91,408 stroke patients. In the pooled data, stroke patients with low education had a higher mortality than their counterparts with high education (pooled RR 1.51, 1.08-2.12) (Figure 4.5-5). Data from Pan et al.'s (2016) and Zhou et al.'s (2006) studies showed that the corresponding figure for ischaemic stroke was 1.24 (1.04-1.48).

Low and High Occupational class

Of the seven studies that were identified, three studies had data which showed association between occupational class and mortality after stroke, comprising 13,219 stroke patients (Zhou et al., 2006, Chen et al., 2015b, Pan et al., 2016). In the pooled data, low occupational class was not associated with mortality; a RR of 2.04 (0.97-4.29) in manual workers versus non-manual workers (Figure 4.5-6). The corresponding figure for ischaemic stroke patients was 2.61 (0.73-9.40), which was pooled from Zhou et al.'s (2006) and Pan et al.'s (2016) studies.

Low and High Income

In the seven published studies, there were four studies which reported the association of income with mortality after stroke, comprising 13,362 stroke patients (Zhou et al., 2006, Sheng et al., 2010, Chen et al., 2015b, Pan et al., 2016). Stroke patients with low income had a higher mortality than their counterparts with high income (pooled RR 1.80, 1.28-2.53) (Figure 4.5-7). Based on the available data from Zhou et al. (2006)'s and Pan et al. (2016)'s studies, the corresponding figure for ischaemic stroke was 2.45 (0.53-11.24).

4.5.4 Discussion

In this systematic review study, nine studies were identified regarding the association between SES and mortality in people after stroke in China. Most of these studies demonstrated an inverse association of low SES with all-cause mortality in patients with stroke. Further pooled data from the available data showed that there were significant associations of rural living, low education and low actual income with increased risk of mortality in stroke patients.

This review and pooled data showed that, in China, stroke patients with low educational level had an increased risk of all-cause mortality. The inverse association of educational level with mortality after stroke also can be found in studies conducted in HICs (Lindmark et al., 2014). Educational level is an independent factor in clinical outcomes and has a significant effect on the risk for stroke (Qureshi et al., 2003). It could potentially affect patients' lifestyles and behavioural manners such as following doctors' treatment instructions and exercises for recovery that were related to their healthcare (Adler and Ostrove, 1999). However, one of the included studies showed that there was no association between educational level and mortality (Zhou et al., 2006). This is the earliest study reviewed, and during the early 2000s, stroke treatment was not as advanced and the mortality was high (Wang et al., 2017c), which was highly determined by other factors, such as family income, medications available and revised guidelines on stroke treatment.

The findings of the associations of low occupational class and income with mortality after stroke in China were consistent with studies in HICs (Langagergaard et al., 2011, Vivanco-Hidalgo et al., 2019). However, the existing studies included in the review showed heterogeneity in the association of either occupational class or income with all-cause mortality after stroke (Zhou et al., 2006, Sheng et al., 2010, Pan et al., 2016). This might be due to the inconsistency in controlling for potential confounders in the studies. Some studies additionally adjusted for health variables such as unhealthy behaviour, cardiovascular disease, and cardiovascular risk factors (Zhou et al., 2006, Pan et al., 2016), while others adjusted for age and sex only (Sheng et al., 2010). The lack of adjustment in the data analysis would introduce confounding bias into the results. Nevertheless, both low occupational class and low income showed an increased mortality in our pooled data.

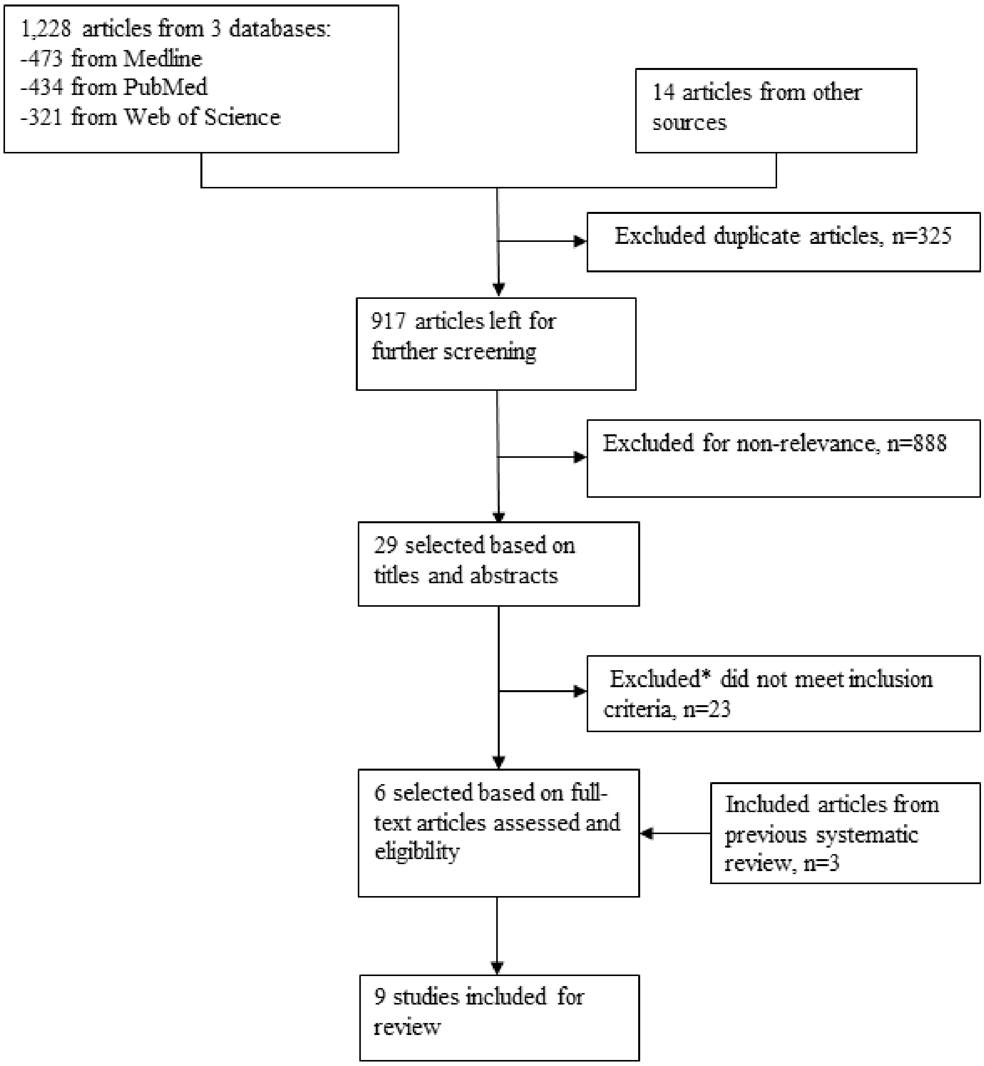
China has had large urban-rural inequalities in educational attainment, job opportunities, healthcare access and health insurance, but few studies have been undertaken to understand their impacts on survival in patients after stroke. There were a couple of papers reporting differences in mortality rate of stroke between urban and rural areas (Zhang et al., 2007, Wang et al., 2017b, Li et al., 2017a); for example, Wang et al. (Wang et al., 2017b) analysed the data of the National Disease Surveillance Points System from 155 urban and rural centres including 480,687 adults aged ≥20 years and reported higher age-standardised mortality of stroke in rural residents (116.8/100,000) than that in urban residents (74.9/100,000). However, all these studies did not adjust for confounders, which may bias the impact of rural-urban inequality on mortality after stroke.

The present study took urban and rural insurance status as one of SES indicators for analysis. The insurance status and the household registration system are closely linked and systemically interdependent (Müller, 2016). It is nearly completely in line with the sociodemographic features of urban and rural living. The findings of studies (Gu et al., 2018, Gu et al., 2019) that stroke patients with rural insurance status had significantly increased HR of around 40% of mortality compared to their counterparts with urban insurance status were similar to those studies where urban and rural living were used as an SES indicator (Chen et al., 2015b). Therefore, the use of urban and rural insurance status could be equivalent to urban-rural living and considered as one of the SES indicators in China.

4.5.5 Conclusions

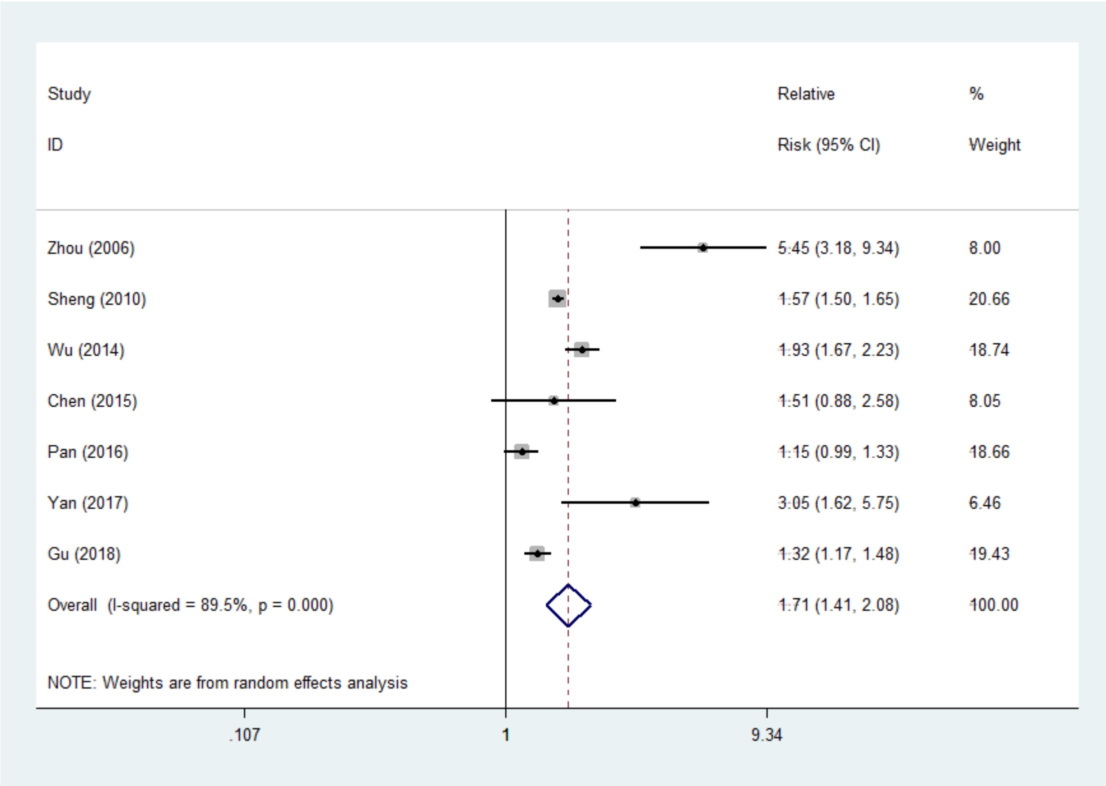
In summary, this systematic literature review and meta-analysis suggested that low SES is associated with increased mortality after stroke in China. Strategies that reduce SES inequality among stroke patients need to be taken and implemented to reduce mortality in patients with stroke in China.

Figure 4.5-1. Flowchart for literature search, and inclusion of studies for the research



*Reasons included: other outcome variables such as prognosis, confounders without adjustment, study design (such as cross-sectional or case control), etc.

Figure 4.5-2. Forest plot for the pooled relative risk (RR) of SES with all-cause mortality after stroke



The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

Figure 4.5-3. Funnel plot assessing publication bias

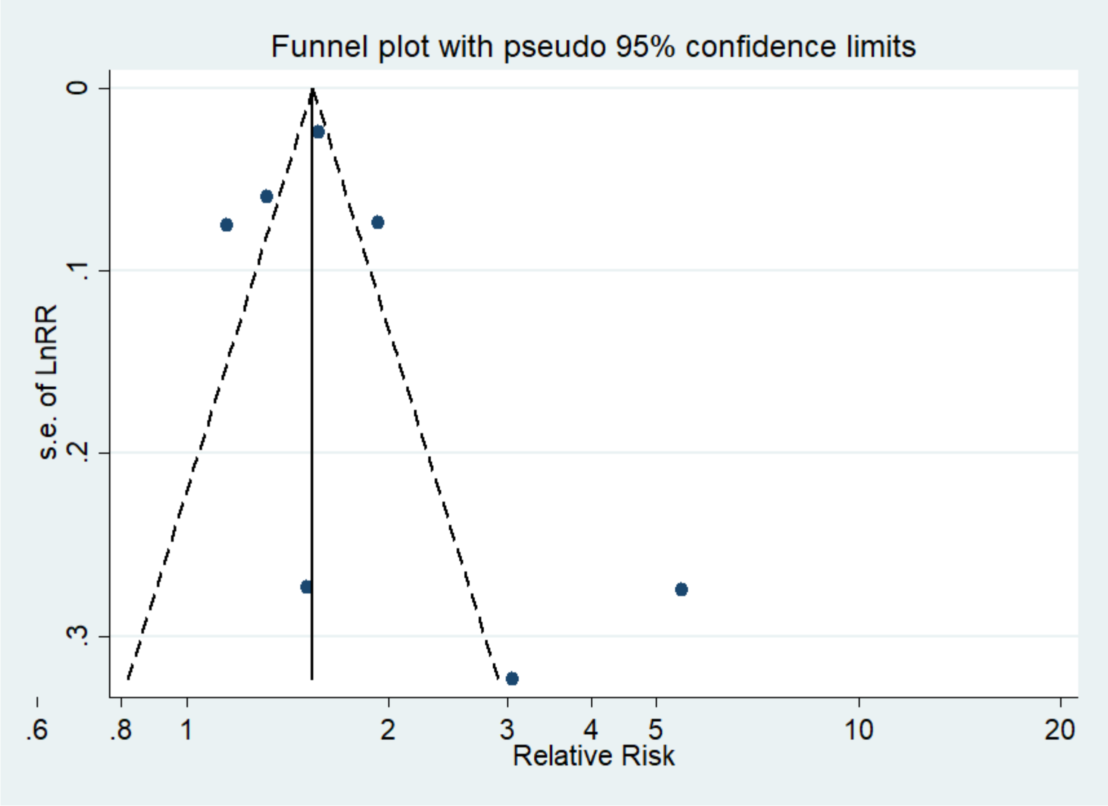
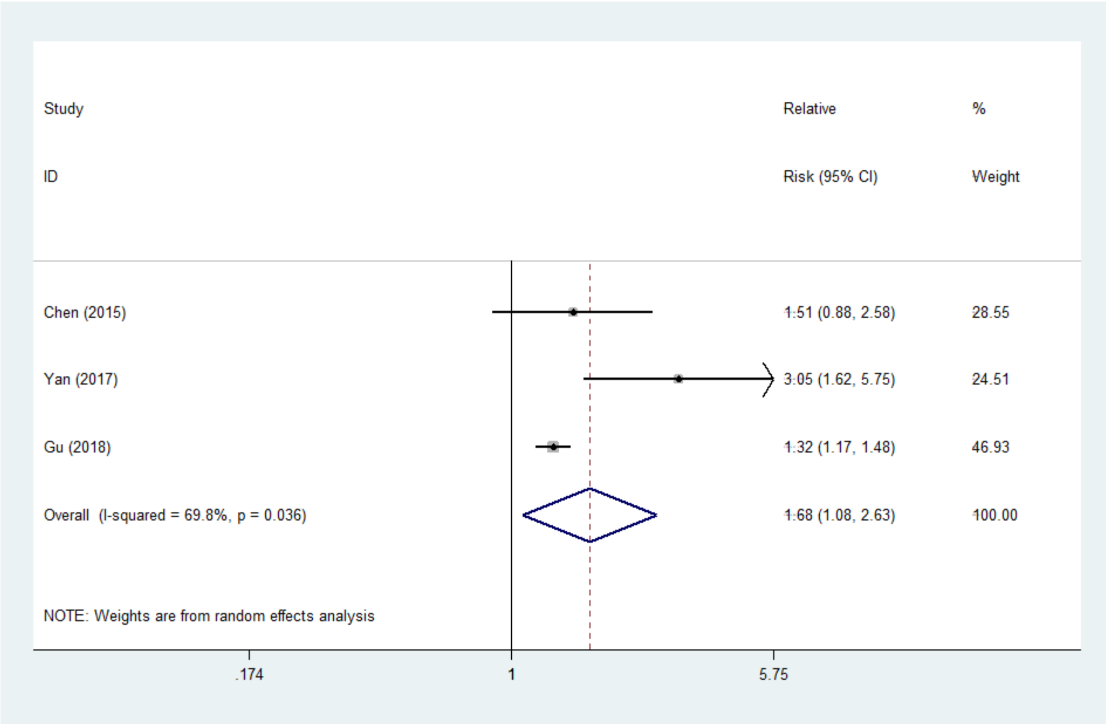
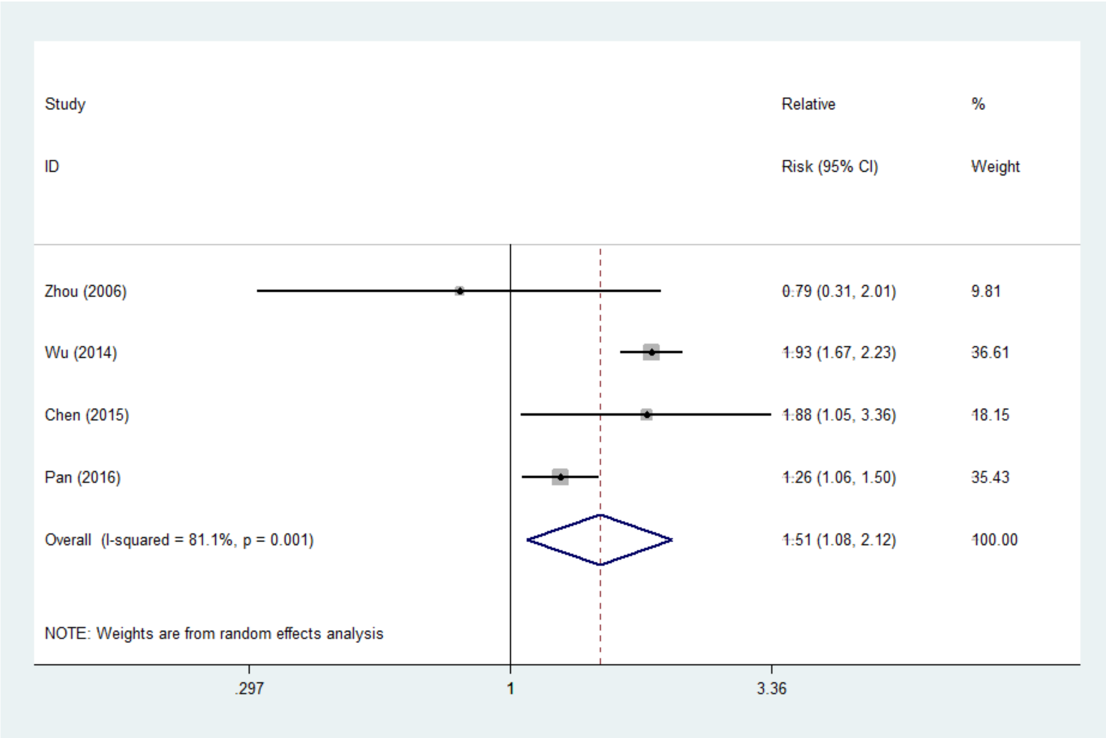


Figure 4.5-4. Forest plot for the pooled relative risk (RR) of rural living with all-cause mortality after stroke



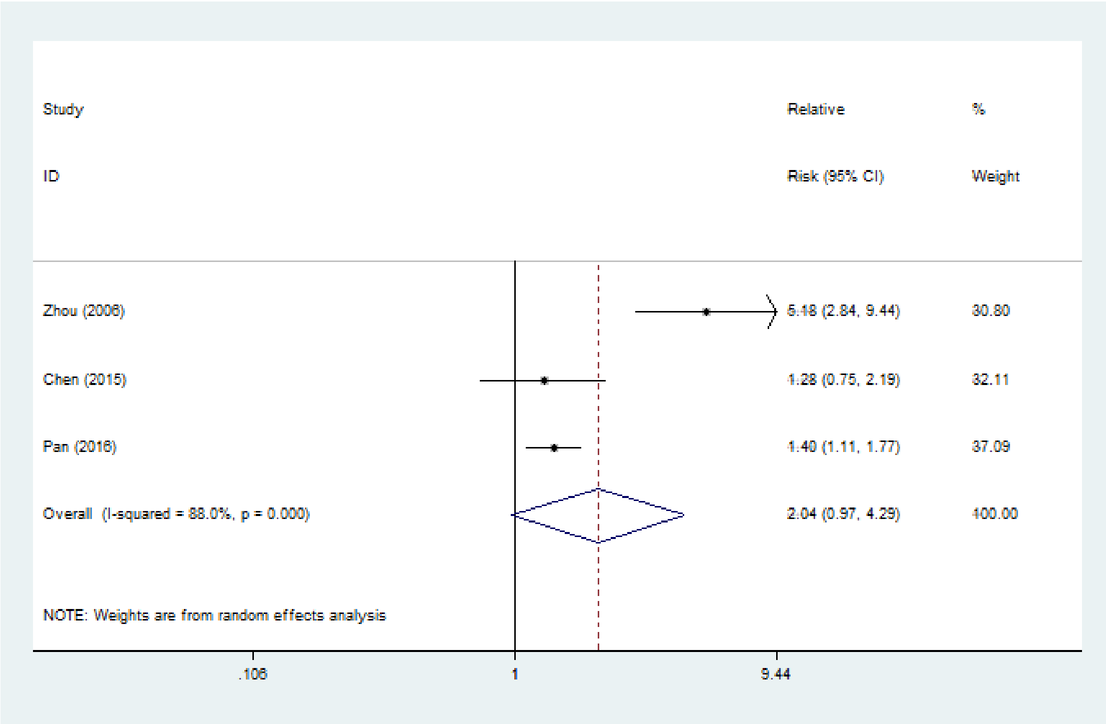
The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

Figure 4.5-5. Forest plot for the pooled relative risk (RR) of low educational level with all-cause mortality after stroke



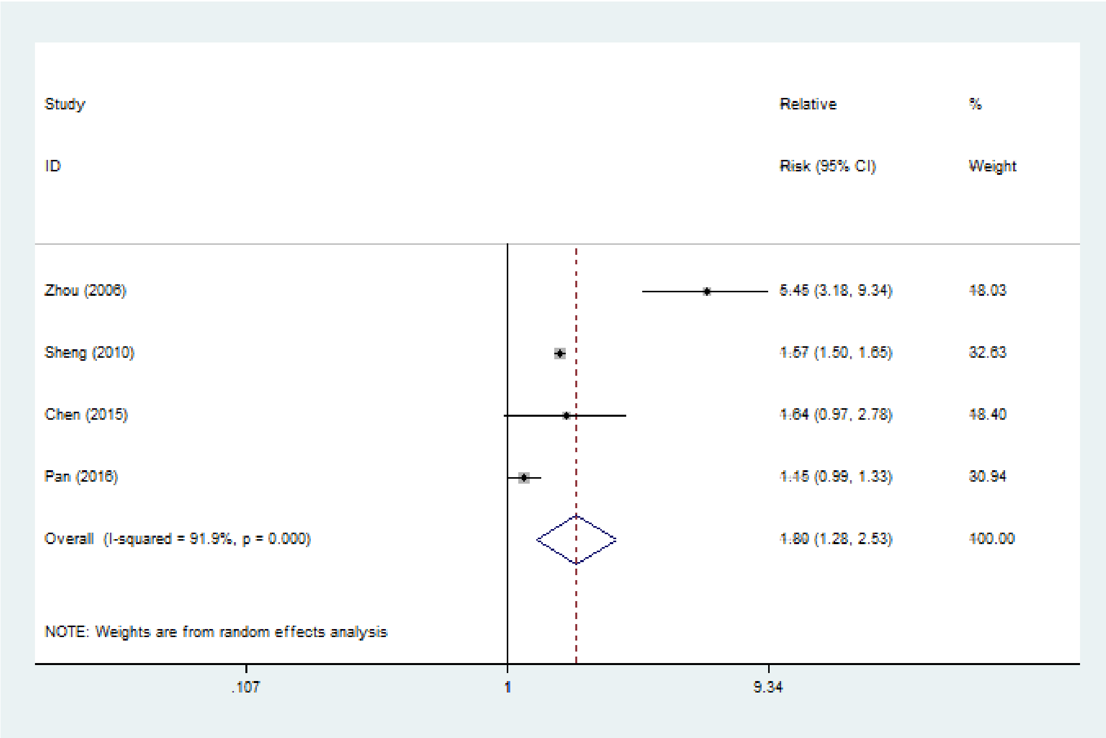
The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

Figure 4.5-6. Forest plot for the pooled relative risk (RR) of low occupational class with all-cause mortality after stroke



The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

Figure 4.5-7. Forest plot for the pooled relative risk (RR) of low income with all-cause mortality after stroke



The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

Table 4.5-1. Characteristics and outcomes of cohort studies for the systematic literature of mortality among people after stroke in China

First author, (study years and place) SES measured	**Recruit and select patients**	**Stroke diagnosis criteria**	**Characteristics of patients**	**Methods of follow-up**	**Data analysis**	**Findings**
Urban-rural only						
Gu (2018) (June 2012 to January 2013, the China National Stroke Registry II [CNSR II], China)	Patients were recruited from 219 hospitals if they met the criteria including (1) age ≥18 years; (2) diagnosis within 7 days of the index event of AIS, TIA, ICH, or SAH. 24,941 patients were included for analysis after excluded 77 with commercial insurance.	AIS was diagnosed according to WHO criteria combined with brain CT or MRI.	12,445 (49.9%) covered by urban insurance, with age 65.8±12.1 and 66.9 % male 10,283 (41.2%) covered by rural insurance, with age 63.1±11.7 and 56.8% male 2213 (8.9%) covered by self-payment, with age 61.3±13.1 and 65.7% male	Followed up by trained research personnel via telephone at 3, 6 and 12 months after stroke onset. 3,377 (13.5%) patients were lost to follow up at 12 months visit.	Cox proportional hazard regression models were used with adjustment for age, mRS, family income, smoking, drinking, NIHSS, cerebrovascular disease type, previous stroke or TIA, heart failure /myocardial infarction, dyslipidaemia, hospital level, antiplatelets and anticoagulants.	2259 (9.1%) deaths Multivariate analysis showed that compared with those covered by urban insurance status, HR of all-cause mortality was 1.32 (1.17-1.48) in those covered by rural insurance status and 1.18 (0.99-1.42) in those with self-payment.
Gu (2019) (June 2012 to	Patients were recruited from 219 hospitals in China if	AIS was diagnosed according to	2,880 women covered by urban insurance, with age	Followed up by trained research personnel via	Cox proportional hazard regression models were used with	558 (9.8%) deaths In multivariate analysis,

January 2013, the China National Stroke Registry II [CNSR II], China)	they were ≥18 years of age and presented within seven days of the index events of AIS, TIA, ICH, or SAH. A total of 5,707 female patients with AIS were enrolled for analysis after excluding 608 who were with other types of insurance, and 852 who were lost to follow-up.	WHO criteria combined with brain CT or MRI.	68.9±11.1 2,827 women covered by rural insurance, with age 65.7±11.4	telephone at 3, 6 and 12 months after stroke onset. 852 (13.0%) female patients were lost to follow up at 12 months visit.	adjustment for age, income, smoking, atrial fibrillation, heart failure, hospital level, NIHSS score, mRS score	compared to patients with urban insurance, the HR of all-cause mortality was 1.40 (1.06-1.84) in patients with rural insurance.
<u>Educational level only</u>						
Liu (2007) (January 2002–Jun 2005, Xijing Hospital of the Fourth Military Medical University, Xi'an, Shanxi, China)	Patients were recruited if they were hospitalised within 14 days after stroke onset Of 846 elderly patients, 485 were analysed after excluded patients with TIA/SAH, and those with serious	AIS was diagnosed using the 9th ICD and confirmed by CT/MRI.	The average age of patients was 67.7 (SD 7.3), (rang 60-93). 321 (66.2%) were men.	Followed up by trained research personnel via telephone or post-communication Duration of follow-up from min 1 day to max 47 months	A stepwise regression model was used with adjustment for age, NIHSS score, history of stroke and educational level.	152 deaths Poor prognosis patients (n=250) including 76 deaths and others with MRS 3-5 scores compared with those with good prognosis (n=235) having MRS 0-2 scores. The regression analysis showed a coefficient of -

	disease of cancer, blood disorder, collagen disease, serious diseases of heart, lung, liver, or kidney.			37 patients (7.6%) were lost to follow-up.		0.042 (SE 0.018), p=0.019 for a continuous variable of educational level. However, mortality risk in relation to educational level could not be identified because the deaths and the poor prognosis patients were categorised into a group to analyse in this study.
Wu (2014) (January 2009-December 2009, "Zhejiang provincial information system for NCDs' surveillance and management", Zhejiang province, China)	Patients were recruited if they met the following criteria (1) <28 days after stroke onset; (2) age ≥35 years; (3) Hukou status located in Zhejiang province. A total 78,189 patients were analysed after excluded patients with TIA/secondary stroke, and those with serious disease of cancer, blood disorder, collagen disease, and serious	Stroke was diagnosed according to WHO criteria	The average age of patients was 71.42±11.92, and 61.65% were cerebral infarctions, 30.42% ICH, 2.32% SAH, and 5.62% unspecified strokes.	Followed up by GPs via telephone/face-to-face interview or electronic registration databases from the CDC and police registration The median follow-up time was 30.46±23.31 months, from min 1 day to max 58 months	Cox proportional hazard regression models were used with adjustment for age, sex, hospitals' level, stroke types, hypertension	33,265 deaths Multivariate adjusted HRs for all-cause mortality were presented as follows: In total University or higher HR=1.00 Middle school HR=0.92 (0.79-1.07) Primary school HR=1.29 (1.11-1.49) Illiterate HR=1.93 (1.67-2.23)

	diseases of heart, lung, liver or kidney.			6,615 patients (9.2%) were lost to follow-up.		
<u>Income only</u>						
Sheng (2010) (January 2001-December 2003, Zupi Country Hospital, Henan, China)	Patients were recruited if they were hospitalised within 48 hours after stroke onset and a stay in hospital ≥14 days A total of 143 patients were recruited for analysis after excluding those with TIA/SAH, and those with serious disease of heart, lung, liver and kidney.	Stroke diagnosed was used the Chinese 3rd revision stroke diagnosis and confirmed by CT/MRI.	The average age of patients was 62.7 (SD 13.8), (range 32-88), with 66.4% of men and 67.1% of ischaemic stroke.	Followed up by trained research personnel via telephone/ mail communication/ face-to-face interview at 2 weeks, 1 month, 2 months, 3 months, 6 months, 1 year, 3 years and 5 years after stroke onset. 12 (8.4%) patients were lost to follow-up.	Cox proportional hazard regression models were used with adjustment for age, injured brain tissues, shift, recurrence, discharge status and social support, the income variable.	71 deaths In a univariate regression analysis, HR of mortality for patients with <¥1000 vs ≥¥1000 per month was 1.57 (1.50-1.65). In stepwise multivariate modelling income was not selected for the analysis due to its significance level.
<u>Multiple SES indicators</u>						
Zhou (2006) (August 1999-August 2002,	The Nanjing Stroke Registry Programme, serving the residents of Nanjing city, a	Stroke was diagnosed using CT/MRI by two	The mean age of the enrolled patients was 71.0 (SD 11.2), (range 23-110). 540	Followed up by researchers via telephone and mail or the	Cox proportional hazard regression models were used to estimate HR with	166 deaths. Multivariate adjusted HRs of mortality were presented

Jingling Hospital, Nanjing, Jiangsu, China)	total of 2200 patients with first-ever stroke were identified. 806 patients with ischemic stroke were analysed, after excluding 563 ICH or 61 SAH and 770 who did not have CT/MRI scans.	qualified neurologists based on the WHO definition.	patients were men (68.1%).	household registry system from the date of stroke onset to the date of death or the end of the study within 3 years after the stroke. None was lost to follow-up.	adjustments for age, sex, smoking, hypertension, diabetes mellitus, hypercholesterolemia, atrial fibrillation, myocardial infarction, prior TIA and NIHSS.	as follows: 1. Educational level University degree=1.00 Technical training 1.81 (0.62-5.28) High secondary school 0.96 (0.33-2.78) Secondary school 0.70 (0.28-1.77) Primary school 0.97 (0.39-2.40) Illiteracy 0.79 (0.31-2.01) 2. Occupational class Non-manual worker=1.00 Manual worker 5.18 (2.84-9.44) Unemployed 5.77 (2.67-12.46) 3. Monthly income (Yuan) ≥¥1000=1.00 ¥1-¥1000 2.22 (1.34-3.66) No income 5.45 (3.18-9.34) 4. Housing space In 40 m^2/person=1.00 In 20-40 m^2/person 1.52 (1.01-2.28) In 10-20 m^2/person 1.17 (0.77-1.77)

						In <10 m^2/person 2.13 (1.23-3.70)
Chen (2015) (2001-2008, Yiming subdistrict of Hefei city and Tangdian district of Yingshang county, Anhui, China)	3336 older adults were recruited in the study (1810 aged ≥65 years in urban and 1709 aged ≥60 years in rural communities) 2978 participants were analysed after excluding those who were lost to follow up. Of them, 167 were stroke patients (125 stroke patients from wave 1 survey and 42 from wave 2 survey).	Stroke was documented based on self-reported doctor's diagnosis.	Of 2,978 participants, their average age was 73.4 (SD 7.0), 53.9% were women and 52.7% were illiterate.	Followed up by survey team via face-to-face interview in 2001-2003 (wave 2) and in 2006-2008 (wave 3). The median year of follow-up was 5.2 years. 358 (10.7%) cohort members were lost to follow-up.	Cox proportional hazard regression models were used to calculate HR with adjustment for age, sex, BMI, smoking status, alcohol drinking, marital status, living alone, hypertension, hypercholesterolemia, diabetes, angina, depression and dementia, and SES indicators apart from itself.	565 deaths were in 2978 participants, 64 in 167 stroke patients. Multivariate adjusted HRs for all-cause mortality among stroke patients were presented as follows: 1. Urban-rurality Urban=1.00 Rural 1.51 (0.88-2.57) 2. Educational level >Primary school=1.00 ≤Primary school 1.88 (1.05-3.36) 3. Occupational class Non-manual=1.00 Manual 1.28 (0.75-2.19) 4. Family income (¥/month) ≥1000=1.00 <1000 1.64 (0.97-2.78)
Pan (2016) (September 2007 to August 2008, the China National	Patients were recruited from 132 hospitals if they were older than 18 years old and presented to hospital within 14	AIS was diagnosed according to the WHO criteria and confirmed by	Of 12,246 patients, the average age was 65.5 (rang 18-100), and 61.8% were male. 38.6% had educational level <6	Followed up by trained interviewed via telephone at 3, 6 and 12 months after stroke	Logistic regression models was used to calculate ORs with adjustment for age, sex, smoking, drinking,	1640 deaths Multivariate adjusted ORs for one-year mortality were presented as follows: 1. Educational level

Stroke Registry [CNSR], China)	days after the onset of symptoms. 12,246 patients were analysed after excluded those without any data of SES and who were lost to follow-up.	brain CT or MRI.	years, 27.0% were manual workers, 34.8% had family income ≤¥1000 per capita per month.	onset. 24 patients (0.2%) were lost to follow-up at 12 months visit.	cardiovascular disease, and risk factors score, previous stroke, prestrike mRS, scores of five medications before admission, stroke subtype, NIHSS on admission, stroke unit admission, swallow test, scores of five medications in hospital, and scores of five medications on hospital discharge.	(years) “>9 years”, OR=1.00 “6-9 years” 1.12 (0.91-1.39) “<6 years” 1.26 (1.06-1.51) 2. Occupational class Non-manual workers, OR=1.00 Manual workers 1.40 (1.11-1.77) No job 1.17 (0.89-1.54) Retired 1.09 (0.87-1.36) 3. Income (RMB/month) >1000, OR=1.00 ≤1000 1.15 (0.99-1.33) 4. Total score of low SES combined For one-year mortality “0”, OR=1.00 “1” 1.33 (1.11-1.59) “2” 1.36 (1.10-1.69) “3” 1.56 (1.23-1.97) For three-month mortality “0”, OR=1.00 “1” 1.30 (1.05-1.61) “2” 1.36 (1.05-1.76) “3” 1.65 (1.23-2.22)
Yan (2017) (September	723 patients with first-ever ischemic	Ischemic stroke was	The average age of patients was	Followed up by trained	Cox proportional hazard regression	39 deaths

2012 to August 2015, Shanghai Tenth People's Hospital, Tongji University School of Medicine, Shanghai region)	stroke aged 18-80 years were enrolled in this study. 471 patients were analysed after excluded 121 patients who were ICH, SAH or other nonvascular disease such as head trauma, blood disease, brain trauma, and seizures, 104 who refused or expressed no interested, and 27 who failed to provide essential data.	defined according to 2013 American Heart Association/American Stroke Association Guidelines and 2013 Updated Definition.	65.9±10.2, and 51.6% were male. Approximately 31.0% of the patients were with a less than high school educational level, and 75% with an annual income less than ¥60,000, 38.2% retired patients	interviewed until 1st Jan 2016. The median follow-up time was 31.6±10.4 months. 12 patients (2.5%) were lost to follow-up.	models were used with adjustment for age, gender, coronary heart disease, hypertension, diabetes mellitus, lipid disorders and smoking, individuals SES, and neighbourhood SES.	Multivariate adjusted HRs for all-cause mortality were presented as follows: 1. Individual SES High HR=1.00 Middle 1.41 (0.80-2.51) Low 2.13 (1.22-3.71) 2. Neighbourhood status Urban HR=1.00 County 1.57 (0.85-2.91) Rural 3.05 (1.62-5.76)

"¥" refers to Renminbi (CNY, Yuan), the official currency of China. Currency exchange rate in 2020: China currency ¥10=US$1.43.

RR, relative risk; HR, hazard ratio; OR, odds ratio; ICD, International Classification of Disease; mRS, Modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale; CVD, cardiovascular disease; TIA, transient ischaemic attack; ICH, intracerebral haemorrhage; SAH, subarachnoid haemorrhage; AIS, acute ischemic stroke; WHO, World Health Organisation; CT, computed tomography; MRI, magnetic resonance confirmation; OCSP, the Oxfordshire Community Stroke Project; TACI, total anterior circulation infarcts; PACI, partial anterior circulation infarcts; POCI, posterior circulation infarcts; LACI, lacunar infarct .

Table 4.5-2. Quality assessment for the 9 articles identified that studied the association of SES with mortality after stroke in China

Study	1	2	3	4	5	6	7	8	9	10
Gu et al. 2019	★	★	★	★	★	★	★	★	★	★
Gu et al. 2018	★	★	★	★	★	★	★	★	★	★
Wu et al. 2014	★	★	★	★	★	★	★	★		★
Liu et al. 2007	★	★	★	★	★	★	★	★		★
Sheng et al. 2010	★	★	★	★	★				★	
Zhou et al. 2006	★	★	★	★	★	★	★	★	★	★
Chen et al. 2015	★	★	★	★	★	★	★		★	★
Pan et al. 2016	★	★	★	★	★	★	★	★	★	★
Yan et al. 2017	★	★	★	★	★	★	★	★	★	★

Cohort Study

1 – Cohort truly representative

2 – Controls derived from the same cohort

3 – Clear measurement of socioeconomic status at baseline

4 – Adequacy Follow-up duration (≥12 months)

5 – Reliable methods of stroke (ie, CT/MRI scan)

6 – Cohort data analysis controlled for age and sex

7 – Cohort data analysis controlled for other confounders (ie, CVDs and risk factors)

8 – Findings interpreted well

9 – Weakness mentioned and explained clearly

10 – Paper written well

CHAPTER FIVE: DISTRIBUTIONS OF DEMOGRAPHIC CHARACTERISTICS AND DISEASE RISK FACTORS AMONG OLDER ADULTS BY SOCIOECONOMIC STATUS

5.1 Introduction

Socioeconomic status (SES) is a powerful predictor of physical and mental health conditions (Kivimäki et al., 2020). Many studies have found increased morbidities and mortality among socioeconomically disadvantaged individuals, and the burden of disease in this group is increasing with population ageing (Mackenbach et al., 2008, Weires et al., 2008, Tucker-Seeley et al., 2011, Lund Jensen et al., 2017, Kivimäki et al., 2020). Previous research showed that people with low SES had greater prevalence of unhealthy behaviours/lifestyles, social isolation, cardiovascular diseases (CVDs), and related CVD risk factors (CVDRFs) (Martikainen et al., 2008, Pampel et al., 2010, de Mestral and Stringhini, 2017, Domènech-Abella et al., 2018). Knowledge of the adverse factors and demographic characteristics related to low SES in older adults are predominantly derived from studies undertaken in high-income countries (HICs), while few studies have been done in low- and middle-income countries (LMICs).

China is the largest LMIC and the most populous country in the world. Over the past four decades, China has experienced rapid economic growth and overall socioeconomic development, along with an increasing gap in income between rich and poor (Sicular et al., 2007). Previous studies showed that in HICs higher SES was related to a healthier lifestyle, but in China this format may not follow up (Kim et al., 2004).

Furthermore, it is unclear whether this pattern applied to social networks and supports, CVDs, and related risk factors among older Chinese. In this Chapter, I examined demographic characteristics and disease risk factors, including behavioural/lifestyle factors, social networks and supports, CVDs, and other related risk factors, among older Chinese with different levels of SES.

5.2 Methods

Studied populations were derived from the Anhui study and the Four-province study in China. The methods of the baseline investigation of the studies have been fully described in Chapter 3.4.

5.2.1 Data analysis

Relevant baseline variables including demographic information, SES, social networks and supports, CVDs, and related risk factors in the Anhui and the Four-province studies were combined for analysis. In total there were 7,650 participants at baseline and 7,593 were left for analysis after excluding 57 participants who had no SES indicator measured. Baseline characteristics of participants, including socio-demography, behaviours/lifestyles, social networks and supports, CVDs and CVDRFs, were described using mean (SD) and percentage (%) and examined differences in their distributions between different groups of SES at baseline using a one-way ANOVA for continuous variables and a Chi-square test for categorical variables.

5.3 Results

Of 7,593 participants in the analysis, the mean age was 71.6 (SD 7.3) years old. There were 55.2% women and 44.8% men, and 43.9% were from the Anhui study and 56.1% from the Four-province study. The findings are presented in five parts in terms of different SES measurements, including urban-rurality, educational level, occupational class, satisfactory income, and financial problems in the past two years.

5.3.1 Urban-rurality

The analysis of 7,593 participants in the study showed 48.7% were from rural areas and 51.3% from urban areas at baseline. 53.7% of women lived in rural areas, and 56.7% of women lived in urban areas. Table 5-1 shows distributions of demographic characteristics, behaviours/lifestyles, SES, social networks and supports, CVDs and CVDRFs by urban-rural living in older adults in China. There was more overweight and obesity in urban areas than rural areas; underweight, overweight and obesity accounted for 5.9%, 32.4% and 10.1% of the total urban population respectively, while they were 8.0%, 26.4% and 8.2% of the rural population. In terms of unhealthy behaviours/lifestyles, people living in rural areas had higher levels of smoking (35.6% vs 15.6%) and drinking alcohol (24.3% vs 17.1%) compared to urban counterparts. People living in rural vs urban areas were more likely to be low SES; illiterate were 69.9% vs 21.5%, manual occupations 87.5% vs 43.4%, poor/average satisfactory income 58.0% vs 27%, and financial problems 43.6% vs 3.0%. However, the majority of participants living in rural areas had higher levels of social networks and supports such as visiting children or other relatives frequently and participating in senior community activities but lower level of group touring or walking. In addition, people living in urban areas had higher prevalence of CVDs and CVDRFs, but lower prevalence of mental disorders (Table 5-1).

Compared to those who lived in urban areas, participants lived in rural areas were more likely to be younger, be men, be not overweight or obese, be smokers and alcohol drinkers, have lower levels of education, occupation, and satisfactory income, have financial problems, be never married or divorced, visit children or other relative frequently, participate in community activities, and have high levels of mental disorders. But they were less likely to have walking or group touring, CVDs and risk factors such as heart disease, stroke, and diabetes (Table 5-1).

5.3.2 Educational level

Of 7,593 participants, those who were illiterate were 3,426 (45.1%), primary school 1,718 (22.6%), secondary school 1,113 (14.7%), and high secondary school or higher 1,336 (17.6%). Table 5-2 shows distributions of demographic characteristics, behaviours/lifestyles, SES, social networks and supports, CVDs and CVDRFs by educational level in older adults in China. Compared to those who were literate, illiterate participants were more likely to be older, be women, be underweight, be never smoking and alcohol drinking, live in rural areas, work as a peasant, have low satisfaction of income, experience financial problems, be never married or divorced status, live alone, visit children or other relatives frequently, participate in community activities, have high levels of hypertension, depression, and dementia. But they were less likely to walk or tour, and have heart disease and diabetes.

5.3.3 Occupational class

Of 7,593 participants, 4,924 (64.8%) were in manual occupations (Table 5-3). Compared to those with non-manual occupations, they were more likely to be younger, be females, be normal weight, be smokers and alcohol drinkers, live in rural areas, have low levels of education and satisfaction of income, have financial problems, be unmarried or divorced, live alone, visit children or other relatives frequently, participate in community activities, and have high levels of depression and dementia, but less likely to walk or tour, have heart disease and diabetes.

5.3.4 Satisfactory income

Of the studied participants, 762 (10.0%) reported "very satisfactory" of satisfaction of income, 3,634 (47.9%) "satisfactory", 2,596 (34.2%) "average", and 601 (7.9%) "poor" (Table 5-4). Participants with average or poor satisfactory income in comparison to those who were (very) satisfaction of income were more likely to be younger, be women, be smokers, live in rural areas, be low levels of education and occupation, have financial problems, be unmarried or divorced, live alone, have high levels of hypertension, depression and dementia. But they were less likely to be overweight/obese, be alcohol drinkers, visit children or other relatives frequently, walk or tour, and have heart disease and diabetes.

5.3.5 Financial problems

Of 7,593 participants, 1,728 (22.8%) had ever experienced financial problems in the past two years (Table 5-5). Participants with financial problems were more likely to be younger, be normal weight, be current smokers, live in rural areas, have low levels of education, occupation and satisfactory income, be unmarried or divorced, live alone, visit children or other relatives frequently, participate in community activities, and have risks of hypertension, depression and dementia, but less likely to walk or tour and have risks of heart disease and diabetes.

5.4 Discussion

The data of the Anhui study and the Four-province study combined showed a high prevalence of low SES in older Chinese at baseline survey, with 48.7% rural living, 45.1% illiterate, 64.8% manual occupations, 42.1% poor or average satisfactory income, and 22.8% having financial problems in the past two years. The data analysis showed that participants with low SES were likely to have unhealthy lifestyles, adverse psychological factors, and more social activities, whereas those with high SES were likely to have higher levels of CVDRFs and CVDs.

Socioeconomic factors – relationships of different SES measurements

The findings from this study reinforced the theory that SES indicators measured by urban-rural living, education, occupational class, satisfactory income, and financial problems were correlated (Geyer et al., 2006). People living in rural areas were more likely to have low levels of education, occupational class, and satisfactory income, and have financial problems, and vice versa. In China, there are large inequalities between urban and rural areas in educational attainment, job opportunities, and income level (Sicular et al., 2007). The quality of education was poor in rural areas of China (Ayoroa et al., 2007). Low levels of occupation and income as a consequence of low education were thus more prevalent in rural areas in China, which might be more likely to suffer from financial problems in late life. Although correlated, they measure different phenomena and tap into different causal mechanisms (Geyer et al., 2006). Therefore, urban-rural living, educational level, occupational class, satisfactory income, and financial problems cannot be used interchangeably as indicators of a hypothetical latent SES dimension.

Behavioural/lifestyle factors

Our data showed that people with low SES were more likely to be current smokers and drinkers. For example, the prevalence of current smoking and drinking in those living in rural vs urban areas were 35.6% vs 15.6% and 24.3% vs 17.1%, respectively. This was consistent with previous studies (Liu et al., 2017). Liu et al. (2017) reported that the prevalence for ex-smoker in rural vs urban areas in China was 8.2% vs 8.8%, and for the current smoker was 55.7% vs 49.6%. Particualrly, it was found that people with higher satisfactory income had higher prevalence of ex-smoking, with 11.4% in very satisfactory group, 9.3% in satisfactory, 8.5% in average, and 8.7% in poor, but they had lower prevalence of current smoking, with 24.3%, 23.6%, 27.2% and 29.3%, respectively. This might be because during the early stages of the epidemiological transition in China (Kim et al., 2004), people with high SES were more likely to have unhealthy lifestlyes such as smoking and drinking. While an increase in the health educaiton promotion, people with high SES would pay more attention to healthy lifestyle and diet.

Social networks and supports factors

Our study showed that people with low SES had a higher prevalence of never married/divorced status and living alone (except for those living in rural areas), although they were more likely to visit children or other relatives. For example, the prevalence of living alone in participants who were illiterate, primary school, secondary school, and high secondary school or high were 12.8%, 8.1%, 6.6%, and 5.5%, respectively. The strong association of low SES with unmarried status and living alone among older adults was consistent with those studies from HICs (Martikainen et al., 2008, Choi and Marks, 2011). However, there were no differences in living status between participants lived in rural and urban areas. One of the reasons for this could be because rural communities, to a large extent, retain many traditional ways of life, where "nurturing children to prevent old age" is still the iron law of people's trust. Living in a three-generation household remains prevalent among older adults in rural China as the traditional custom.

Our study showed that fewer participants with low SES had walking or group tours, but more of them participated in community activities. One of the reasons for this might be because for those who were low SES, money saving would be considered a priority. Due to insufficient money, people with low SES were more likely to participate in community activities during a leisure time, such as square dancing and singing, rather than participating in tourism activities.

Cardiovascular disease and related risk factors

There has been more attention to the prevalence of CVD and related risk factors associated with SES in older age in HICs (Kaplan et al., 2010, Ogden et al., 2017), showing low SES associated with increased prevalence. This was consistent with the variable of hypertension in our study. However, in our study, the prevalence of overweight/obesity and diabetes increased with increasing SES. Our study also showed higher prevalence of heart disease among those with high SES. Obesity and diabetes were two leading causes to develop heart disease (Peters et al., 2014, Carbone et al., 2019). The prevalence of overweight/obesity, diabetes and heart disease was lower as SES increased in HICs, but higher as SES increased in LMICs (Dinsa et al., 2012, Rosengren et al., 2019). It could be as a result of epidemiological transition in the early stages, and lifestyle changes in China due to increased economic development in the past four decades and urbanisation. It is also possible that the differences in the stages of epdiemiological transition among LMICs may explain some of the opposite findings of increased prevalence of CVDs and related risk factors among high SES groups.

Our data showed that people with low SES had higher prevalence of depression and dementia. It is consistent with previous community-based studies among older adults (McDougall et al., 2007, Scazufca et al., 2008). However, it was found that in the current study the prevalence of depression and dementia was lower among Chinese older adults. The prevalence of depressive disorders in the world for the elderly population was 10.3% (Barua et al., 2011), which was much higher than that of 4.1% in our study. One of the reasons for this was there were higher levels of social networks and supports (e.g., more frequency of visiting children or other relatives and participating community activities) among older people with low SES in China (Chen et al., 2005).

5.5 Conclusions

This Chapter demonstrated the distributions of demographic characteristics, behaviours/lifestyles, social networks and supports, CVDs and CVDRFs among older Chinese with different levels of SES. Most of the characteristics identified in our study showed that people with low SES had lower prevalence of CVDs and related risk factors, except for psychosocial aspects such as depression and dementia, but had higher levels of unhealthy behaviours/lifestyles and social networks and supports. The findings of those different measurement of SES in relation to demographic characteristics and risk factors could be applied in the following Chapters, which examined predictions of SES to the incidence of heart disease and stroke and all-cause mortality among older people with heart disease or/and stroke. Adjustment for important confounders would help identify independent impact of SES on the incidence and mortality of heart disease and stroke in older people in China.

Table 5-1. Distributions of demographic characteristics, behaviours/lifestyles, social networks and supports, CVDs and CVDRFs by urban-rural living among older adults in China

Variable	All Participants n=7593		Urban n=3894	(%)	Rural n=3699	(%)	P Value*
Age (years)							
Mean (SD)	71.6	7.3	72.7	7.0	70.4	7.3	*<0.001*
Sex							
Women	4195	55.2	2207	56.7	1988	53.7	*0.010*
Men	3398	44.8	1687	43.3	1711	46.3	
Province							
Anhui	3336	43.9	1736	44.6	1600	43.3	*0.161*
Guangdong	982	12.9	480	12.3	502	13.6	
Shanghai	1226	16.1	653	16.8	573	15.5	
Heilongjiang	1021	13.4	517	13.3	504	13.6	
Shanxi	1028	13.5	508	13.0	520	14.1	
BMI (kg/m^2)							
Cut-off point							
<18.5	524	6.9	228	5.9	296	8.0	*<0.001*
18.5-<24.0	4137	54.5	2014	51.7	2123	57.4	
24.0-<28.0	2238	29.5	1260	32.4	978	26.4	
≥28.0	694	9.1	392	10.1	302	8.2	
Smoking							
Never-smoking	4401	58.0	2401	61.7	2000	54.1	*<0.001*
Ex-smoking	698	9.2	315	8.1	383	10.4	
Current-smoking	1924	25.3	608	15.6	1316	35.6	
Missing*	570	7.5	570	14.6	0	0.0	
Alcohol drinking in the last 2 years							
No	6028	79.4	3230	82.9	2798	75.6	*<0.001*
Yes	1563	20.6	664	17.1	899	24.3	
Missing	2	0.0	0	0.0	2	0.1	
Educational level							
≥High secondary school	1336	17.6	1284	33.0	52	1.4	*<0.001*
Secondary school	1113	14.7	870	22.3	243	6.6	
Primary school	1718	22.6	901	23.1	817	22.1	
Illiterate	3426	45.1	839	21.5	2587	69.9	
Occupational class							
Official/teacher	1615	21.3	1520	39.0	95	2.6	*<0.001*
Business/other	1054	13.9	686	17.6	368	9.9	
Manual labourer	1325	17.5	1218	31.3	107	2.9	

Peasant	3599	47.4	470	12.1	3129	84.6	
Satisfactory income							
Very satisfactory	762	10.0	515	13.2	247	6.7	*<0.001*
Satisfactory	3634	47.9	2328	59.8	1306	35.3	
Average	2596	34.2	914	23.5	1682	45.5	
Poor	601	7.9	137	3.5	464	12.5	
Financial problems in the past two years							
No	5865	77.2	3778	97.0	2087	56.4	*<0.001*
Yes	1728	22.8	116	3.0	1612	43.6	
Social network and Hobbies							
Marriage status							
Married	5395	71.1	2687	69.0	2708	73.2	*<0.001*
Never married/Divorced	223	2.9	57	1.5	166	4.5	
Widow	1975	26.0	1150	29.5	825	22.3	
Living with							
Somebody	6869	90.5	3524	90.5	3345	90.4	*0.919*
No-one	724	9.5	370	9.5	354	9.6	
Frequency of visiting children or other relatives							
Daily	2999	39.5	1277	32.8	1722	46.6	*<0.001*
At least weekly	2655	35.0	1668	42.8	987	26.7	
At least monthly or less often	1577	20.8	724	18.6	853	23.1	
Never	360	4.7	224	5.8	136	3.7	
Missing*	2	0.0	1	0.0	1	0.0	
Walking or group touring							
Yes	4038	53.7	2851	74.1	1187	32.3	*<0.001*
No	3480	46.3	996	25.9	2484	67.7	
Community activity participating							
Yes	2278	30.0	938	24.1	1340	36.2	*<0.001*
No	5301	69.8	2955	75.9	2346	63.4	
Missing*	14	0.2	1	0.0	13	0.4	
Co-morbidities							
Hypertension							
No	3484	45.9	1803	46.3	1681	45.4	*0.056*
Yes	3997	52.6	1980	50.8	2017	54.5	
Missing*	112	1.5	111	2.9	1	0.0	

Heart disease							
No	6387	84.1	3048	78.3	3339	90.3	*<0.001*
Yes	1128	14.9	813	20.9	315	8.5	
Missing*	78	1.0	33	0.8	45	1.2	
Stroke							
No	7267	95.7	3702	95.1	3565	96.4	*0.003*
Yes	307	4.0	183	4.7	124	3.4	
Missing*	19	0.3	9	0.2	10	0.3	
Diabetes							
No	7081	93.3	3490	89.6	3591	97.1	*<0.001*
Yes	469	6.2	383	9.8	86	2.3	
Missing*	43	0.6	21	0.5	22	0.6	
Depression							
No	7279	95.9	3782	97.1	3497	94.5	*<0.001*
Yes	309	4.1	108	2.8	201	5.4	
Missing*	5	0.1	4	0.1	1	0.0	
Dementia							
No	6962	91.7	3713	95.4	3249	87.8	*<0.001*
Yes	626	8.2	177	4.5	449	12.1	
Missing*	5	0.1	4	0.1	1	0.0	

*P-value in the Chi-square test was calculated based on available data, not including those "missing" data.

Table 5-2. Distributions of demographic characteristics, behaviours/lifestyles, social networks and supports, CVDs and CVDRFs by educational level among older adults in China

Variable	Illiterate n=3426	(%)	Primary school n=1718	(%)	Secondary school n=1113	(%)	≥High secondary school n=1336	(%)	P Value*
Age (years)									
Mean (SD)	72.6	7.6	70.5	7.2	70.5	6.7	71.4	6.3	*<0.001*
Sex									
Women	2333	68.1	873	50.8	482	43.3	507	37.9	*<0.001*
Men	1093	31.9	845	49.2	631	56.7	829	62.1	
Province									
Anhui	1699	49.6	405	23.6	458	41.2	774	57.9	*<0.001*
Guangdong	486	14.2	420	24.4	62	5.6	14	1.0	
Shanghai	483	14.1	285	16.6	196	17.6	262	19.6	
Heilongjiang	406	11.9	298	17.3	159	14.3	158	11.8	
Shanxi	352	10.3	310	18.0	238	21.4	128	9.6	
BMI (kg/m^2)									
Cut-off point									
<18.5	278	8.1	122	7.1	63	5.7	61	4.6	*<0.001*
18.5-<24.0	1951	56.9	959	55.8	567	50.9	660	49.4	
24.0-<28.0	901	26.3	460	26.8	373	33.5	504	37.7	
≥28.0	296	8.6	177	10.3	110	9.9	111	8.3	
Smoking									
Never-smoking	2197	64.1	909	52.9	598	53.7	697	52.2	*<0.001*

Ex-smoking	263	7.7	196	11.4	124	11.1	115	8.6	
Current-smoking	881	25.7	524	30.5	273	24.5	246	18.4	
Missing*	85	2.5	89	5.2	118	10.6	278	20.8	
Alcohol drinking in the last 2 years									
No	2838	82.8	1273	74.1	837	75.2	1080	80.8	*<0.001*
Yes	588	17.2	443	25.8	276	24.8	256	19.2	
Missing*	0	0.0	2	0.1	0	0.0	0	0.0	
Urban-rurality									
Urban	839	24.5	901	52.4	870	78.2	1284	96.1	*<0.001*
Rural	2587	75.5	817	47.6	243	21.8	52	3.9	
Occupational class									
Official/teacher	39	1.1	135	7.9	465	41.8	976	73.1	*<0.001*
Business/other	441	12.9	297	17.3	127	11.4	189	14.1	
Manual labourer	326	9.5	526	30.6	332	29.8	141	10.6	
Peasant	2620	76.5	760	44.2	189	17.0	30	2.2	
Satisfactory income									
Very satisfactory	212	6.2	179	10.4	148	13.3	223	16.7	*<0.001*
Satisfactory	1235	36.0	857	49.9	633	56.9	909	68.0	
Average	1578	46.1	555	32.3	281	25.2	182	13.6	
Poor	401	11.7	127	7.4	51	4.6	22	1.6	
Financial problems in the past two years									
No	2029	59.2	1512	88.0	1025	92.1	1299	97.2	*<0.001*

Yes	1397	40.8	206	12.0	88	7.9	37	2.8	
Social network and Hobbies									
Marriage status									
Married	2164	63.2	1280	74.5	885	79.5	1066	79.8	*<0.001*
Never married/Divorced	145	4.2	33	1.9	28	2.5	17	1.3	
Widow	1117	32.6	405	23.6	200	18.0	253	18.9	
Living with									
Somebody	2987	87.2	1579	91.9	1040	93.4	1263	94.5	*<0.001*
No-one	439	12.8	139	8.1	73	6.6	73	5.5	
Frequency of visiting children or other relatives									
Daily	1717	50.1	559	32.5	315	28.3	408	30.5	*<0.001*
At least weekly	848	24.8	687	40.0	513	46.1	607	45.4	
At least monthly or less often	699	20.4	370	21.5	244	21.9	264	19.8	
Never	161	4.7	101	5.9	41	3.7	57	4.3	
Missing*	1	0.0	1	0.1	0	0.0	0	0.0	
Walking or group touring									
Yes	1305	38.4	955	56.3	737	66.9	1041	78.9	*<0.001*
No	2094	61.6	742	43.7	365	33.1	279	21.1	
Community activity participating									

Yes	1200	35.0	356	20.7	268	24.1	454	34.0	
No	2222	64.9	1356	78.9	841	75.6	882	66.0	*<0.001*
Missing*	4	0.1	6	0.3	4	0.4	0	0.0	
<u>*Co-morbidities*</u>									
Hypertension									
No	1473	43.0	831	48.4	557	50.0	623	46.6	*<0.001*
Yes	1884	55.0	854	49.7	550	49.4	709	53.1	
Missing*	69	2.0	33	1.9	6	0.5	4	0.3	
Heart disease									
No	3065	89.5	1449	84.3	869	78.1	1004	75.1	*<0.001*
Yes	333	9.7	237	13.8	235	21.1	323	24.2	
Missing*	28	0.8	32	1.9	9	0.8	9	0.7	
Stroke									
No	3270	95.4	1661	96.7	1058	95.1	1278	95.7	*0.126*
Yes	142	4.1	54	3.1	54	4.9	57	4.3	
Missing*	14	0.4	3	0.2	1	0.1	1	0.1	
Diabetes									
No	3288	96.0	1601	93.2	995	89.4	1197	89.6	*<0.001*
Yes	115	3.4	103	6.0	115	10.3	136	10.2	
Missing*	23	0.7	14	0.8	3	0.3	3	0.2	
Depression									
No	3249	94.8	1648	95.9	1078	96.9	1304	97.6	*<0.001*
Yes	172	5.0	70	4.1	35	3.1	32	2.4	
Missing*	5	0.1	0	0.0	0	0.0	0	0.0	
Dementia									
No	2943	85.9	1612	93.8	1087	97.7	1320	98.8	*<0.001*

Yes	478	14.0	106	6.2	26	2.3	16	1.2
Missing*	5	0.1	0	0.0	0	0.0	0	0.0

*P-value in the Chi-square test was calculated based on available data, not including those “missing” data.

Table 5-3. Distributions of demographic characteristics, behaviours/lifestyles, social networks and supports, CVDs and CVDRFs by occupational class among older adults in China

Variable	Non-manual* n=2669	(%)	Manual* n=4924	(%)	P Value†
Age (years)					
Mean (SD)	72.3	6.9	71.2	7.5	*<0.001*
Sex					
Women	1404	52.6	2791	56.7	*0.001*
Men	1265	47.4	2133	43.3	
Province					
Anhui	1325	49.6	2011	40.8	*<0.001*
Guangdong	218	8.2	764	15.5	
Shanghai	341	12.8	885	18.0	
Heilongjiang	337	12.6	684	13.9	
Shanxi	448	16.8	580	11.8	
BMI (kg/m^2)					
Cut-off point$					
<18.5	171	6.4	353	7.2	*<0.001*
18.5-<24.0	1369	51.3	2768	56.2	
24.0-<28.0	885	33.2	1353	27.5	
≥28.0	244	9.1	450	9.1	
Smoking					
Never-smoking	1493	55.9	2908	59.1	*<0.001*
Ex-smoking	234	8.8	464	9.4	
Current-smoking	516	19.3	1408	28.6	
Missing†	426	16.0	144	2.9	
Alcohol drinking in the last 2 years					
No	2192	82.1	3836	77.9	*<0.001*
Yes	477	17.9	1086	22.1	
Missing†	0	0.0	2	0.0	
Urban-rurality					
Urban	2206	82.7	1688	34.3	*<0.001*
Rural	463	17.3	3236	65.7	
Educational level					
≥High secondary school	1165	43.6	171	3.5	*<0.001*
Secondary school	592	22.2	521	10.6	
Primary school	432	16.2	1286	26.1	
Illiterate	480	18.0	2946	59.8	
Satisfactory income					
Very satisfactory	409	15.3	353	7.2	*<0.001*

Satisfactory	1613	60.4	2021	41.0	
Average	552	20.7	2044	41.5	
Poor	95	3.6	506	10.3	
Financial problems in the past two years					
No	2551	95.6	3314	67.3	*<0.001*
Yes	118	4.4	1610	32.7	
Social network and Hobbies					
Marriage status					
Married	1919	71.9	3476	70.6	*<0.001*
Never married/Divorced	36	1.3	187	3.8	
Widow	714	26.8	1261	25.6	
Living with					
Somebody	2472	92.6	4397	89.3	*<0.001*
No-one	197	7.4	527	10.7	
Frequency of visiting children or other relatives					
Daily	814	30.5	2185	44.4	*<0.001*
At least weekly	1136	42.6	1519	30.8	
At least monthly or less often	580	21.7	997	20.2	
Never	139	5.2	221	4.5	
Missing†	0	0.0	2	0.0	
Walking or group touring					
No	780	29.6	2700	55.3	
Yes	1852	70.4	2186	44.7	*<0.001*
Community activity participating					
No	1920	71.9	3381	68.7	*0.003*
Yes	744	27.9	1534	31.2	
Missing†	5	0.2	9	0.2	
Co-morbidities					
Hypertension					
No	1249	46.8	2235	45.4	*0.559*
Yes	1407	52.7	2590	52.6	
Missing†	13	0.5	99	2.0	
Heart disease					
No	2079	77.9	4308	87.5	*<0.001*
Yes	568	21.3	560	11.4	

Missing†	22	0.8	56	1.1	
Stroke					
No	2545	95.4	4722	95.9	*0.179*
Yes	119	4.5	188	3.8	
Missing†	5	0.2	14	0.3	
Diabetes					
No	2408	90.2	4673	94.9	*<0.001*
Yes	248	9.3	221	4.5	
Missing†	13	0.5	30	0.6	
Depression					
No	2589	97.0	4690	95.2	*<0.001*
Yes	79	3.0	230	4.7	
Missing†	1	0.0	4	0.1	
Dementia					
No	2544	95.3	4418	89.7	*<0.001*
Yes	124	4.6	502	10.2	
Missing†	1	0.0	4	0.1	

*Manual occupation was from peasants and manual labourer, and non-manual occupation from official/teacher and business/other.

$The cut-off points for BMI variable used in this study were based on the BMI classification recommended for Asian Chinese population by the Chinese government (Chen, 2008).

†P-value in the Chi-square test was calculated based on available data, not including those "missing" data.

Table 5-4. Distributions of demographic characteristics, behaviours/lifestyles, social networks and supports, CVDs and CVDRFs by satisfactory income among older adults in China

Variable	Very satisfactory		Satisfactory		Average		Poor		P Value*
	n=762	(%)	n=3634	(%)	n=2596	(%)	n=601	(%)	
Age (years)									
Mean (SD)	71.9	7.1	71.8	7.1	71.3	7.6	71.3	7.3	*0.010*
Sex									
Women	406	53.3	1931	53.1	1515	58.4	343	57.1	*<0.001*
Men	356	46.7	1703	46.9	1081	41.6	258	42.9	
Province									
Anhui	337	44.2	1622	44.6	1086	41.8	291	48.4	*<0.001*
Guangdong	87	11.4	577	15.9	288	11.1	30	5.0	
Shanghai	96	12.6	533	14.7	537	20.7	60	10.0	
Heilongjiang	196	25.7	438	12.1	355	13.7	32	5.3	
Shanxi	46	6.0	464	12.8	330	12.7	188	31.3	
BMI (kg/m^2)									
Cut-off point									
<18.5	43	5.6	217	6.0	213	8.2	51	8.5	*<0.001*
18.5-<24.0	388	50.9	1965	54.1	1425	54.9	359	59.7	
24.0-<28.0	255	33.5	1104	30.4	724	27.9	155	25.8	
≥28.0	76	10.0	348	9.6	234	9.0	36	6.0	
Smoking									
Never-smoking	412	54.1	2064	56.8	1574	60.6	351	58.4	*0.021*
Ex-smoking	87	11.4	338	9.3	221	8.5	52	8.7	

Current-smoking	185	24.3	856	23.6	707	27.2	176	29.3	
Missing*	78	10.2	376	10.3	94	3.6	22	3.7	
Alcohol drinking in the last 2 years									
No	590	77.4	2851	78.5	2092	80.6	495	82.4	*0.028*
Yes	172	22.6	781	21.5	504	19.4	106	17.6	
Missing*	0	0.0	2	0.1	0	0.0	0	0.0	
Urban-rurality									
Urban	515	67.6	2328	64.1	914	35.2	137	22.8	*<0.001*
Rural	247	32.4	1306	35.9	1682	64.8	464	77.2	
Educational level									
≥High secondary school	223	29.3	909	25.0	182	7.0	22	3.7	*<0.001*
Secondary school	148	19.4	633	17.4	281	10.8	51	8.5	
Primary school	179	23.5	857	23.6	555	21.4	127	21.1	
Illiterate	212	27.8	1235	34.0	1578	60.8	401	66.7	
Occupational class									
Official/teacher	281	36.9	1077	29.6	226	8.7	31	5.2	*<0.001*
Business/other	128	16.8	536	14.7	326	12.6	64	10.6	
Manual labourer	138	18.1	748	20.6	379	14.6	60	10.0	
Peasant	215	28.2	1273	35.0	1665	64.1	446	74.2	
Financial problems in the past two years									
No	700	91.9	3080	84.8	1717	66.1	368	61.2	*<0.001*
Yes	62	8.1	554	15.2	879	33.9	233	38.8	

Social network and Hobbies									
Marriage status									
Married	544	71.4	2715	74.7	1787	68.8	349	58.1	*<0.001*
Never married/Divorced	10	1.3	53	1.5	99	3.8	61	10.1	
Widow	208	27.3	866	23.8	710	27.3	191	31.8	
Living with									
Somebody	699	91.7	3354	92.3	2339	90.1	477	79.4	*<0.001*
No-one	63	8.3	280	7.7	257	9.9	124	20.6	
Frequency of visiting children or other relatives									
Daily	325	42.7	1364	37.5	1091	42.0	219	36.4	*<0.001*
At least weekly	279	36.6	1412	38.9	774	29.8	190	31.6	
At least monthly or less often	135	17.7	697	19.2	608	23.4	137	22.8	
Never	23	3.0	160	4.4	122	4.7	55	9.2	
Missing*	0	0.0	1	0.0	1	0.0	0	0.0	
Walking or group touring									
Yes	530	70.6	2194	61.0	1152	44.7	162	27.2	*<0.001*
No	221	29.4	1400	39.0	1425	55.3	434	72.8	
Community activity participating									
Yes	233	30.6	1104	30.4	786	30.3	155	25.8	*0.128*

No	528	69.3	2520	69.3	1807	69.6	446	74.2	
Missing*	1	0.1	10	0.3	3	0.1	0	0.0	
Co-morbidities									
Hypertension									
No	314	41.2	1683	46.3	1243	47.9	244	40.6	*<0.001*
Yes	438	57.5	1889	52.0	1315	50.7	355	59.1	
Missing*	10	1.3	62	1.7	38	1.5	2	0.3	
Heart disease									
No	596	78.2	3002	82.6	2253	86.8	536	89.2	*<0.001*
Yes	157	20.6	598	16.5	312	12.0	61	10.1	
Missing*	9	1.2	34	0.9	31	1.2	4	0.7	
Stroke									
No	735	96.5	3486	95.9	2476	95.4	570	94.8	*0.374*
Yes	26	3.4	138	3.8	114	4.4	29	4.8	
Missing*	1	0.1	10	0.3	6	0.2	2	0.3	
Diabetes									
No	699	91.7	3336	91.8	2476	95.4	570	94.8	*<0.001*
Yes	58	7.6	279	7.7	105	4.0	27	4.5	
Missing*	5	0.7	19	0.5	15	0.6	4	0.7	
Depression									
No	739	97.0	3521	96.9	2484	95.7	535	89.0	*<0.001*
Yes	23	3.0	111	3.1	109	4.2	66	11.0	
Missing*	0	0.0	2	0.1	3	0.1	0	0.0	
Dementia									
No	716	94.0	3402	93.6	2316	89.2	528	87.9	*<0.001*
Yes	46	6.0	230	6.3	277	10.7	73	12.1	

Missing*	0	0.0	2	0.1	3	0.1	0	0.0

*P-value in the Chi-square test was calculated based on available data, not including those "missing" data.

Table 5-5. Distributions of demographic characteristics, behaviours/lifestyles, social networks and supports, CVDs and CVDRFs by financial problems among older adults in China

Variable	No n=5865	(%)	Yes n=1728	(%)	P Value*
Age (years)					
Mean (SD)	71.8	7.2	70.9	7.5	*<0.001*
Sex					
Women	3264	55.7	931	53.9	*0.192*
Men	2601	44.3	797	46.1	
Province					
Anhui	1812	30.9	1524	88.2	*<0.001*
Guangdong	960	16.4	22	1.3	
Shanghai	1185	20.2	41	2.4	
Heilongjiang	922	15.7	99	5.7	
Shanxi	986	16.8	42	2.4	
BMI (kg/m^2)					
Cut-off point					
<18.5	432	7.4	92	5.3	*0.011*
18.5-<24.0	3152	53.7	985	57.0	
24.0-<28.0	1743	29.7	495	28.6	
≥28.0	538	9.2	156	9.0	
Smoking					
Never-smoking	3435	58.6	966	55.9	*<0.001*
Ex-smoking	569	9.7	129	7.5	
Current-smoking	1316	22.4	608	35.2	
Missing*	545	9.3	25	1.4	
Alcohol drinking in the last 2 years					
No	4666	79.6	1362	78.8	*0.490*
Yes	1197	20.4	366	21.2	
Missing*	2	0.0	0	0.0	
Urban-rurality					
Urban	3778	64.4	116	6.7	*<0.001*
Rural	2087	35.6	1612	93.3	
Educational level					
≥High secondary school	1299	22.1	37	2.1	*<0.001*
Secondary school	2029	34.6	1397	80.8	
Primary school	1512	25.8	206	11.9	
Illiterate	1025	17.5	88	5.1	
Occupational class					
Official/teacher	1540	26.3	75	4.3	*<0.001*

Business/other	1011	17.2	43	2.5	
Manual labourer	1250	21.3	75	4.3	
Peasant	2064	35.2	1535	88.8	
Satisfactory income					
Very satisfactory	700	11.9	62	3.6	*<0.001*
Satisfactory	3080	52.5	554	32.1	
Average	1717	29.3	879	50.9	
Poor	368	6.3	233	13.5	
Social network and Hobbies					
Marriage status					
Married	4204	71.7	1191	68.9	*<0.001*
Never married/Divorced	121	2.1	102	5.9	
Widow	1540	26.3	435	25.2	
Living with					
Somebody	5384	91.8	1485	85.9	*<0.001*
No-one	481	8.2	243	14.1	
Frequency of visiting children or other relatives					
Daily	1816	31.0	1183	68.5	*<0.001*
At least weekly	2393	40.8	262	15.2	
At least monthly or less often	1366	23.3	211	12.2	
Never	288	4.9	72	4.2	
Missing*	2	0.0	0	0.0	
Walking or group touring					
Yes	3390	58.4	648	37.8	*<0.001*
No	2414	41.6	1066	62.2	
Community activity participating					
Yes	1161	19.8	1117	64.6	
No	4690	80.0	611	35.4	*<0.001*
Missing*	14	0.2	0	0.0	
Co-morbidities					
Hypertension					
No	2738	46.7	746	43.2	*0.002*
Yes	3019	51.5	978	56.6	
Missing*	108	1.8	4	0.2	
Heart disease					
No	4808	82.0	1579	91.4	*<0.001*

Yes	988	16.8	140	8.1	
Missing*	69	1.2	9	0.5	
Stroke					
No	5616	95.8	1651	95.5	*0.405*
Yes	231	3.9	76	4.4	
Missing*	18	0.3	1	0.1	
Diabetes					
No	5391	91.9	1690	97.8	*<0.001*
Yes	438	7.5	31	1.8	
Missing*	36	0.6	7	0.4	
Depression					
No	5659	96.5	1620	93.8	*<0.001*
Yes	201	3.4	108	6.3	
Missing*	5	0.1	0	0.0	
Dementia					
No	5441	92.8	1521	88.0	*<0.001*
Yes	419	7.1	207	12.0	
Missing*	5	0.1	0	0.0	

*P-value in the Chi-square test was calculated based on available data, not including those "missing" data.

CHAPTER SIX: IMPACT OF SOCIOECONOMIC STATUS ON INCIDENCE OF HEART DISEASE: THE ANHUI COHORT AND THE FOUR-PROVINCE COHORT STUDIES

6.1 Introduction

Heart disease (HD) is the first leading cause of death in the world (Naghavi et al., 2017, Kyu et al., 2018). Previous studies showed that low socioeconomic status (SES) was associated with increased incidence of HD in the general population (de Mestral and Stringhini, 2017, Backholer et al., 2017). Most of the evidence regarding the association of SES with risk of incident HD was from high income countries (HICs), while such analyses remained largely absent in low- and middle-income countries (LMICs) (de Mestral and Stringhini, 2017). There were also few studies examining the association of SES with incidence of HD among older adults (Wang et al., 2017a, de Mestral and Stringhini, 2017). Studying older populations in LMICs may offer internationally applicable insights into the effect of SES on incidence of HD and support actions on health inequalities to improve outcomes.

China is the largest LMIC in terms of population and area. Coronary heart disease (CHD) has been the second leading cause of death in the Chinese population (Zhou et al., 2016). Previous systematic review showed that evidence of the association of SES with risk of incident HD remains limited in China (Chapter 4.2). Existing literature reported inconsistent findings in the risk of incident HD associated with SES among older adults. In this Chapter, the association of SES with incidence of HD were examined among older adults in China.

6.2 Methods

The studied populations were derived from the Anhui cohort and the Four-province cohort studies in China. The methods of the baseline investigation and the follow-up of the study have been fully described in Chapter 3.4.

6.2.1 Data analysis

Data from the two cohort studies would be analysed separately. In the Anhui cohort study, the data from 2,540 cohort members were analysed after excluding 492 who had HD at baseline and 304 who were lost to follow up. In the Four-province cohort study, the data from 2,753 cohort members were left after excluding 640 who had HD at baseline, 56 who had no SES indicators measured and 865 participants who were lost to follow-up. We employed multivariate Cox regression analysis to calculate HRs of the incidence of HD and their 95% CIs in relation to each of the SES indicators. In the Four-province cohort study, we further analysed the associations in subgroups by HD subtypes including CHD and HVD (or others).

6.2.2 Meta-analysis

I pooled the data from the current cohort studies' findings with the previous studies that were identified and reviewed in Chapter 4.2 to assess the associations with risk of incident HD in China.

6.3 Results

6.3.1 Anhui cohort study

Of 2,540 participants, the average age was 71.1 years (SD 7.0), 52.0% were women and 47.3% lived in rural areas. Compared to those lived in rural areas, participants lived in urban areas were more likely to be obese, be never smoking, have higher levels of education, occupational class, and satisfactory income, be married, have diabetes, and have higher a score of activity of daily living (ADL), but less likely to have financial problems, be visited by children and other relatives, and have dementia and depression (Table 6-1).

Over the median 6.4 years' follow-up, 469 incident cases of HD occurred. Table 6-2 shows numbers, incidence and adjusted HRs of HD in participants associated with SES. The HR of incident HD was significantly lower in participants living in rural vs urban areas; the age-sex adjusted HR was 0.61 (0.51-0.74). After adjustment for age, sex, BMI, smoking, drinking, educational level, marital status, and frequency of visiting children or other relatives, the HR was 0.64 (0.49-0.85). Further adjustment for hypertension, stroke, diabetes, ADL, depression, and dementia did not substantially change the HR (0.66, 0.49-0.88) (Table 6-2). In other words, when comparing urban to rural, these matched figures were 1.64 (1.35-1.96), 1.56 (1.18-2.04) and 1.52 (1.14-2.04), respectively. That is, older people living in urban vs rural areas in China had an increased risk of incident HD.

There were no significant associations of education, occupational class, satisfactory income, and financial problems with HD incidence, although increased HRs were significant in participants with high vs low SES in the age and sex adjusted models (Table 6-2).

6.3.2 Four-province cohort study

Over the median 3.1 years' follow-up, there were 327 incident HD cases, of which 197 were CHD cases and 130 were HVD (or others). Table 6-3 shows the number and adjusted HRs of incident HD in participants associated with SES. In the age and sex adjusted model, the HR of HD was significantly lower in participants living in rural compared to urban areas (0.55, 0.43-0.70). After adjustment for more confounders the

HR was 0.49 (0.34-0.68) in the model 2 and 0.48 (0.34-0.69) in the model 3 (Table 6-3). In analysis of HD subtypes, rural living was also significantly associated with lower risk of CHD and HVD (or others); the fully-adjusted HR of CHD was 0.64 (0.42-0.99) and of HVD (or others) 0.28 (0.15-0.52) (Tables 6-4 and 6-5).

There were no significant associations of education, occupational class, satisfactory income, financial problems, and personal income with HD incidence, except for low family income associated with increased risk of HD (1.42, 1.00-2.00) (Table 6-3). In the analysis of HD subtypes, the associations of these SES with incidence of CHD and HVD (or others) were not significant (Tables 6-4 and 6-5).

6.3.3 Pooled data from the Anhui cohort and the Four-province cohort to examine the impact of SES on HD incidence

Figure 6-1 shows pooled data for each SES indicator separately. The incidence of HD was significantly increased in participants with urban vs rural living (1.79, 1.40-2.29), but there were not significant in either low vs high levels of education, occupational class, satisfactory income, or having financial problems (Figure 6-1).

6.3.4 Meta-analysis of these new data of all types of HD with those from identified studies

In the meta-analysis, I included the current two cohorts' findings and any available data from the four studies which were identified and reviewed in Chapter 4.2, including the two case-control studies of Guo et al. (Guo et al., 2012) and Liu et al. (Liu and Yan, 2016) and the two cohort studies of Lee et al. (Lee et al., 2000) and Wang et al. (Wang et al., 2017a). The total number of HD patients involved for analysis was 5,785. Based on the current two cohort studies and one of results of above identified studies, which was selected according to the order of rural-urban living, education, income, and occupation, the random effect model analysis showed the pooled RR of risk of incident HD in participants with low vs high SES was 1.00 (0.74-1.35) (Figure 6-2). Stratified data by study design showed that the pooled RR of risk of incident HD in the case-control studies was 1.70 (0.85-3.41), and in the cohort studies 0.83 (0.55-1.24) (Figure 6-2).

Using data from Liu et al.'s study and the current two cohort studies, the pooled RR of incident HD in participants with rural vs urban living was 0.83 (0.43-1.58) (Figure 6-3).

The pooled RR of incident HD in participants with low vs high education was increased (pooled RR 1.14, 1.01-1.28), which was pooled from five studies by Lee et al., Guo et al., and Wang et al. and the current two cohort studies (Figure 6-4). Within all cohort studies it remained significant (1.10, 1.00-1.20) (Figure 6-4).

The pooled data for low levels of occupation and income did not show significant associations with risk of incident HD. The pooled RR of incident HD in participants with low vs high occupational class was 1.00 (0.72-1.37), which was pooled from studies of Lee et al., Guo et al., and Liu et al. and the current two cohort studies (Figure 6-5); the corresponding pooled RR was 1.98 (0.33-11.85) in case-control studies and 0.89 (0.72-1.10) in the cohort studies (Figure 6-5). Based on the available data from Guo et al., Liu et al., and the data of satisfactory income from the current two cohort studies, the pooled data of incident HD was 0.96 (0.81-1.12) in participants with low vs high income (Figure 6-6).

6.4 Discussion

In this Chapter, the two community-based cohort studies of older adults were examined, with pooled data from previous studies to assess the associations of SES with risk of incident HD in China. The data shows that older people living in urban China and with low levels of education and family income had significantly increased risk of incident HD.

In our study there were no associations between educational level and incidence of HD, but low education associated with risk of HD showed a marginal significance in the pooled data with previous identified studies. Association of low educational level with increased risk of HD was consistent with previous studies from HICs (Thurston et al., 2005, Lewis et al., 2015). This could be explained by lifestyles, in that low educated people may be more likely to have adverse health behaviours, such as unhealthy eating habits, which may increase the incidence of HD.

Our data of the Four-province cohort study showed that low family income was associated with increased incidence of HD. This is consistent with previous studies undertaken in HICs (Thurston et al., 2005, Khaing et al., 2017). In a 2017 meta-analysis of 12 studies from Europe, Khaing et al. found that lower income was associated with increased risk of HD; the pooled RR of low vs high income was 1.74 (1.31-2.32) (Khaing et al., 2017). Nevertheless, individual data of income, such as satisfactory income, financial problems, and personal income did not show significant associations with risk of incident HD in our two cohort studies. One of the reasons for this could be attributed to the Chinese tradition that older adults usually live with their children or relatives. Income shared by family affects family members' lifestyles and eating habits to large extent, and thus family-related factors may play a more important role in the risk of HD among older Chinese people.

The current study did not find a significant association between occupational class and risk of incident HD. This is different from the results in previous studies from HICs

(Tenkanen et al., 1997, Ramsay et al., 2009, Backholer et al., 2017). In the UK, a population-based cohort of 3,761 participants aged 60-79 years with 6.5 years follow-up showed that the HR for incident CHD was 2.14 (1.06-4.33) in these with unskilled occupations versus professional occupations (Ramsay et al., 2009). Lee et al (Lee et al., 2000) suggested that compared to other SES indicators, occupational class was not a significant predictor in the association with HD incidence in China. It may help explain why there was no association of occupational class with incident HD in our study.

Our study showed that urban living was significantly associated with increased incidence of all types of HD, which was persistent in subtypes of HD in the Four-province study. In contrast to other SES indicators, the association of rural-urban living with the risk of HD has been rarely studied. In our previous systematic literature review (Chapter 4.2), few studies have been done to examine the difference between urban and rural living in the risk of HD in China (Wu et al., 2015, Liu and Yan, 2016). Data from Zhejiang provincial information system between 2010 and 2012 showed a higher incidence rate of acute coronary events in urban areas than that in rural areas, with the age-standardised incidence of 87.90 vs 77.36 per 100,000 population in urban and rural areas, respectively (Wu et al., 2015). Nevertheless, some studies did not adjust for any confounders and thus the residual effects could not be removed. After adjustment for many important confounders in our study, it was further confirmed that older people living in the urban areas in China have increased incidence of HD.

6.5 Conclusions

This Chapter reported SES inequality in the risk of incident HD in China. Urban living and low levels of education and family income were significantly associated with increased risk of HD in China. Health promotion for urban residents and those who have a low educational level and family income would be helpful for reducing HD incidence in China. Further cohort studies are needed to analyse the impacts of SES on specific types of HD among older Chinese people.

Table 6-1. Sociodemographic and characteristics of participants with rural and urban living at baseline in the Anhui cohort study, China

Variables	All Participants		Rural n=1338	(%)	Urban n=1202	(%)	P* value
Age (years)							
Mean (SD)	71.7	7.0	70.8	7.6	72.6	6.1	*<0.001*
Sex							
Women	1321	52.0	684	51.1	637	53.0	*0.345*
Men	1219	48.0	654	48.9	565	47.0	
BMI (kg/m^2)							
Cut-off point							
<18.5	349	13.7	192	14.3	157	13.1	*0.011*
18.5-<24.0	828	32.6	465	34.8	363	30.2	
24.0-<28.0	829	32.6	428	32.0	401	33.4	
≥28.0	534	21.0	253	18.9	281	23.4	
Smoking							
Never-smoking	1821	71.7	849	63.5	972	80.9	*<0.001*
Current- or Ex-smoking	719	28.3	489	36.5	230	19.1	
Alcohol drinking in the last 2 years							
No	2037	80.2	1059	79.1	978	81.4	*0.162*
Yes	503	19.8	279	20.9	224	18.6	
Educational level							
≥High secondary school	530	20.9	13	1.0	517	43.0	*<0.001*
Secondary school	310	12.2	44	3.3	266	22.1	
Primary school	310	12.2	117	8.7	193	16.1	
Illiterate	1390	54.7	1164	87.0	226	18.8	
Main Occupation							
Official/ Teacher	705	27.8	37	2.8	668	55.6	*<0.001*
Business/Other	197	7.8	11	0.8	186	15.5	
Manual labourer	318	12.5	15	1.1	303	25.2	
Peasant	1320	52.0	1275	95.3	45	3.7	
Satisfactory income							
Very satisfactory	238	9.4	42	3.1	196	16.3	*<0.001*
Satisfactory	1183	46.6	400	29.9	783	65.1	
Average	882	34.7	700	52.3	182	15.1	
Poor	237	9.3	196	14.6	41	3.4	
Financial problems in the past two years							
No	1273	50.1	113	8.4	1160	96.5	*<0.001*
Yes	1267	49.9	1225	91.6	42	3.5	

Social network and Hobbies							
Marriage status							
Married	1833	72.2	936	70.0	897	74.6	*<0.001*
Never married	97	3.8	89	6.7	8	0.7	
Widowed (Divorced)	610	24.0	313	23.4	297	24.7	
Frequency of visiting children or other relatives							
Never	91	3.6	34	2.5	57	4.7	*<0.001*
At least monthly or less often	297	11.7	112	8.4	185	15.4	
At least weekly	637	25.1	179	13.4	458	38.1	
Daily	1515	59.6	1013	75.7	502	41.8	
Co-morbidities							
Hypertension							
No	1096	43.1	577	43.1	519	43.2	*0.978*
Yes	1444	56.9	761	56.9	683	56.8	
Diabetes							
No	2414	95.0	1327	99.2	1087	90.4	*<0.001*
Yes	119	4.7	11	0.8	108	9.0	
Missing*	7	0.3	0	0.0	7	0.6	
Stroke							
No	2432	95.7	1285	96.0	1147	95.4	*0.783*
Yes	103	4.1	53	4.0	50	4.2	
Missing*	5	0.2	0	0.0	5	0.4	
Activity of daily living (score)							
0	2317	91.2	1262	94.3	1055	87.8	*<0.001*
1-4	118	4.6	36	2.7	82	6.8	
≥5	105	4.1	40	3.0	65	5.4	
Dementia							
No	2082	82.0	1049	78.4	1033	85.9	*<0.001*
Yes	458	18.0	289	21.6	169	14.1	
Depression							
No	2342	92.2	1203	89.9	1139	94.8	*<0.001*
Yes	198	7.8	135	10.1	63	5.2	

*P-value in the Chi-square test was calculated based on available data, not including those "missing" data.

Table 6-2. Number, rate and HR of incident HD in older people with low vs high SES in China: Anhui cohort study

SES variable	Non-Heart Disease Nos. (%)	Heart disease Nos. (%)	P	PYAR* (Incidence)	HR[1]†	95% CI	P	HR[2]†	95% CI	P	HR[3]†	95% CI	P
Urban-Rural													
Urban	916 (76.2)	286 (23.8)	<0.001	6835.0 (41.8)	1.00			1.00			1.00		
Rural	1155 (86.3)	183 (13.7)		7664.7 (23.9)	0.61	0.51-0.74	<0.001	0.64	0.49-0.85	0.002	0.66	0.49-0.88	0.005
Total	2071 (81.5)	469 (18.5)		14499.7 (32.3)									
Educational Level													
Non-illiterate	894 (77.7)	256 (22.3)	<0.001	6668.2 (38.4)	1.00			1.00			1.00		
Illiterate	1177 (84.7)	213 (15.3)		7831.5 (27.2)	0.71	0.59-0.86	<0.001	1.02	0.78-1.33	0.898	1.06	0.80-1.39	0.694
Total	2071 (81.5)	469 (18.5)		14499.7 (32.3)									
Occupational Class													
Non-manual	686 (76.1)	216 (23.9)	<0.001	5188.8 (41.6)	1.00			1.00			1.00		
Manual	1385 (84.6)	253 (15.4)		9310.9 (27.2)	0.67	0.56-0.81	<0.001	0.87	0.66-1.14	0.312	0.89	0.68-1.17	0.409
Total	2071 (81.5)	469 (18.5)		14499.7 (32.3)									
Satisfactory Income													
≥Satisfactory	1120 (78.8)	301 (21.2)	<0.001	8180.3 (36.8)	1.00			1.00			1.00		
<Satisfactory	951 (85.0)	168 (15.0)		6319.3 (26.6)	0.75	0.62-0.91	0.003	0.91	0.73-1.14	0.408	0.89	0.70-1.11	0.293
Total	2071 (81.5)	469 (18.5)		14499.7 (32.3)									
Financial problems in the past two years													
No	980 (77.0)	293 (23.0)	<0.001	7222.6 (40.6)	1.00			1.00			1.00		
Yes	1091 (86.1)	176 (13.9)		7277.1 (24.2)	0.64	0.53-0.77	<0.001	0.94	0.62-1.42	0.771	1.00	0.66-1.51	0.987
Total	2071 (81.5)	469 (18.5)		14499.7 (32.3)									

*PYAR (Incidence): person-year at risk (incidence rate); incidence rate per 1000 person-years.
†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.
HR[1]: adjusted for age (cont.) and sex;
HR[2]: adjusted for age (cont.), sex, BMI, smoke, alcohol drinking, urban-rural, educational level, marital status, frequency of visiting children or relatives;
HR[3]: adjusted for age (cont.), sex, BMI, smoke, alcohol drinking, urban-rural, educational level, marital status, frequency of visiting children or relatives, hypertension, stroke, diabetes, ADL, depression, and dementia.

Table 6-3. Number, rate and HR of incident HD in older people with low vs high SES in China: Four-province cohort study

SES variable	Non-Heart Disease Nos. (%)	Heart disease Nos. (%)	P	PYAR* (Incidence)	HR¹†	95% CI	P	HR²†	95% CI	P	HR³†	95% CI	P
Urban-Rural													
Urban	1041 (87.6)	147 (12.4)	0.484	3442.3 (42.7)	1.00			1.00			1.00		
Rural	1385 (88.5)	180 (11.5)		4957.3 (36.3)	0.55	0.43-0.70	<0.001	0.49	0.34-0.68	<0.001	0.48	0.34-0.69	<0.001
Total	2426 (88.1)	327 (11.9)		8399.7 (38.9)									
Educational Level													
Non-illiterate	1343 (89.0)	166 (11.0)	0.117	4509.4 (36.8)	1.00			1.00			1.00		
Illiterate	1083 (87.1)	161 (12.9)		3890.2 (41.4)	0.68	0.53-0.87	0.002	0.87	0.66-1.15	0.331	0.89	0.67-1.17	0.398
Total	2426 (88.1)	327 (11.9)		8399.7 (38.9)									
Occupational Class													
Non-manual	246 (87.2)	36 (12.8)	0.627	811.8 (44.3)	1.00			1.00			1.00		
Manual	2180 (88.2)	291 (11.8)		7587.9 (38.4)	0.73	0.51-1.05	0.093	1.03	0.69-1.54	0.880	1.04	0.69-1.56	0.844
Total	2426 (88.1)	327 (11.9)		8399.7 (38.9)									
Satisfactory Income													
≥Satisfactory	1372 (88.3)	181 (11.7)	0.681	4582.3 (39.5)	1.00			1.00			1.00		
<Satisfactory	1054 (87.8)	146 (12.2)		3817.4 (38.2)	0.68	0.55-0.85	0.001	0.92	0.73-1.16	0.471	0.91	0.72-1.15	0.435
Total	2426 (88.1)	327 (11.9)		8399.7 (38.9)									
Financial problems in the past two years													
No	2332 (88.5)	304 (11.5)	0.008	8065.1 (37.7)	1.00			1.00			1.00		
Yes	94 (80.3)	23 (19.7)		334.6 (68.7)	2.24	1.46-3.42	<0.001	1.30	0.82-2.04	0.262	1.27	0.80-2.00	0.307
Total	2426 (88.1)	327 (11.9)		8399.7 (38.9)									
Personal Income (RMB)													
≥2000	1851 (88.9)	232 (11.1)	0.022	6337.3 (36.6)	1.00			1.00			1.00		
<2000	484 (85.4)	83 (14.6)		1779.8 (46.6)	0.94	0.72-1.21	0.609	1.05	0.79-1.39	0.762	1.06	0.80-1.41	0.688
Total	2335 (88.1)	315 (11.9)		8117.1 (38.8)									
Family Income (RMB)													

≥2000	1686 (87.4)	242 (12.8)	0.881	6055.0 (40.0)	1.00			1.00			1.00		
<2000	381 (87.2)	56 (12.6)		1248.1 (44.9)	1.70	1.26-2.29	<0.001	1.38	0.98-1.94	0.064	1.42	1.00-2.00	0.049
Total	2067 (87.4)	298 (12.6)		7303.1 (40.8)									

*PYAR (Incidence): person-year at risk (incidence rate); incidence rate per 1000 person-years.
†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.
HR^1: adjusted for age (cont.) and sex;
HR^2: adjusted for age (cont.), sex, province, BMI, smoke, alcohol drinking, urban-rural, educational level, marital status, frequency of visiting children or relatives;
HR^3: adjusted for age (cont.), sex, province, BMI, smoke, alcohol drinking, urban-rural, educational level, marital status, frequency of visiting children or relatives, hypertension, stroke, diabetes, ADL, depression, and dementia.

Table 6-4. Number, rate and HR of incident coronary heart disease (CHD) in older people with low vs high SES in China: Four-province cohort study

SES variable	Non-CHD Nos. (%)	CHD Nos. (%)	P	HR*	95% CI	P
Urban-Rural						
Urban	1041 (91.5)	97 (8.5)	0.085	1.00		
Rural	1385 (93.3)	100 (6.7)		0.64	0.42-0.99	0.043
Total	2426 (92.5)	197 (7.5)				
Educational Level						
Non-illiterate	1343 (92.5)	109 (7.5)	0.994	1.00		
Illiterate	1083 (92.5)	88 (7.5)		0.97	0.68-1.38	0.858
Total	2426 (92.5)	197 (7.5)				
Occupational Class						
Non-manual	246 (90.4)	26 (9.6)	0.176	1.00		
Manual	2180 (92.7)	171 (7.3)		1.03	0.63-1.66	0.913
Total	2426 (92.5)	197 (7.5)				
Satisfactory Income						
≥Satisfactory	1372 (92.5)	111 (7.5)	0.955	1.00		
<Satisfactory	1054 (92.5)	86 (7.5)		0.98	0.73-1.32	0.880
Total	2426 (92.5)	197 (7.5)				
Financial problems in the past two years						
No	2332 (92.9)	179 (7.1)	<0.001	1.00		
Yes	94 (83.9)	18 (16.1)		1.26	0.73-2.16	0.411
Total	2426 (92.5)	197 (7.5)				
Personal Income (RMB)						
≥2000	1851 (93.0)	140 (7.0)	0.092	1.00		
<2000	484 (90.8)	49 (9.2)		0.90	0.62-1.31	0.592
Total	2335 (92.5)	189 (7.5)				
Family Income (RMB)						
≥2000	1686 (92.5)	137 (7.5)	0.073	1.00		
<2000	381 (89.9)	43 (10.1)		1.19	0.79-1.81	0.406
Total	2067 (92.0)	180 (8.0)				

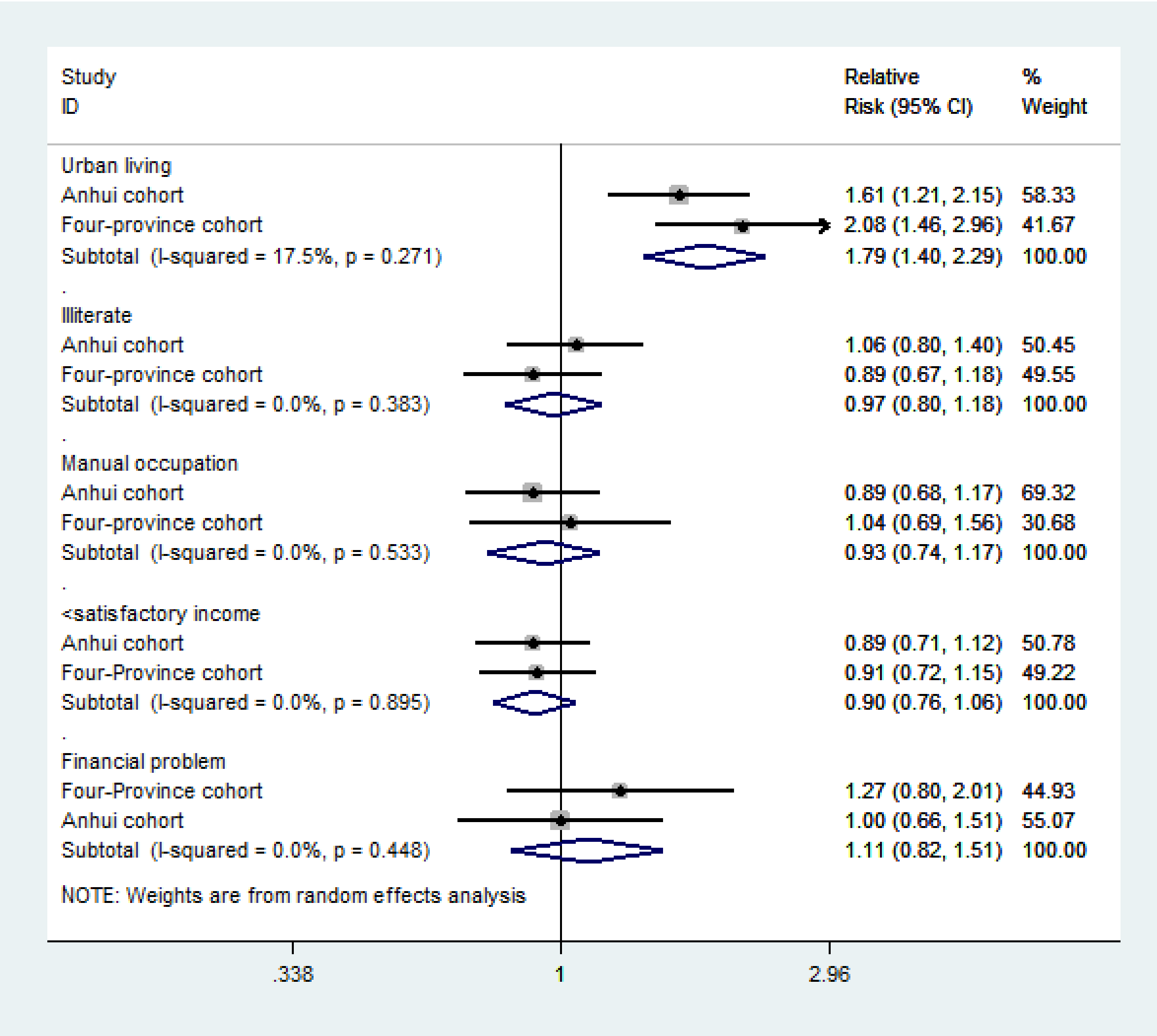
*HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.
HR: adjusted for age (cont.), sex, province, BMI, smoke, alcohol drinking, urban-rural, educational level, marital status, frequency of visiting children or relatives, hypertension, stroke, diabetes, ADL, depression, and dementia.

Table 6-5. Number, rate and HR of incident heart valve disease (HVD) (or others) in older people with low vs high SES in China: Four-province cohort study

SES variable	Non-HVD Nos. (%)	HVD Nos. (%)	P	HR*	95% CI	P
Urban-Rural						
Urban	1041 (95.4)	50 (4.6)	0.318	1.00		
Rural	1385 (94.5)	80 (5.5)		0.28	0.15-0.52	<0.001
Total	2426 (94.9)	130 (5.1)				
Educational Level						
Non-illiterate	1343 (95.9)	57 (4.1)	0.010	1.00		
Illiterate	1083 (93.7)	73 (6.3)		0.81	0.51-1.28	0.361
Total	2426 (94.9)	130 (5.1)				
Occupational Class						
Non-manual	246 (96.1)	10 (3.9)	0.365	1.00		
Manual	2180 (94.8)	120 (5.2)		1.09	0.51-2.34	0.827
Total	2426 (94.9)	130 (5.1)				
Satisfactory Income						
≥Satisfactory	1372 (95.1)	70 (4.9)	0.544	1.00		
<Satisfactory	1054 (94.6)	60 (5.4)		0.78	0.54-1.14	0.196
Total	2426 (94.9)	130 (5.1)				
Financial problems in the past two years						
No	2332 (94.9)	125 (5.1)	0.987	1.00		
Yes	94 (94.9)	5 (5.1)		0.97	0.38-2.49	0.956
Total	2426 (94.9)	130 (5.1)				
Personal Income (RMB)						
≥2000	1851 (95.3)	92 (4.7)	0.093	1.00		
<2000	484 (93.4)	34 (6.6)		1.21	0.77-1.89	0.406
Total	2335 (94.9)	126 (5.1)				
Family Income (RMB)						
≥2000	1686 (94.1)	105 (5.9)	0.042	1.00		
<2000	381 (96.7)	13 (3.3)		1.48	0.77-2.85	0.244
Total	2067 (94.6)	118 (5.4)				

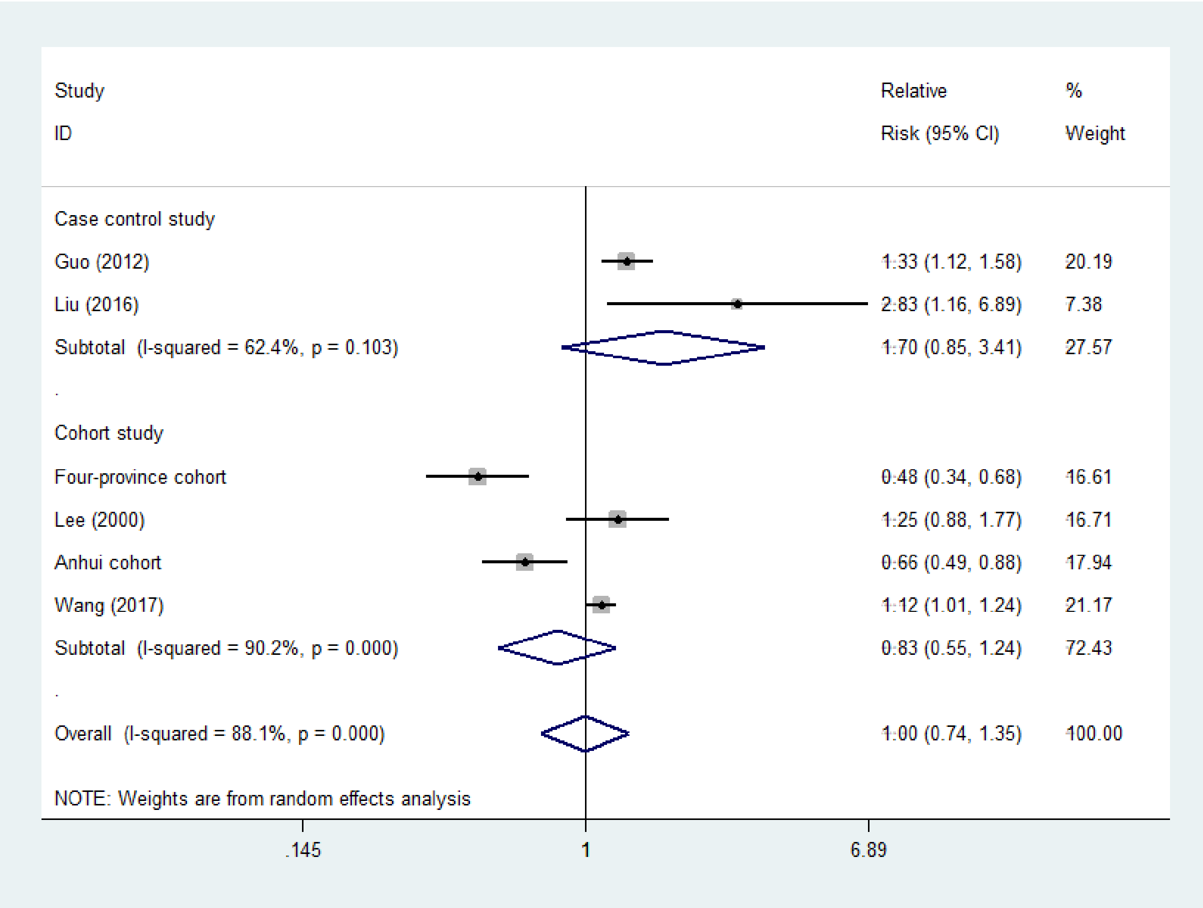
*HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.
HR: adjusted for age (cont.), sex, province, BMI, smoke, alcohol drinking, urban-rural, educational level, marital status, frequency of visiting children or relatives, hypertension, stroke, diabetes, ADL, depression, and dementia.

Figure 6-1. Forest plot for the pooled relative risk (RR) of SES with risk of incident heart disease from the Anhui cohort and the Four-province cohort studies



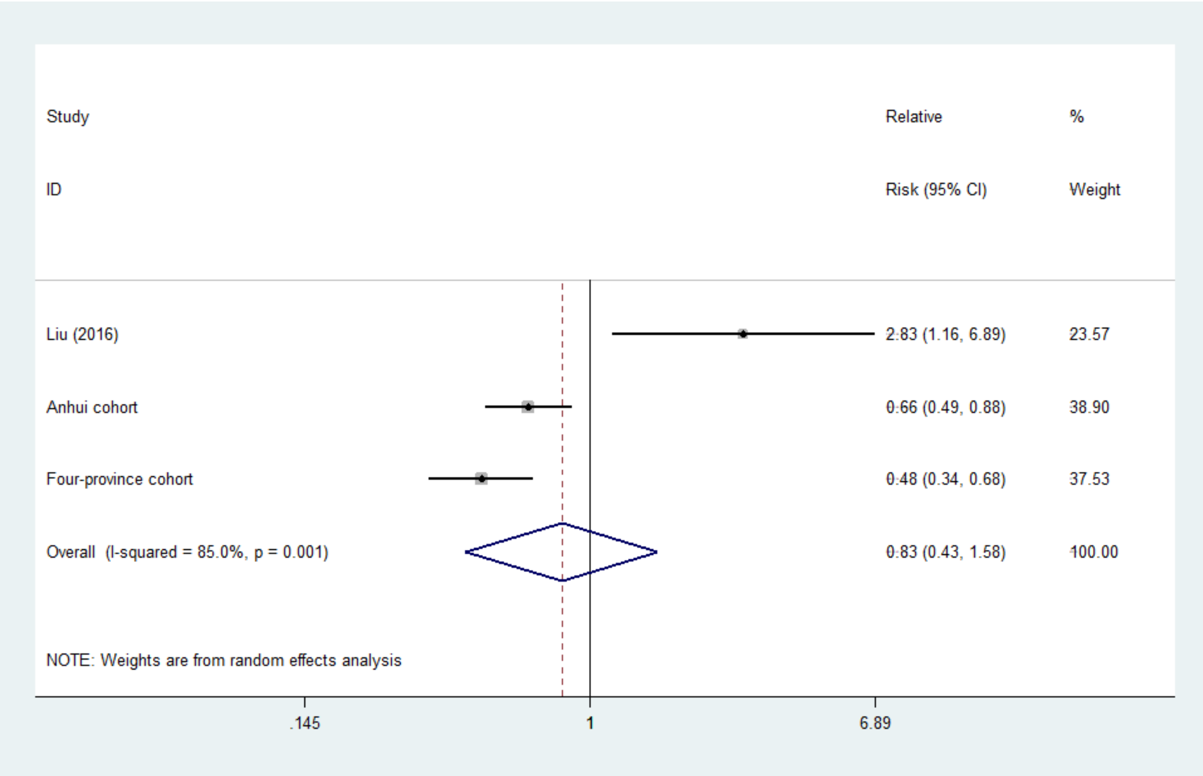
The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

Figure 6-2. Forest plot showing pooled estimates of all studies for low SES with risk of incident heart disease



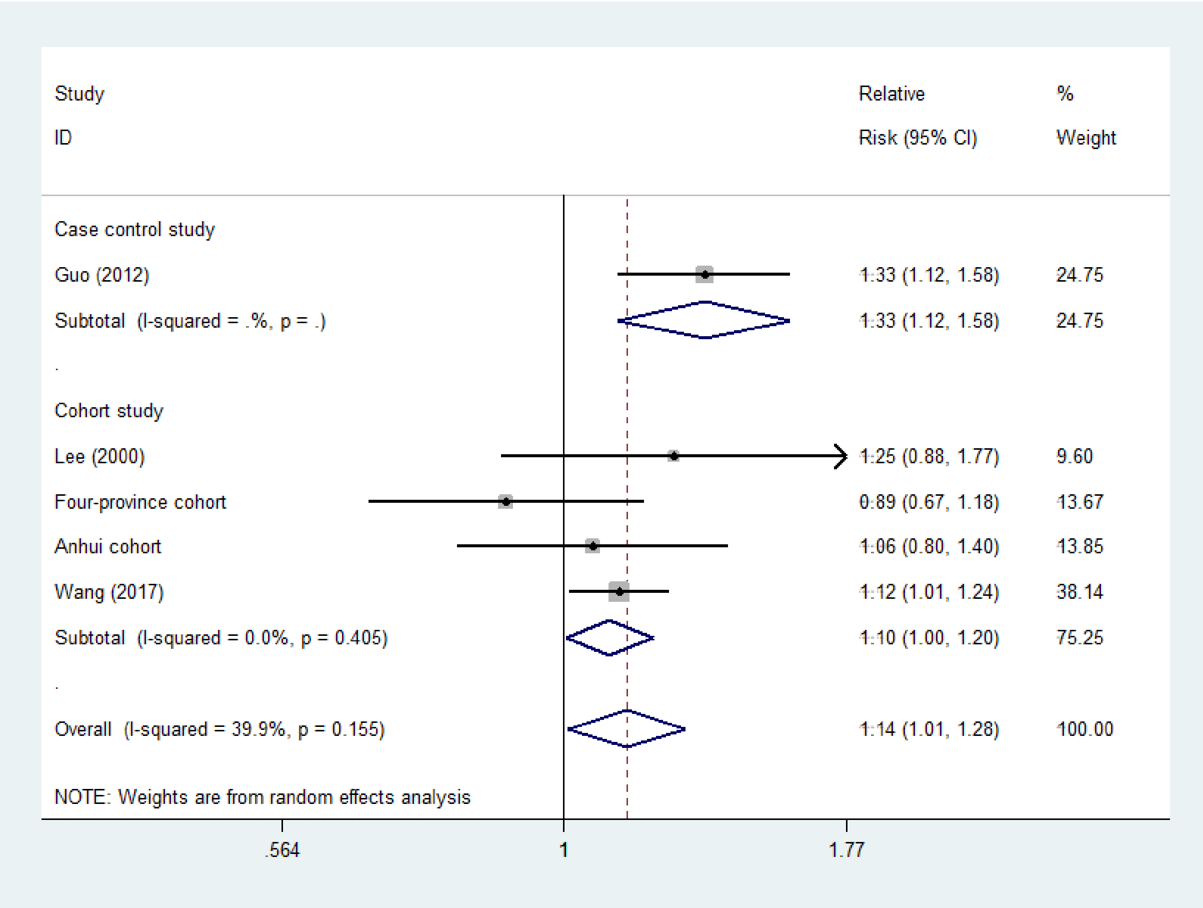
The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

Figure 6-3. Forest plot showing pooled estimates of all studies for rural living with risk of incident heart disease



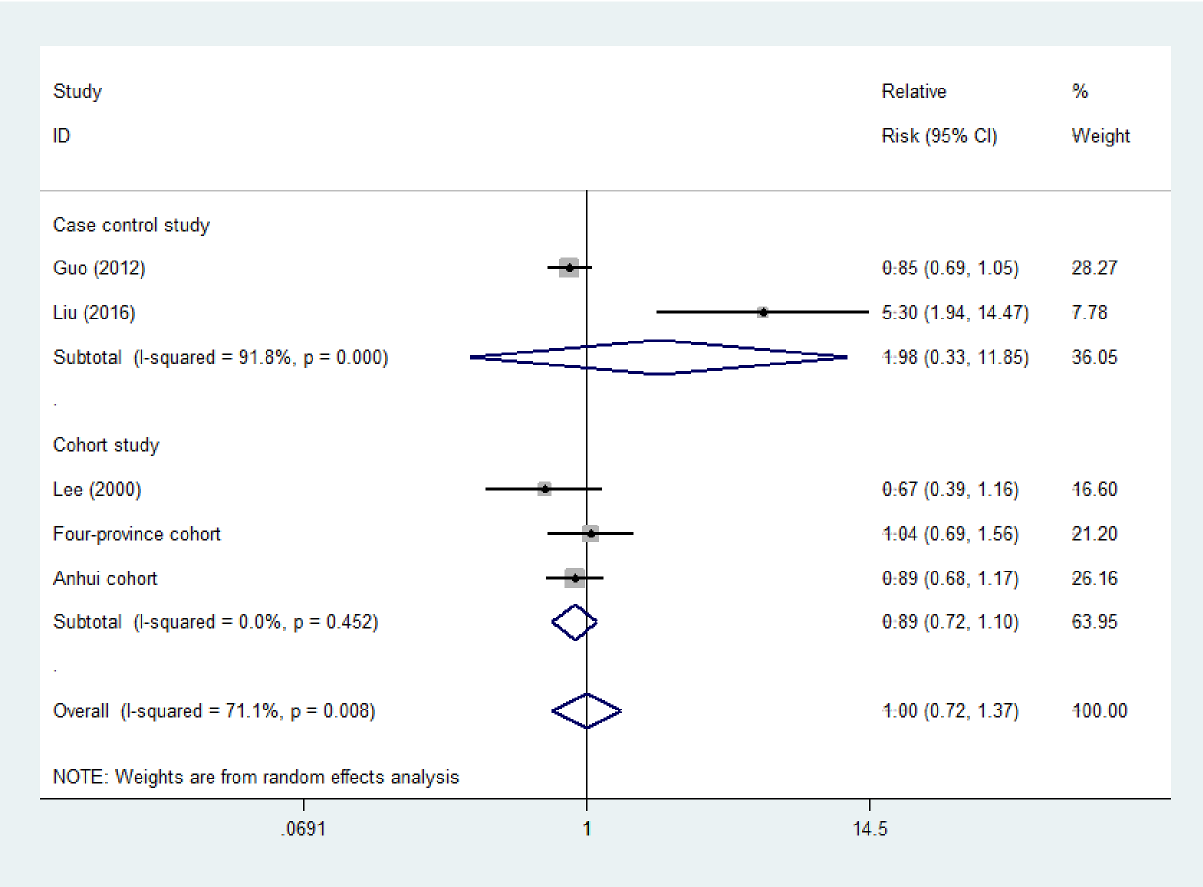
The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

Figure 6-4. Forest plot showing pooled estimates of all studies for low education with risk of incident heart disease



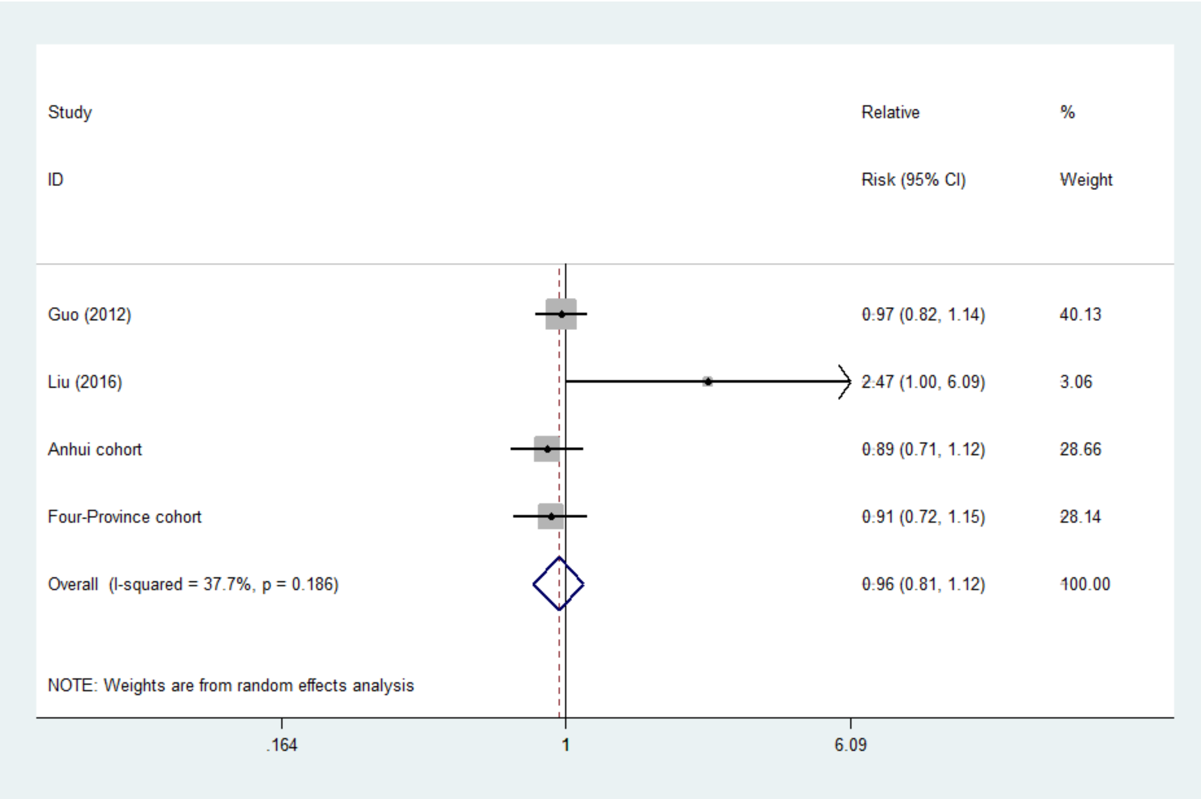
The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

Figure 6-5. Forest plot showing pooled estimates of all studies for low occupational class with risk of incident heart disease



The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

Figure 6-6. Forest plot showing pooled estimates of all studies for low income with risk of incident heart disease



The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

CHAPTER SEVEN: IMPACT OF SOCIOECONOMIC STATUS ON ALL-CAUSE MORTALITY IN OLDER PEOPLE WITH HEART DISEASE: THE ANHUI COHORT AND THE FOUR-PROVINCE COHORT STUDIES

7.1 Introduction

While the coronary heart disease (CHD) mortality has fallen by more than half in high income countries (HICs), the trend of CHD mortality is increasing in low and middle income countries (LMICs) (Finegold et al., 2013), particularly among individuals of lower socioeconomic status (SES) (Lotufo et al., 2013). Data for a middle-aged population suggested that heart disease (HD) patients with low SES had higher mortality than their counterparts with high SES (Jones et al., 2015, Kelli et al., 2019, Moissl et al., 2019). However, there has been less investigation on the impact of SES measured in older age on the mortality after HD. Furthermore, knowledge of the impact of SES on mortality among patients with HD is predominately derived from studies carried out in HICs, while few studies have been done in LMICs (de Mestral and Stringhini, 2017). Previous studies have shown that the impact of SES on mortality after cardiovascular disease, including HD, may be stronger in LMICs than HICs (Rosengren et al., 2019). In LMICs there are more and more people who have been affected by cardiac conditions as results of acquisition of lifestyle-related risk factors and population ageing (Gaziano et al., 2010).

China is the biggest LMIC in the world, where CHD has been the second leading cause of death (Zhou et al., 2016), with an estimated 1.7 million deaths occurring due to CHD in 2016 (Zhao et al., 2018). The burden of HD in China has been increasing (Zhang et al., 2008), and it is predicted to be the first cause of death nationally in the near future (Zhou et al., 2016). However, few studies have been done to examine the association of SES with mortality in Chinese people with HD. No study has assessed the impact of multiple indicators of SES, including urban-rurality, educational level, occupational class, and income, on mortality in patients with HD in China. In this Chapter, I examined data from two community-based cohort studies and carried out a meta-analysis with previous identified studies to assess the impact of SES on the mortality among patients with HD in China.

7.2 Methods

The studied populations were derived from the Anhui cohort study and the Four-province cohort studies in China. The methods of the baseline investigation and the follow-up of both studies have been fully reported in Chapter 3.4.

7.2.1 Data analysis

Due to small numbers of HD patients at baseline in the Anhui cohort and the Four-province cohorts, I combined their data for analysis, including baseline variables of demographic information, SES, social networks and supports, psychosocial aspects, CVDs and other chronic disease risk factors and mortality in the follow-up.

The distributions of baseline risk factors among participants with versus without HD at baseline were examined using a one-way ANOVA for continuous variables and a Chi-square test for category variables. I employed Cox regression models to calculate hazard ratios (HRs) and their 95% confidence intervals (CIs) of all-cause mortality in participants with versus without HD first. Then, within the population of HD patients, I examined mortality in relation to low vs high levels of SES.

7.2.2 Meta-analysis

The findings of the Anhui cohort and the Four-province cohort studies were pooled with those from previous studies which were identified and reviewed in Chapter 4.3, to assess the impacts of different SES measurements on all-cause mortality in HD patients. This will increase the study power in the cohort study for examining the impact.

7.3 Results

7.3.1 Combined data of the Anhui and the Four-province cohort studies

Baseline characteristics

There were 2,978 participants in the Anhui cohort study who were followed up for 10.04 years and 3,132 participants who were followed up for 4.3 years. Thus, data of 6,110 participants in total were examined, of which 806 (13.2%) participants (438 were from the Anhui study) were documented as having HD at baseline.

Table 7-1 shows characteristics of participants with and without HD. Compared to participants without HD, patients with HD were older (72.2 vs 71.3 years) and more likely to be from the Anhui cohort, be overweight/obese, be ex-smokers and non-drinkers, live in urban areas, have high levels of education, occupation and satisfactory income, visit children or other relatives frequently, like to walk or tour, have high levels of hypertension, stroke, and diabetes, but less likely to have financial problems and participate in community activity (Table 7-1).

All-cause mortality in participants with HD in comparison to those without HD

Over the mean follow-up of 4.7 years, 927 cohort members died; mortality was 32.2 per 1000 person-years. There were no differences in mortality between participants with and without HD (31.7 vs 32.3 per 1000 person-years) (p=0.775); the age-sex adjusted HR of mortality in participants with HD was 0.95 (95% CI 0.79-1.15) (Table 7-2). After adjustment for age, sex, provinces, BMI, smoking status, alcohol drinking, urban-rural living, educational level, marital status, the HR was 1.09 (0.90-1.32). Further adjustment for hypertension, stroke, diabetes, depression and dementia would not substantially change the HR (Table 7-2).

Tables 7-3 to 7-9 shows number of deaths and mortality among HD patients with low and high SES.

Rural and Urban areas: patients living in rural areas had increased mortality (46.9 per 1000 person-years) in comparison to their urban counterparts (26.7); age-sex adjusted HR of mortality was 2.10 (1.45-3.05). HR was substantially increased after further adjustment for other confounders; 2.95 (1.70-5.10) in model 2, and 3.57 (2.01-6.34) in model 3 (Table 7-3).

Low and High Educational level: HD patients who were illiterate had a significantly higher mortality (41.3 per 1000 person-years) than those with any school education (28.0); the age-sex adjusted HR for mortality in HD patients who were illiterate was 1.61 (1.09-2.37). The HR did not have substantial change in further adjustment analysis; 1.59 (1.06-2.39) in model 2, and 1.59 (1.05-2.39) in model 3 (Table 7-4).

Low and High Occupational class: mortality in manual workers was 39.0 per 1000 person-years, which was significantly higher than that in non-manual workers (26.3); the age-sex adjusted HR of mortality in HD patients with manual vs non-manual occupations was 1.68 (1.17-2.42). Further adjustment and fully adjusted analysis decreased the HRs to an insignificant level; 1.40 (0.87-2.24) in model 2, and 1.49 (0.93-2.40) in model 3, respectively (Table 7-5).

Low and High Satisfactory income: mortality in patients with low satisfactory income was 44.7 per 1000 person-years, significantly higher than that in those with high satisfactory income (26.9); age-sex adjusted HR for mortality in low vs high satisfactory incomes was 1.71 (1.19-2.47). After adjustment for more confounders the HR was around 1.20, but not statistically significant (Table 7-6).

Financial problems: mortality in patients with financial problems was 62.2 per 1000 person-years, significantly higher than in those without financial problems (26.3); age-sex adjusted HR for mortality was 2.44 (1.65-3.61). After adjustment for more confounders the HR was around 2.50, which was statistically significant (Table 7-7).

Low and High Personal income: mortality in the low personal income group was 65.5 per 1000 person-years and 28.9 in the high personal income group; the age and sex adjusted HR of mortality in HD patients with low vs high personal incomes was 2.61 (1.50-4.53). After further adjustment for other confounders, the increased HRs were not changed substantially (Table 7-8).

Low and High Family income: mortality was 56.8 per 1000 person-years in patients with low family income and 35.5 in high family income; the age and sex adjusted HR for mortality in HD patients with low versus high family income was 1.86 (1.04-3.33). However, after adjustment for more confounders the increased HR became insignificant (Table 7-9).

7.3.2 Meta-analysis of these new data from the current study with those from identified studies

In the meta-analysis, I included the current cohort findings and any available data from three studies which were identified and reviewed in Chapter 4.3 (Weng et al., 1990, Xiang et al., 2018, Huo et al., 2019). The total number of HD patients involved for analysis was 7,400. Based on the current cohort study and one of the results from the above identified studies, which was selected according to the order of SES composites score, urban-rurality, educational level, and occupation, the pooled data showed statistical significance in mortality between patients with low vs high SES (the pooled RR 2.65, 2.06-3.41).

Using data from Huo's study (Huo et al., 2019) and the current cohort study, the pooled RR for mortality in patients with low vs high education was 1.70 (1.17-2.48). The pooled RR for mortality in HD patients with manual vs non-manual occupations was 1.93 (1.22-3.05), which was pooled from Weng et al.'s study (Weng et al., 1990) and the current cohort study. However, the pooled data for mortality in HD patients with rural vs urban living was 1.68 (0.39-7.18), which was pooled from the current study and Xiang et al.'s study (Xiang et al., 2018).

7.4 Discussion

In this chapter, I examined the association of different SES measurements with all-cause mortality in community-based cohort of patients with HD. The data has shown that low SES was associated with increased mortality after HD in China. The impact of different measurements of SES demonstrated that HD patients with rural living, financial problems, and low levels of education, occupation and personal income had increased mortality.

Current literature shows that few studies have examined the impact of HD on all-cause mortality in the community-dwelling older people, particularly in LMICs. In our study of China, patients with HD did not show increased risk of all-cause mortality. However, in Australia, Almeida et al. (Almeida et al., 2012) carried out a community-based cohort study of 4,805 participants aged 69-87 with a mean follow-up of 6.0 years and found that participants with CHD had a 60% increased risk of all-cause mortality when compared to their counterparts without (HR 1.6, 1.4-1.8). The differences in the findings between our study and the Australian study could be because HD mortality in China is relatively lower compared to those in Western countries, and older Chinese without HD could have relatively high mortality.

Our study showed that HD patients with low levels of education had increased mortality. The inverse association of education with mortality among HD patients was consistent with those in previous studies from HICs (Dzayee et al., 2013, Kelli et al., 2019) and also China (Huo et al., 2019). In a recent cohort study from the US, Kelli et al. reported that CHD patients with low education were associated with a 26% to 52% increased risk of all-cause mortality (Kelli et al., 2019). In Sweden, Dzayee et al. examined a cohort of patients who underwent a first isolated coronary artery bypass grafting (CABG) and found that patients with low educational level had a 20-80% increased mortality compared to those with more than 12 years of education (Dzayee et al., 2013). Similarly, the recent study of 3,369 AMI patients (median age 61 years) from 53 hospitals in China (Huo et al., 2019) showed that the HR of 1-year mortality was significantly increased in patients who were illiterate compared to those with college education (2.37, 1.13-6.83).

The current study showed that mortality was increased significantly in HD patients with low personal income. Literature on the association of actual income with mortality was limited among HD patients (de Mestral and Stringhini, 2017), but such inverse association was reported previously in the general populations. Previous studies showed that people with low income had around a two-fold increased risk of death from any causes and from CHD (Salonen, 1982, Bucher and Ragland, 1995). Nevertheless, our data did not show a significant association between family income and mortality. This might be due to more missing data on family income, which may decrease the statistical significance after multivariate adjustments.

Our data showed that HD patients with financial problems had increased mortality, which is consistent with other studies (Moran et al., 2019). Whether or not having financial problems in the past two years is a measure to assess the financial burden patients undergo with their quality of life. Previous studies showed that financial problems were significantly associated with higher risk of HD (Moran et al., 2019).

Our study showed that low level of occupation was associated with increased mortality in patients with HD. More evidence from HICs has confirmed the impact of low occupational class on mortality of HD (Mackenbach et al., 2000, Emberson et al., 2004). One of the reasons for it could be because patients with low occupational class are more likely to be exposed to hazardous substances and have higher prevalence of unhealthy behaviours such as smoking and drinking.

The current study did not find a significant association of satisfactory income with mortality in patients with HD. Satisfaction of income as a qualitative measure involved patients' feelings about their financial conditions. It could be a good predictor of CVD risk factors such as diabetes and mental disorders (Chen et al., 2011, Chen et al., 2012b). In this study, I analysed the data of the actual income and found consistent findings with previous studies that HD patients with low personal income had increased mortality.

Compared to other indicators of SES above, the impact of rural-urban disparity on mortality in HD patients has rarely been studied previously (Kulshreshtha et al., 2014). Most studies were only about differences in mortality rate of HD between rural and urban areas. In the US, data from the National Centre for Health Statistics showed that age-adjusted CHD mortality was higher in rural areas (173/ per 100,000) than in urban areas (164 per 100,000) (Kulshreshtha et al., 2014). Similarly, a recent study in China also reported a slightly higher mortality rate of CHD in rural areas. The Report on Cardiovascular Disease in China 2018 showed that CHD mortality rates for rural and urban areas were 118.74 per 100,000 and 113.46 per 100,000, respectively (Ma et al., 2020). Nevertheless, all these studies did not adjust for confounders to assess the impact of rural-urban disparity on mortality of HD, and thus residual effects could not be removed. After adjustment for many important confounders (e.g., unhealthy behaviours, mental disorders, and comorbidities), our study further confirmed the association of rural living with increased mortality of HD in older Chinese people, contributing to literature.

7.5 Conclusions

This Chapter study demonstrated the evidence of an increased risk of all-cause mortality in older people with HD, who had low SES in terms of rural living, low levels of education, occupation, and personal income, and having financial problems. To reduce income inequality, through reducing income-related disparities in healthcare access as well as income gap between urban and rural areas, would be helpful to increase survival among older Chinese people with HD. Further cohort studies are required to elucidate the association of SES with mortality in specific types of HD.

Table 7-1. Sociodemographic and characteristics of participants with and without heart disease at baseline in the cohort study, China

Variables	All participants		Non-Heart Disease n=5304	(%)	Heart disease n=806	(%)	P* value
Age (years)							
Mean (SD)	71.4	7.1	71.3	7.2	72.2	6.6	*<0.001*
Sex							
Women	3296	53.9	2847	53.7	449	55.7	*0.281*
Men	2814	46.1	2457	46.3	357	44.3	
Province							
Anhui	2978	48.7	2540	47.9	438	54.3	*0.001*
Guangdong	894	14.6	866	16.3	28	3.5	
Shanghai	925	15.1	769	14.5	156	19.4	
Heilongjiang	451	7.4	330	6.2	121	15.0	
Shanxi	862	14.1	800	15.1	62	7.7	
BMI (kg/m^2)							
Cut-off point							
<18.5	420	6.9	375	7.1	45	5.6	*<0.001*
18.5-<24.0	3367	55.1	2982	56.2	385	47.8	
24.0-<28.0	1777	29.1	1491	28.1	286	35.5	
≥28.0	546	8.9	456	8.6	90	11.2	
Smoking							
Never-smoking	3476	56.9	3036	57.2	440	54.6	*<0.001*
Ex-smoking	552	9.0	456	8.6	96	11.9	
Current-smoking	1593	26.1	1438	27.1	155	19.2	
Missing	489	8.0	374	7.1	115	14.3	
Alcohol drinking in the last 2 years							
No	4806	78.7	4122	77.7	684	84.9	*<0.001*
Yes	1301	21.3	1179	22.2	122	15.1	
Missing	3	0.0	3	0.1	0	0.0	
Urban-rurality							
Urban	2947	48.2	2391	45.1	556	69.1	*<0.001*
Rural	3163	51.8	2914	54.9	249	30.9	
Educational level							
≥High Secondary school	1039	17.0	801	15.1	238	29.5	*<0.001*
Secondary school	844	13.8	682	12.9	162	20.1	
Primary school	1341	21.9	1182	22.3	159	19.7	
Illiterate	2886	47.2	2639	49.8	247	30.6	
Occupational class							
Official/teacher	1278	20.9	987	18.6	291	36.1	*<0.001*

Business/other	813	13.3	700	13.2	113	14.0	
Manual labourer	946	15.5	768	14.5	178	22.1	
Peasant	3073	50.3	2849	53.7	224	27.8	
Satisfactory income							
Very satisfactory	586	9.6	477	9.0	109	13.5	*<0 .001*
Satisfactory	2938	48.1	2502	47.2	436	54.1	
Average	2090	34.2	1881	35.5	209	25.9	
Poor	496	8.1	444	8.4	52	6.5	
Financial problems in the past two years							
No	4611	75.5	3920	73.9	691	85.7	*<0.001*
Yes	1499	24.5	1384	26.1	115	14.3	
Social network and Hobbies							
Marriage status							
Married	4484	73.4	3881	73.2	603	74.	*0.183*
Never married/Divorced	191	3.1	174	3.3	17	2.1	
Widow	1435	23.5	1249	23.5	186	23.1	
Frequency of visiting children or other relatives							
Never	282	4.6	242	4.6	40	5.0	*<0.001*
At least monthly or less often	1192	19.5	1016	19.2	176	21.8	
At least weekly	2030	33.2	1720	32.4	310	38.5	
Daily	2600	42.6	2320	43.7	280	34.7	
Missing	6	0.1	6	0.1	0	0.0	
Walking or group touring							
No	2875	47.7	2599	49.6	276	34.8	*<0.001*
Yes	3158	52.3	2641	50.4	517	65.2	
Community activity participating							
No	4110	67.3	3540	66.7	570	70.7	*0.030*
Yes	1984	32.5	1748	33.0	236	29.3	
Missing	16	0.3	16	0.3	0	0.0	
Co-morbidities							
Hypertension							
No	2795	45.7	2488	46.9	307	38.1	*<0.001*
Yes	3223	52.7	2729	51.5	494	61.3	
Missing	92	1.5	87	1.6	5	0.6	
Stroke							

No	5862	95.9	5109	96.3	753	93.4	*<0.001*
Yes	231	3.8	179	3.4	52	6.5	
Missing*	17	0.3	16	0.3	1	0.1	
Diabetes							
No	5733	93.8	5027	94.8	706	87.6	*<0.001*
Yes	342	5.6	247	4.7	95	11.8	
Missing*	35	0.6	30	0.6	5	0.6	
Depression							
No	5845	95.7	5079	95.8	766	95.0	*0.389*
Yes	260	4.3	220	4.1	40	5.0	
Missing*	5	0.1	5	0.1	0	0.0	
Dementia							
No	5614	91.9	4862	91.7	752	93.3	*0.220*
Yes	491	8.0	437	8.2	54	6.7	
Missing*	5	0.1	5	0.1	0	0.0	

*P-value in the Chi-square test was calculated based on available data, not including those “missing” data.

Table 7-2. Numbers of deaths and adjusted hazard ratios of all-cause mortality in older people in China

Baseline HD	Nos of Deaths/participants (%)	Person-years	Mortality*	HR[1]† (95% CI)	P-value	HR[2]† (95% CI)	P-value	HR[3]† (95% CI)	P-value
No	802/5304 (15.1)	24,864.3	32.3	1.00		1.00		1.00	
Yes	125/806 (15.5)	3,939.5	31.7	0.95 0.79-1.15	0.589	1.09 0.90-1.32	0.395	1.01 0.83-1.23	0.940
Total	927/6110 (15.2)	28,803.8	32.2						

*Mortality rate per 1000 person-years.
†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.
HR[1]: adjusted for age (cont.) and sex;
HR[2]: adjusted for age (cont.), sex, province, BMI, smoke, alcohol drinking, urban-rural, educational level, marital status;
HR[3]: adjusted for age (cont.), sex, province, BMI, smoke, alcohol drinking, urban-rural, educational level, marital status, hypertension, stroke, diabetes, depression, and dementia.

Table 7-3. Numbers of deaths and adjusted hazard ratios for all-cause mortality between urban and rural living in patients with heart disease in China

Urban-Rural Variable	Nos of Deaths/participants (%)	Person-years	Mortality*	HR[1]† (95% CI)	P-value	HR[2]† (95% CI)	P-value	HR[3]† (95% CI)	P-value
Urban	79/557 (14.2)	2958.6	26.7	1.00		1.00		1.00	
Rural	46/249 (18.5)	980.8	46.9	2.10 1.45-3.05	<0.001	2.95 1.70-5.10	<0.001	3.57 2.01-6.34	<0.001
Total	125/806 (15.5)	3936.5	31.8						

*Mortality rate per 1000 person-years.
†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.
HR[1]: adjusted for age (cont.) and sex;
HR[2]: adjusted for age (cont.), sex, province, BMI, smoke, alcohol drinking, educational level, marital status;
HR[3]: adjusted for age (cont.), sex, province, BMI, smoke, alcohol drinking, educational level, marital status, hypertension, stroke, diabetes, depression, and dementia.

Table 7-4. Numbers of deaths and adjusted hazard ratios for all-cause mortality between high and low educational level in patients with heart disease in China

Educational Variable	Nos of Deaths/participants (%)	Person-years	Mortality*	HR[1]† (95% CI)	P-value	HR[2]† (95% CI)	P-value	HR[3]† (95% CI)	P-value
Non-illiterate	79/559 (14.1)	2,826.3	28.0	1.00		1.00		1.00	
Illiterate	46/247 (18.6)	1,113.2	41.3	1.61 1.09-2.37	0.016	1.59 1.06-2.39	0.026	1.59 1.05-2.39	0.028
Total	125/806 (15.5)	3936.5	31.8						

*Mortality rate per 1000 person-years.
†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.
HR[1]: adjusted for age (cont.) and sex;
HR[2]: adjusted for age (cont.), sex, province, BMI, smoke, alcohol drinking, urban-rural, marital status;
HR[3]: adjusted for age (cont.), sex, province, BMI, smoke, alcohol drinking, urban-rural, marital status, hypertension, stroke, diabetes, depression, and dementia.

Table 7-5. Numbers of deaths and adjusted hazard ratios for all-cause mortality between high and low occupational class in patients with heart disease in China

Occupational Variable	Nos of Deaths/participants (%)	Person-years	Mortality*	HR[1]† (95% CI)	P-value	HR[2]† (95% CI)	P-value	HR[3]† (95% CI)	P-value
Non-manual	59/404 (14.6)	2,245.2	26.3	1.00		1.00		1.00	
Manual	66/402 (16.4)	1,694.3	39.0	1.68 1.17-2.42	0.005	1.40 0.87-2.24	0.162	1.49 0.93-2.40	0.097
Total	125/806 (15.5)	3936.5	31.8						

*Mortality rate per 1000 person-years.
†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.
HR[1]: adjusted for age (cont.) and sex;
HR[2]: adjusted for age (cont.), sex, province, BMI, smoke, alcohol drinking, urban-rural, educational level, marital status;
HR[3]: adjusted for age (cont.), sex, province, BMI, smoke, alcohol drinking, urban-rural, educational level, marital status, hypertension, stroke, diabetes, depression, and dementia.

Table 7-6. Numbers of deaths and adjusted hazard ratios for all-cause mortality between high and low satisfactory income in patients with heart disease in China

Satisfactory Income Variable	Nos of Deaths/participants (%)	Person-years	Mortality*	HR^1† (95% CI)	P-value	HR^2† (95% CI)	P-value	HR^3† (95% CI)	P-value
≥Satisfactory	77/545 (14.1)	2865.6	26.9	1.00		1.00		1.00	
<Satisfactory	48/261 (18.4)	1073.9	44.7	1.71 1.19-2.46	0.004	1.22 0.79-1.89	0.377	1.22 0.79-1.89	0.379
Total	125/806 (15.5)	3936.5	31.8						

*Mortality rate per 1000 person-years.

†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.

HR^1: adjusted for age (cont.) and sex;

HR^2: adjusted for age (cont.), sex, province, BMI, smoke, alcohol drinking, urban-rural, educational level, marital status;

HR^3: adjusted for age (cont.), sex, province, BMI, smoke, alcohol drinking, urban-rural, educational level, marital status, hypertension, stroke, diabetes, depression, and dementia.

Table 7-7. Numbers of deaths and adjusted hazard ratios for all-cause mortality between "No" and "Yes" financial problems in patients with heart disease in China

Financial problems	Nos of Deaths/participants (%)	Person-years	Mortality*	HR[1]† (95% CI)	P-value	HR[2]† (95% CI)	P-value	HR[3]† (95% CI)	P-value
No	88/691 (12.7)	3345.0	26.3	1.00		1.00		1.00	
Yes	37/115 (32.2)	594.5	62.2	2.45 1.65-3.61	<0.001	2.25 1.20-4.20	0.011	2.84 1.51-5.36	0.001
Total	125/806 (15.5)	3936.5	31.8						

*Mortality rate per 1000 person-years.
†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.
HR[1]: adjusted for age (cont.) and sex;
HR[2]: adjusted for age (cont.), sex, province, BMI, smoke, alcohol drinking, urban-rural, educational level, marital status;
HR[3]: adjusted for age (cont.), sex, province, BMI, smoke, alcohol drinking, urban-rural, educational level, marital status, hypertension, stroke, diabetes, depression, and dementia.

Table 7-8. Numbers of deaths and adjusted hazard ratios for all-cause mortality between high and low personal income in patients with heart disease in China

Personal income (RMB)	Nos of Deaths/participants (%)	Person-years	Mortality*	HR^1† (95% CI)	P-value	HR^2† (95% CI)	P-value	HR^3† (95% CI)	P-value
≥2000	32/391 (8.2)	1105.7	28.9	1.00		1.00		1.00	
<2000	22/123 (17.9)	335.7	65.5	2.61 1.50-4.53	0.001	3.22 1.38-7.52	0.007	2.68 1.08-6.65	0.033
Total	54/514 (10.5)	1441.4	37.5						

Data of actual incomes was from Anhui cohort wave 3 and Four-Province cohort studies, in which of 565 eligible HD patients in the two cohorts, 51 missing occurred in annual personal income.
*Mortality rate per 1000 person-years.
†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.
HR^1: adjusted for age (cont.) and sex;
HR^2: adjusted for age (cont.), sex, province, BMI, smoke, alcohol drinking, urban-rural, educational level, marital status;
HR^3: adjusted for age (cont.), sex, province, BMI, smoke, alcohol drinking, urban-rural, educational level, marital status, hypertension, stroke, diabetes, depression, and dementia.

Table 7-9. Numbers of deaths and adjusted hazard ratios for all-cause mortality between high and low family income in patients with heart disease in China

Family income (RMB)	Nos of Deaths/participants (%)	Person-years	Mortality*	HR[1]† (95% CI)	P-value	HR[2]† (95% CI)	P-value	HR[3]† (95% CI)	P-value
≥2000	37/367 (10.1)	1042.2	35.5	1.00		1.00		1.00	
<2000	17/112 (15.2)	299.5	56.8	1.86 1.04-3.33	0.036	1.71 0.71-4.09	0.228	1.46 0.59-3.62	0.414
Total	54/479 (11.3)	1341.7	40.2						

Data of actual incomes was from Anhui cohort wave 3 and Four-Province cohort studies, in which of 565 eligible HD patients in the two cohorts, 86 missing occurred in family annual income per person.

*Mortality rate per 1000 person-years.

†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.

HR[1]: adjusted for age (cont.) and sex;

HR[2]: adjusted for age (cont.), sex, province, BMI, smoke, alcohol drinking, urban-rural, educational level, marital status;

HR[3]: adjusted for age (cont.), sex, province, BMI, smoke, alcohol drinking, urban-rural, educational level, marital status, hypertension, stroke, diabetes, depression, and dementia.

CHAPTER EIGHT: IMPACT OF SOCIOECONOMIC STATUS ON INCIDENCE OF STROKE: THE ANHUI COHORT AND THE FOUR-PROVINCE COHORT STUDIES

8.1 Introduction

Previous studies showed that low socioeconomic status (SES) was associated with increased incidence of stroke (Cox et al., 2006, Addo et al., 2012, Marshall et al., 2015, Khaing et al., 2017). Most of existing studies examining the association were undertaken in high income countries (HICs), and their findings may not be applicable to low- and middle-income countries (LMICs).

China had the highest estimated lifetime risk of stroke worldwide (Feigin et al., 2018) and around 5.5 million new stroke cases occurred every year (Johnson et al., 2019). Also, gap in SES has been increased over the past four years. However, the impact of SES on the incidence of stroke remains unclear in China. Systematic review in Chapter 4.4 showed that only a couple of studies have been undertaken in China to assess the association of SES with incident stroke, with some inconsistent findings in China (Wang et al., 2005, Wu et al., 2011, Zhang et al., 2013, Song et al., 2014, Li et al., 2019, Wang et al., 2019). Most of them were the case-control studies, and did not adjust for enough confounding variables when examining incident stroke in relation to SES (Zhang et al., 2013, Wang et al., 2019). There was no study to assess the impact of different SES indicators on incidence of stroke simultaneously.

Previous studies from HICs showed gender differences in the association of SES with incident stroke; in low SES category, men had higher incidence of stroke than women (Ferrario et al., 2017). However, no cohort study has examined gender differences in the association in China. In general, older women in China have lower SES than their male counterparts. In this

Chapter, I investigated the impact of multiple measurements of SES on the incidence of stroke in older Chinese and their gender differences through examining data of the Anhui cohort and the Four-province cohort studies.

8.2 Methods

The studied populations were derived from the Anhui cohort and the Four-province cohort studies in China. The methods of the baseline investigation and the follow-up of both cohort studies have been fully described in Chapter 3.4.

8.2.1 Data analysis

In the Anhui cohort study, the data from 2,852 cohort members were analysed after excluding 141 participants with stroke at baseline and 343 who were lost to follow-up. In the Four-province cohort study, the data from 3,016 cohort members were analysed, after excluding 166 participants who had stroke at baseline, 1,102 who were lost to follow-up, and 30 who had no SES indicator measured. Baseline characteristics and cardiovascular disease risk factors (CVDRFs) of participants were described using mean (standard deviation, SD) and percentage (%) and differences in their distributions between women and men at baseline were examined using a one-way ANOVA for continuous variables and a Chi-square test for categorical variables. Individual SES variables were grouped into (1) low, (2) middle, and (3) high levels. In the Four-province study, baseline annual personal income and family income were divided into three groups according to their respective tertile cut-off points.

Multivariate adjusted Cox regression models were employed to examine the risk of incident stroke in relation to each of SES indicators in the two cohorts respectively. The hazard ratio (HR) and its 95% confidence intervals (CIs) were calculated for incidence of stroke. Apart from the examining independent effect of one SES indicator from other SES, all other SES indicators were included in the models for full adjustment. In the full model data analysis, the impacts in women and men were investigated separately. To increase the study power, I pooled the findings from the Anhui cohort study and the Four-province cohort study to examine the impact of SES on incidence of stroke.

8.2.2 Meta-analysis

The new findings from the two cohorts were combined with those from the previous studies, which were identified and reviewed in Chapter 4.4.

8.3 Results

8.3.1 Anhui cohort study

Of 2,852 participants, the average age was 71.7 years (SD 6.9), 51.8% were women, and 48.2% lived in rural areas. Compared with men, women were more likely to have low levels of education, occupation, and satisfactory income, be obese, be widowed, and have high levels of depression and dementia, but were more likely to have never smoked, not drink, live with children and/or grandchildren, and be visited daily by children or other relatives (Table 8-1).

Over the 10 years follow-up, 211 cases of stroke were identified. Table 8-2 shows numbers, incidence and adjusted HRs of stroke in participants living in urban and rural areas. HR for stroke in participants living in rural areas was significantly increased with adjustment for different sets of confounders, including other SES indicators (HR 2.49, 95% CI 1.19-5.22). Separate data analysis for women showed a fully adjusted HR of 3.64 (1.17-11.32) and for men 2.23 (0.81-6.19) (Table 8-4).

There were no significant associations of education, occupation, satisfactory income and financial problems with incident stroke, although increased HRs in participants with low levels of education and occupation and financial problems were significant before adjustment for other SES (Table 8-3). However, separate data analysis by gender showed that there were significantly increased risks of stroke in women with low education (3.68, 1.70-7.97) (Table 8-4).

8.3.2 Four-province cohort study

Of 3,016 participants, the average age was 71.0 years (SD 7.3), 56.0% were women, and 55.6% lived in rural areas. Compared with men, women were more likely to be recruited from Guangdong province, have low levels of education and occupation, be obese, be widowed, and have high levels of depression and dementia, but were more likely to be never smoking, not drink, live alone, and be daily visited by children or other relatives (Table 8-5).

Over the 3 years follow-up, 113 cases of incident stroke occurred. Compared with those living in urban areas, participants in rural areas had a fully adjusted HR of 1.34 (0.78-2.30) of incident stroke (Table 8-6). There were no significant associations of education, satisfactory income, and financial problems with incident stroke, except for high occupational class appearing to be associated with increased stroke (1.79, 1.01-3.13) (Table 8-6). Separate data analysis for women and men showed similar findings to those for the combined sample and there were no significantly increased HRs in these associations (Table 8-7), except for men with high occupation having increased the risk of stroke (2.17, 1.08-4.35) (Table 8-7).

Table 8-8 shows numbers, incidence and adjusted HRs of stroke in participants with different levels of annual personal and family incomes. Significantly increased risk of incident stroke was seen in women with low annual personal income (3.05, 1.17-8.00) and in men with high family income (2.38, 1.14-4.76 versus middle income; p=0.037 in three group differences).

8.3.3 Pooled data from the Anhui cohort and the Four-province cohort to examine the impact of SES on incidence of stroke

Table 8-9 showed pooled data for women and men separately. The risk of stroke was significantly increased in women with rural living (2.39, 1.18-4.83) or low education (2.26, 1.19-4.27), and other HRs were not statistically significant (Table 8-9). In all women and men, pooled data from the two cohorts showed a significantly increased risk of stroke in participants living in rural areas (1.66, 1.08-2.57), and high occupation (1.56, 1.01-2.38) (Table 8-9).

8.3.4 Meta-analysis of these new data of two cohorts with those from identified studies

I combined new findings from the two cohorts with any SES-matched findings available from those 7 studies which were identified and reviewed in Chapter 4.4 (Wang et al., 2005, Wu et al., 2011, Zhang et al., 2013, Song et al., 2014, Li et al., 2019, Wang et al., 2019, Wu et al., 2019). There were 8,602 stroke cases for analysis in total. The random effect model analysis showed that the overall RR of incident stroke in those with low SES compared to those with high SES was 1.10 (0.78-1.54) (Figure 8-1). Within all case-control studies, it was 0.90 (0.61-1.33), and in the cohort studies, it was 1.98 (1.21-3.26) (Figure 8-1).

Low and High Educational level

Together with the 7 identified studies, there were 9 datasets to be pooled for low educational level (Wang et al., 2005, Wu et al., 2011, Zhang et al., 2013, Song et al., 2014, Li et al., 2019, Wang et al., 2019, Wu et al., 2019), which included 8,602 stroke cases in total. Pooling data of the RR of incident stroke in those with low versus high educational level was 0.97 (0.72-1.31) (Figure 8-2). Within the cohort studies, it was 1.64 (0.97-2.76) (Figure 8-2).

Low and high levels of other SES

Data of other SES in relation to incident stroke cannot be pooled due to limited data available, except for the actual income (pooled RR 1.19, 0.38-3.70) (Figure 8-3).

8.4 Discussion

The community-based cohort studies in Anhui and other 4 provinces examined the impact of different measurements of SES on incidence of stroke in older people in China. Pooling data with previous cohort studies demonstrated an increased incidence of stroke in relation to low SES, which was largely for people who lived in rural areas. Women who had low education or low personal income also had increased incidence of stroke, as did men with high occupational class or family income.

In the study, it was found that women with illiteracy had significantly increased risk of stroke compared to their counterparts who attained at least primary school. The association of low education with increased risk of stroke was found in the HICs. A cohort of 21,443 US adults with a mean follow-up of 15.2 years showed that at ages greater than 50 years, the incidence of stroke was higher in those with ≤12 years education (HR 1.3, 1.0-1.6) (Qureshi et al., 2003). In Australia women with least education versus highest education had increased risk of stroke (Jackson et al., 2018). However, the present study from the male population did not show a significant association of low educational level with increased risk of stroke. It may be because other factors, e.g., smoking and alcohol drinking in Chinese men, play a more important role in the aetiology of stroke, covering the impact of low education on incidence of stroke.

This study showed that high level of occupational class was associated with increased incidence of stroke, mainly in men. This is different from those in previous studies undertaken in HICs (McFadden et al., 2009). One of the reasons for it could be attributed to epidemiological transition in the early stages that those with high occupational class are more likely to have adverse lifestyles including smoking (Wang et al., 2018), drinking (Wu et al., 2008), sedentary behaviour (Chen et al., 2015a), and psychological stress (Yang et al., 2012b), especially men. These lifestyles are associated with increased risk of stroke.

The data of the Four-province study showed that men with high family income had an increased risk of stroke in comparison to their counterparts with low and middle family income. This could be explained by lifestyle changes among them; the Chinese men with high income experienced and adopted unhealthy lifestyles, such as smoking, alcohol drinking, a diet with high caloric and sugar intakes, prolonged sedentary behaviours and inadequate physical activities (Kim et al., 2004). The pattern of high income associated with high incidence of stroke was also observed in HICs. In USA, the incidence of stroke was increased in people aged above 75 with higher income (HR 2.33, 1.16-4.55) (Avendano et al., 2006a). In France, the Three-City Study (3C study) demonstrated that in those aged over 65 years there was an 80% increased risk of ischemic stroke in those with higher income compared to lower income group after adjustment for all potential risk factors including education (HR 1.77, 1.20-2.61) (Grimaud et al., 2010). In the present study, high income is partly in line with high occupational class, and to a large extent a man's earnings and occupation would determine his family's SES. Therefore, the explanations relating to some risk factors for incident stroke in high occupational class also could be applied to men with high family income.

The present study did not find a significant association of satisfactory income or financial problems with incidence of stroke. Satisfactory level of income involved people's feeling about income, while the financial problems in the past two years reflected "the financial crisis". These proxies could be good for examining the risk of mental disorders and other chronic diseases (Chen et al., 2012a, Chen et al., 2012b). In this study, the data of the actual income from the Four-province study was analysed and showed that older women with low personal income had increased risk of stroke. The finding is consistent with other studies (Li et al., 2008). In Sweden, a cohort with 10 years follow-up showed that the incidence of stroke was significantly increased (HR 1.75, 1.36-2.25) in women who were in the lowest quartile of income compared with the women being in the highest quartile (Li et al., 2008).

Compared to other indicators of SES above, the impact of the rural-urban disparity on incident stroke has rarely been studied. Based on existing literature, there were few published studies, and they were only about differences in incidence rate of stroke between rural and urban areas. In a large-scale population-based cohort study in Portugal, Correia et al. examined the data from an older population aged 65+ years and found that the annual incidence of stroke per 1000 population was higher in rural (from 9.5 to 20.2) than in urban areas (from 6.8 to 10.9) (Correia et al., 2004). Data from young and middle aged populations in a study in China also showed that incidence of stroke in rural areas was significantly greater than that of their urban counterparts (Wang et al., 2017b). However in sub-Saharan Africa, a community-based study of the Tanzania Stroke Incidence Project found that there was higher incidence of stroke in older people living in urban versus rural areas, which could be due to high prevalence of stroke risk factors at a community level in the urban region (Walker et al., 2010). These studies showed significant differences in the incidence of stroke between rural and urban. However, they did not adjust for any confounders in the analysis and the residual effects on the differences they found would not be removed. The present study, with adjustment for many important confounders, showed that older people living in the rural areas in China had significantly increased risk of stroke.

The study has identified that women were more evident in the disparities of incident stroke in terms of levels of education and income, apart from rurality. The women in the study were born in a turbulent age when most of them had no opportunities to attain schooling and work outside due to many factors, e.g., poverty, Chinese tradition. Also, female education was rarely given priority due to poverty and patriarchal attitudes (Yu and Sarri, 1997), thus causing a high illiterate rate in older women (Li, 2005). Older women in China are still among the most economically disadvantaged population groups. Consequently, once they experienced some economic problems, they would have increased risk of incident stroke.

8.5 Conclusions

This study demonstrated SES inequalities in the risk of stroke in China. The rurality was a main resource of incident stroke inequality. There were gender differences in the impact of SES on stroke incidence; in women increased incidence of stroke was associated with low education and low personal income, while in men it was with high occupational class and high family income. The gender-specific strategies and preventive interventions of health promotion targeting people living in rural areas, through reducing socioeconomic deprivation, would be helpful in campaigns to reduce incidence of stroke in China.

Table 8-1. Distribution of sociodemographic and characteristics of participants by gender at baseline in the Anhui cohort study, China

Variable	All Participants N=2852		Women n=1477	Women (%)	Men n=1375	Men (%)	P* value
Age (years)							
Mean (SD)	71.7	6.9	71.6	7.1	71.9	6.6	*0.377*
Smoking							
Never-smoking	2070	72.6	1360	92.1	710	51.6	*<0.001*
Current- or Ex-smoking	782	27.4	117	7.9	665	48.4	
Alcohol drinking in the last 2 years							
No	2295	80.5	1377	93.2	918	66.8	*<0.001*
Yes	557	19.5	100	6.8	457	33.2	
BMI (kg/m^2)							
Cut-off point							
<18.5	393	13.8	212	14.4	181	13.2	*0.033*
18.5-<24.0	910	31.9	438	29.7	472	34.3	
24.0-<28.0	925	32.4	482	32.6	443	32.2	
≥28.0	624	21.9	345	23.4	279	20.3	
Socio-economic status							
Urban-rurality							
Urban	1478	51.8	770	52.1	708	51.5	*0.732*
Rural	1374	48.2	707	47.9	667	48.5	
Educational level							
≥High Secondary school	665	23.3	240	16.2	425	30.9	*<0.001*
Secondary school	388	13.6	181	12.3	207	15.1	
Primary school	361	12.7	183	12.4	178	12.9	
Illiterate	1438	50.4	873	59.1	565	41.1	
Main occupation							
Official/Teacher	892	31.3	334	22.6	558	40.6	*<0.001*
Business/Other	210	7.4	136	9.2	74	5.4	
Manual labourer/Housewife	428	15.0	299	20.2	129	9.4	
Peasant	1322	46.4	708	47.9	614	44.7	
Satisfactory income							
Very satisfactory	294	10.3	155	10.5	139	10.1	*0.035*
Satisfactory	1387	48.6	682	46.2	705	51.3	
Average	923	32.4	511	34.6	412	30.0	
Poor	248	8.7	129	8.7	119	8.7	
Financial problems in the past two years							
No	1547	54.2	803	54.4	744	54.1	*0.890*
Yes	1305	45.8	674	45.6	631	45.9	

Social network and support							
Marital status							
Married	2068	72.5	992	67.2	1076	78.3	*<0.001*
Never married/Divorcees	116	4.1	13	0.9	103	7.5	
Widowed	668	23.4	472	32.0	196	14.3	
Living with							
No-one	318	11.2	165	11.2	153	11.1	*<0.001*
Spouse only	1177	41.3	557	37.7	620	45.1	
Children and/or grandchildren only	428	15.0	302	20.4	126	9.2	
Spouse and/or grandchildren and/or parents	803	28.2	393	26.6	410	29.8	
Others	126	4.4	60	4.1	66	4.8	
Frequency of visiting children or other relatives							
<Yearly or Never	99	3.5	44	3.0	55	4.0	*0.001*
At least Monthly or less often	337	11.8	159	10.8	178	12.9	
At least weekly	766	26.9	368	24.9	398	28.9	
Everyday	1650	57.9	906	61.3	744	54.1	
Co-morbidities							
Hypertension							
No	1206	42.3	632	42.8	574	41.7	*0.573*
Yes	1646	57.7	845	57.2	801	58.3	
Heart disease							
No	2424	85.0	1256	85.0	1168	84.9	*0.854*
Yes	415	14.6	213	14.4	202	14.7	
Missing*	13	0.5	8	0.5	5	0.4	
Diabetes							
No	2687	94.2	1384	93.7	1303	94.8	*0.341*
Yes	157	5.5	87	5.9	70	5.1	
Missing*	8	0.3	6	0.4	2	0.1	
Activity of daily living (score)							
0	2643	92.7	1368	92.6	1275	92.7	*0.966*
1-4	123	4.3	65	4.4	58	4.2	
≥5	86	3.0	44	3.0	42	3.1	
GMS-AGECAT diagnosis							
“Well”	2150	75.4	1053	71.3	1097	79.8	*<0.001*
Depression-subcase	96	3.4	49	3.3	47	3.4	
Depression-case	112	3.9	80	5.4	32	2.3	
Dementia-subcase	293	10.3	175	11.8	118	8.6	
Dementia-case	201	7.0	120	8.1	81	5.9	

*P-value in the chi-square test was calculated based on available data, not including these “missing” data.

Table 8-2. Number, rate and hazard ratio of incident stroke in older people with urban and rural living in China: the Anhui cohort study

Urban-rural SES variable	Nos of stroke /participants	PYAR* (Incidence)	HR^1 95% CI	HR^2 95% CI	HR^3 95% CI	HR^4 95% CI	HR^5 95% CI	HR^6 95% CI
Urban	100 / 1478	10210.1 (9.79)	1.00	1.00	1.00	1.00	1.00	1.00
Rural	111 / 1374	8427.6 (13.17)	1.88 1.38-2.56	2.07 1.45-2.96	1.58 1.00-2.48	2.27 1.24-4.17	2.44 1.41-4.24	2.49 1.19-5.22

*PYAR (Incidence): person-year at risk (Incidence rate); Incidence rate per 1000 person-years.
HR^1: adjusted for age (cont.), sex, BMI, smoking, alcohol consumption;
HR^2: adjusted for age (cont.), sex, BMI, smoking, alcohol consumption, marital status, frequency of visiting children or other relatives, hypertension, heart disease, diabetes, activity of daily living, depression, and dementia;
HR^3: educational level variable was added in the model 2 for adjustment;
HR^4: occupational class variable was added in the model 2 for adjustment;
HR^5: satisfactory income variable was added in the model 2 for adjustment;
HR^6: educational level, occupational class, and satisfactory income variables were added in the model 2 for adjustment.

Table 8-3. Number, rate and hazard ratio of incident stroke in older people with other SES indicators in China: the Anhui cohort study

Individual SES variable	Nos of stroke/participants	PYAR* (Incidence)	HR[1] 95% CI	HR[2] 95% CI	HR[3] 95% CI	HR[4] 95% CI	HR[5] 95% CI	HR[6] 95% CI
Educational level[a]								
High	64/1053	7358.1 (8.70)	1.00	1.00	1.00	1.00	1.00	1.00
Middle	26/361	2369.8 (10.97)	1.40 0.88-2.23	1.43 0.89-2.31	1.33 0.78-2.26	1.38 0.85-2.25	1.31 0.80-2.13	1.27 0.75-2.18
Low	121/1438	8909.7 (13.58)	2.07 1.49-2.88	2.06 1.43-2.95	1.78 1.06-2.97	1.99 1.31-3.02	1.56 0.99-2.48	1.63 0.96-2.77
Occupational class[b]								
High	72/1102	7674.9 (9.38)	1.00	1.00	1.00	1.00	1.00	1.00
Middle	36/428	2862.3 (12.58)	1.46 0.96-2.20	1.41 0.93-2.15	1.40 0.92-2.14	1.11 0.69-1.81	1.35 0.88-2.05	1.15 0.71-1.88
Low	103/1322	8100.5 (12.72)	1.83 1.32-2.54	1.89 1.30-2.73	1.77 1.12-2.82	1.24 0.73-2.08	0.98 0.54-1.78	0.78 0.40-1.50
Satisfactory Income[c]								
High	25/294	2026.9 (12.33)	1.00	1.00	1.00	1.00	1.00	1.00
Middle	89/1387	9379.4 (9.49)	0.76 0.49-1.19	0.82 0.52-1.29	0.75 0.47-1.18	0.75 0.48-1.19	0.74 0.47-1.16	0.72 0.46-1.14
Low	97/1171	7231.4 (13.41)	1.28 0.82-2.00	1.17 0.74-1.86	0.87 0.53-1.42	0.89 0.54-1.46	0.84 0.51-1.37	0.79 0.48-1.31
Financial problems in the past two years[d]								
No	106/1547	10582.8 (10.02)	1.00	1.00	1.00	1.00	1.00	1.00
Yes	105/1305	8054.8 (13.04)	1.73 1.28-2.34	1.77 1.27-2.47	1.34 0.90-1.98	1.46 0.92-2.31	1.03 0.58-1.82	0.99 0.56-1.73

Classification of low, middle and high levels in SES variables: **Education** was classified as follows: (1) low: illiterate, (2) middle: primary school, and (3) high: secondary school or higher; **Occupational class** was classified as follows: (1) low: peasant, (2) middle: manual labourer or housewife, and (3) high:

official/teacher or business/other; **Satisfactory income** was classified as follows: (1) low: poor or average, (2) middle: satisfactory, and (3) high: very satisfactory.

*PYAR (Incidence): person-year at risk (Incidence rate); Incidence rate per 1000 person-years.

HR[1]: adjusted for age (cont.), sex, BMI, smoking, alcohol consumption;

HR[2]: adjusted for age (cont.), sex, BMI, smoking, alcohol consumption, marital status, frequency of visiting children or other relatives, hypertension, heart disease, diabetes, activity of daily living, depression, and dementia;

HR[3]: a: occupational class variable, b: satisfactory income variable, c & d: educational level variable was added in the model 2 for adjustment, respectively;

HR[4]: a: satisfactory income variable, b: educational level variable, c & d: occupational class variable was added in the model 2 for adjustment, respectively;

HR[5]: urban-rural variable was added in the model 2 for adjustment;

HR[6]: urban-rural, educational level, occupational class, and satisfactory income (or financial problems) variables were added in the model 2 for adjustment.

Table 8-4. Hazard ratios of incident stroke by SES in women and men: the Anhui cohort study

SES variables	Anhui cohort					
	Women			Men		
	Nos of stroke /participants	PYAR† (Incidence)	HR‡ 95% CI	Nos of stroke /participants	PYAR† (Incidence)	HR‡ 95% CI
Urban-rurality						
Urban	49/770	5415.2 (9.05)	1.00	51/708	4794.8 (10.64)	1.00
Rural	51/707	4490.4 (11.36)	3.64 1.17-11.32	60/667	3937.3 (15.24)	2.23 0.81-6.19
Educational level*						
High	19/421	3050.3 (6.23)	1.00	45/632	4307.8 (10.45)	1.00
Middle	10/183	1253.7 (7.98)	1.59 0.66-3.85	16/178	1116.1 (14.34)	1.07 0.52-2.20
Low	71/873	5601.6 (12.67)	3.68 1.70-7.97	50/565	3308.1 (15.11)	0.93 0.44-1.98
Occupational class*						
High	29/470	3333.9 (8.70)	1.00	43/632	4341.0 (9.91)	1.00
Middle	22/299	2074.2 (10.61)	0.73 0.36-1.47	14/129	788.1 (17.76)	1.53 0.77-3.06
Low	49/708	4497.5 (10.89)	0.43 0.16-1.18	54/614	3603.0 (14.99)	1.20 0.49-2.94
Satisfactory Income*						
High	13/155	1066.5 (12.19)	1.00	12/139	960.4 (12.49)	1.00
Middle	41/682	4742.0 (8.65)	0.62 0.32-1.20	48/705	4637.4 (10.35)	0.74 0.38-1.44
Low	46/640	4097.1 (11.23)	0.62 0.30-1.28	51/531	3134.3 (16.27)	0.83 0.40-1.73
Financial problems in the past two years						
No	54/803	5618.0 (9.61)	1.00	52/744	4964.8 (10.47)	1.00
Yes	46/674	4287.5 (10.73)	0.68 0.31-1.49	59/631	3767.3 (15.66)	1.74 0.77-3.92

*Classification of low, middle and high levels in SES variables: **Education** was classified as follows: (1) low: illiterate, (2) middle: primary school, and (3) high: secondary school or higher; **Occupational class** was classified as follows: (1) low: peasant, (2) middle: manual labourer or housewife, and (3) high: official/teacher or business/other; **Satisfactory income** was classified as follows: (1) low: poor or average, (2) middle: satisfactory, and (3) high: very satisfactory.
†PYAR (Incidence): person-year at risk (Incidence rate); Incidence rate per 1000 person-years.
‡Models are adjusted for: age (cont.), sex, BMI, smoking, alcohol consumption, marital status, frequency of visiting children or other relatives, hypertension, heart disease, diabetes, activity of daily living, depression, dementia, and urban-rurality, education, occupation, satisfactory income (or financial problems).

Table 8-5. Distribution of socio-demographic and characteristics of participants by gender at baseline in the Four-province cohort study, China

Variable	All Participants N=3016		Women n=1688	Women (%)	Men n=1328	Men (%)	P* value
Age (years)							
Mean (SD)	71.0	7.3	70.9	7.3	71.1	7.2	*0.443*
Province							
Guangdong	867	28.7	534	31.6	333	25.1	*<0.001*
Shanghai	881	29.2	491	29.1	390	29.4	
Heilongjiang	427	14.2	234	13.9	193	14.5	
Shanxi	841	27.9	429	25.4	412	31.0	
Smoking							
Never-smoking	1882	62.4	1382	81.9	500	37.7	*<0.001*
Ex-smoking	355	11.8	89	5.3	266	20.0	
Current-smoking	759	25.2	201	11.9	558	42.0	
Missing*	20	0.7	16	0.9	4	0.3	
Alcohol drinking							
Never-drinking	2272	75.3	1557	92.2	715	53.8	*<0.001*
Ex-drinking	228	7.6	37	2.2	191	14.4	
Current-drinking	480	15.9	69	4.1	411	30.9	
Missing*	36	1.2	25	1.5	11	0.8	
BMI (kg/m^2)							
Cut-off point							
<18.5	248	8.2	156	9.2	92	6.9	*0.001*
18.5-<24.0	1751	58.1	942	55.8	809	60.9	
24.0-<28.0	765	25.4	427	25.3	338	25.5	
≥28.0	252	8.4	163	9.7	89	6.7	
Socio-economic status							
Urban-rurality							
Urban	1339	44.4	773	45.8	566	42.6	*0.082*
Rural	1677	55.6	915	54.2	762	57.4	
Educational level							
≥High Secondary school	336	11.1	124	7.3	212	16.0	*<0.001*
Secondary school	419	13.9	154	9.1	265	20.0	
Primary school	935	31.0	449	26.6	486	36.6	
Illiterate	1326	44.0	961	56.9	365	27.5	
Main occupation							
Official/Teacher	331	11.0	94	5.6	237	17.8	*<0.001*
Business/Other	262	8.7	141	8.4	121	9.1	
Manual labourer/Housewife	808	26.8	541	32.0	267	20.1	
Peasant	1615	53.5	912	54.0	703	52.9	
Satisfactory income							

Very satisfactory	272	9.0	144	8.5	128	9.6	*0.213*
Satisfactory	1447	48.0	792	46.9	655	49.3	
Average	1072	35.5	617	36.6	455	34.3	
Poor	225	7.5	135	8.0	90	6.8	
Financial problems in the past two years							
No	2889	95.8	1612	95.5	1277	96.2	*0.369*
Yes	127	4.2	76	4.5	51	3.8	
Social network and support							
Marital status							
Married	2239	74.2	1129	66.9	1110	83.6	*<0.001*
Never married/Divorcees	67	2.2	24	1.4	43	3.2	
Widowed	710	23.5	535	31.7	175	13.2	
Living with							
Live alone	245	8.1	171	10.1	74	5.6	*<0.001*
Live with others	2771	91.9	1517	89.9	1254	94.4	
Frequency of visiting children or other relatives							
<Yearly or Never	163	5.4	85	5.0	78	5.9	*0.002*
At least Monthly or less often	1146	38.0	668	39.6	478	36.0	
At least weekly	864	28.6	441	26.1	423	31.9	
Everyday	841	27.9	493	29.2	348	26.2	
Missing*	2	0.1	1	0.1	1	0.1	
Co-morbidities							
Hypertension							
No	1516	50.3	816	48.3	700	52.7	*0.049*
Yes	1410	46.8	810	48.0	600	45.2	
Missing*	90	3.0	62	3.7	28	2.1	
Heart disease							
No	2633	87.3	1452	86.0	1181	88.9	*0.057*
Yes	338	11.2	205	12.1	133	10.0	
Don’t know	37	1.2	25	1.5	12	0.9	
Missing*	8	0.3	6	0.4	2	0.2	
Diabetes							
No	2837	94.1	1589	94.1	1248	94.0	*0.942*
Yes	160	5.3	88	5.2	72	5.4	
Don’t know	17	0.6	10	0.6	7	0.5	
Missing*	2	0.1	1	0.1	1	0.1	
Activity of daily living (score)							
0	2826	93.7	1594	94.4	1232	92.8	*0.079*
1-4	123	4.1	65	3.9	58	4.4	
≥5	67	2.2	29	1.7	38	2.9	

GMS-AGECAT diagnosis							
"Well"	2295	76.1	1207	71.5	1088	81.9	*<0.001*
Depression-subcase	88	2.9	47	2.8	41	3.1	
Depression-case	117	3.9	87	5.2	30	2.3	
Dementia-subcase	259	8.6	163	9.7	96	7.2	
Dementia-case	252	8.4	180	10.7	72	5.4	
Missing*	5	0.2	4	0.2	1	0.1	

*P-value in the chi-square test was calculated based on available data, not including these "missing" data.

Table 8-6. Number, rate and hazard ratio of incident stroke in older people with different SES measurement in China: the Four-province cohort study

SES variable	Nos of stroke/participants	PYAR† (Incidence)	HR[1] 95% CI	HR[2] 95% CI	HR[3] 95% CI	HR[4] 95% CI	HR[5] 95% CI	HR[6] 95% CI
Urban-rurality*								
Urban	47/1339	3869.8 (12.15)	1.00	1.00	1.00	1.00	1.00	1.00
Rural	66/1677	5293.7 (12.47)	1.05 0.67-1.65	1.01 0.62-1.63	1.07 0.64-1.79	1.32 0.79-2.20	1.05 0.64-1.71	1.34 0.78-2.30
Educational level*								
High	24/755	2229.8 (10.76)	1.00	1.00	1.00	1.00	1.00	1.00
Middle	36/935	2795.2 (12.88)	0.96 0.55-1.68	0.86 0.49-1.53	0.99 0.54-1.82	0.89 0.50-1.58	0.85 0.47-1.53	0.93 0.50-1.74
Low	53/1326	4138.5 (12.81)	0.94 0.53-1.65	0.84 0.46-1.51	1.13 0.58-2.18	0.87 0.48-1.60	0.81 0.43-1.53	1.03 0.52-2.05
Occupational class*								
High	26/593	1719.1 (15.12)	1.00	1.00	1.00	1.00	1.00	1.00
Middle	33/808	2422.6 (13.62)	1.10 0.65-1.87	1.04 0.61-1.79	1.04 0.61-1.78	1.04 0.59-1.82	1.06 0.62-1.82	1.07 0.61-1.88
Low	54/1615	5021.8 (10.75)	0.61 0.37-1.01	0.61 0.37-1.01	0.61 0.36-1.03	0.58 0.33-1.02	0.56‡ 0.33-0.95	0.56‡ 0.32-0.99
Satisfactory Income*								
High	7/272	781.2 (8.96)	1.00	1.00	1.00	1.00	1.00	1.00
Middle	58/1447	4277.2 (13.56)	1.60 0.72-3.55	1.43 0.64-3.18	1.42 0.64-3.17	1.44 0.65-3.22	1.43 0.64-3.19	1.47 0.66-3.28
Low	48/1297	4105.2 (11.69)	1.36 0.61-3.05	1.18 0.52-2.66	1.19 0.53-2.70	1.31 0.58-2.98	1.17 0.52-2.65	1.31 0.58-2.98
Financial problems in the past two years*								
No	109/2889	8805.8 (12.38)	1.00	1.00	1.00	1.00	1.00	1.00

Yes	4/127	357.7 (11.18)	0.85 0.31-2.35	0.70 0.24-1.98	0.70 0.25-2.00	0.76 0.27-2.15	0.70 0.24-1.98	0.75 0.26-2.13

*Classification of low, middle and high levels in SES variables: **Education** was classified as follows: (1) low: illiterate, (2) middle: primary school, and (3) high: secondary school or higher; **Occupational class** was classified as follows: (1) low: peasant, (2) middle: manual labourer or housewife, and (3) high: official/teacher or business/other; **Satisfactory income** was classified as follows: (1) low: poor or average, (2) middle: satisfactory, and (3) high: very satisfactory.

†PYAR (Incidence): person-year at risk (Incidence rate); Incidence rate per 1000 person-years.

HR^1: adjusted for age (cont.), sex, BMI, province, smoking status, alcohol consumption;

HR^2: adjusted for age (cont.), sex, BMI, province, smoking status, alcohol consumption, marital status, frequency of visiting children or other relatives, hypertension, heart disease, diabetes, activity of daily living, depression, and dementia;

HR^3, HR^4, HR^5, and HR^6 adjustments were the same as those in Table 1 footnotes.

‡Those HR for incident stroke in officials/teachers/businessmen/others vs peasants was 1.79 (1.05-3.03) in model 5, and 1.79 (1.01-3.13) in model 6.

Table 8-7. Hazard ratios of incident stroke by SES in women and men: the Four-province cohort study

SES variable	Four-province cohort					
	Women			Men		
	Nos of stroke /participants	PYAR† (Incidence)	HR‡ 95% CI	Nos of stroke /participants	PYAR† (Incidence)	HR‡ 95% CI
Urban-rurality*						
Urban	19/773	2245.2 (8.46)	1.00	28/566	1624.7 (17.23)	1.00
Rural	28/915	2905.9 (9.64)	1.84 0.75-4.49	38/762	2387.8 (15.91)	1.25 0.60-2.58
Educational level*						
High	7/278	831.2 (8.42)	1.00	17/477	1398.6 (12.16)	1.00
Middle	7/449	1333.5 (5.25)	0.37 0.11-1.21	29/486	1461.8 (19.84)	1.22 0.56-2.63
Low	33/961	2986.5 (11.05)	0.80 0.26-2.47	20/365	1152.1 (17.36)	1.06 0.44-2.58
Occupational class*						
High	6/235	690.1 (8.69)	1.00	20/358	1029.0 (19.44)	1.00
Middle	15/541	1624.9 (9.23)	1.01 0.35-2.93	18/267	797.8 (22.56)	1.20 0.59-2.44
Low	26/912	2836.1 (9.17)	0.69 0.22-2.12	28/703	2185.7 (12.81)	0.46[$] 0.23-0.93
Satisfactory Income*						
High	3/144	420.9 (7.13)	1.00	4/128	360.3 (11.10)	1.00
Middle	20/792	2357.3 (8.48)	1.07 0.30-3.76	38/655	1919.9 (19.79)	1.88 0.64-5.52
Low	24/752	2372.9 (10.11)	1.20 0.34-4.25	24/545	1732.3 (13.85)	1.34 0.43-4.19
Financial problems in the past two years*						
No	46/1612	4932.3 (9.33)	1.00	63/1277	3873.5 (16.26)	1.00
Yes	1/76	218.8 (4.57)	0.49 0.06-3.79	3/51	138.9 (21.60)	0.91 0.25-3.25

*Classification of low, middle and high levels in SES variables: **Education** was classified as follows: (1) low: illiterate, (2) middle: primary school, and (3) high: secondary school or higher; **Occupational class** was classified as follows: (1) low: peasant, (2) middle: manual labourer or housewife, and (3) high: official/teacher or business/other; **Satisfactory income** was classified as follows: (1) low: poor or average, (2) middle: satisfactory, and (3) high: very satisfactory.
†PYAR (Incidence): person-year at risk (Incidence rate); Incidence rate per 1000 person-years.
‡Model 6 data analysis: adjusted for age (cont.), sex, BMI, (province for the Four-province cohort,) smoking status, alcohol consumption, marital status, frequency of visiting children or other relatives, hypertension, heart disease, diabetes, activity of daily living, depression, dementia, and **other all SES**.
[$]HR for incident stroke in men with high occupation vs low occupation was 2.17 (1.08-4.35).

Table 8-8. Number, rate and hazard ratio of incident stroke in older people with actual income in China: the Four-province cohort study

Annual income (RMB)	All participants			Women			Men		
	Nos of stroke /participants	PYAR* (Incidence)	HR† 95% CI	Nos of stroke /participants	PYAR* (Incidence)	HR† 95% CI	Nos of stroke /participants	PYAR* (Incidence)	HR† 95% CI
Personal									
≥10,000	48/1377	4061.7 (11.82)	1.00	12/682	2019.9 (5.94)	1.00	36/695	2041.8 (17.63)	1.00
4,800-<10,000	21/568	1744.3 (12.04)	1.14 0.60-2.19	10/334	1008.1 (9.92)	2.14 0.78-5.91	11/234	736.2 (14.94)	0.87 0.37-2.07
0-<4,800	43/969	3078.2 (13.97)	1.54 0.83-2.86	24/603	1932.9 (12.42)	3.05 1.17-8.00	19/366	1145.3 (16.59)	0.96 0.41-2.24
Family (per person)									
≥12,000	53/1133	3575.4 (14.82)	1.00	15/595	1914.1 (7.84)	1.00	38/538	1661.3 (22.87)	1.00‡
4,800-<12,000	25/737	2307.1 (10.84)	0.66 0.40-1.10	13/419	1308.5 (9.94)	1.02 0.45-2.33	12/318	998.6 (12.02)	0.42 0.21-0.88
0-<4,800	24/755	2174.7 (11.04)	0.75 0.37-1.50	13/416	1199.4 (10.84)	1.71 0.62-4.71	11/339	975.2 (11.28)	0.37 0.13-1.07

The top tertile of actual personal and family income were treated as the high level. Of 3,016 eligible participants in the Four-province cohort study, 102 missing occurred in annual personal income and 391 missing in family annual income per person.

*PYAR (Incidence): person-year at risk (Incidence rate); Incidence rate per 1000 person-years.

† Models are adjusted for: age (cont.), sex, BMI, smoking, alcohol consumption, marital status, frequency of visiting children or other relatives, hypertension, heart disease, diabetes, activity of daily living, depression, dementia, and urban-rurality, education, occupation.

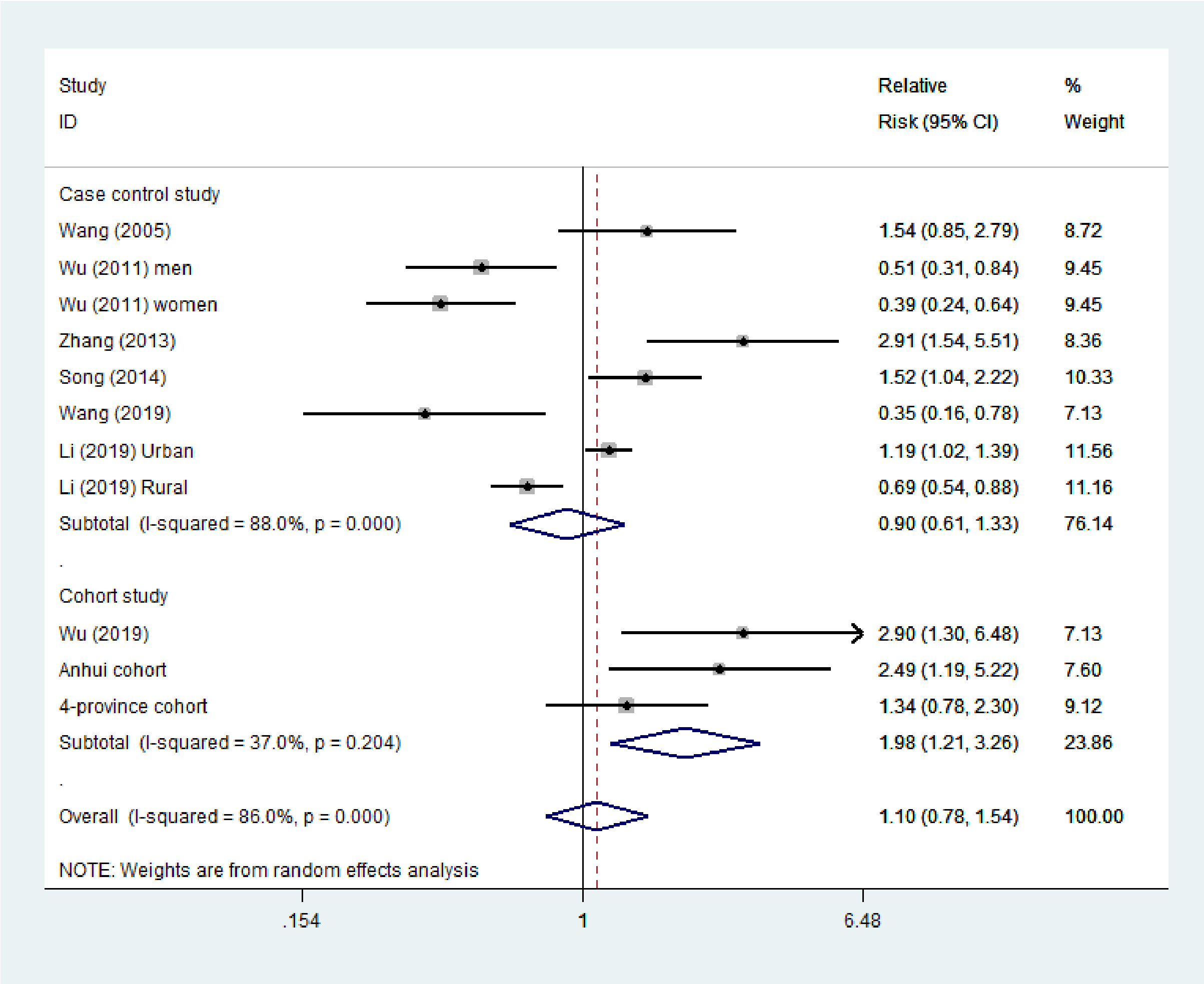
‡The overall P-value for family income in men was 0.037.

Table 8-9. Pooled hazard ratio of incident stroke in different SES indicators among participants from the Anhui cohort and the Four-province cohort studies

SES variable	All participants		Women		Men	
	HR*	95% CI	HR*	95% CI	HR*	95% CI
Urban-rurality						
Urban	1.00		1.00		1.00	
Rural	1.66	1.08-2.57	2.39	1.18-4.83	1.52	0.84-2.75
Educational level						
High	1.00		1.00		1.00	
Middle	1.11	0.74-1.67	0.95	0.47-1.94	1.14	0.67-1.93
Low	1.37	0.88-2.12	2.26	1.19-4.27	0.98	0.55-1.74
Occupational class						
High	1.00		1.00		1.00	
Middle	1.12	0.77-1.61	0.81	0.45-1.45	1.36	0.83-2.23
Low	0.64	0.42-0.99	0.53	0.25-1.12	0.66	0.38-1.15
Satisfactory Income						
High	1.00		1.00		1.00	
Middle	0.95	0.48-1.88	0.70	0.39-1.25	1.07	0.44-2.61
Low	0.91	0.58-1.43	0.73	0.39-1.37	0.96	0.52-1.77
Financial problems in the past two years						
No	1.00		1.00		1.00	
Yes	0.93	0.57-1.53	0.65	0.31-1.36	1.45	0.73-2.87

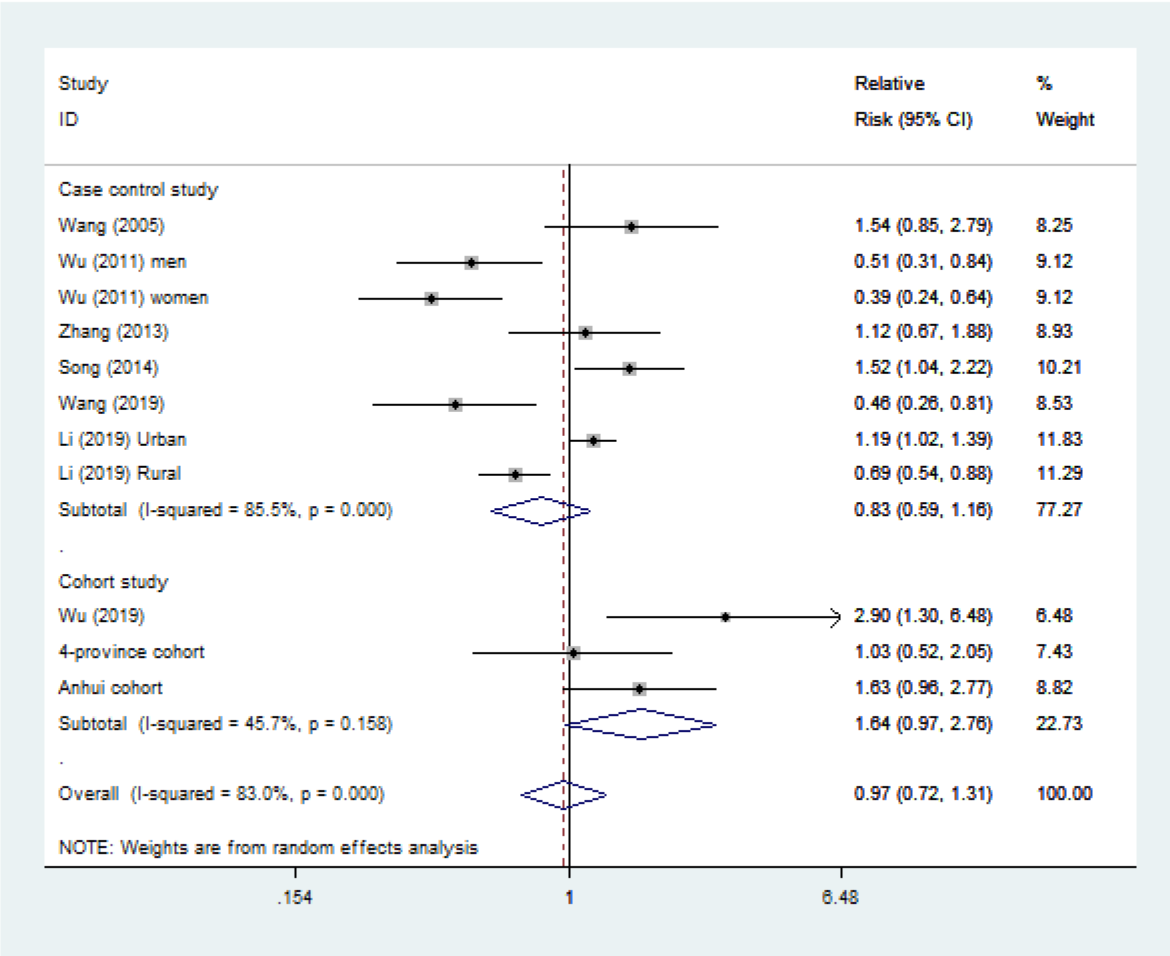
*Models are adjusted for: age (cont.), sex, BMI, smoking, alcohol consumption, marital status, frequency of visiting children or other relatives, hypertension, heart disease, diabetes, activity of daily living, depression, dementia, and urban-rurality, education, occupation, satisfactory income (or financial problems).

Figure 8-1. Forest plot for the pooled relative risk (RR) of SES with risk of incident stroke



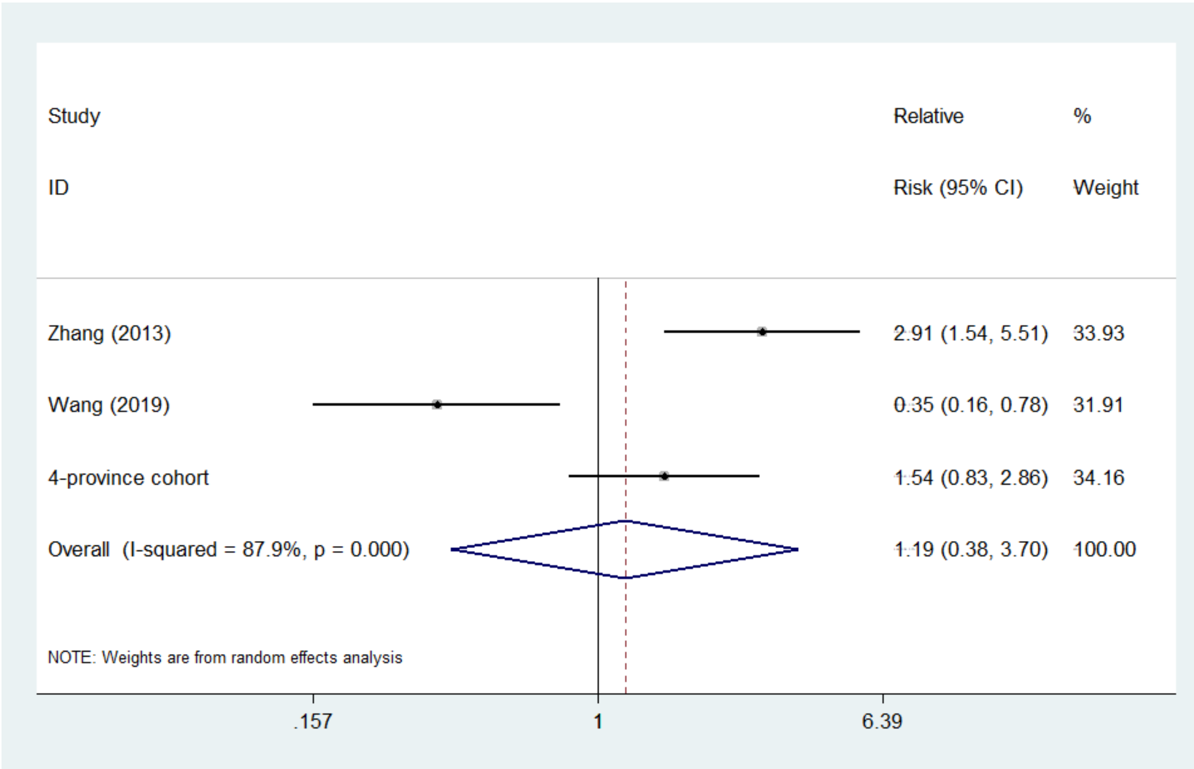
The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

Figure 8-2. Forest plot for the pooled relative risk (RR) of low educational level with risk of incident stroke



The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

Figure 8-3. Forest plot for the pooled relative risk (RR) of low actual income with risk of incident stroke



The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

CHAPTER NINE: IMPACT OF SOCIOECONOMIC STATUS ON ALL-CAUSE MORTALITY IN OLDER PEOPLE WITH STROKE: THE FIVE PROVINCES COHORT STUDIES

9.1 Introduction

Previous studies suggested that stroke patients with low socioeconomic status (SES) had a significant increase in mortality (Addo et al., 2012). However, knowledge about the impact of SES on mortality after stroke are predominantly from high income countries (HICs) (Cox et al., 2006, Addo et al., 2012, Chen et al., 2014b, Marshall et al., 2015). The findings from HICs studies may not be generalisable to LMICs. Fewer studies have been done in LMICs to investigate the impact of SES on mortality in patients with stroke (Marshall et al., 2015). Understanding the impact of SES on stroke mortality in LMICs and how different measurements of SES are associated with mortality after stroke would help improve the outcome of stroke globally and tackle inequalities in stroke survival.

China is the biggest LMIC. It has the highest estimated lifetime risk of stroke in the world, according to the GBD Study (Collaborators, 2018). The age-standardised mortality of stroke in China is 114.8/100,000 person-years, the highest among all LMICs and more than two million people die of stroke annually (Johnson et al., 2019, Wang et al., 2017b). Over the past 40 years, China has observed an increasing gap in income between the rich and poor (Han et al., 2016). Previous hospital-based studies (Pan et al., 2016, Yan et al., 2017, Gu et al., 2018, Gu et al., 2019) in stroke patients with low SES showed an increased risk of mortality compared to their counterparts with high SES in China. However, there were very few community-based cohort studies to assess the impact of multiple measurements of SES on mortality after stroke in China.

Thus, in this Chapter, I examined the data from the 5-province cohort study to assess the impact of SES on all-cause mortality in stroke patients following investigation on the association of stroke with all-cause mortality in older people. I also pooled the findings of previously identified studies on this topic (Chapter 4.5) with the 5-province data to determine the impact of SES on all-cause mortality in stroke patients in China.

9.2 Methods

The study populations were derived from the Four-province cohort study, and also from the third wave survey of the Anhui cohort study, because Chen et al. (Chen et al., 2015b) has used data from the Anhui cohort wave 1 to wave 3 to assess the association of SES with mortality in older people with stroke. The methods of the baseline investigation and the follow-up of both studies have been fully reported before (Chapter 3.4).

9.2.1 Data analysis

Data of 4,314 participants in the Four-province cohort study was merged with 1,757 participants in the Anhui cohort study for analysis, due to the same survey protocol being used and the increased study power (Chen et al., 2013b). Of the 6,071 participants at baseline, 48 had no SES indicator measured and 1,906 participants were lost to follow-up. Thus, data of 4,117 cohort members were left for analysis, of which 134 participants had stroke at baseline.

The distributions of baseline risk factors among participants with and without stroke were described using mean (standard deviation, SD) and percentage (%), and the differences in the distribution were examined using one-way ANOVA analysis for continuous variables and the Chi-square test for categorical variables. The risk of death was examined using Cox regression in three serially adjusted models to calculate hazard ratio (HR) of all-cause mortality and its 95%

confidence interval (CI) among patients with stroke compared to those participants without stroke at baseline. In stroke patients, the impact of each of the SES indicators was further examined on all-cause mortality. In the actual incomes, baseline annual personal income and family income were divided equally into two groups and the low actual incomes were treated as low SES.

9.2.2 Meta-analysis

The findings of impact of SES on all-cause mortality in stroke patients from the 5-province cohort study were pooled with those from the studies that were identified in Chapter 4.5. I pooled data of SES measurement in older people in place of ischaemic stroke assessment.

9.3 Results

9.3.1 The five-province cohort study

Baseline characteristics

Of the 4,117 participants, 134 (3.3%) participants were documented as having stroke at baseline. Table 9-1 shows characteristics of participants. Compared to participants without stroke, stroke patients were older (74.1 vs 72.0 years) and more likely to live in urban areas, never drink alcohol (abstinence), have higher occupational class, and have CVD-related co-morbidities including hypertension, hypercholesterolemia, heart disease, angina, diabetes, depression and dementia (Table 9-1).

All-cause mortality in participants with and without baseline stroke

Over the median follow-up of 3.0 years, the cohort had 325 participants who died: 31 deaths in patients with stroke (23.1%) and 294 in those without stroke (7.4%).

Table 9-2 shows numbers of deaths, mortality rate and adjusted HRs for mortality among participants with and without stroke. Stroke participants had a higher risk of mortality (86.3 per 1000 person-years) than those without stroke (24.6 per 1000 person-years) ($p<0.001$). After adjusted for age and sex, the HR for all-cause mortality in participants with stroke versus without stroke was 3.11 (95% CI 2.15-4.51) (Table 9-2). Further adjustment for province, BMI, smoke, alcohol drinking, marital status, urban-rural, educational level, occupational class, and satisfactory income would not substantially change the HR, while in the full adjustment including co-morbidities, the HR was 2.99 (2.03-4.39) (Table 9-2).

All-cause mortality in relation to different measures of SES in stroke patients

Rural and Urban areas

Table 9-3 shows number and adjusted hazard ratios of mortality among stroke patients living in rural and urban areas. Mortality rate per 1000 person-years was 97.0 in rural and 77.3 in urban areas. The age and sex adjusted HR for mortality in stroke patients with rural living compared to those with urban living was 2.46 (1.12-5.43). Further adjustment for province, BMI, smoking, drinking, marital status, and educational level, the HR decreased to insignificant level (2.26, 0.86-5.99), while in the full adjustment analysis including co-morbidities, the HR was reduced and became not statistically significant (1.98, 0.70-5.59) (Table 9-3).

Low and High Educational level

Table 9-4 shows number and adjusted HRs of mortality among stroke patients in educational level. Mortality rate per 1000 person-years was 103.8 in patients who were illiterate and 73.2 in patients with school education. The age and sex adjusted HR for mortality in illiterate patients compared to non-illiterate patients was 1.55 (0.70-3.45). Further adjustment with more confounding variables and the fully adjusted analysis would not change the findings of no association between illiteracy and mortality (Table 9-4).

Low and High Occupational class

Table 9-5 shows number and adjusted HRs of mortality among stroke patients in occupational class. Mortality rate per 1000 person-years was 80.4 in the manual worker group and 97.7 in the non-manual group. The age and sex adjusted HR for mortality in stroke patients with manual vs non-manual occupations was 0.85 (0.41-1.78). Both further adjustment and fully adjusted analysis showed no significant association of occupational class with mortality in stroke patients (Table 9-5).

Satisfactory income

Table 9-6 shows number and adjusted HRs of mortality among stroke patients with low versus high satisfactory income. Mortality rate per 1000 person-years was 87.3 in the low satisfactory income group and 85.2 in the high satisfactory income group. The age and sex adjusted HR for mortality in stroke patients with low vs high satisfactory incomes was 1.14 (0.56-2.33). Further adjustment and fully adjusted analysis showed no significant association of satisfactory income with stroke mortality (Table 9-6).

Personal income

Table 9-7 shows number adjusted HRs of mortality among stroke patients with low and high personal income. Mortality rate per 1000 person-years was 114.2 in patients with low personal income and 69.9 in patients with high personal income. The age and sex adjusted HR for mortality in stroke patients with low vs high personal incomes was 2.31 (1.08-4.91). Further adjustment for province, BMI, smoking, drinking, marital status, urban-rurality and educational level reduced the HR (1.83, 0.64-5.23), and fully adjustment analysis further reduced the HR (1.47, 0.44-4.87) (Table 9-7).

Family income

Table 9-8 shows number and adjusted HRs of mortality among stroke patients with low and high family income. Mortality rate per 1000 person-years was 120.4 in patients with low family income and 68.6 in patients with high family income. The age and sex adjusted HR for mortality in stroke patients with low versus high family income was 4.17 (1.63-10.63). Both further adjustment and fully adjusted analysis did not reduce the HR, but made the HR insignificant (5.67, 0.98-32.77; 6.25, 0.86-45.44) (Table 9-8).

9.3.2 Pooled data from the 5-province cohort study and those from identified studies

I pooled data from the 5-province cohort study and any matched SES measurements available from those seven studies which were identified and reviewed in Chapter 4.5 (Zhou et al., 2006, Sheng et al., 2010, Wu et al., 2014, Chen et al., 2015b, Pan et al., 2016, Yan et al., 2017, Gu et al., 2018). In total, there were 116,963 stroke patients for analysis. The random effect model analysis showed that stroke patients with low SES had increased mortality (the pooled RR 1.72, 1.42-2.07) (Figure 9-1).

According to the different measurements of SES available in the studies, the meta-analysis was performed as follows.

Rural and Urban areas

Together with the current 5-province cohort study, there were four datasets to be pooled (Chen et al., 2015b, Yan et al., 2017, Gu et al., 2018), which included 25,713 stroke patients in total. The pooled data of the RR of mortality after stroke in patients living in rural vs urban areas was 1.69 (1.15-2.48), p=0.007 (Figure 9-2). In the studies which measured SES in older people (Chen et al., 2015b and the 5-province cohort study), the corresponding figure was 1.60 (1.00-2.57), p=0.054.

Low and High Educational level

Five studies were analysed after adding in the 5-province cohort study (Zhou et al., 2006, Wu et al., 2014, Chen et al., 2015b, Pan et al., 2016), which included 91,542 stroke patients. In the pooled data, stroke patients with low educational level had a higher mortality than their counterparts with high educational level (pooled RR 1.48, 1.09-2.03; p=0.0131) (Figure 9-3). The pooled data for older people was 1.64 (1.01-2.66), p=0.047 (available data from Chen et al., (2015b) and the 5-province cohort study).

Low and High Occupational class

There were four studies after adding in the 5-province cohort study (Zhou et al., 2006, Chen et al., 2015b, Pan et al., 2016), comprising 13,353 stroke patients. There was no statistical significance in mortality among stroke patients with low versus high occupational class; the pooled RR was 1.60 (0.82-3.12), p=0.173 in manual workers versus non-manual workers (Figure 9-4). The corresponding figure for older people was 1.04 (0.66-1.62), p=0.877, which was pooled from Chen et al.'s (2015b) and the 5-province cohort studies.

Low and High Income

A total of five studies reported the association of personal income, after adding in the 5-province cohort study, comprising 13,496 stroke patients (Zhou et al., 2006, Sheng et al., 2010, Chen et al., 2015b, Pan et al., 2016). The pooled data of mortality in stroke patients with low versus high personal income was 1.77 (1.28-2.45), p=0.001 (Figure 9-5). Based on available data from Chen et al.'s (2015b) and the 5-province cohort studies, the pooled data in older people was 1.61 (1.00-2.61), p=0.052.

9.4 Discussion

This Chapter analysed the data of the 5-province cohort study to assess the increased mortality in older adults with stroke living in rural and urban communities in China. The findings suggested that patients with stroke had an approximately three times higher risk of death compared to those without stroke, which was higher than other studies in HICs (Kim and Lee, 2018, Razmara et al., 2017). In South Korea, Kim and Lee (Kim and Lee, 2018) examined the data from a population-based cohort of 22,792 participants aged ≥60 with 11 years follow-up and found the fully-adjusted HR for all-cause mortality in those with versus without stroke was 1.23 (1.17-1.30). A US cohort study of participants aged 65-74 with 10 years follow-up showed that compared to those without stroke, the HR for all-cause mortality was 1.64 (1.17-2.32) in stroke patients (Razmara et al., 2017). Apart from our 5-province study showing a stronger impact of stroke on all-cause mortality than those in HICs, other studies in China also demonstrated high mortality after stroke. Sai et al. (Sai et al., 2007) followed up a cohort of 1,268 participants aged ≥55 for 18 years in Xi'an, China and found that compared to those without stroke at baseline, stroke patients had a more than doubled risk of all-cause mortality (2.24, 1.24-4.02). Chen et al. (Chen et al., 2015b) carried out a cohort study of 2,978 participants aged ≥60 years with a median follow-up of 5.2 years in Anhui, China and observed that the risk of all-cause mortality in stroke patients was nearly doubled (multivariate adjusted HR 1.91, 1.45-2.52) in comparison to participants without stroke at baseline. The higher risk of mortality in China than those in HICs may reflect poorer therapy for stroke and more inequalities in health care.

The study in this Chapter mainly examined the data from the 5-province cohort study and pooled all data from previous identified studies to determine the associations between different indicators of SES and all-cause mortality after stroke in China. The 5-province cohort study showed that while the SES indicators of occupational class and self-reported satisfactory income were not associated with increased mortality, rural living, low education and low personal and family incomes increased mortality in patients with stroke, although all were not statistically significant due to small sample size. Pooled data from the 5-province cohort study and identified studies of the Chinese population showed that there were significant associations of rural living, low education and low actual income with increased risk of mortality in stroke patients.

The overall findings in this Chapter demonstrated that the SES inequality of survival in stroke patients was higher in China than in HICs. Studies undertaken in HICs showed a weak or insignificant association of SES with mortality after stroke. A large-scale population-based stroke registry study of 4,398 stroke patients in South London, UK, revealed that SES, which was measured by the Carstairs index score, was associated with mortality after stroke; compared to those with the highest sextile of Carstairs score, patients with the lowest sextile had a fully adjusted HR of 1.23 (1.05-1.44) for 3-month mortality and 1.13 (1.01-1.25) for 17-year mortality (Chen et al., 2014b). Studies from Australia and New Zealand using area-level SES showed that there was no association of SES with 30-day or 1-year case fatality (Heeley et al., 2011). In an Italian study of 10,033 stroke cases in patients aged 35-84 years old, there was no association of socioeconomic disparities with short-term or first-year mortality in either ischaemic or haemorrhagic stroke

(Cesaroni et al., 2009). These studies may reflect that in HICs there were less inequalities in stroke survival, while the inequality in China has increased alongside economic growth over the last four decades.

In the current study of pooling all available data, we have found that rural Chinese patients had over a 70% increase in mortality compared with their urban counterparts. In China, there were wide inequalities between rural and urban areas due to disparities in health service access and social health insurance schemes (Liu et al., 2007a, Gu et al., 2018, Gu et al., 2019). Liu et al. reported that stroke care had improved over time in urban areas, in terms of rates of admission to hospital and access to CT or MRI scans, but it remained poor in rural areas (Liu et al., 2007a). Also, Gu et al. reported that patients who were covered by rural insurance used fewer medications for stroke treatment and were not admitted to tertiary hospitals as much, which may be due to the lower insurance premiums and reimbursement rates in rural insurance (Gu et al., 2018, Gu et al., 2019). These factors may partly explain the disparity between urban and rural areas in the risk of mortality after stroke in China.

Our pooled data of Chinese population studies showed that stroke patients with low educational level were associated with increased risk of mortality. This association was also reported in other countries, including HICs. In Sweden, Lindmark et al. (Lindmark et al., 2014) examined the data of a Swedish stroke register with 62,497 stroke patients and found that the HR of case fatality at 29 days-1 year after stroke in patients with only primary school education was 1.25 (1.04-1.49), higher than those in patients with higher levels of education. In Brazil, the EMMA study of 655 stroke patients with 4-year follow-up revealed that the risk of mortality was 2-times higher among illiterate patients compared to those with ≥8 years schooling (HR 1.83, 1.26-2.68) (Goulart et al., 2013). The association of low education with increased mortality after stroke could be explained by secondary prevention and medication adherence. Previous studies showed that education was the strongest factor for the control of CVD risk factors such as hypertension, hypercholesterolemia and diabetes (Liu et al., 2011). The proportions of being unaware, untreated, and uncontrolled CVD risk factors were higher among stroke patients with low education (Liu et al., 2011). Due to a lack of knowledge about stroke and the reasons medication is needed, low educated patients also showed less adherence to medication at discharge (Chambers et al., 2011). These factors may result in higher mortality in stroke patients with low educational level.

China had no significant differences in mortality after stroke between non-manual and manual workers. This could reflect the fact that non-manual patients with stroke had a similarly high risk of mortality to that in manual workers. It may raise the point that participants who had relatively high occupational class did not have a lower level of CVD risk factors than their counterparts who were in low occupational class. Previous studies suggested that CVD risk factors increased as SES increased in LMICs (Wu et al., 2013, Rosengren et al., 2019). Patients with high occupational class may have high levels of unhealthy lifestyles and behaviours such as smoking (Wang et al., 2018), heavy alcohol drinking (Wu et al., 2008), and sedentary behaviour (Chen et al., 2015a). These factors may result in high mortality in stroke patients. Thus, reducing these factors across occupational classes of workers could help improve the rate of surviving after stroke in China.

Pooled RR in the current study showed that low income is a stronger predictor for increased mortality in patients with stroke in China than other indicators of SES. The association of low income with increased mortality in stroke patients is also observed in HICs (Kapral et al., 2012, Lindmark et al., 2014). In Canada, a population-based cohort study of 7,816 stroke patients showed that the risk of mortality was increased in those with low vs high income, with an HR of 1.18 (1.03-1.29) (Kapral et al., 2012). The data from the Swedish stroke register of 62,497 patients showed that in multivariate analysis, HR was increased in stroke patients with low income compared to those with high income (1.37, 1.19-1.56) (Lindmark et al., 2014). In China, there has been an increasing gap in income between the rich and poor along with economic development over the past four decades. Previous studies showed that poor financial status was the most frequently reported barrier to stroke treatment and care (Kapral et al., 2002, Pratt et al., 2003). Low income patients were less likely than those with high income to receive high-quality health care service. Furthermore, due to inadequate insurance coverage, they may struggle to afford high-cost medical treatment and long-term care for post-stroke after discharge. These may result in higher risk of death in stroke patients with low income.

9.5 Conclusions

The 5-province cohort data did not show significant associations of SES with mortality in older people with stroke, but when pooled with data from previous identified studies, showed a significant association of low SES with increased risk of mortality. Pooled data further showed that living in rural areas and having low levels of income and education have all played an important role in this association. To reduce socioeconomic inequality in mortality after stroke, healthcare policies targeting people in low SES groups are required to reduce inequalities in stroke treatment and care, particularly for those living in rural areas and with low income.

Table 9-1. Sociodemographic and characteristics of participants: the 5-province cohort study, China

Variable	All Participants N=4117		Stroke n=134	(%)	Non-stroke n=3983	(%)	P* value
Age (years)							
Mean (SD)	72.0	7.3	74.1	7.3	72.0	7.3	*0.001*
Sex							
Women	2274	55.2	69	51.5	2205	55.4	*0.376*
Men	1843	44.8	65	48.5	1778	44.6	
Province							
Guangdong	894	21.7	19	14.2	875	22.0	*0.004*
Shanghai	923	22.4	42	31.3	881	22.1	
Heilongjiang	451	11.0	23	17.2	428	10.7	
Shanxi	862	20.9	21	15.7	841	21.1	
Anhui	987	24.0	29	21.6	958	24.1	
Smoking							
Never-smoking	2566	62.3	84	62.7	2482	62.3	*0.310*
Ex-smoking	490	11.9	21	15.7	469	11.8	
Current-smoking	1038	25.2	29	21.6	1009	25.3	
Missing	23	0.6	0	0.0	23	0.6	
Alcohol drinking							
Never	3031	73.6	96	71.6	2935	73.7	*<0.001*
Ex-drink	357	8.7	24	17.9	333	8.4	
Current-drink	689	16.7	13	9.7	676	17.0	
Missing	40	1.0	1	0.7	39	1.0	
BMI (kg/m^2)							
Cut-off point							
<18.5	374	9.1	13	9.7	361	9.1	*0.742*
18.5-<24.0	2399	58.3	72	53.7	2327	58.4	
24.0-<28.0	1026	24.9	38	28.4	988	24.8	
≥28.0	318	7.7	11	8.2	307	7.7	
Socio-economic status							
Urban-rurality							
Urban	1708	41.5	72	53.7	1636	41.1	*0.003*
Rural	2409	58.5	62	46.3	2347	58.9	
Educational level							
≥High Secondary school	499	12.1	13	9.7	486	12.2	*0.061*
Secondary school	547	13.3	28	20.9	519	13.0	
Primary school	1093	26.5	35	26.1	1058	26.6	
Illiterate	1978	48.0	58	43.3	1920	48.2	
Main occupation							
Official/Teacher	536	13.0	25	18.7	511	12.8	*0.003*
Business/others	370	9.0	17	12.7	353	8.9	
Manual labourer	903	21.9	38	28.4	865	21.7	
Peasant	2308	56.1	54	40.3	2254	56.6	

Satisfactory income							
Very satisfactory	332	8.1	11	8.2	321	8.1	*0.445*
Satisfactory	1825	44.3	51	38.1	1774	44.5	
Average	1652	40.1	59	44.0	1593	40.0	
Poor	308	7.5	13	9.7	295	7.4	
Social network and support							
Marital status							
Married	3011	73.1	102	76.1	2909	73.0	*0.580*
Never married/Divorcees	111	2.7	2	1.5	109	2.7	
Widowed	994	24.1	30	22.4	964	24.2	
Missing	1	0.0	0	0.0	1	0.0	
Living with							
Somebody	3685	89.5	122	91.0	3563	89.5	*0.769*
Alone	425	10.3	12	9.0	413	10.4	
Missing	7	0.2	0	0.0	7	0.2	
Group touring							
No	3802	92.3	123	91.8	3679	92.4	*0.855*
Yes	296	7.2	9	6.7	287	7.2	
Missing	19	0.5	2	1.5	17	0.4	
Co-morbidities							
Hypertension							
No	2117	51.4	47	35.1	2070	52.0	*<0.001*
Yes	1865	45.3	83	61.9	1782	44.7	
Missing	135	3.3	4	3.0	131	3.3	
Hypercholesterolemia							
No	3973	96.5	119	88.8	3854	96.8	*<0.001*
Yes	133	3.2	14	10.4	119	3.0	
Missing	11	0.3	1	0.7	10	0.3	
Heart disease							
No	3511	85.3	96	71.6	3415	85.7	*<0.001*
Yes	541	13.1	34	25.4	507	12.7	
Missing	65	1.6	4	3.0	61	1.5	
Angina							
No	3885	94.4	119	88.8	3766	94.6	*0.007*
Yes	199	4.8	13	9.7	186	4.7	
Missing	33	0.8	2	1.5	31	0.8	
Diabetes							
No	3863	93.8	113	84.3	3750	94.2	*<0.001*
Yes	226	5.5	17	12.7	209	5.2	
Missing	28	0.7	4	3.0	24	0.6	
GMS-AGECAT diagnosis							
"Well"	2990	72.6	84	62.7	2906	73.0	*<0.001*
Depression-subcase	125	3.0	6	4.5	119	3.0	
Depression-case	178	4.3	18	13.4	160	4.0	
Dementia-subcase	415	10.1	8	6.0	407	10.2	

Dementia-case	403	9.8	17	12.7	386	9.7
Missing	6	0.1	1	0.7	5	0.1

*P-value in the Chi-square test was calculated based on available data, not including those “missing” data.

Table 9-2. Numbers of deaths and adjusted hazard ratio for all-cause mortality of stroke among older adults in China: the 5-province cohort study

Stroke	Nos of Deaths/participants (%)	Person-years	Mortality rate*	HR[1]† 95% CI	P-value	HR[2]† 95% CI	P-value	HR[3]† 95 CI	P-value
No	294/3983 (7.4)	11960.7	24.6	1.00		1.00		1.00	
Yes	31/134 (23.1)	359.1	86.3	3.11 2.15-4.51	<0.001	3.33 2.28-4.86	<0.001	2.99 2.03-4.39	<0.001
Total	325/4117 (7.9)	12319.8	26.4						

*Mortality rate per 1000 person-years.
†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.
HR[1]: adjusted for age (cont.) and sex;
HR[2]: adjusted for age (cont.), sex, province, BMI, smoke, drinking, marital status, urban-rural, educational level, occupational class, and satisfactory income;
HR[3]: adjusted for age (cont.), sex, province, BMI, smoke, drinking, marital status, urban-rural, educational level, occupational class, and satisfactory income, hypertension, hypercholesterolemia, heart disease, diabetes, depression, and dementia.

Table 9-3. Number of deaths and adjusted hazard ratio for urban-rural living among patients with stroke: the 5-province cohort study, China

Urban-Rural Variable	Stroke	Nos of Deaths/participants (%)	Person-years	Mortality rate*	HR[1]† 95% CI	P-value	HR[2]† 95% CI	P-value	HR[3]† 95% CI	P-value
Urban	**Yes**	15/72 (20.8)	194.1	77.3	1.00		1.00		1.00	
Rural	**Yes**	16/62 (25.8)	165.0	97.0	2.46 1.12-5.43	0.026	2.26 0.86-5.99	0.100	1.98 0.70-5.59	0.198
Total		31/134 (23.1)	359.1	86.3						

*Mortality rate per 1000 person-years.
†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.
HR[1]: adjusted for age (cont.) and sex;
HR[2]: adjusted for age (cont.), sex, province, BMI, smoke, drinking, marital status, and educational level;
HR[3]: adjusted for age (cont.), sex, province, BMI, smoke, drinking, marital status, educational level, hypertension, hypercholesterolemia, heart disease, diabetes, depression, and dementia.

Table 9-4. Number of deaths and adjusted hazard ratio for educational level among patients with stroke: the 5-province cohort study, China

Educational Variable	**Stroke**	Nos of Deaths/participants (%)	Person-years	Mortality rate*	HR[1]† 95% CI	P-value	HR[2]† 95% CI	P-value	HR[3]† 95% CI	P-value
Non-illiterate	**Yes**	15/76 (19.7)	205.0	73.2	1.00		1.00		1.00	
Illiterate	**Yes**	16/58 (27.6)	154.1	103.8	1.55 0.70-3.45	0.279	1.31 0.57-2.99	0.528	1.19 0.49-2.87	0.707
Total		31/134 (23.1)	359.1	86.3						

*Mortality rate per 1000 person-years.
†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.
HR[1]: adjusted for age (cont.) and sex;
HR[2]: adjusted for age (cont.), sex, province, BMI, smoke, drinking, marital status, and urban-rurality;
HR[3]: adjusted for age (cont.), sex, province, BMI, smoke, drinking, marital status, urban-rurality, hypertension, hypercholesterolemia, heart disease, diabetes, depression, and dementia.

Table 9-5. Number of deaths and adjusted hazard ratio for occupational class among patients with stroke: the 5-province cohort study, China

Occupational Variable	Stroke	Nos of Deaths/participants (%)	Person-years	Mortality rate*	HR[1]† 95% CI	P-value	HR[2]† 95% CI	P-value	HR[3]† 95% CI	P-value
Non-manual	**Yes**	12/47 (25.5)	122.8	97.7	1.00		1.00		1.00	
Manual	**Yes**	19/87 (21.8)	236.3	80.4	0.85 0.41-1.78	0.669	0.70 0.30-1.59	0.390	0.63 0.28-1.45	0.281
Total		31/134 (23.1)	359.1	86.3						

*Mortality rate per 1000 person-years.
†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.
HR[1]: adjusted for age (cont.) and sex;
HR[2]: adjusted for age (cont.), sex, province, BMI, smoke, drinking, marital status, urban-rurality, and educational level;
HR[3]: adjusted for age (cont.), sex, province, BMI, smoke, drinking, marital status, urban-rurality, educational level, hypertension, hypercholesterolemia, heart disease, diabetes, depression, and dementia.

Table 9-6. Number of deaths and adjusted hazard ratio for satisfactory income among patients with stroke: the 5-province cohort study, China

Satisfactory Income Variable	**Stroke**	Nos of Deaths/participants (%)	Person-years	Mortality rate*	HR[1]† 95% CI	P-value	HR[2]† 95% CI	P-value	HR[3]† 95% CI	P-value
>Average	**Yes**	14/62 (22.6)	164.3	85.2	1.00		1.00		1.00	
≤Average	**Yes**	17/72 (23.6)	194.8	87.3	1.14 0.56-2.33	0.715	0.94 0.42-2.10	0.883	0.81 0.36-1.84	0.616
Total		31/134 (23.1)	359.1	86.3						

*Mortality rate per 1000 person-years.
†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.
HR[1]: adjusted for age (cont.) and sex;
HR[2]: adjusted for age (cont.), sex, province, BMI, smoke, drinking, marital status, urban-rurality, and educational level;
HR[3]: adjusted for age (cont.), sex, province, BMI, smoke, drinking, marital status, urban-rurality, educational level, hypertension, hypercholesterolemia, heart disease, diabetes, depression, and dementia.

Table 9-7. Number of deaths and adjusted hazard ratio for personal income among patients with stroke: the 5-province cohort study, China

Personal Income Variable	**Stroke**	Nos of Deaths/particip ants (%)	Person-years	Mortality rate*	HR^1† 95% CI	P-value	HR^2† 95% CI	P-value	HR^3† 95% CI	P-value
≥8000	**Yes**	13/68 (19.1)	186.1	69.9	1.00		1.00		1.00	
<8000	**Yes**	15/50 (30.0)	131.4	114.2	2.31 1.08-4.91	0.030	1.83 0.64-5.23	0.262	1.47 0.44-4.87	0.531
Total		28/118 (23.7)	317.5	88.2						

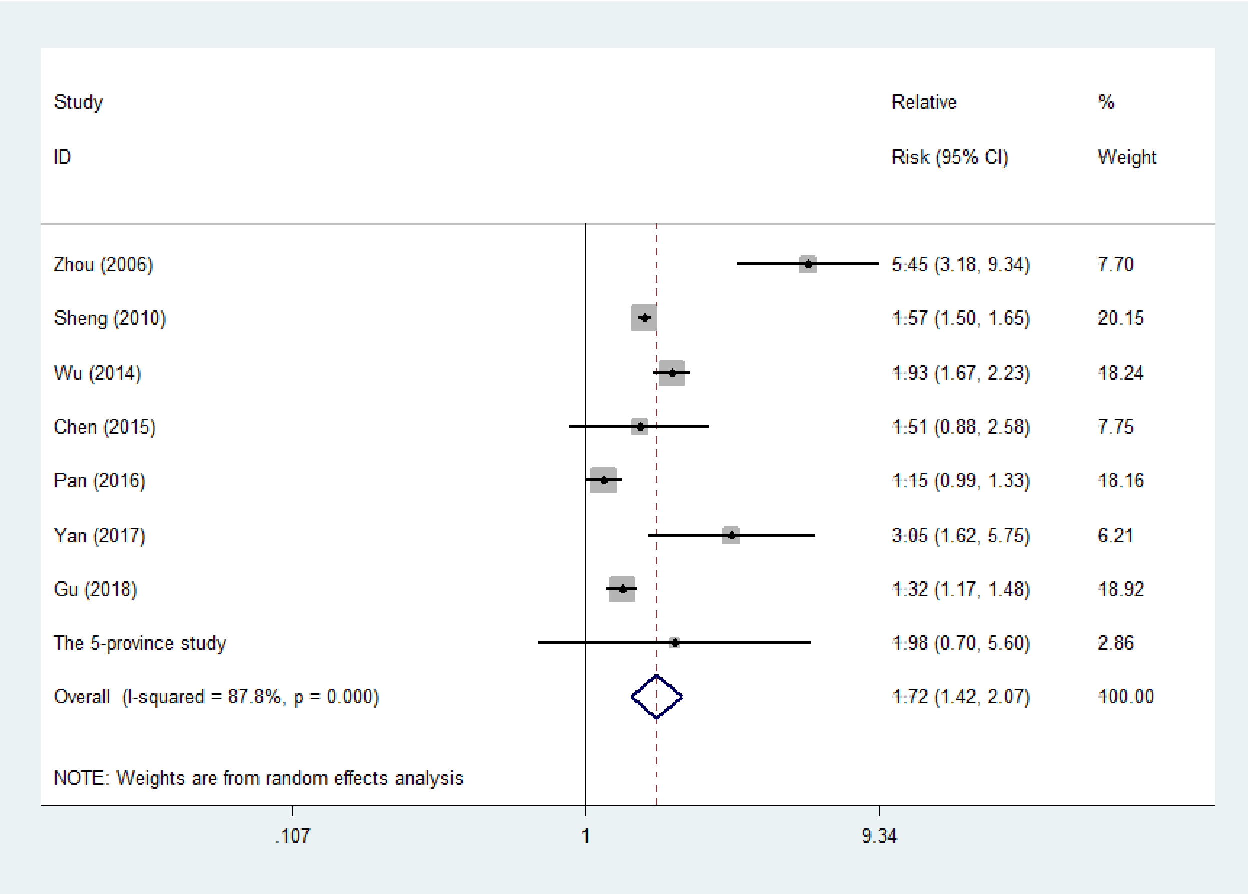
*Mortality rate per 1000 person-years.
†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.
HR^1: adjusted for age (cont.) and sex;
HR^2: adjusted for age (cont.), sex, province, BMI, smoke, drinking, marital status, urban-rurality, and educational level;
HR^3: adjusted for age (cont.), sex, province, BMI, smoke, drinking, marital status, urban-rurality, educational level, hypertension, hypercholesterolemia, heart disease, diabetes, depression, and dementia.

Table 9-8. Number of deaths and adjusted hazard ratio for family income among patients with stroke: the 5-province cohort study, China

Family Income Variable	Stroke	Nos of Deaths/participants (%)	Person-years	Mortality rate*	HR[1]† 95% CI	P-value	HR[2]† 95% CI	P-value	HR[3]† 95% CI	P-value
≥10000	**Yes**	13/67 (19.4)	189.5	68.6	1.00		1.00		1.00	
<10000	**Yes**	11/38 (28.9)	91.4	120.4	4.17 1.63-10.63	0.003	5.67 0.98-32.77	0.053	6.25 0.86-45.44	0.070
Total		24/105	280.9	189.0						

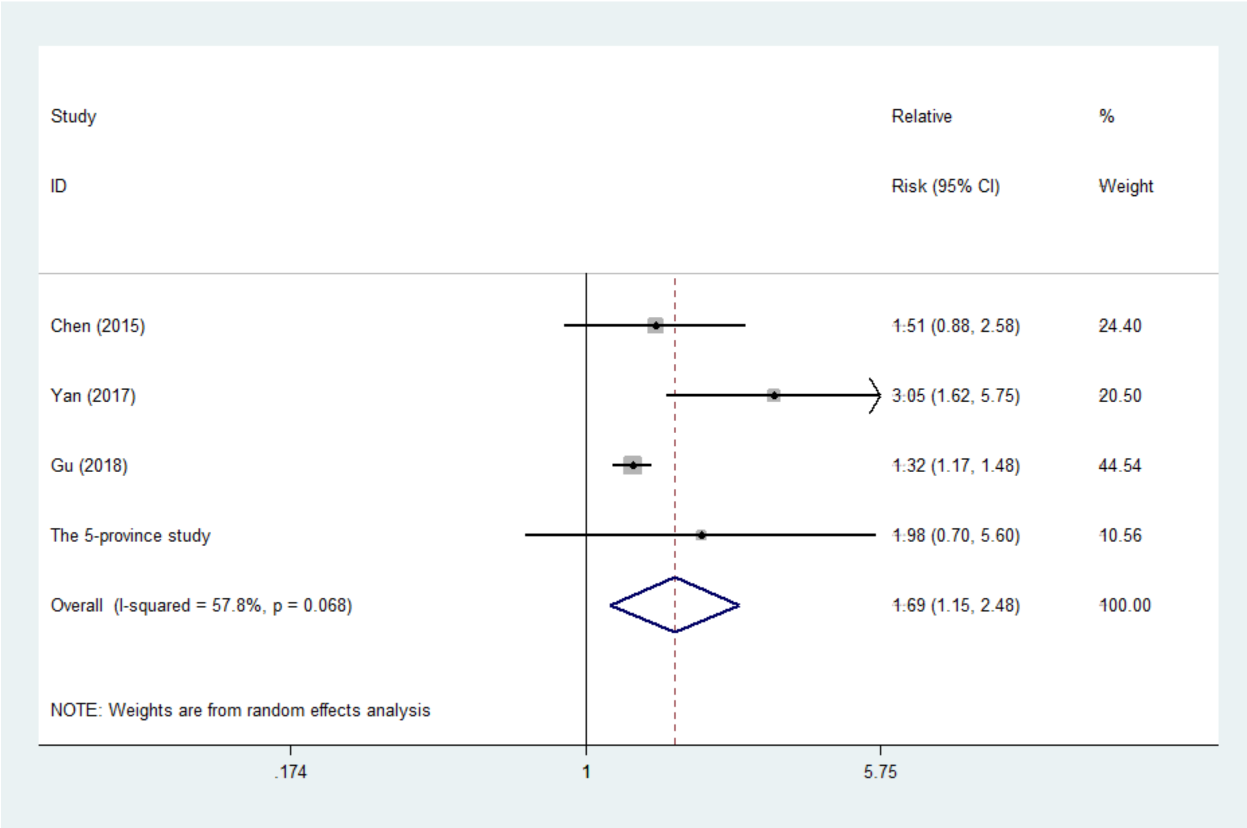
*Mortality rate per 1000 person-years.
†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.
HR[1]: adjusted for age (cont.) and sex;
HR[2]: adjusted for age (cont.), sex, province, BMI, smoke, drinking, marital status, urban-rurality, and educational level;
HR[3]: adjusted for age (cont.), sex, province, BMI, smoke, drinking, marital status, urban-rurality, educational level, hypertension, hypercholesterolemia, heart disease, diabetes, depression, and dementia.

Figure 9-1. Forest plot for the pooled relative risk (RR) of SES with all-cause mortality after stroke



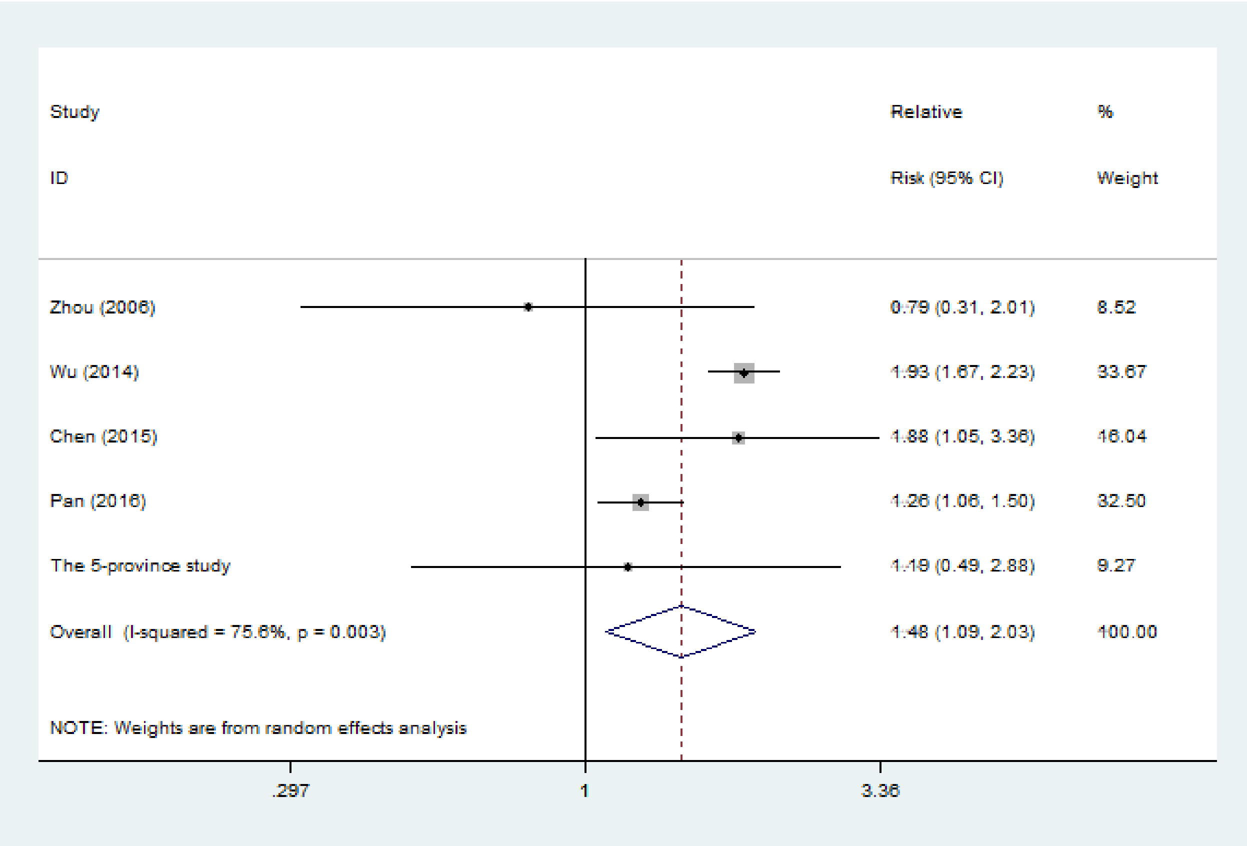
The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

Figure 9-2. Forest plot for the pooled relative risk (RR) of rural living with all-cause mortality after stroke



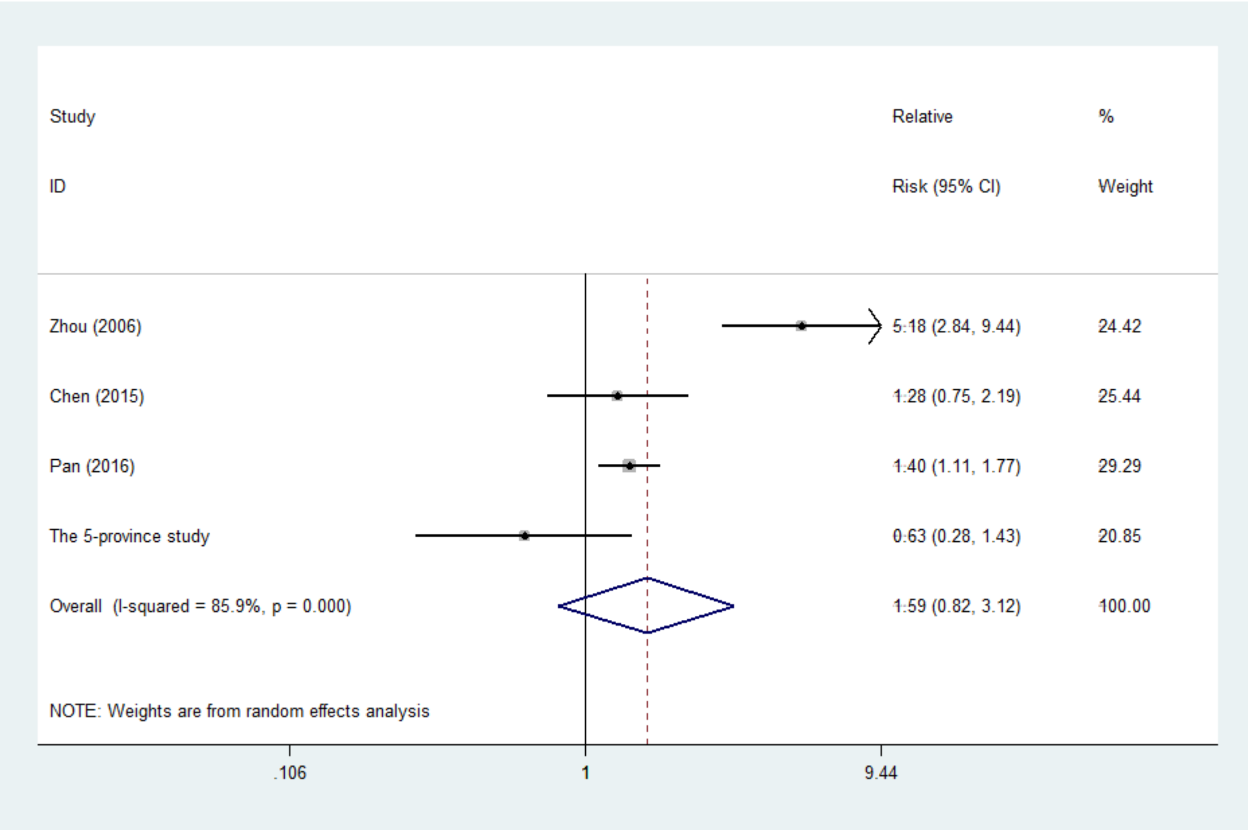
The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

Figure 9-3. Forest plot for the pooled relative risk (RR) of low educational level with all-cause mortality after stroke



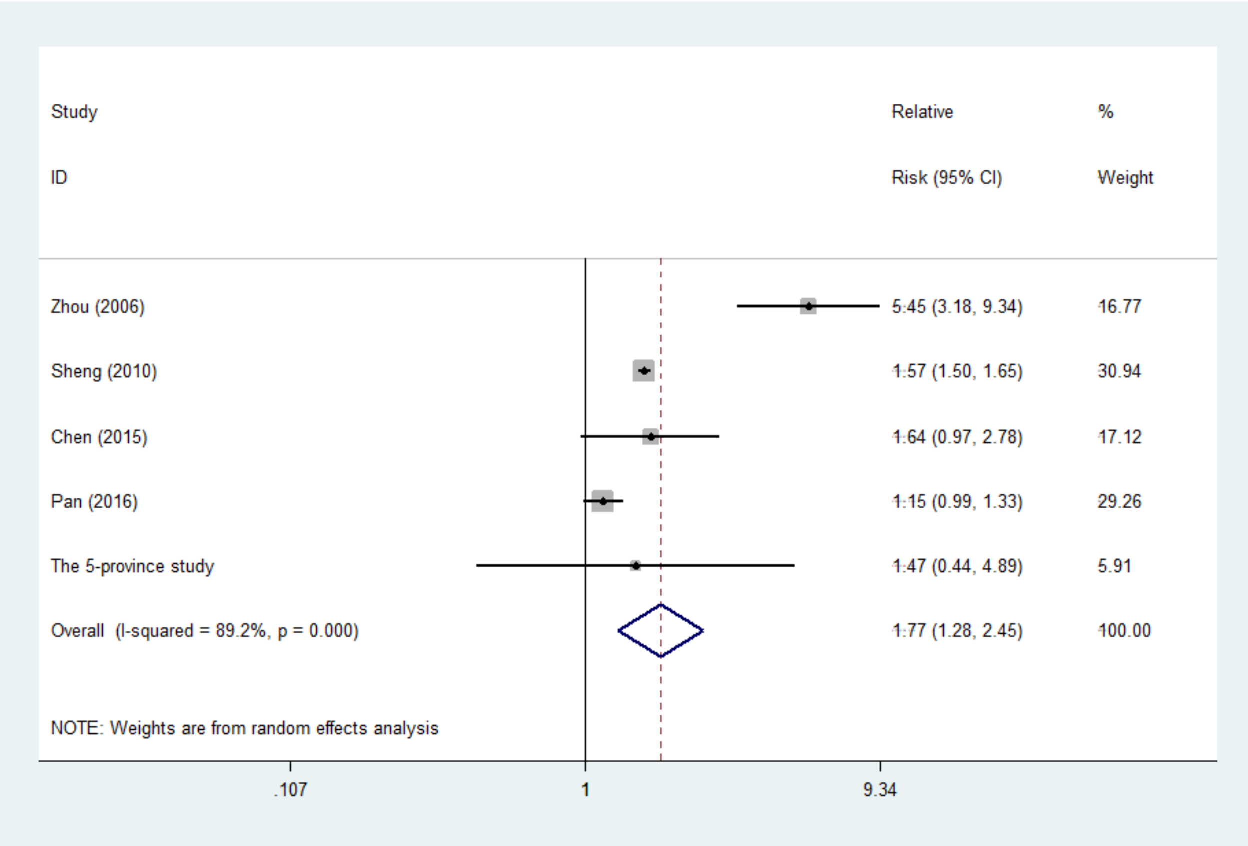
The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

Figure 9-4. Forest plot for the pooled relative risk (RR) of low occupational class with all-cause mortality after stroke



The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

Figure 9-5. Forest plot for the pooled relative risk (RR) of low income with all-cause mortality after stroke



The study-specific RR and 95% CI are represented by the black diamond and the horizontal line, respectively; the area of the grey square is proportional to the specific-study weight to the overall meta-analysis. The centre of the open diamond and the vertical dashed line represent the pooled RR and the width of the open diamond represents the pooled 95% CI.

CHAPTER TEN: IMPACTS OF SOCIOECONOMIC STATUS ON ALL-CAUSE MORTALITY IN THOSE WITH EITHER HEART DISEASE OR STROKE AND THOSE WITH NEITHER: THE ANHUI COHORT AND THE FOUR-PROVINCE COHORT STUDIES

10.1 Introduction

Cardiovascular diseases (CVDs) are the leading cause of death from chronic disease globally, taking an estimated 17.9 million lives each year, representing 31% of all global deaths (WHO, 2017). Evidence showed that over three quarters of global deaths due to CVD took place in low- and middle-income countries (LMICs) (Bovet and Paccaud, 2011). CVDs are mainly a group of disorders of the heart and vessels and include coronary heart disease (CHD), cerebrovascular disease, rheumatic heart disease and other conditions. According to WHO (2017) estimates, four out of five CVD deaths are due to heart disease (HD) and stroke. Previous studies in LMICs showed that older people with low socioeconomic status (SES) had increased all-cause mortality, particularly in those who had HD or stroke (Ferri et al., 2012) . Literature on the impact of SES on all-cause mortality has been predominantly derived from high income countries (HICs), which may not be applicable to those in LMICs. Fewer studies have been conducted in LMICs to assess the impact of SES on all-cause mortality.

China is the largest LMIC. Due to lifestyle changes, urbanisation, and accelerate population ageing, the burden of CVD has increased, particularly HD and stroke. It was reported that there were approximately 2.4 million deaths from CHD and ischaemic stroke in 2016, representing more than 61% of deaths from CVD and 25% of all deaths (Zhao et al., 2018). Over the past four decades, China has experienced rapid economic development, along with an increasing gap in income between rich and poor (Sicular et al., 2007). However, it is not known whether socioeconomic inequalities are associated with increased mortality in older people who had either HD or stroke, in comparison to those who are free of HD and stroke.

Previous studies showed some inconsistent findings of the association between SES and all-cause mortality (Ferri et al., 2012, Toch-Marquardt et al., 2014, Tanaka et al., 2019). Few studies have assessed the impacts of different SES indicators on mortality simultaneously. Few studies have investigated the differences in the impact between older people who had either HD or stroke and those who had neither condition. In this Chapter, I examine data from two community-based cohort studies in China to assess the impact of multiple measurements of SES on all-cause mortality in older people who had either HD or stroke and their counterparts who were free of HD and stroke at baseline.

10.2 Methods

Studied populations were derived from the Anhui cohort study and the Four-province cohort study in China. The methods of the baseline investigation and the follow-up of the studies have been fully described in Chapter 3.4.

10.2.1 Data analysis

In the Anhui cohort study, the data from 2,978 cohort members were analysed after excluding 358 participants who were lost to follow-up. In the Four-province cohort study, the data from 3,121 cohort members were analysed, after excluding 1,163 participants who were lost to follow-up and 30 who had no SES indicator measured.

Multivariate adjusted Cox regression models were employed to examine the risk of all-cause mortality in relation to each of SES indicators in the two cohorts respectively. The hazard ratio (HR) and its 95% confidence intervals (CIs) were calculated for all-cause mortality. Apart from examining the effect of SES on all-cause mortality in the participants, the impacts in these who had either HD or stroke and those who had neither condition were assessed separately. In order to increase the study power, the findings from the Anhui cohort study and the Four-province cohort study were pooled to examine the impacts of SES on mortality in those who had either HD or stroke and those who had neither condition.

10.3 Results

10.3.1 Mortality in Anhui cohort study

Of 2,978 participants, the average age was 71.8 years (SD 6.9), 51.9% were women, and 48.0% lived in rural areas. Compared with survivors, deaths were more likely to be older, be men, be current smokers, be underweight, live in rural areas, have low levels of education, occupation, and satisfactory income, have financial problems, be never married/divorcees, have stroke, and have high levels of depression and dementia, but were less likely to visit children or other relatives frequently, participate in group tours or community activities, and have hypercholesterolemia (Table 10-1).

During the median follow-up of 7.1 years, 671 deaths were documented. Table 10-2 shows numbers, mortality rate, and adjusted HRs of all-cause mortality in participants living in urban and rural areas. Participants living in rural areas had a higher risk of mortality (44.2 per 1000 person-years) than those living in urban areas (26.9 per 1000 person-years). Age-sex adjusted HR of mortality in participants living in rural areas was 1.66 (1.42-1.93) (Table 10-2). Further adjustment for BMI, smoking, drinking, educational level, marriage status, frequency of visiting children or other relatives, walking or group touring would slightly increase the HR to 1.80 (1.38-2.34), while in the full adjustment including hypertension, hypercholesterolemia, HD, stroke, diabetes, depression, and dementia, the HR was not substantially changed (1.83, 1.40-2.39) (Table 10-2). Separate data analysis for participants with either HD or stroke showed a fully adjusted HR of 2.34 (1.34-4.09) (Table 10-4) and for participants with neither HD nor stroke 1.74 (1.28-2.36) (Table 10-5).

Table 10-3 shows numbers, mortality rate, and adjusted HRs of all-cause mortality in participants with low versus high SES. There were no significant associations of education, satisfactory income, and financial problems with all-cause mortality, except for participants with low occupational class associated with increased mortality (the fully adjusted HR 1.33, 1.04-1.70) (Table 10-3). Separate data analysis in older people with either HD or stroke and those with neither showed that there were significantly increased risks of mortality in those who had HD or stroke with low occupational class (1.64, 1.03-2.62) and with financial problems (2.16, 1.11-4.18) (Table 10-4), while there were no associations of SES with mortality in those who were free of these diseases (Table 10-5).

10.3.2 Mortality in Four-province cohort study

Of 3,121 participants, the average age was 71.1 years (SD 7.3), and 55.2% lived in rural areas. Over 3.1 years follow-up, 255 deaths were documented. Participants who died in comparison to surviving cohort members, were more likely to be older, be men, be underweight, have low educational level, be widowed, have stroke and high level of dementia, but were less likely to visit children or other relatives frequently, be helped when needed, and participate in group tours or community activities (Table 10-6).

Table 10-7 shows numbers, mortality rate, and adjusted HRs of all-cause mortality in participants living in urban and rural areas. Compared with those living in urban areas, fully-adjusted HR of all-cause mortality in participants in rural areas was 0.89 (0.65-1.21) (Table 7). There were no significant associations of education, occupational class, satisfactory income, and financial problems with all-cause mortality (Table 10-8). Separate data analysis showed similar HRs between participants who have either HD or stroke and those who had neither condition in educational level, occupational class, and financial problems (Table 10-9), except for in those who had neither HD nor stroke low satisfaction of income associated with excess mortality at borderline significant (1.34, 1.00-1.79), p=0.054 (Table 10-10).

Table 10-11 shows numbers, mortality rate, and adjusted HRs of all-cause mortality in participants with low and high levels of personal and family incomes. There were no significant associations of personal or family incomes with mortality (Table 10-11), as did these who had either HD or stroke (Table 10-12) and those who had neither (Table 10-13).

10.3.3 Pooled data from the Anhui cohort and the Four-province cohort studies

Table 10-14 shows pooled data of HRs of mortality in people with low SES from the two cohorts. Pooled data for those who had either HD or stroke living in rural areas showed significantly increased risk of mortality (2.01, 1.26-3.20). Pooled HRs for those who had neither HD nor stroke were not significant in mortality associated with any SES indicators.

10.4 Discussion

The two community-based cohort studies investigated the associations of different measurements of SES with all-cause mortality, and their associations in those who had either HD or stroke and in those who had neither condition in China. The Anhui cohort study demonstrated that rural living was a main resource of inequality in mortality; people with low occupational class had increased mortality, mainly in those with HD or stroke, as did HD or stroke patients with financial problems. The Four-province cohort study did not show these associations, but when pooled with data from the Anhui cohort study, showed a significant association of rural living with increased mortality in people with HD or stroke.

In the Anhui cohort study, it was found that low level of occupational class was associated with increased risk of mortality in the general population. The association of low occupational class with increased mortality has been well studied previously (Rostad et al., 2009, Toch-Marquardt et al., 2014). A meta-analysis of 12,373 participants aged ≥65 years with 3-5 years follow-up in Latin America, India, and China showed that the per level of decrease in occupational attainment (four levels; professional versus clerical or trade, skilled or semiskilled manual worker, and unskilled labourer) was associated with increased mortality, with the pooled HR of 1.05 (1.00-1.11) in the fully adjusted model (Ferri et al., 2012). Low occupational class (manual labourer/peasant) associated with increase mortality might be attributed to exposure to occupational health hazards more frequent in manual jobs.

Our findings of the Anhui cohort study further showed that association between low occupation class and excess mortality was mainly explained by participants with either HD or stroke. The differential effect of low occupational class on mortality between those who had either HD or stroke and those who had neither condition has not been directly investigated previously in a prospective cohort study, but a large amount of evidence indicated that low occupational class was associated with increased mortality after HD and stroke (Arrich et al., 2005, Zhou et al., 2006, Addo et al., 2012, Pan et al., 2016). In further, low occupational class was associated with increased mortality from HD or stroke in the general population (Kunst et al., 1999, Emberson et al., 2004, Lazzarino et al., 2013). In the UK, data from 66,500 participants who were free of CVDs at baseline with a median follow-up time of 7.9 years showed that the multivariate adjusted HR for one-category increase in low occupational class (three categories in total; semiroutine/unskilled workers and skilled manual/nonmanual workers versus professional/managerial positions) were 1.18 for CHD-death (1.07-1.30) and 1.15 for stroke-death (1.00-1.31) (Lazzarino et al., 2013).

Our Anhui cohort data showed that rural living was associated with increased mortality, and when pooled with the Four-province cohort data remained a significant association in those who had HD or stroke. Existing literature on the impact of rural-urban disparity on mortality after HD or stroke was limited in HICs, but this impact has been well studied previously in China (Xiang et al., 2018, Gu et al., 2018). For example, data from the China National Stroke Registry II (CNSR II) of 24,941 stroke patients showed that compared to those with urban insurance, the fully-adjusted HR of 1-year mortality was increased in those with rural insurance (1.32, 1.17-1.48) (Gu et al., 2018).

Data of the Anhui cohort study showed that having financial problems was associated with increased mortality in participants with either HD or stroke. This association was consistent with previous studies in HICs (Elfassy et al., 2019). A US cohort of 3,937 black and white participants aged 23-35 years with 10-year follow-up showed that higher income volatility and more income drops were associated with greater CVD risk (high vs low volatility HR 2.07, 1.10-3.90; ≥2 versus 0 income drops: HR 2.54, 1.24-5.19) and all-cause mortality (high vs low volatility HR 1.78, 1.03-3.09; ≥2 vs 0 income drops: HR 1.92, 1.07-3.44) (Elfassy et al., 2019).

The current study did not find a significant association of educational level and satisfactory/actual income with mortality. Education affects behaviour, lifestyle, and social networks, while income is associated with material resources or a material standard of living. These indicators were important predictors for mortality after HD and stroke in HICs (Huisman et al., 2005, Lindmark et al., 2014, Kelli et al., 2019). Nevertheless, educational level and income could be good for examining the impact of mortality in those with mental disorders such as depression and dementia (Chen et al., 2014a).

In the current study, several SES indicators (e.g., urban-rural living, occupational class, financial problems) were associated with increased mortality in the Anhui cohort, but none was found in the Four-province cohort. This might be because the Anhui cohort was followed up over 10 years and thus the number of deaths was big enough to increase study power, while in the Four-province cohort, due to short term follow-up (around 4 years), a small number of deaths were difficult to reach statistical significance in relation to SES. For example, in the Four-province cohort, the HR of 1.48 (0.50-4.37) for low personal income in participants with

HD or stroke would be statistically significant if having large sample size. In addition, the baseline investigation in the Anhui cohort study was started in 2001, which was 5-7 years earlier than that in the Four-province cohort study. In this period, SES inequalities might be reduced due to rapid economic development and social welfare improvement, particularly rural-urban inequality, and thus the impact of SES disparity was not significant on mortality. Nevertheless, more studies are needed to investigate the associations of SES with mortality in the whole of the Chinese population using long-term cohorts with the latest data.

10.5 Conclusions

This Chapter demonstrated SES inequality in all-cause mortality in older people, mainly in those who had either HD or stroke. The Anhui cohort study showed that rural living was a main resource of inequality in mortality; low occupational class and financial problems were associated with increased mortality in those with HD or stroke. The Four-province cohort study did not show an association of SES with mortality in those with HD or stroke and those with neither, but in pooled data, older people living in rural areas with HD or stroke had increased risk of mortality, which was consistent with the results in Chapters Seven and Nine. General socioeconomic improvement and targeting groups at high risk of mortality, particularly those who had HD or stroke associated with rural living, low occupational class, and having financial problems, would be helpful to reduce inequality in survival in older Chinese. Nevertheless, more studies are needed to investigate the associations between SES and mortality using large-scale cohorts with long-term follow-up time.

Table 10-1. Sociodemographic and characteristics of participants in the Anhui cohort study, China

Variables	All Participants N=2978		Death n=671	(%)	Survival n=2307	(%)	P* value
Demographic factors							
Age (years)							
Mean (SD)	71.8	6.9	74.0	8.1	71.2	6.3	<0.001
Sex							
Women	1546	51.9	300	44.7	1246	54.0	*<0.001*
Men	1432	48.1	371	55.3	1061	46.0	
Smoking							
Never-smoking	1506	50.6	278	41.4	1228	53.2	*0.001*
Ex-smoking	182	6.1	43	6.4	139	6.0	
Current-smoking	801	26.9	200	29.8	601	26.1	
Missing	489	16.4	150	22.4	339	14.7	
Alcohol drinking							
No	2416	81.1	549	81.8	1867	80.9	*0.604*
Yes	562	18.9	122	18.2	440	19.1	
BMI (kg/m^2)							
Cut-off point							
<18.5	411	13.8	158	23.5	253	11.0	*<0.001*
18.5-<24.0	947	31.8	208	31.0	739	32.0	
24.0-<28.0	966	32.4	178	26.5	788	34.2	
≥28.0	654	22.0	127	18.9	527	22.8	
Socio-economic status							
Urban-rurality							
Urban	1549	52.0	286	42.6	1263	54.7	*<0.001*
Rural	1429	48.0	385	57.4	1044	45.3	
Educational level							
≥High Secondary school	692	23.2	99	14.8	593	25.7	*<0.001*
Secondary school	403	13.5	79	11.8	324	14.0	
Primary school	370	12.4	83	12.4	287	12.4	
Illiterate	1513	50.8	410	61.1	1103	47.8	
Main occupation							
Official/Teacher	929	31.2	149	22.2	780	33.8	*<0.001*
Business/Other	242	8.1	54	8.0	188	8.1	
Manual labourer	400	13.4	97	14.5	303	13.1	
Peasant	1407	47.2	371	55.3	1036	44.9	
Satisfactory income							
Very satisfactory	305	10.2	55	8.2	250	10.8	*<0.001*
Satisfactory	1442	48.4	285	42.5	1157	50.2	
Average	967	32.5	234	34.9	733	31.8	
Poor	264	8.9	97	14.5	167	7.2	
Financial problems in the past two years							
No	1616	54.3	309	46.1	1307	56.7	*<0.001*
Yes	1362	45.7	362	53.9	1000	43.3	

Social network and support							
Marital status							
Married	2162	72.6	429	63.9	1733	75.1	*<0.001*
Never married/Divorcees	121	4.1	43	6.4	78	3.4	
Widowed	695	23.3	199	29.7	496	21.5	
Frequency of visiting children or other relatives							
More than yearly or never	105	3.5	36	5.4	69	3.0	*0.004*
At least Monthly or less often	356	12.0	76	11.3	280	12.1	
At least weekly	794	26.7	156	23.2	638	27.7	
Everyday	1723	57.9	403	60.1	1320	57.2	
Help available when needed							
No	186	6.2	52	7.7	134	5.8	*0.067*
Yes	2792	93.8	619	92.3	2173	94.2	
Walking or group touring							
Yes	1730	58.1	314	46.8	1416	61.4	*<0.001*
No	1248	41.9	357	53.2	891	38.6	
Participating community activities							
Yes	1579	53.	327	48.7	1252	54.3	*0.011*
No	1399	47.0	344	51.3	1055	45.7	
Co-morbidities							
Hypertension							
No	1240	41.6	261	38.9	979	42.4	*0.102*
Yes	1738	58.4	410	61.1	1328	57.6	
Hypercholesterolemia							
No	2744	92.1	633	94.3	2111	91.5	*0.003*
Yes	210	7.1	30	4.5	180	7.8	
Missing	24	0.8	8	1.2	16	0.7	
Heart disease							
No	2526	84.8	569	84.8	1957	84.8	*0.861*
Yes	438	14.7	97	14.5	341	14.8	
Missing	14	0.5	5	0.7	9	0.4	
Stroke							
No	2846	95.6	611	91.1	2235	96.9	*<0.001*
Yes	126	4.2	59	8.8	67	2.9	
Missing	6	0.2	1	0.1	5	0.2	
Diabetes							
No	2800	94.0	627	93.4	2173	94.2	*0.357*
Yes	169	5.7	43	6.4	126	5.5	
Missing	9	0.3	1	0.1	8	0.3	
Depression							
No	2746	92.2	593	88.4	2153	93.3	*<0.001*

Depression-subcase	104	3.5	34	5.1	70	3.0	
Depression-case	128	4.3	44	6.6	84	3.6	
Dementia							
No	2448	82.2	510	76.0	1938	84.0	*<0.001*
Dementia-subcase	307	10.3	66	9.8	241	10.4	
Dementia-case	223	7.5	95	14.2	128	5.5	

*P-value in the Chi-square test was calculated based on available data, not including those "missing" data.

Table 10-2. Numbers of deaths, mortality rate, and adjusted HR for all-cause mortality in older adults from urban and rural areas in China: the Anhui cohort study

Urban-rural SES variable	Numbers of Deaths/participants (%)	Person-years	Mortality rate*	HR^1† 95% CI	P-value	HR^2† 95% CI	P-value	HR^3† 95% CI	P-value
Urban	286/1549 (18.5)	10613.4	26.9	1.00		1.00		1.00	
Rural	385/1429 (26.9)	8715.7	44.2	1.66 1.42-1.93	<0.001	1.80 1.38-2.34	<0.001	1.83 1.40-2.39	<0.001
Total	671/2978 (22.5)	19329.1	34.7						

*Mortality rate per 1000 person-years.

†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.

HR^1: adjusted for age and sex;

HR^2: adjusted for age, sex, BMI, smoke, drinking, educational level, marriage status, frequency of visiting children or other relatives, walking or group touring;

HR^3: adjusted for age, sex, BMI, smoke, drinking, educational level, marriage status, frequency of visiting children or other relatives, walking or group touring, hypertension, hypercholesterolemia, heart disease, stroke, diabetes, depression, and dementia.

Table 10-3. Numbers of deaths and adjusted HR for all-cause mortality in older adults with low and high SES in China: the Anhui cohort study

SES Variables	Nos of Deaths/participants (%)	Person-years	Mortality rate*	HR[1]† 95% CI	P-value	HR[2]† 95% CI	P-value	HR[3]† 95% CI	P-value
Educational level									
Non-illiterate	261/1465 (17.8)	10046.6	26.0	1.00		1.00		1.00	
Illiterate	410/1513 (27.1)	9282.5	44.2	1.72 1.47-2.02	<0.001	1.24 0.99-1.54	0.063	1.14 0.91-1.43	0.242
Occupational class									
Non-manual	203/1171 (17.3)	8115.8	25.0	1.00		1.00		1.00	
Manual	468/1807 (25.9)	11213.3	41.7	1.74 1.47-2.05	<0.001	1.31 1.03-1.68	0.031	1.33 1.04-1.70	0.025
Satisfactory income									
>Average	340/1747 (19.5)	11794.9	28.8	1.00		1.00		1.00	
≤Average	331/1231 (26.9)	7534.2	43.9	1.52 1.31-1.77	<0.001	1.03 0.86-1.24	0.725	0.98 0.82-1.17	0.806
Financial problems in the past two years									
No	309/1616 (19.1)	10988.7	28.1	1.00		1.00		1.00	
Yes	362/1362 (26.6)	8340.4	43.4	1.53 1.31-1.78	<0.001	0.85 0.64-1.15	0.297	0.93 0.70-1.24	0.621

Total	671/2978 (22.5)	19329.1	34.7

*Mortality rate per 1000 person-years.
†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.
HR^1: adjusted for age and sex;
HR^2: adjusted for age, sex, BMI, smoke, drinking, urban-rurality, educational level, marriage status, frequency of visiting children or other relatives, walking or group touring;
HR^3: adjusted for age, sex, BMI, smoke, drinking, urban-rurality, educational level, marriage status, frequency of visiting children or other relatives, walking or group touring, hypertension, hypercholesterolemia, heart disease, stroke, diabetes, depression, and dementia.

Table 10-4. Numbers of deaths and adjusted HR for all-cause mortality among older adults with HD or stroke in China: the Anhui cohort study

SES Variables	Nos of Deaths/participants (%)	Person-years	Mortality rate*	HR[1]† 95% CI	P-value	HR[2]† 95% CI	P-value	HR[3]† 95% CI	P-value
Urban-rural									
Urban	88/397 (22.2)	2633.0	33.4	1.00		1.00		1.00	
Rural	62/144 (43.1)	802.5	77.3	2.39 1.72-3.33	<0.001	2.07 1.21-3.53	0.008	2.34 1.34-4.09	0.003
Educational level									
Non-illiterate	73/349 (20.9)	2346.5	31.1	1.00		1.00		1.00	
Illiterate	77/192 (40.1)	1089.0	70.7	2.30 1.64-3.24	<0.001	1.26 0.78-2.03	0.346	1.17 0.72-1.91	0.521
Occupational class									
Non-manual	63/304 (20.7)	2049.3	30.7	1.00		1.00		1.00	
Manual	87/237 (36.7)	1386.2	62.8	2.21 1.58-3.09	<0.001	1.58 0.99-2.51	0.056	1.64 1.03-2.62	0.039
Satisfactory income									
>Average	83/375 (22.1)	2518.8	33.0	1.00		1.00		1.00	
≤Average	67/166 (40.4)	916.7	73.1	2.15 1.56-2.98	<0.001	1.36 0.91-2.03	0.129	1.33 0.89-1.97	0.161
Financial problems in the past two years									
No	83/391 (21.2)	2616.5	31.7	1.00		1.00		1.00	

Yes	67/150 (44.7)	819.0	81.8	2.58 1.86-3.57	<0.001	2.18 1.09-4.37	0.028	2.16 1.11-4.18	0.023
Total	150/541 (27.7)	3435.5	43.7						

*Mortality rate per 1000 person-years.

†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.

HR^{1}: adjusted for age and sex;

HR^{2}: adjusted for age, sex, BMI, smoke, drinking, urban-rurality, educational level, marriage status, frequency of visiting children or other relatives, walking or group touring;

HR^{3}: adjusted for age, sex, BMI, smoke, drinking, urban-rurality, educational level, marriage status, frequency of visiting children or other relatives, walking or group touring, hypertension, hypercholesterolemia, diabetes, depression, and dementia.

Table 10-5. Numbers of deaths and adjusted HR for all-cause mortality among older adults without heart disease and stroke in China: the Anhui cohort study

SES Variables	Nos of Deaths/participants (%)	Person-years	Mortality rate*	HR[1]† 95% CI	P-value	HR[2]† 95% CI	P-value	HR[3]† 95% CI	P-value
Urban-rural									
Urban	198/1152 (17.2)	7980.5	24.8	1.00		1.00		1.00	
Rural	323/1285 (25.1)	7913.2	40.8	1.65 1.38-1.97	<0.001	1.90 1.40-2.57	<0.001	1.74 1.28-2.36	<0.001
Educational level									
Non-illiterate	188/1116 (16.8)	7700.2	24.4	1.00		1.00		1.00	
Illiterate	333/1321 (25.2)	8193.5	40.6	1.69 1.41-2.03	<0.001	1.24 0.96-1.59	0.104	1.18 0.92-1.52	0.198
Occupational class									
Non-manual	140/867 (16.1)	6066.5	23.1	1.00		1.00		1.00	
Manual	381/1570 (24.3)	9827.2	38.8	1.73 1.42-2.11	<0.001	1.31 0.98-1.75	0.073	1.27 0.95-1.71	0.107
Satisfactory income									
>Average	257/1372 (18.7)	9276.2	27.7	1.00		1.00		1.00	
≤Average	264/1065 (24.8)	6617.5	39.9	1.44 1.21-1.71	<0.001	0.98 0.80-1.20	0.848	0.91 0.74-1.12	0.360
Financial problems in the past two years									
No	226/1225 (18.4)	8372.2	27.0	1.00		1.00		1.00	

Yes	295/1212 (24.3)	7521.4	39.2	1.43 1.20-1.70	<0.001	0.73 0.54-1.00	0.053	0.83 0.61-1.13	0.238
Total	521/2437 (21.4)	15893.6	32.8						

*Mortality rate per 1000 person-years.
†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.
HR[1]: adjusted for age and sex;
HR[2]: adjusted for age, sex, BMI, smoke, drinking, urban-rurality, educational level, marriage status, frequency of visiting children or other relatives, walking or group touring;
HR[3]: adjusted for age, sex, BMI, smoke, drinking, urban-rurality, educational level, marriage status, frequency of visiting children or other relatives, walking or group touring, hypertension, hypercholesterolemia, diabetes, depression, and dementia.

Table 10-6. Sociodemographic and characteristics of participants in the 4-province cohort study, China

Variable	All Participants N=3121		Death n=255	(%)	Survival n=2866	(%)	P* value
Demographic factors							
Age (years) Mean (SD)	71.1	(7.3)	77.2	(7.9)	70.5	(7.0)	*<0.001*
Sex							
Women	1742	55.8	118	46.3	1624	56.7	*0.001*
Men	1379	44.2	137	53.7	1242	43.3	
Province							
Guangdong	886	28.4	72	28.2	814	28.4	*0.392*
Shanghai	923	29.6	71	27.8	852	29.7	
Heilongjiang	450	14.4	31	12.2	419	14.6	
Shanxi	862	27.6	81	31.8	781	27.3	
Smoking							
Never-smoking	1946	62.4	147	57.6	1799	62.8	*0.065*
Ex-smoking	369	11.8	43	16.9	326	11.4	
Current-smoking	786	25.2	64	25.1	722	25.2	
Missing	20	0.6	1	0.4	19	0.7	
Alcohol drinking							
No	2348	75.2	182	71.4	2166	75.6	*0.160*
Yes	736	23.6	69	27.1	667	23.3	
Missing	37	1.2	4	1.6	33	1.2	
BMI (kg/m^2)							
Cut-off point							
<18.5	259	8.3	38	14.9	221	7.7	*<0.001*
18.5-<24.0	1807	57.9	156	61.2	1651	57.6	
24.0-<28.0	795	25.5	49	19.2	746	26.0	
≥28.0	260	8.3	12	4.7	248	8.7	
Socio-economic status							
Urban-rurality							
Urban	1398	44.8	127	49.8	1271	44.3	*0.093*
Rural	1723	55.2	128	50.2	1595	55.7	
Educational level							
≥High Secondary school	347	11.1	29	11.4	318	11.1	*0.003*
Secondary school	441	14.1	26	10.2	415	14.5	
Primary school	965	30.9	62	24.3	903	31.5	
Illiterate	1368	43.8	138	54.1	1230	42.9	
Main occupation							
Official/Teacher	349	11.2	34	13.3	315	11.0	*0.630*
Business/Other	570	18.3	45	17.6	525	18.3	
Manual labourer	546	17.5	40	15.7	506	17.7	
Peasant	1656	53.1	136	53.3	1520	53.0	
Satisfactory income							
Very satisfactory	281	9.0	21	8.2	260	9.1	*0.065*
Satisfactory	1491	47.8	108	42.4	1383	48.3	

Average	1118	35.8	98	38.4	1020	35.6	
Poor	231	7.4	28	11.0	203	7.1	
Financial problems in the past two years							
No	2984	95.6	241	94.5	2743	95.7	*0.371*
Yes	137	4.4	14	5.5	123	4.3	
Social network and support							
Marital status							
Married	2315	74.2	148	58.0	2167	75.6	*<0.001*
Never married/Divorcees	68	2.2	3	1.2	65	2.3	
Widowed	738	23.6	104	40.8	634	22.1	
Frequency of visiting children or other relatives							
More than yearly or never	176	5.6	30	11.8	146	5.1	*<0.001*
At least Monthly or less often	1186	38.0	86	33.7	1100	38.4	
At least weekly	882	28.3	58	22.7	824	28.8	
Everyday	875	28.0	81	31.8	794	27.7	
Missing	2	0.1	0	0.0	2	0.1	
Help available when needed							
Yes	3006	96.3	238	93.3	2768	96.6	*0.011*
No	109	3.5	16	6.3	93	3.2	
Missing	6	0.2	1	0.4	5	0.2	
Walking or group touring							
Yes	243	7.8	11	4.3	232	8.1	*0.031*
No	2866	91.8	243	95.3	2623	91.5	
Missing	12	0.4	1	0.4	11	0.4	
Participating in community activities							
Yes	405	13.0	21	8.2	384	13.4	*0.019*
No	2704	86.6	233	91.4	2471	86.2	
Missing	12	0.4	1	0.4	11	0.4	
Co-morbidities							
Hypertension							
No	1551	49.7	118	46.3	1433	50.0	*0.320*
Yes	1478	47.4	127	49.8	1351	47.1	
Missing	92	2.9	10	3.9	82	2.9	
Hypercholesterolemia							
No	3022	96.8	245	96.1	2777	96.9	*0.863*
Yes	93	3.0	8	3.1	85	3.0	
Missing	6	0.2	2	0.8	4	0.1	
Heart disease							
No	2707	86.7	222	87.1	2485	86.7	*0.707*
Yes	367	11.8	28	11.0	339	11.8	

Missing	47	1.5	5	2.0	42	1.5	
Stroke							
No	3008	96.4	229	89.8	2779	97.0	*<0.001*
Yes	105	3.4	26	10.2	79	2.8	
Missing	8	0.3	0	0.0	8	0.3	
Diabetes							
No	2925	93.7	234	91.8	2691	93.9	*0.164*
Yes	173	5.5	19	7.5	154	5.4	
Missing	23	0.7	2	0.8	21	0.7	
Depression							
No	2893	92.7	229	89.8	2664	93.0	*0.300*
Depression-subcase	91	2.9	9	3.5	82	2.9	
Depression-case	132	4.2	15	5.9	117	4.1	
Missing	5	0.2	2	0.8	3	0.1	
Dementia							
No	2587	82.9	188	73.7	2399	83.7	*<0.001*
Dementia-subcase	264	8.5	24	9.4	240	8.4	
Dementia-case	265	8.5	41	16.1	224	7.8	
Missing	5	0.2	2	0.8	3	0.1	

*P-value in the Chi-square test was calculated based on available data, not including those "missing" data.

Table 10-7. Numbers of deaths and adjusted HR for all-cause mortality in older adults from urban and rural areas in China: the 4-province cohort study

Urban-rural variable	Nos of Deaths/participants (%)	Person-years	Mortality rate*	HR[1]† 95% CI	P-value	HR[2]† 95% CI	P-value	HR[3]† 95% CI	P-value
Urban	127/1398 (9.1)	4027.6	31.5	1.00		1.00		1.00	
Rural	128/1723 (7.4)	5414.1	23.6	0.99 0.77-1.28	0.939	0.81 0.60-1.09	0.158	0.89 0.65-1.21	0.461
Total	255/3121 (8.2)	9441.7	27.0						

*Mortality rate per 1000 person-years.

†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.

HR[1]: adjusted for age and sex;

HR[2]: adjusted for age, sex, province, BMI, smoke, drinking, educational level, marriage status, frequency of visiting children or other relatives, walking or group touring;

HR[3]: adjusted for age, sex, province, BMI, smoke, drinking, educational level, marriage status, frequency of visiting children or other relatives, walking or group touring, hypertension, hypercholesterolemia, heart disease, stroke, diabetes, depression, and dementia.

Table 10-8. Numbers of deaths and adjusted HR for all-cause mortality in older adults from low and high SES in China: the 4-province cohort study

SES Variables	Nos of Deaths/participants (%)	Person-years	Mortality rate*	HR[1]† 95% CI	P-value	HR[2]† 95% CI	P-value	HR[3]† 95% CI	P-value
Educational level									
Non-illiterate	117/1753 (6.7)	5192.6	22.5	1.00		1.00		1.00	
Illiterate	138/1368 (10.1)	4249.0	32.5	1.23 0.94-1.61	0.134	1.24 0.92-1.68	0.160	1.19 0.87-1.62	0.285
Occupational class									
Non-manual	79/919 (8.6)	2698.0	29.3	1.00		1.00		1.00	
Manual	176/2202 (8.0)	6743.7	26.1	0.94 0.72-1.22	0.620	0.97 0.72-1.30	0.826	0.95 0.71-1.27	0.724
Satisfactory income									
>Average	129/1772 (7.3)	5195.4	24.8	1.00		1.00		1.00	
≤Average	126/1349 (9.3)	4246.3	29.7	1.29 1.01-1.65	0.045	1.26 0.97-1.63	0.090	1.20 0.92-1.56	0.188
Financial problems in the past two years									
No	241/2984 (8.1)	9053.7	26.6	1.00		1.00		1.00	
Yes	14/137 (10.2)	388.0	36.1	1.47 0.86-2.52	0.162	1.35 0.78-2.34	0.282	1.20 0.69-2.09	0.516

Total	255/3121 (8.2)	9441.7	27.0

*Mortality rate per 1000 person-years.

†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.

HR[1]: adjusted for age and sex;

HR[2]: adjusted for age, sex, province, BMI, smoke, drinking, urban-rurality, educational level, marriage status, frequency of visiting children or other relatives, walking or group touring;

HR[3]: adjusted for age, sex, province, BMI, smoke, drinking, urban-rurality, educational level, marriage status, frequency of visiting children or other relatives, walking or group touring, hypertension, hypercholesterolemia, heart disease, stroke, diabetes, depression, and dementia.

Table 10-9. Numbers of deaths and adjusted HR for all-cause mortality among older adults with HD or stroke in China: the 4-province cohort study

SES variables	Nos of Deaths/participants (%)	Person-years	Mortality rate*	HR[1]† 95% CI	P-value	HR[2]† 95% CI	P-value	HR[3]† 95% CI	P-value
Urban-rural									
Urban	27/249 (10.8)	686.7	39.3	1.00		1.00		1.00	
Rural	19/194 (9.8)	552.9	34.4	1.58 0.84-2.98	0.155	1.60 0.74-3.44	0.235	1.42 0.61-3.29	0.418
Educational level									
Non-illiterate	27/288 (9.4)	801.4	33.7	1.00		1.00		1.00	
Illiterate	19/155 (12.3)	438.2	43.4	1.26 0.66-2.42	0.485	1.21 0.55-2.68	0.634	1.07 0.46-2.48	0.876
Occupational class									
Non-manual	20/159 (12.6)	435.9	45.9	1.00		1.00		1.00	
Manual	26/284 (9.2)	803.7	32.4	0.64 0.35-1.15	0.134	0.58 0.29-1.12	0.106	0.68 0.33-1.38	0.282
Satisfactory income									
>Average	27/255 (10.6)	705.2	38.3	1.00		1.00		1.00	
≤Average	19/188 (10.1)	534.4	35.6	1.00 0.55-1.80	0.989	0.80 0.42-1.54	0.508	0.81 0.41-1.58	0.530
Financial problems in the past two years									
No	44/414 (10.6)	1158.9	38.0	1.00		1.00		1.00	

Yes	2/29 (6.9)	80.7	24.8	0.83 0.20-3.44	0.793	0.68 0.15-2.98	0.605	0.44 0.09-2.03	0.292
Total	46/443 (10.4)	1239.6	37.1						

*Mortality rate per 1000 person-years.

†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.

HR[1]: adjusted for age and sex;

HR[2]: adjusted for age, sex, province, BMI, smoke, drinking, educational level, marriage status, frequency of visiting children or other relatives, walking or group touring;

HR[3]: adjusted for age, sex, province, BMI, smoke, drinking, educational level, marriage status, frequency of visiting children or other relatives, walking or group touring, hypertension, hypercholesterolemia, diabetes, depression, and dementia.

Table 10-10. Numbers of deaths and adjusted HR for all-cause mortality in older adults without heart disease and stroke in China: the 4-province cohort study

SES variables	Nos of Deaths/participants (%)	Person-years	Mortality rate*	HR[1]† 95% CI	P-value	HR[2]† 95% CI	P-value	HR[3]† 95% CI	P-value
Urban-rural									
Urban	100/1148 (8.7)	3337.9	30.0	1.00		1.00		1.00	
Rural	108/1522 (7.1)	4841.1	22.3	0.93 0.70-1.23	0.621	0.77 0.56-1.07	0.120	0.82 0.59-1.15	0.243
Educational level									
Non-illiterate	90/1458 (6.2)	4370.7	20.6	1.00		1.00		1.00	
Illiterate	118/1212 (9.7)	3808.3	31.0	1.25 0.93-1.69	0.139	1.29 0.93-1.80	0.130	1.25 0.89-1.76	0.199
Occupational class									
Non-manual	59/758 (7.8)	2256.3	26.1	1.00		1.00		1.00	
Manual	149/1912 (7.8)	5922.8	25.2	1.03 0.76-1.39	0.859	1.10 0.79-1.54	0.568	1.09 0.78-1.53	0.601
Satisfactory income									
>Average	102/1512 (6.7)	4475.5	22.8	1.00		1.00		1.00	
≤Average	106/1158 (9.2)	3703.6	28.6	1.35 1.02-1.77	0.033	1.36 1.02-1.83	0.037	1.34 1.00-1.79	0.054
Financial problems in the past two years									
No	196/2562 (7.7)	7871.7	24.9	1.00		1.00		1.00	

Yes	12/108 (11.1)	307.3	39.0	1.66 0.92-2.97	0.090	1.49 0.82-2.71	0.187	1.39 0.76-2.53	0.285
Total	208/2670 (7.8)	8179.0	25.4						

*Mortality rate per 1000 person-years.

†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.

HR^1: adjusted for age and sex;

HR^2: adjusted for age, sex, province, BMI, smoke, drinking, urban-rurality, educational level, marriage status, frequency of visiting children or other relatives, walking or group touring;

HR^3: adjusted for age, sex, province, BMI, smoke, drinking, urban-rurality, educational level, marriage status, frequency of visiting children or other relatives, walking or group touring, hypertension, hypercholesterolemia, diabetes, depression, and dementia.

Table 10-11. Number of deaths and adjusted HR for all-cause mortality in older adults with personal and family incomes in China: the 4-province cohort study

Annual income (¥)	Nos of Deaths/participants (%)	Person-years	Mortality rate*	HR[1]† 95% CI	P-value	HR[2]† 95% CI	P-value	HR[3]† 95% CI	P-value
Personal income									
>8000	121/1509 (8.0)	4419.8	27.4	1.00		1.00		1.00	
≤8000	126/1506 (8.4)	4731.4	26.6	1.10 0.85-1.42	0.470	1.02 0.71-1.45	0.933	1.00 0.70-1.44	0.984
Family income									
>10000	105/1219 (8.6)	3817.2	27.5	1.00		1.00		1.00	
≤10000	115/1498 (7.7)	4482.5	25.7	1.14 0.87-1.49	0.338	0.88 0.64-1.23	0.463	0.88 0.62-1.24	0.448

Of 3121 participants, 106 did not have personal income data, 404 did not have family income data.

*Mortality rate per 1000 person-years.

†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.

HR[1]: adjusted for age and sex;

HR[2]: adjusted for age, sex, province, BMI, smoke, drinking, urban-rurality, educational level, marriage status, frequency of visiting children or other relatives, walking or group touring;

HR[3]: adjusted for age, sex, province, BMI, smoke, drinking, urban-rurality, educational level, marriage status, frequency of visiting children or other relatives, walking or group touring, hypertension, hypercholesterolemia, heart disease, stroke, diabetes, depression, and dementia.

Table 10-12. Number of deaths and adjusted HR for all-cause mortality among older adults with heart disease or stroke in China: the 4-province cohort study

Annual income (¥)	Nos of Deaths/participants (%)	Person-years	Mortality rate*	HR[1]† 95% CI	P-value	HR[2]† 95% CI	P-value	HR[3]† 95% CI	P-value
Personal income									
>10000	21/210 (10.0)	595.0	35.3	1.00		1.00		1.00	
≤10000	25/226 (11.1)	625.5	40.0	1.57 0.86-2.88	0.143	1.36 0.53-3.53	0.526	1.48 0.50-4.37	0.479
Family income									
>11000	20/210 (9.5)	623.6	32.1	1.00		1.00		1.00	
≤11000	23/205 (11.2)	537.9	42.8	1.89 1.03-3.50	0.041	1.73 0.68-4.38	0.251	1.43 0.49-4.17	0.511

Of 443 participants, 7 did not have personal income data, 28 did not have family income data.

*Mortality rate per 1000 person-years.

†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.

HR[1]: adjusted for age and sex;

HR[2]: adjusted for age, sex, province, BMI, smoke, drinking, urban-rurality, educational level, marriage status, frequency of visiting children or other relatives, walking or group touring;

HR[3]: adjusted for age, sex, province, BMI, smoke, drinking, urban-rurality, educational level, marriage status, frequency of visiting children or other relatives, walking or group touring, hypertension, hypercholesterolemia, diabetes, depression, and dementia.

Table 10-13. Number of deaths and adjusted HR for all-cause mortality among older adults without heart disease and stroke in China: the 4-province cohort study

Annual income (¥)	Nos of Deaths/participants (%)	Person-years	Mortality rate*	HR[1]† 95% CI	P-value	HR[2]† 95% CI	P-value	HR[3]† 95% CI	P-value
Personal income									
>8000	96/1256 (7.6)	3712.1	25.9	1.00		1.00		1.00	
≤8000	104/1317 (7.9)	4201.2	24.8	1.04 0.78-1.39	0.77	0.99 0.68-1.46	0.974	1.00 0.68-1.48	0.987
Family income									
>10000	84/1002 (8.4)	3176.1	26.4	1.00		1.00		1.00	
≤10000	92/1295 (7.1)	3947.7	23.3	1.04 0.77-1.39	0.819	0.78 0.55-1.12	0.181	0.77 0.54-1.12	0.168

Of 2670 participants, 97 did not have personal income data, 373 did not have family income data.

*Mortality rate per 1000 person-years.

†HR indicates hazard ratio; 95% CI indicates 95% confidence intervals.

HR[1]: adjusted for age and sex;

HR[2]: adjusted for age, sex, province, BMI, smoke, drinking, urban-rurality, educational level, marriage status, frequency of visiting children or other relatives, walking or group touring;

HR[3]: adjusted for age, sex, province, BMI, smoke, drinking, urban-rurality, educational level, marriage status, frequency of visiting children or other relatives, walking or group touring, hypertension, hypercholesterolemia, diabetes, depression, and dementia.

Table 10-14. Pooled HR of all-cause mortality in different SES indicators among participants from the Anhui cohort and the Four-province cohort studies

SES variables	HD or stroke		Non-HD or stroke	
	HR*	95% CI	HR*	95% CI
Urban-rurality				
Urban	1.00		1.00	
Rural	2.01	1.26-3.20	1.20	0.57-2.50
Educational level				
Non-illiterate	1.00		1.00	
Illiterate	1.14	0.75-1.75	1.20	0.98-1.47
Occupational class				
Non-manual	1.00		1.00	
Manual	1.10	0.47-2.60	1.19	0.95-1.48
Satisfactory Income				
Average	1.00		1.00	
≤Average	1.17	0.83-1.65	1.09	0.75-1.59
Financial problem in the past two years				
No	1.00		1.00	
Yes	1.15	0.25-5.28	1.00	0.62-1.64

*Models are adjusted for: age (cont.), sex, (province), BMI, smoke, drinking, urban-rurality, educational level, marriage status, frequency of visiting children or other relatives, walking or group touring, hypertension, hypercholesterolemia, heart disease, stroke, diabetes, depression, and dementia.

CHAPTER ELEVEN: GENERAL DISCUSSION AND CONCLUSIONS

11.1 Introduction

This chapter presents general discussions in the associations of socioeconomic status (SES) with incidence and mortality of heart disease (HD) and stroke. The thesis research strengths and limitations are discussed, followed by suggestions for future research. The implications of the thesis research are also underlined and the conclusions are made.

11.2 Overall findings of SES associated with the risks of incident HD and stroke and all-cause mortality

This thesis was conducted to examine the impact of multiple SES measurements on the incidence and mortality of HD and stroke in older people in China. All these were achieved by conducting and examining five original cohort studies and incorporating comprehensive systematic literature reviews and meta-analysis. In this PhD study, the association of SES with incidence and mortality of HD and stroke varied with SES indicators. Rural living was associated with increased mortality of HD and increased incidence of stroke, while urban living was associated with increased incidence of HD. Low educational level was associated with increased mortality of HD, while high occupational class predicted increased incidence of stroke. Low income or having financial problems was associated with increased incidence of HD and stroke and increased mortality of HD. These impacts of SES on the risk of HD and stroke were largely attributed to rural living, low occupational class and having financial problems, particularly in those with either HD or stroke.

11.3 Relationships among different measurements of SES

Educational level, occupational class, income, and urban-rurality as typical measurements of SES are the most common used in health studies in China (Chen et al., 2014a, Pan et al., 2016, Yan et al., 2017). Individuals with higher education would have better occupation and correspondingly higher income in adulthood, and higher occupational class would have higher income. Low levels of education, occupational class, and income are more prevalent in rural populations in China due to urban-rural inequality. Although they are somehow overlapped in relation to late-life health (Darin-Mattsson et al., 2017), the impact of different SES indicators on outcomes could be different and the size and strength of the impact varied by indicator (Geyer et al., 2006). These indicators may follow different pathways in impacting those health outcomes and implementation of future intervention.

It is also argued that any single SES indicator may not be able to measure the SES of an individual comprehensively or directly (Galobardes et al., 2007). For example, in western countries an adult's SES could be largely determined by his or her educational level (White et al., 2015, de Mestral and Stringhini, 2017), but educational level only acts as an indirect index of SES in the context of China because it has been considered to be less valid and sensitive than income (Xu et al., 2008, Pan et al., 2016, Darin-Mattsson et al., 2017). In China, during the period of rapid economic transition, many people with low educational level may have higher income than those with high education, resulting from opening and doing their own business, and thus being able to afford high-quality healthcare and have better health outcomes. Their low education might not accurately indicate their socioeconomic position in adulthood, and might not be associated with late-life health. Therefore, to employ multiple SES indicators in health studies would help identify the pathways of the association of SES with health and reduce confounding effects between SES indicators.

11.4 Association of SES with heart diseases and stroke

11.4.1 SES and incidence of heart disease and stroke

The current study showed significant associations of SES with incidence of HD and stroke. Our findings showed that low SES measured by all indicators was associated with increased incidence of HD and stroke, except for occupational class; low levels of education and family income associated with incidence of HD, and rural living and low levels of education and personal income were associated with increased risk of stroke. Inverse associations of education and income with risk of HD and stroke were consistent with previous studies (Khaing et al., 2017). In a 2017 meta-analysis of 72 cohort studies, Khaing et al. reported that incidence of HD and stroke was significantly increased in people with lower levels of education and income (Khaing et al., 2017). However, previous systematic reviews papers did not include or detect such a comparison in the risks of HD and stroke between people living in rural and urban areas (Khaing et al., 2017, Backholer et al., 2017). One of the reasons for it is that existing studies are mostly from HICs in Europe and North America, where there are no significant differences between urban and rural living in terms of education attainment, job opportunity, income and healthcare access. In rural China, some risk factors such as hypertension were common and uncontrolled (Wang et al., 2017b). A health survey on 45,108 participants aged 35-70 years recruited from 70 rural and 45 urban communities in China demonstrated that people living in rural areas had higher prevalence of hypertension, particularly its unaware, untreated and uncontrolled level (Li et al., 2016). Hypertension and its unaware, untreated and uncontrolled status are a main risk factor for stroke (Han et al., 2017). However, primary care and preventive care access remain poor in rural areas (Huang et al., 2016), including lack of facilities such as CT or MRI scan for the diagnosis of stroke (Liu et al., 2007a). People who live in rural areas might not receive adequate preventive interventions for high risk factors and thus would have increased risk of stroke (Li et al., 2018).

This PhD study found that participants living in urban areas were likely to be associated with increased incidence of HD and high occupational class associated with increased incidence of stroke. These findings of high SES associated with increased risk of HD and stroke were different from those in previous studies from HICs (Khaing et al., 2017, de Mestral and Stringhini, 2017). This might be attributed to lifestyle changes in the early stages with rapid economic development in China (Kim et al., 2004, Wang et al., 2019). The adoption of Western lifestyle and dietary habits, primarily higher caloric and sugar intake, prolonged sedentary behaviours, using labour-saving devices, and inadequate physical activities, have increased significantly among the higher SES groups, resulting in a greater prevalence of noncommunicable health condition such as obesity, hypertension and the metabolic syndrome among older adults (Sun et al., 2014). For example, diabetes is a prime risk factor for HD and stroke. A study by Bragg et al. reported that the prevalence of diabetes was two-times higher in urban than in rural areas of China (8.1% vs 4.1%) (Bragg et al., 2017). These lifestyles and CVDRFs are important risk factors for the development of HD and stroke.

11.4.2 SES and all-cause mortality in patients with heart disease and stroke

In the current study, low SES was associated with increased mortality in people with HD and stroke. Our data showed excessive mortality in HD patients living in rural, having low levels of education and personal income and having financial problems, and in stroke patients living in rural, and having low levels of education and income. The findings of the association of low SES with increased mortality of HD and stroke were consistent with those in previous studies from HICs and from China (de Mestral and Stringhini, 2017, Khaing et al., 2017, Wang et al., 2020).

While some SES indicators (e.g., urban living and non-manual occupation) showed positive associations with incidence of HD and stroke in the current study, no SES indicator showed such association with mortality of HD and stroke, suggesting SES inequality is likely to result in survival disparity rather than incidence in China. The findings are consistent with previous studies in LMICs (Yusuf et al., 2014). For example, data from 628 urban and rural communities in 14 LMICs showed that risk-factor burden was greater in urban areas, while case fatality were more common in rural areas (Yusuf et al., 2014).

Restricted access to quality health systems may partly explain why there are worse outcomes in rural areas. The availability of healthcare substantially differs between rural and urban areas in China. People living in rural areas are more likely to have limited access to healthcare for timely diagnosis and treatment of HD and stroke compared with those living in urban areas. Detection and treatment of HD and stroke are mostly in certain tertiary care centres, nearly all of which are in urban areas, and rural healthcare facilities are unable to provide a similar standard of postoperative management for rural people. In addition, there has been big inequality between rural and urban in the health insurance system for older adults in China. For example, medical schemes reimburse only around 50% of inpatient expenditures for rural people, as are 70%-80% for urban residents (Li et al., 2017b). Many long-standing health conditions in older people require long-term outpatients visits to primary and secondary care, which may not be covered by insurance schemes, and thus health care use among older people living in rural areas remains an economic burden (Wu et al., 2016). These could be some possible explanations for an association of living in rural areas with increased mortality of HD.

In China, low income or financial problems have been associated with reduced healthcare use. Most people did not have any health insurance coverage before the insurance system reform more than 10 years ago in China. The out-of-pocket cost of medication is a burden for high-risk patients with HD, which would result in barriers to healthcare access (Khera et al., 2019). It was found that compared to those with higher income, people with lower income were significantly less likely to use outpatient services (OR 0.65, 0.44-0.95) and inpatient services (0.71, 0.51-1.00) (Luo et al., 2009).

This PhD study has identified that low educational level was associated with increased mortality in patients with HD and stroke. It is widely recognised that education can improve health by increasing health knowledge and healthy lifestyle/behaviours, which was found to be inversely associated with all-cause mortality, especially for CHD mortality (Puddu et al., 2011, Menotti et al., 2014, Menotti et al., 2016). Educational level was also an important determinant of medication adherence. Previous studies showed that there was an 8% lower adherence to medications at 1 year in MI patients with educational level <12 years (66% vs 74% in those with ≥12 years) (Pandey et al., 2017). Poor adherence leads to increased HD exacerbations, reduced physical function, and high risk for hospital admission and death. It was found that medication adherence interventions were significantly associated with decreased mortality among heart failure patients (RR 0.89, 0.81-0.99), and decreased odds for hospital readmission (OR 0.79, 0.71-0.89) (Ruppar et al., 2016). These factors might lead to increased mortality in HD and stroke patients.

11.5 Strengths and limitations

11.5.1 Strengths and limitations of SES measurements which were used in the current study

Multiple measurements of SES were used to assess their impacts on incidence of HD and stroke and mortality in patients with HD and stroke. Their strengths and limitations have been shown in following table, which are also linked and compared to those in Chapter One.

SES indicators	Strengths	Limitations
Educational level	(A) To a large extent, educational level was the most stable measurement of SES among older people in the Chinese context, which was acquired during childhood and youth, and generally stabilised in the adult years. Thus it could be more likely to avoid being affected by health impairments that may emerge in adulthood.	(a) Educational level may not fully determine an older adult's SES in China since the Chinese society has been undergoing a rapid transition over the past 40 years, which is considered to be less valid and sensitive than income (Xu et al., 2008). (b) In the current thesis, educational levels of more than high secondary school were merged as one category because there were few participants with college or university degree. The difference between college/university and high secondary school in health status has not been well studied in the current analyses.
Occupational class	(A) In the Chinese context, occupation was an explicit SES indicator that could largely reflect resources available and social status directly (Fujishiro et al., 2010).	(a) An occupation can cover a large range of social standing within a society, e.g., the occupation 'teacher' in the questionnaire was equally applicable to a university professor as well as one who was a tutor for primary school pupils. In further studies, job titles include the terms "executive," "manager," "chief," "supervisor," etc. should be collected and stratified to analyse. (b) Occupation may not allow classification of individuals who do not work or retired. Although occupation can be classified based on their previous full-time job, it may not be able to reflect the current status exactly.

Income	(A) Four types of income assessment, including satisfactory income, personal income, family income, and financial problems in the past 2 years were used to examine their impacts on health status. The satisfactory level of income involved individuals' feeling about income, while the financial problems reflected 'the financial crisis'. Using objective multiple measurements would be more comprehensive to evaluate the participants' financial situation, minimising bias.	(a) Baseline incomes were taken as SES indicators in the thesis. However, income or poverty is a dynamic not a static concept. Although some people face long periods of sustained financial hardship, a large number of others move in and out of poverty in various ways and for differing periods of time, especially during rapid economic development. Without taking time into account it is impossible fully to appreciate the impact of income or poverty on health status (Benzeval and Judge, 2001).
Urban-rural areas	(A) Urban/rural area was employed as one of SES indicators in the thesis. Urban/rural area is a more appropriate area-level SES indicator in developing countries (Zimmer et al., 2010), particularly in China where there are large disparities in education, occupation opportunities, income, health services, political rights, and social welfares.	(a) There are differences between urban and rural areas in healthcare services in China. However, data on healthcare resources was not collected and adjusted in the analysis. Whether the effect of urban and rural disparity on health status could be explained by healthcare services is still unclear.

11.5.2 Strengths of the study

The main strength of this PhD study lies in the use of two population-based follow-up cohort studies in China to identify the impact of multiple measurements of SES on incidence of HD and stroke and mortality of HD and stroke among older adults. The thesis has contributed to increase knowledge about the associations of SES with HD and stroke in LMICs, where few population-based cohort studies have been done among older communities. The Anhui and Four-province cohort studies with large sample sizes were followed up over 10 years and 4 years, respectively. The detailed confounding variables, including socio-demographic covariates, lifestyles, social network and support, and medical co-morbidities, allowed us to comprehensively explore the associations of SES with the incidence and mortality of HD and stroke. The systematic literature review and meta-analysis of combining published papers with our new studies further ensured our findings of the impacts of SES on incidence and mortality of HD and stroke in China.

11.5.3 Limitations of the study

Although our studies in this thesis provided new insight into the associations of SES with incidence and mortality of HD and stroke among older people in China, there are some limitations.

First, although the sample size for the two prospective cohort studies was large, when the cohort data were stratified for further analysis the number of deaths in HD and stroke patients were not large and multiple adjustment analysis produced a wide 95% confidence interval, reducing the statistical significance. Therefore, it requires a larger cohort study to examine the impact of multiple SES on mortality in older people with HD and stroke who live in the community. Nevertheless, our pooled data with identified studies could increase the study power.

Second, in the community-based setting of our study, the information of HD and stroke was collected using self-reported doctor-diagnosis in the questionnaires, but not medical records. This may have caused some misclassification on HD and stroke diagnosis, which would bias the associations between SES and incidence and mortality of HD and stroke, probably intending towards the null hypothesis. In addition, more detailed information about the subtypes of HD and stroke in the Anhui cohort study and subtypes of stroke in the four-province cohort study were not recorded, and thus it is unclear whether there were significant differences in the impact of SES on their subtypes. However, previous studies have assessed the validity of self-reported doctor's diagnosis of HD and stroke in older adults (Kehoe et al., 1994, Engstad et al., 2000), demonstrating smaller difference between self-reported and doctor-reported in prevalence of HD and stroke. Also, hospital-based cohort studies mostly showed inverse associations of SES with incidence and mortality of any specific types of HD and stroke (Khaing et al., 2017, Wang et al., 2020). Nevertheless, further studies focused on this issue were needed in China, including detailed data collection using CT or MRI for HD and stroke diagnosis and their subtypes identification, to clarify the effects of these SES indicators on the incidence and mortality of HD and stroke and their subtypes in community-dwelling older adults.

Third, there were a number of cohort members lost to follow-up; in the Anhui cohort the overall lost to follow up rate in the waves 2-4 interviews (excluding deaths) was 10.7% and in the Four-province cohort study the rate of lost to follow up was 27%. There is evidence that in China the cohort study in the earlier dates would have higher rates of participants' response and follow-up. The reasons for this could be (1) in the earlier dates the participants who were recruited for study felt they "have to participate and complete" the study, and with time they realised that they could decline and withdraw from the study, which are ensured through improved consents in the study, (2) during the period of 2005-2015, China had many residential area houses reformed and rearranged due to rapid economic development and urbanisation and some participants moved to new homes that we could not trace their new address during the follow-up. It would be difficult to say whether those lost to follow up had higher or lower level of incidence and mortality of HD and stroke than other cohort members. The bias, if any, could be in any direction for the association of SES with incidence of HD and stroke and with mortality in people with HD and stroke. For example, previous studies in the Anhui cohort (Chen et al., 2014a) did not show significant differences in SES (including rural-urban, educational level, occupational class and income) and baseline health conditions such as obesity, hypertension and diabetes between those followed up and lost to follow up, suggesting that incidence of HD and stroke might be similar between two groups. Meanwhile, data of the Four-province cohort study showed significant differences in the baseline characteristics and risk factors, which may introduce direction bias in the association of SES with outcomes (Appendix 2). Nevertheless, the rate of lost to follow up in our study is similar to those in some studies undertaken in HICs, e.g., 13.0% in a Canadian cohort of 10 years follow up (Padfield et al., 2017) and 28.1% in a Spanish cohort of 3 years follow up (Vega et al., 2010). Thus the findings of our cohort studies could be comparable with those in HICs. More community-based cohort studies with a lower level of lost to follow-up are required to examine the association of SES with incidence and mortality of HD and stroke in older Chinese in the future.

Finally, like other studies in the analysis for the associations of SES with incidence and mortality of HD and stroke (Yan et al., 2017, Wang et al., 2017a, Huo et al., 2019, Wu et al., 2019), we did not adjust for variables of healthcare utilisation due to data unavailable. Previous studies showed that healthcare utilization and service availability would reduce the risk of CVD and improve survivals of patients (Jiang et al., 2015), and high SES was associated with these utilization (Levy et al., 2020) and high quality healthcare access including detection and treatment for HD and stroke are mostly located in urban areas. If the analysis included for healthcare for adjustment, the HR of HD incidence in participants living in urban versus rural would be further increased. In other SES data analysis, I adjusted for the rural-urban, which included information on the healthcare utilization and service availability. Thus these confounding effects would be minimised.

11.6 Implication of findings

Socioeconomic circumstances of older people shaped a wide array of conditions of HD and stroke. The findings from this PhD thesis study have demonstrated inequalities in the incidence and mortality of HD and stroke in terms of different measurements of SES in older adults in China. These call for public health initiatives on prevention and intervention for HD and stroke. This thesis has provided evidence that the impact of SES on incidence and mortality of HD and stroke varied with different SES indicators, suggesting different potential pathways in future interventions. This required population-based public health strategies targeting different SES groups involving comprehensive approaches to reduce incidence and mortality of HD and stroke in older Chinese.

In our study, the rurality was a main cause of inequality in terms of SES in China. The community-based interventions, which include timely detection and control of CVD risk factors (e.g., hypertension) should be an essential and effective public health service to reduce incidence of stroke in rural areas. Alternatively, enhancing opportunities for low SES individuals in rural areas, particularly those with low levels of education and income, to receive adequate healthcare access might help reduce mortality in HD and stroke patients and ameliorate SES disparities between rural and urban in health outcomes. Most importantly, policy should be constructed to reduce inequality in welfare, including improving health insurance coverage and reimbursement rate in rural areas, to encourage people to use health services when needed.

The findings in this thesis study showed that urban living was associated with increased incidence of HD and high occupational class associated with incidence of stroke in China. Preventive interventions for urban residents, particularly men with high occupational class, are essential during epidemiological transition in the early stages. Increasing public health education, through promoting healthy lifestyle and diet, would be helpful to reduce HD and stroke incidence in China. In addition, the gender-specific strategies are needed to be considered in public health interventions, preventive healthcare access, and training of medical personnel.

Overall, as population aging and rapid economic growth in China, the toll of socioeconomic disadvantage is likely to increase, along with the increased incidence and mortality of HD and stroke. Heath promotions aimed at providing both economic and social resources towards public health education, financial resources support and adequate healthcare access among socioeconomic deprived older populations may contribute to reducing SES inequality and the burden of HD and stroke.

11.7 Suggestions for future research

HD and stroke are the two leading causes of death and causes of disease burden worldwide. The rapid rise in HD and stroke in LMICs is partly attributed to SES inequalities (Gaziano et al., 2010). The findings from my thesis research have increased knowledge of the impact of SES inequalities on the incidence and mortality of HD and stroke in China. Due to the increase in the ageing population and lack of data for investigating the impact of SES on heart disease and stroke in LMICs, it is paramount that future studies should continue to investigate SES inequality in the risk of HD and stroke among older adults. To drive and guide future studies to further explore the association of SES with HD and stroke in LMICs, based on the findings of this thesis and systematically reviewed other related studies, I would suggest the followings:

- Future population-based studies should include medical records to document medications (e.g., drug therapy) for risk factors data analysis and also measures of computerised tomography or magnetic resonance imaging in their investigation to validate and diagnose HD and stroke events.
- The thesis found gender differences in the impact of SES on incidence of stroke among older adults. Studies which include a larger sample of participants would be needed to understand whether or not there are gender differences in the impact of SES on all-cause mortality among patients with stroke, and on the risk and mortality of HD.
- Early-life SES plays an important role in late-life health outcomes. Previous studies showed that SES inequalities in HD and stroke at old age may originate early in life (Havranek et al., 2015, de Mestral and Stringhini, 2017), as possible consequences of cumulative effect of exposures to adverse socioeconomic circumstances throughout the life course (Ben-Shlomo and Kuh, 2002). Therefore, apart from SES measured in older age, SES measurement in early life could be collected for more analysis to examine their combined or interaction effects with SES in older age on disease outcomes.
- Future research will be needed to understand the mechanisms, which explain why some high SES groups were associated with increased incidence of HD and stroke in older age and why only low SES groups were associated with mortality of HD and stroke.
- The data of healthcare utilisation and medical insurance level should be collected in future studies. They would be included in analysis for adjustment and help examine pathways of the impacts of SES on HD and stroke in future research.
- Future research could have interventional components, for example increase in income among older people who are poor, and health services and education in the rural areas. These could

further assess the magnitudes of the impacts of SES on incidence and mortality of HD and stroke and examine the pathways of different SES impacts on the outcomes.

11.8 Conclusions

This PhD thesis research found SES inequalities in incidence and mortality of HD and stroke among older adults. In China older people living in urban and with low family income had increased risk of incident HD, while rural living and high occupational class were associated with increased incidence of stroke. With respect to the impact of SES on all-cause mortality, the findings from the original studies of the two cohort studies showed that rural living, having financial problems, and low levels of education and income were significantly associated with increased mortality in older people with HD. Although the data of two cohorts did not show a significant association of SES with all-cause mortality in participants with stroke probably due to its small sample size, pooled data from all published studies in China showed that stroke patients with rural living and low levels of education and income had increased mortality.

SES differences can typically lead to health inequality. The findings of this PhD study will benefit to social epidemiology and public health agenda to promote appropriate health interventions and strategies, with more resources being allocated in older people with low SES, to address inequality in the burden of HD and stroke in the world, particularly in LMICs and China. Increasing heath education in the high-risk groups and introducing evidence-based interventions from HICs will help reduce incidence of HD and stroke and improve survival in patients with HD and stroke.

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APPENDIX 1. The Main Syntax of Data Analysis for Each Chapter

Chapter Five: Distributions of demographic characteristics and disease risk factors among older adults by SES

```
USE ALL.

COMPUTE filter_$=(province_53<6 and education_53<>999 and occupation_53<>999 and xxx<>1 and income_53<>999 and d2_53<>999).

VARIABLE LABEL filter_$ 'italstat5yearsfollowup_rc <=1 (FILTER)'.

VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.

FORMAT filter_$ (f1.0).

FILTER BY filter_$.

EXECUTE.
```

Table 5-1. Distributions of demographic characteristics, behaviours/lifestyles, social networks and supports, CVDs and CVDRFs by urban-rural living among older adults in China

```
ONEWAY age_53 BY urban_rural_53

  /STATISTICS DESCRIPTIVES

  /MISSING ANALYSIS.


CROSSTABS

  /TABLES= sex_53 province_53 BMICUT_53 smoke_53 a6_m education_53 occupation_53 income_53 d2_53 marriage_53 C1_53 c4_53 e4_53 e6_53 hptn_53 b2_53 b5_53 b6_53 depression_yesno dementia_yesno by urban_rural_53

  /FORMAT=AVALUE TABLES

  /STATISTICS=CHISQ

  /CELLS=count COLUMN

  /COUNT ROUND CELL.
```

Table 5-2. Distributions of demographic characteristics, behaviours/lifestyles, social networks and supports, CVDs and CVDRFs by educational level among older adults in China

```
ONEWAY age_53 BY education_53

  /STATISTICS DESCRIPTIVES
```

```
  /MISSING ANALYSIS.


CROSSTABS

  /TABLES= sex_53 province_53 BMICUT_53 smoke_53 a6_m urban_rural_53 occupation_53 income_53 d2_53 marriage_53 C1_53 c4_53 e4_53 e6_53 hptn_53 b2_53 b5_53 b6_53 depression_yesno dementia_yesno by education_53

  /FORMAT=AVALUE TABLES

  /STATISTICS=CHISQ

  /CELLS=count COLUMN

  /COUNT ROUND CELL.
```

Table 5-3. Distributions of demographic characteristics, behaviours/lifestyles, social networks and supports, CVDs and CVDRFs by occupational class among older adults in China

```
RECODE occupation_53 (1=1) (2=1) (3=2) (4=2) INTO Occupation_manual.

EXECUTE.


ONEWAY age_53 BY Occupation_manual

  /STATISTICS DESCRIPTIVES

  /MISSING ANALYSIS.


CROSSTABS

  /TABLES= sex_53 province_53 BMICUT_53 smoke_53 a6_m urban_rural_53 education_53 income_53 d2_53 marriage_53 C1_53 c4_53 e4_53 e6_53 hptn_53 b2_53 b5_53 b6_53 depression_yesno dementia_yesno by Occupation_manual

  /FORMAT=AVALUE TABLES

  /STATISTICS=CHISQ

  /CELLS=count COLUMN

  /COUNT ROUND CELL.
```

Table 5-4. Distributions of demographic characteristics, behaviours/lifestyles, social networks and supports, CVDs and CVDRFs by satisfactory income among older adults in China

```
ONEWAY age_53 BY income_53
  /STATISTICS DESCRIPTIVES
  /MISSING ANALYSIS.


CROSSTABS
  /TABLES= sex_53 province_53 BMICUT_53 smoke_53 a6_m urban_rural_53 education_53
occupation_53 d2_53 marriage_53 C1_53 c4_53 e4_53 e6_53 hptn_53 b2_53 b5_53 b6_53
depression_yesno dementia_yesno by  income_53
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=count COLUMN
  /COUNT ROUND CELL.
```

Table 5-5. Distributions of demographic characteristics, behaviours/lifestyles, social networks and supports, CVDs and CVDRFs by financial problems among older adults in China

```
ONEWAY age_53 BY d2_53
  /STATISTICS DESCRIPTIVES
  /MISSING ANALYSIS.


CROSSTABS
  /TABLES= sex_53 province_53 BMICUT_53 smoke_53 a6_m urban_rural_53 education_53
occupation_53 income_53 marriage_53 C1_53 c4_53 e4_53 e6_53 hptn_53 b2_53 b5_53 b6_53
depression_yesno dementia_yesno by d2_53
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=count COLUMN
  /COUNT ROUND CELL.
```

Chapter Six: Impact of SES on Incidence of Heart Disease: the Anhui cohort and the Four-province cohort studies

Table 6-1. Socio-demographic and characteristics of participants with rural and urban areas at baseline in the Anhui cohort study, China

```
USE ALL.

COMPUTE filter_$=(T_full_w4>=0 and b2_w1<>1 ).

VARIABLE LABELS filter_$ 'T_full_w4>0 (FILTER)'.

VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.

FORMATS filter_$ (f1.0).

FILTER BY filter_$.

EXECUTE.


ONEWAY age BY urban_rural

  /MISSING ANALYSIS.


CROSSTABS

  /TABLES= sex BMICUT smoke01 a6_m  education_level_m occupation_m income d2 Marriage_m C4_m hptn_yesno b6 b5 ADL_group Dementia_wz Depression_wz BY urban_rural

  /FORMAT=AVALUE TABLES

  /CELLS=count column

  /STATISTICS=CHISQ

  /COUNT ROUND CELL.
```

Table 6-2. Number, rate and HR of incident HD in older people with low vs high SES in China: Anhui cohort study

```
COXREG Time_HD

  /STATUS=HD_incident(1)

  /CONTRAST (sex)=Indicator(1)

  /CONTRAST (BMICUT)=Indicator(2)

  /CONTRAST (smoke01)=Indicator(1)
```

/CONTRAST (a6_m)=Indicator(1)

/CONTRAST (urban_rural)=Indicator (1)

/CONTRAST (Edu_illiterate)=Indicator(2)

/CONTRAST (occ_manual)=Indicator(2)

/CONTRAST (inc_satisf)=Indicator(2)

/CONTRAST (d2)=Indicator(1)

/CONTRAST (Marriage_m)=Indicator(1)

/CONTRAST (C4_m)=Indicator(4)

/CONTRAST (group_hptn140)=Indicator(1)

/CONTRAST (b5)=Indicator(1)

/CONTRAST (b6)=Indicator(1)

/CONTRAST (ADL_group)=Indicator(1)

/CONTRAST (dementia_dep)=Indicator(1)

/METHOD=ENTER age sex BMICUT smoke01 a6_m urban_rural Edu_illiterate Marriage_m C4_m group_hptn140 b5 b6 ADL_group dementia_dep

/PRINT=CI(95)

/CRITERIA=PIN(.05) POUT(.10) ITERATE(20).

/*Variables of “occ_manual” “inc_satisf” and “d2” were included into the Cox regression model when analysed occupational class, satisfactory income and financial problems, respectively.

Table 6-3. Number, rate and HR of incident HD in older people with low vs high SES in China: 4-province cohort study

USE ALL.

COMPUTE filter_$=(province<5 and fiveP6071followup<3 and HD_totalw3<>1 and education_level_m<>999 and occupation_m<>999 and income_m<>999 and d2<>999 and a5<>999).

VARIABLE LABELS filter_$ 'province<5 and fiveProvinces6071=1 (FILTER)'.

VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.

FORMATS filter_$ (f1.0).

FILTER BY filter_$.

```
EXECUTE.

COXREG FT5province1
  /STATUS=HD_totalw4(1)
  /CONTRAST (sex_rc)=Indicator(1)
  /CONTRAST (province)=Indicator(1)
  /CONTRAST (BMICUT_CN)=Indicator(2)
  /CONTRAST (smoke_wz)=Indicator(1)
  /CONTRAST (drink_wz)=Indicator(1)
  /CONTRAST (district)=Indicator(1)
  /CONTRAST (Edu_illiterate)=Indicator(2)
  /CONTRAST (occupation_teach)=Indicator(2)
  /CONTRAST (income_2x)=Indicator(2)
  /CONTRAST (d2)=Indicator(1)
  /CONTRAST (income51_higlow)=Indicator(2)
  /CONTRAST (income52_higlow)=Indicator(2)
  /CONTRAST (marriage_wz)=Indicator(1)
  /CONTRAST (c6_wz)=Indicator(3)
  /CONTRAST (hypertesion140yes)=Indicator(1)
  /CONTRAST (b5_wz)=Indicator(1)
  /CONTRAST (b6_wz)=Indicator(1)
  /CONTRAST (ADL_group)=Indicator(1)
  /CONTRAST (DepressionGMS)=Indicator(1)
  /CONTRAST (DementiaGMS)=Indicator(1)
  /METHOD=ENTER   age_yao sex_rc province BMICUT_CN  smoke_wz drink_wz district
Edu_illiterate marriage_wz c6_wz hypertesion140yes b5_wz b6_wz ADL_group DepressionGMS
DementiaGMS
  /PRINT=CI(95)
  /CRITERIA=PIN(.05) POUT(.10) ITERATE(20).
```

/*Variables of "occupation_teach" "income_2x" "d2" "income51_higlow" "income52_higlow" were included into the Cox regression model when analysed occupational class, satisfactory income, financial problems, personal income, and family income, respectively.

Table 6-4. Number, rate and HR of incident coronary heart disease (CHD) in older people with low vs high SES in China: 4-province cohort study

```
COXREG FT5province1
  /STATUS= CHD_totalw4(1)
  /CONTRAST (sex_rc)=Indicator(1)
  /CONTRAST (province)=Indicator(1)
  /CONTRAST (BMICUT_CN)=Indicator(2)
  /CONTRAST (smoke_wz)=Indicator(1)
  /CONTRAST (drink_wz)=Indicator(1)
  /CONTRAST (district)=Indicator(1)
  /CONTRAST (Edu_illiterate)=Indicator(2)
  /CONTRAST (occupation_teach)=Indicator(2)
  /CONTRAST (income_2x)=Indicator(2)
  /CONTRAST (d2)=Indicator(1)
  /CONTRAST (income51_higlow)=Indicator(2)
  /CONTRAST (income52_higlow)=Indicator(2)
  /CONTRAST (marriage_wz)=Indicator(1)
  /CONTRAST (c6_wz)=Indicator(3)
  /CONTRAST (hypertesion140yes)=Indicator(1)
  /CONTRAST (b5_wz)=Indicator(1)
  /CONTRAST (b6_wz)=Indicator(1)
  /CONTRAST (ADL_group)=Indicator(1)
  /CONTRAST (DepressionGMS)=Indicator(1)
  /CONTRAST (DementiaGMS)=Indicator(1)
```

```
 /METHOD=ENTER   age_yao sex_rc province BMICUT_CN  smoke_wz drink_wz district
Edu_illiterate marriage_wz c6_wz hypertesion140yes b5_wz b6_wz ADL_group DepressionGMS
DementiaGMS

 /PRINT=CI(95)

 /CRITERIA=PIN(.05) POUT(.10) ITERATE(20).
```

/*Variables of "occupation_teach" "income_2x" "d2" "income51_higlow" "income52_higlow" were included into the Cox regression model when analysed occupational class, satisfactory income, financial problems, personal income, and family income, respectively.

Table 6-5. Number, rate and HR of incident heart valve disease (HVD) (or others) in older people with low vs high SES in China: 4-province cohort study

```
COXREG FT5province1

 /STATUS=HVD_totalw4wjz(1)

 /CONTRAST (sex_rc)=Indicator(1)

 /CONTRAST (province)=Indicator(1)

 /CONTRAST (BMICUT_CN)=Indicator(2)

 /CONTRAST (smoke_wz)=Indicator(1)

 /CONTRAST (drink_wz)=Indicator(1)

 /CONTRAST (district)=Indicator(1)

 /CONTRAST (Edu_illiterate)=Indicator(2)

 /CONTRAST (occupation_teach)=Indicator(2)

 /CONTRAST (income_2x)=Indicator(2)

 /CONTRAST (d2)=Indicator(1)

 /CONTRAST (income51_higlow)=Indicator(2)

 /CONTRAST (income52_higlow)=Indicator(2)

 /CONTRAST (marriage_wz)=Indicator(1)

 /CONTRAST (c6_wz)=Indicator(3)

 /CONTRAST (hypertesion140yes)=Indicator(1)

 /CONTRAST (b5_wz)=Indicator(1)

 /CONTRAST (b6_wz)=Indicator(1)
```

```
  /CONTRAST (ADL_group)=Indicator(1)

  /CONTRAST (DepressionGMS)=Indicator(1)

  /CONTRAST (DementiaGMS)=Indicator(1)

  /METHOD=ENTER   age_yao sex_rc province BMICUT_CN  smoke_wz drink_wz district
Edu_illiterate marriage_wz c6_wz hypertesion140yes b5_wz b6_wz ADL_group DepressionGMS
DementiaGMS

  /PRINT=CI(95)

  /CRITERIA=PIN(.05) POUT(.10) ITERATE(20).
```

/*Variables of "occupation_teach" "income_2x" "d2" "income51_higlow" "income52_higlow" were included into the Cox regression model when analysed occupational class, satisfactory income, financial problems, personal income, and family income, respectively.

Chapter Seven: Impact of SES on All-cause Mortality in Older People with Heart disease: the Anhui cohort and the Four-province cohort studies

Table 7-1. Socio-demographic and clinical characteristics of participants with and without heart disease at baseline in the cohort study, China

```
RECODE b2_53 (0=0) (1=1) (8=0) (SYSMIS=8) INTO b2_Heart.

EXECUTE.


IF  (b2_Heart=0 and HD_combined=0) b2_Heart_alltypesxx=0.

IF  (b2_Heart=1 or HD_combined=1) b2_Heart_alltypesxx=1.

EXECUTE.


RECODE b2_Heart_alltypesxx (0=0) (1=1) (SYSMIS=0) INTO b2_Heart_alltypes.

EXECUTE.


CROSSTABS

  /TABLES= sex_53 province_53 BMICUT_53 smoke_53 a6_m education_53 occupation_53 income_m
marriage_53 marriage_53 C1_53 c4_53 e4_53 e6_53  hptn_53 b6_53  b5_53 depression_yesno
dementia_yesno by b2_Heart_alltypes

  /FORMAT=AVALUE TABLES
```

```
  /STATISTICS=CHISQ
  /CELLS=COUNT COLUMN
  /COUNT ROUND CELL.
```

Table 7-2. Numbers of deaths and adjusted hazard ratios of all-cause mortality in older people in China

```
CROSSTABS
  /TABLES= b2_Heart_alltypes by Death_53
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT ROW
  /COUNT ROUND CELL.

COXREG Time_53
  /STATUS=Death_53 (1)
  /CONTRAST (b2_Heart_alltypes)=Indicator(1)
  /CONTRAST (sex_53)=Indicator(1)
  /CONTRAST (province_53)=Indicator(1)
  /CONTRAST (BMICUT_53)=Indicator(2)
  /CONTRAST (smoke_53)=Indicator(1)
  /CONTRAST (a6_m)=Indicator(1)
  /CONTRAST (urban_rural_53)=Indicator(1)
  /CONTRAST (Edu_illiterate)=Indicator(2)
  /CONTRAST (marriage_53)=Indicator(1)
  /CONTRAST (hptn_53)=Indicator(1)
  /CONTRAST (b5_53)=Indicator(1)
  /CONTRAST (b6_53)=Indicator(1)
  /CONTRAST (depression_yesno)=Indicator(1)
  /CONTRAST (dementia_yesno)=Indicator(1)
```

```
  /METHOD=ENTER   b2_Heart_alltypes age_53 sex_53 province_53 BMICUT_53 smoke_53 a6_m urban_rural_53 Edu_illiterate marriage_53 hptn_53 b5_53 b6_53 depression_yesno dementia_yesno

  /PRINT=CI(95)

  /CRITERIA=PIN(.05) POUT(.10) ITERATE(20).
```

Table 7-3. Numbers of deaths and adjusted hazard ratios for all-cause mortality between urban and rural living in patients with heart disease in China

```
USE ALL.

COMPUTE filter_$=(Time_53>=0 and education_53<>999 and occupation_53<>999 and income_m<>999 and xxx<>1 and b2_Heart_alltypes<>0).

VARIABLE LABEL filter_$ 'italstat5yearsfollowup_rc <=1 (FILTER)'.

VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.

FORMAT filter_$ (f1.0).

FILTER BY filter_$.

EXECUTE.


CROSSTABS

  /TABLES= urban_rural_53 by Death_53

  /FORMAT=AVALUE TABLES

  /STATISTICS=CHISQ

  /CELLS=COUNT ROW

  /COUNT ROUND CELL.


COXREG Time_53

  /STATUS=Death_53 (1)

  /CONTRAST (b2_Heart_alltypes)=Indicator(1)

  /CONTRAST (sex_53)=Indicator(1)

  /CONTRAST (province_53)=Indicator(1)

  /CONTRAST (BMICUT_53)=Indicator(2)

  /CONTRAST (smoke_53)=Indicator(1)
```

```
  /CONTRAST (a6_m)=Indicator(1)
  /CONTRAST (urban_rural_53)=Indicator(1)
  /CONTRAST (Edu_illiterate)=Indicator(2)
  /CONTRAST (occupation_teach)=Indicator(2)
  /CONTRAST (income_2x)=Indicator(2)
  /CONTRAST (d2_53)=Indicator(1)
  /CONTRAST (marriage_53)=Indicator(1)
  /CONTRAST (hptn_53)=Indicator(1)
  /CONTRAST (b5_53)=Indicator(1)
  /CONTRAST (b6_53)=Indicator(1)
  /CONTRAST (depression_yesno)=Indicator(1)
  /CONTRAST (dementia_yesno)=Indicator(1)
  /METHOD=ENTER  urban_rural_53 age_53 sex_53 province_53 BMICUT_53 smoke_53 a6_m
Edu_illiterate marriage_53 hptn_53 b5_53 b6_53 depression_yesno dementia_yesno
  /PRINT=CI(95)
  /CRITERIA=PIN(.05) POUT(.10) ITERATE(20).
```

/* Table 7-4 (5, 6, and 7): Variables of "Edu_illiterate", "occupation_teach", "income_2x", and "d2_53" were included into the above Cox regression model (Table 7-3) when analysed educational level, occupational class, satisfactory income, and financial problems, respectively.

Table 7-8. Numbers of deaths and adjusted hazard ratios for all-cause mortality between high and low personal income in patients with heart disease in China

```
USE ALL.
COMPUTE filter_$=(province<6 and fiveP6071followup<3 and education_level_m<>999 and
occupation_m<>999 and income_m<>999 and d2<>999 and a5<>999 and CHD_HVD_others1<>0 ).
VARIABLE LABELS filter_$ 'province<5 and fiveProvinces6071=1 (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMATS filter_$ (f1.0).
FILTER BY filter_$.
```

```
EXECUTE.

CROSSTABS
  /TABLES= income51_higlow  income52_higlow  BY fiveP6071followup
  /FORMAT=AVALUE TABLES
  /CELLS=COUNT ROW
  /STATISTICS=CHISQ
  /COUNT ROUND CELL.

COXREG FT5province1
  /STATUS=fiveP6071followup(2)
  /CONTRAST (sex_rc)=Indicator(1)
  /CONTRAST (province)=Indicator(1)
  /CONTRAST (BMICUT_CN)=Indicator(2)
  /CONTRAST (smoke_wz)=Indicator(1)
  /CONTRAST (drink_wz)=Indicator(1)
  /CONTRAST (district)=Indicator(1)
  /CONTRAST (Edu_illiterate)=Indicator(2)
  /CONTRAST (marriage_wz)=Indicator(1)
  /CONTRAST (hypertesion140yes)=Indicator(1)
  /CONTRAST (b5_wz)=Indicator(1)
  /CONTRAST (b6_wz)=Indicator(1)
  /CONTRAST (DepressionGMS)=Indicator(1)
  /CONTRAST (DementiaGMS)=Indicator(1)
  /CONTRAST (income51_higlow)=Indicator(2)
  /CONTRAST (income52_higlow)=Indicator(2)
  /METHOD=ENTER income51_higlow age_yao sex_rc province BMICUT_CN smoke_wz drink_wz
district Edu_illiterate marriage_wz  hypertesion140yes b5_wz b6_wz DepressionGMS DementiaGMS
  /PRINT=CI(95)
```

```
/CRITERIA=PIN(.05) POUT(.10) ITERATE(20).
```

/* Table 7-9: Variable of “income52_higlow” was included into the above Cox regression model (Table 7-8) when analysed family income.

Chapter Eight: Impact of SES on Incidence of Stroke: the Anhui cohort and the Four-province cohort studies

Table 8-1. Distribution of socio-demographic and clinical characteristics of participants by gender at baseline in the Anhui cohort study, China

```
USE ALL.

COMPUTE filter_$=(b5<>1 and T_full_stroke_w4>=0).

VARIABLE LABEL filter_$ 'italstat5yearsfollowup_rc <=1 (FILTER)'.

VALUE LABELS filter_$  0 'Not Selected' 1 'Selected'.

FORMAT filter_$ (f1.0).

FILTER BY filter_$.

EXECUTE.


CROSSTABS

  /TABLES=     Smoke01 a6_m BMICUT urban_rural education_level_m occupation_m income
d2 Marriage_3grp c1_new1 C4_m  group_hptn140 b2 b6 ADL_group dementia_dep BY sex

  /FORMAT=AVALUE TABLES

  /STATISTICS=CHISQ

  /CELLS= COUNT COLUMN

  /COUNT ROUND CELL.
```

Table 8-2 (and 3). Number, rate and hazard ratio of incident stroke in older people with urban and rural living (and other SES indicators) in China: the Anhui cohort study

```
CROSSTABS

  /TABLES= urban_rural BY Stroke_full_w4

  /FORMAT=AVALUE TABLES
```

```
  /CELLS=COUNT
  /COUNT ROUND CELL.

RECODE education_level_m (1=1) (2=2) (3=3) (4=3) INTO education_HigMidLow.
EXECUTE.
RECODE occupation_m (1=1) (2=2) (3=3) (4=3) INTO occupation_HigMidLow.
EXECUTE.
RECODE income_m (1=1) (2=2) (3=3) (4=3) INTO income_HigMidLow.
EXECUTE.

COXREG T_full_stroke_w4
  /STATUS=Stroke_full_w4(1)
  /CONTRAST (urban_rural)=Indicator (1)
  /CONTRAST (education_HigMidLow)=Indicator(3)
  /CONTRAST (occupation_m_wz)=Indicator(3)
  /CONTRAST (income_HigMidLow)=Indicator(1)
  /CONTRAST (d2)=Indicator(1)
  /CONTRAST (sex)=Indicator(1)
  /CONTRAST (BMICUT)=Indicator(2)
  /CONTRAST (smoke01)=Indicator(1)
  /CONTRAST (a6_m)=Indicator(1)
  /CONTRAST (Marriage_3grp)=Indicator(1)
  /CONTRAST (C4_m)=Indicator(3)
  /CONTRAST (hptn_yesno)=Indicator(1)
  /CONTRAST (b2)=Indicator(1)
  /CONTRAST (b6)=Indicator(1)
  /CONTRAST (ADL_group)=Indicator(1)
  /CONTRAST (dementia_dep)=Indicator(1)
```

```
  /METHOD=ENTER  urban_rural education_HigMidLow occupation_m_wz income_HigMidLow age sex BMICUT smoke01 a6_m Marriage_3grp C4_m hptn_yesno b2 b6 ADL_group dementia_dep

  /PRINT=CI(95)

  /CRITERIA=PIN(.05) POUT(.10) ITERATE(20).
```

Table 8-4. Hazard ratios of incident stroke by SES in women and men: the Anhui cohort study

```
SORT CASES BY sex.

SPLIT FILE LAYERED BY sex.
```

/* Repeated the above Cox regression models (Table 8-2) to analyse the gender difference in the association of SES with incidence of stroke.

Table 8-5. Distribution of socio-demographic and clinical characteristics of participants by gender at baseline in the Four-province cohort study, China

```
USE ALL.

COMPUTE filter_$=(b5<>1 and province<5 and fiveP6071followup<3 and education_level_m<>999 and occupation_m<>999 and income_m<>999 and d2<>999 and a5<>999).

VARIABLE LABELS filter_$ 'province<5 and fiveProvinces6071=1 (FILTER)'.

VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.

FORMATS filter_$ (f1.0).

FILTER BY filter_$.

EXECUTE.


CROSSTABS

  /TABLES= province smoke_wz drink_wz BMICUT_CN district education_level_m occupation_m a5 d2 marriage_wzx c1_wz c6_wz hypertesion140yes b2_wz b6_wz ADL_group Dementia_dep BY sex_rc

  /FORMAT=AVALUE TABLES

  /CELLS=COUNT COLUMN

  /STATISTICS=CHISQ

  /COUNT ROUND CELL.
```

Table 8-6. Number, rate and hazard ratio of incident stroke in older people with different SES measurement in China: the Four-province cohort study

```
CROSSTABS
  /TABLES= district education_HigMidLow occupation_HigMidLow income_HigMidLow_x
income_orgi d2 BY incidentstroke_new
  /FORMAT=AVALUE TABLES
  /CELLS=COUNT
  /COUNT ROUND CELL.


COXREG FT5province1
  /STATUS=incidentstroke_new(1)
  /CONTRAST (district)=Indicator(1)
  /CONTRAST (education_HigMidLow)=Indicator(3)
  /CONTRAST (occupation_HigMidLow)=Indicator(3)
  /CONTRAST (income_orgi)=Indicator(1)
  /CONTRAST (d2)=Indicator(1)
  /CONTRAST (sex_rc)=Indicator(1)
  /CONTRAST (province)=Indicator(1)
  /CONTRAST (BMICUT_CN)=Indicator(2)
  /CONTRAST (smoke_wz)=Indicator(1)
  /CONTRAST (drink_wz)=Indicator(1)
  /CONTRAST (marriage_wz)=Indicator(1)
  /CONTRAST (c6_wz)=Indicator(3)
  /CONTRAST (hypertesion140yes)=Indicator(1)
  /CONTRAST (b2_wz)=Indicator(1)
  /CONTRAST (b6_wz)=Indicator(1)
  /CONTRAST (ADL_group)=Indicator(1)
  /CONTRAST (Dementia_dep)=Indicator(1)
```

/METHOD=ENTER district education_HigMidLow occupation_HigMidLow income_orgi age_yao sex_rc province BMICUT_CN smoke_wz drink_wz marriage_wz c6_wz hypertesion140yes b2_wz b6_wz ADL_group Dementia_dep

/PRINT=CI(95)

/CRITERIA=PIN(.05) POUT(.10) ITERATE(20).

/*In adjustment analysis for "financial problems (d2)", "satisfactory income (income_orgi)" did not include into the Cox regression model.

Table 8-7. Hazard ratios of incident stroke by SES in women and men: the Four-province cohort study

SORT CASES BY sex_rc.

SPLIT FILE LAYERED BY sex_rc.

/* Using the above Cox regression models (Table 8-6) to analyse the gender difference in the association of SES with incidence of stroke.

Table 8-8. Number, rate and hazard ratio of incident stroke in older people with actual income in China: the Four-province cohort study

IF (a51<4800) income51_4P=1.

IF (a51>=4800 and a51<10000) income51_4P=2.

IF (a51>=10000) income51_4P=3.

EXECUTE.

IF (a52<4800) income52_4P=1.

IF (a52>=4800 and a52<12000) income52_4P=2.

IF (a52>=12000) income52_4P=3.

EXECUTE.

COXREG FT5province1

/STATUS=incidentstroke_new(1)

/CONTRAST (district)=Indicator(1)

/CONTRAST (education_HigMidLow)=Indicator(3)

```
 /CONTRAST (occupation_HigMidLow)=Indicator(3)
 /CONTRAST (sex_rc)=Indicator(1)
 /CONTRAST (province)=Indicator(1)
 /CONTRAST (BMICUT_CN)=Indicator(2)
 /CONTRAST (smoke_wz)=Indicator(1)
 /CONTRAST (drink_wz)=Indicator(1)
 /CONTRAST (marriage_wz)=Indicator(1)
 /CONTRAST (c6_wz)=Indicator(3)
 /CONTRAST (hypertesion140yes)=Indicator(1)
 /CONTRAST (b2_wz)=Indicator(1)
 /CONTRAST (b6_wz)=Indicator(1)
 /CONTRAST (ADL_group)=Indicator(1)
 /CONTRAST (Dementia_dep)=Indicator(1)
 /CONTRAST (income51_4P)=Indicator(3)
 /CONTRAST (income52_4P)=Indicator(3)
 /METHOD=ENTER  income51_4P district education_HigMidLow occupation_HigMidLow age_yao
sex_rc province BMICUT_CN smoke_wz drink_wz marriage_wz c6_wz hypertesion140yes b2_wz
b6_wz ADL_group Dementia_dep
 /PRINT=CI(95)
 /CRITERIA=PIN(.05) POUT(.10) ITERATE(20).
```

/*Variable of "income51_4P" was replaced by "income52_4P" in the above Cox regression model (Table 8-8) when analysed family income.

Table 8-9. Pooled hazard ratio of incident stroke in different SES indicators among participants from the Anhui cohort and the Four-province cohort studies

/*Pooled hazard ratios were analysed using Stata statistical software.

Chapter Nine: Impact of SES on All-cause Mortality in Older People with Stroke: the Five provinces cohort studies

Table 9-1. Sociodemographic and characteristics of participants: the 5-province cohort study, China

```
USE ALL.
```

```
COMPUTE filter_$=(province<6 and fiveP6071followup<3 and education_level_m<>999 and occupation_m<>999 and a5<>999).

VARIABLE LABELS filter_$ 'province<5 and fiveProvinces6071=1 (FILTER)'.

VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.

FORMATS filter_$ (f1.0).

FILTER BY filter_$.

EXECUTE.


CROSSTABS

  /TABLES= sex_rc province smoke_wz drink_wz BMICUT_CN district education_level_m occupation_m income_orgi marriage_wzx c1 e4_wzx  hypertesion140yes b3_wzx b2_wzx b4_wzx b6_wzx Dementia_dep BY b5_wzx

  /FORMAT=AVALUE TABLES

  /CELLS= COUNT COLUMN

/STATISTICS=CHISQ

  /COUNT ROUND CELL.
```

Table 9-2. Numbers of deaths and adjusted hazard ratio for all-cause mortality of stroke among older adults in China: the 5-province cohort study

```
CROSSTABS

  /TABLES=  b5_wzx BY fiveP6071followup

  /FORMAT=AVALUE TABLES

  /STATISTICS=CHISQ

  /CELLS= COUNT  ROW

  /COUNT ROUND CELL.


COXREG FT5province1

  /STATUS=fiveP6071followup(2)

  /CONTRAST (b5_wzx)=Indicator(1)

  /CONTRAST (sex_rc)=Indicator(1)
```

```
  /CONTRAST (province)=Indicator(1)

  /CONTRAST (BMICUT_CN)=Indicator(2)

  /CONTRAST (smoke_wzxx)=Indicator(1)

  /CONTRAST (drink_wzxx)=Indicator(1)

  /CONTRAST (marriage_wzxx)=Indicator(1)

  /CONTRAST (district)=Indicator(1)

  /CONTRAST (education_level_m_HigLow)=Indicator(1)

  /CONTRAST (occupation_m_HigLow)=Indicator(1)

  /CONTRAST (income_org_HigLow)=Indicator(1)

  /CONTRAST (hypertesion140yesxx)=Indicator(1)

  /CONTRAST (b3_wzxx)=Indicator(1)

  /CONTRAST (b2_wzxx)=Indicator(1)

  /CONTRAST (b6_wzxx)=Indicator(1)

  /CONTRAST (Dementia_dep_wzxx)=Indicator(1)

  /METHOD=ENTER b5_wzx age_yao sex_rc province BMICUT_CN smoke_wzxx drink_wzxx
marriage_wzxx district education_level_m_HigLow occupation_m_HigLow income_org_HigLow
hypertesion140yesxx b3_wzxx b2_wzxx b6_wzxx Dementia_dep_wzxx

  /PRINT=CI(95)

  /CRITERIA=PIN(.05) POUT(.10) ITERATE(20).
```

Table 9-3. Number of deaths and adjusted hazard ratio for urban-rural living among patients with stroke: the 5-province cohort study, China

```
USE ALL.

COMPUTE filter_$=(province<6 and fiveP6071followup<3 and education_level_m<>999 and
occupation_m<>999 and a5<>999 and b5_wzx=1).

VARIABLE LABELS filter_$ 'province<5 and fiveProvinces6071=1 (FILTER)'.

VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.

FORMATS filter_$ (f1.0).

FILTER BY filter_$.

EXECUTE.
```

```
COXREG FT5province1
  /STATUS=fiveP6071followup(2)
  /CONTRAST (b5_wzx)=Indicator(1)
  /CONTRAST (sex_rc)=Indicator(1)
  /CONTRAST (province)=Indicator(1)
  /CONTRAST (BMICUT_CN)=Indicator(2)
  /CONTRAST (smoke_wzxx)=Indicator(1)
  /CONTRAST (drink_wzxx)=Indicator(1)
  /CONTRAST (marriage_wzxx)=Indicator(1)
  /CONTRAST (district)=Indicator(1)
  /CONTRAST (education_level_m_HigLow)=Indicator(1)
  /CONTRAST (occupation_m_HigLow)=Indicator(1)
  /CONTRAST (income_org_HigLow)=Indicator(1)
  /CONTRAST (hypertesion140yesxx)=Indicator(1)
  /CONTRAST (b3_wzxx)=Indicator(1)
  /CONTRAST (b2_wzxx)=Indicator(1)
  /CONTRAST (b6_wzxx)=Indicator(1)
  /CONTRAST (Dementia_dep_wzxx)=Indicator(1)
  /METHOD=ENTER district age_yao sex_rc provincexx BMICUT_CNxx smoke_wzxx drink_wzxx
marriage_wzxx education_level_m_HigLow hypertesion140yesxx b3_wzxx b2_wzxx b6_wzxx
Dementia_dep_wzxx
  /PRINT=CI(95)
```

Table 9-4. Number of deaths and adjusted hazard ratio for educational level among patients with stroke: the 5-province cohort study, China

```
COXREG FT5province1
  /STATUS=fiveP6071followup(2)
  /CONTRAST (b5_wzx)=Indicator(1)
  /CONTRAST (sex_rc)=Indicator(1)
```

```
  /CONTRAST (province)=Indicator(1)
  /CONTRAST (BMICUT_CN)=Indicator(2)
  /CONTRAST (smoke_wzxx)=Indicator(1)
  /CONTRAST (drink_wzxx)=Indicator(1)
  /CONTRAST (marriage_wzxx)=Indicator(1)
  /CONTRAST (district)=Indicator(1)
  /CONTRAST (education_level_m_HigLow)=Indicator(1)
  /CONTRAST (occupation_m_HigLow)=Indicator(1)
  /CONTRAST (income_org_HigLow)=Indicator(1)
  /CONTRAST (hypertesion140yesxx)=Indicator(1)
  /CONTRAST (b3_wzxx)=Indicator(1)
  /CONTRAST (b2_wzxx)=Indicator(1)
  /CONTRAST (b6_wzxx)=Indicator(1)
  /CONTRAST (Dementia_dep_wzxx)=Indicator(1)
  /CONTRAST (income51_4P_higlow)=Indicator(2)
  /CONTRAST (income52_4P_higlow)=Indicator(2)
  /METHOD=ENTER district age_yao sex_rc provincexx BMICUT_CNxx smoke_wzxx drink_wzxx
marriage_wzxx education_level_m_HigLow hypertesion140yesxx b3_wzxx b2_wzxx b6_wzxx
Dementia_dep_wzxx
  /PRINT=CI(95)
```

/***Table 9-5, -6, -7, and -8.** Variables of “occupation_m_HigLow” “income_org_HigLow” “income51_4P_higlow” “income52_4P_higlow” were included into the Cox regression model when analysed occupational class, satisfactory income, personal income, and family income, respectively.

Chapter Ten: Impacts of SES on All-cause Mortality in Those with Either Heart Disease or Stroke and Those with Neither: the Anhui cohort and the Four-province cohort studies

Table 10-1. Sociodemographic and characteristics of participants in the Anhui cohort study, China

```
USE ALL.
COMPUTE filter_$=(T_full_w4>=0).
```

```
VARIABLE LABELS filter_$ 'T_full_w4>0 (FILTER)'.

VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.

FORMATS filter_$ (f1.0).

FILTER BY filter_$.

EXECUTE.


CROSSTABS

  /TABLES=  sex Smoke_3group_1 a6_m BMICUT urban_rural education_level_m occupation_m
income d2 Marriage_3grp C4_m c7 e4 e6 hypertension01 b3 b2 b5 b6 depression_GMS dementia_GMS
by Death_2011

  /FORMAT=AVALUE TABLES

  /STATISTICS=CHISQ

  /CELLS= COUNT COLUMN

  /COUNT ROUND CELL.
```

Table 10-2. Numbers of deaths, mortality rate, and adjusted HR for all-cause mortality in older adults from urban and rural areas in China: the Anhui cohort study

```
CROSSTABS

  /TABLES=  urban_rural by Death_2011

  /FORMAT=AVALUE TABLES

  /STATISTICS=CHISQ

  /CELLS=COUNT ROW

  /COUNT ROUND CELL.


COXREG T_full_w4

  /STATUS=Death_2011(1)

  /CONTRAST (sex)=Indicator(1)

  /CONTRAST (BMICUT)=Indicator(2)

  /CONTRAST (Smoke_3group_1)=Indicator(1)

  /CONTRAST (a6_m)=Indicator(1)
```

```
/CONTRAST (Marriage_3grp)=Indicator(1)
/CONTRAST (C4_m)=Indicator(4)
/CONTRAST (e4)=Indicator(2)
/CONTRAST (urban_rural)=Indicator (1)
/CONTRAST (education_level_m_higlow)=Indicator(2)
/CONTRAST (occupation_m_higlow)=Indicator(2)
/CONTRAST (income_higlow)=Indicator(1)
/CONTRAST (d2)=Indicator (1)
/CONTRAST (hypertension01)=Indicator(1)
/CONTRAST (b3_wz)=Indicator(1)
/CONTRAST (b2_wz)=Indicator(1)
/CONTRAST (b5_wz)=Indicator(1)
/CONTRAST (b6_wz)=Indicator(1)
/CONTRAST (depression_GMS)=Indicator(1)
/CONTRAST (dementia_GMS)=Indicator(1)
/METHOD=ENTER age sex BMICUT Smoke_3group_1 a6_m urban_rural education_level_m_higlow Marriage_3grp C4_m e4 hypertension01 b3_wz b2_wz b5_wz b6_wz depression_GMS dementia_GMS
/PRINT=CI(95)
/CRITERIA=PIN(.05) POUT(.10) ITERATE(20).
```

Table 10-3. Numbers of deaths and adjusted HR for all-cause mortality in older adults with low and high SES in China: the Anhui cohort study

```
CROSSTABS
/TABLES= education_level_m_higlow occupation_m_higlow income_higlow d2 by Death_2011
/FORMAT=AVALUE TABLES
/STATISTICS=CHISQ
/CELLS=COUNT ROW
/COUNT ROUND CELL.
```

```
COXREG T_full_w4
  /STATUS=Death_2011(1)
  /CONTRAST (sex)=Indicator(1)
  /CONTRAST (BMICUT)=Indicator(2)
  /CONTRAST (Smoke_3group_1)=Indicator(1)
  /CONTRAST (a6_m)=Indicator(1)
  /CONTRAST (urban_rural)=Indicator (1)
  /CONTRAST (education_level_m_higlow)=Indicator(2)
  /CONTRAST (occupation_m_higlow)=Indicator(2)
  /CONTRAST (income_higlow)=Indicator(1)
  /CONTRAST (d2)=Indicator (1)
  /CONTRAST (Marriage_3grp)=Indicator(1)
  /CONTRAST (C4_m)=Indicator(4)
  /CONTRAST (e4)=Indicator(2)
  /CONTRAST (hypertension01)=Indicator(1)
  /CONTRAST (b3_wz)=Indicator(1)
  /CONTRAST (b2_wz)=Indicator(1)
  /CONTRAST (b5_wz)=Indicator(1)
  /CONTRAST (b6_wz)=Indicator(1)
  /CONTRAST (depression_GMS)=Indicator(1)
  /CONTRAST (dementia_GMS)=Indicator(1)
  /METHOD=ENTER age sex BMICUT Smoke_3group_1 a6_m urban_rural education_level_m_higlow
Marriage_3grp C4_m e4 hypertension01 b3_wz b2_wz b5_wz b6_wz depression_GMS dementia_GMS
  /PRINT=CI(95)
  /CRITERIA=PIN(.05) POUT(.10) ITERATE(20).
```

/*Variables of “occupation_m_higlow” “income_higlow” and “d2” were included into the Cox regression model when analysed occupational class, satisfactory income, and financial problems, respectively.

Table 10-4. Numbers of deaths and adjusted HR for all-cause mortality among older adults with HD or stroke in China: the Anhui cohort study

```
USE ALL.

COMPUTE filter_$=(T_full_w4>=0 and (b2=1 or b5=1)).

VARIABLE LABELS filter_$ 'T_full_w4>0 (FILTER)'.

VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.

FORMATS filter_$ (f1.0).

FILTER BY filter_$.

EXECUTE.


COXREG T_full_w4

  /STATUS=Death_2011(1)

  /CONTRAST (sex)=Indicator(1)

  /CONTRAST (BMICUT)=Indicator(2)

  /CONTRAST (Smoke_3group_1)=Indicator(1)

  /CONTRAST (a6_m)=Indicator(1)

  /CONTRAST (urban_rural)=Indicator (1)

  /CONTRAST (education_level_m_higlow)=Indicator(2)

  /CONTRAST (occupation_m_higlow)=Indicator(2)

  /CONTRAST (income_higlow)=Indicator(1)

  /CONTRAST (d2)=Indicator (1)

  /CONTRAST (Marriage_3grp)=Indicator(1)

  /CONTRAST (C4_m)=Indicator(4)

  /CONTRAST (e4)=Indicator(2)

  /CONTRAST (hypertension01)=Indicator(1)

  /CONTRAST (b3_wz)=Indicator(1)

  /CONTRAST (b6_wz)=Indicator(1)

  /CONTRAST (depression_GMS)=Indicator(1)

  /CONTRAST (dementia_GMS)=Indicator(1)
```

/METHOD=ENTER age sex BMICUT Smoke_3group_1 a6_m urban_rural education_level_m_higlow Marriage_3grp C4_m e4 hypertension01 b3_wz b6_wz depression_GMS dementia_GMS

/PRINT=CI(95)

/CRITERIA=PIN(.05) POUT(.10) ITERATE(20).

/*Variables of "occupation_m_higlow" "income_higlow" and "d2" were included into the Cox regression model when analysed occupational class, satisfactory income, and financial problems, respectively.

Table 10-5. Numbers of deaths and adjusted HR for all-cause mortality among older adults without heart disease and stroke in China: the Anhui cohort study

USE ALL.

COMPUTE filter_$=(T_full_w4>=0 and b2<>1 and b5<>1).

VARIABLE LABELS filter_$ 'T_full_w4>0 (FILTER)'.

VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.

FORMATS filter_$ (f1.0).

FILTER BY filter_$.

EXECUTE.

/*Repeated above Cox regression analysis (Table 10-4) and analysed SES variables accordingly.

Table 10-6. Sociodemographic and characteristics of participants in the 4-province cohort study, China

USE ALL.

COMPUTE filter_$=(province<5 and fiveP6071followup<3 and education_level_m<>999 and occupation_m<>999 and a5<>999 and d2<>999).

VARIABLE LABELS filter_$ 'province<5 and fiveProvinces6071=1 (FILTER)'.

VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.

FORMATS filter_$ (f1.0).

FILTER BY filter_$.

EXECUTE.

CROSSTABS

```
 /TABLES= sex_rc province smoke_wz drink_wzxx BMICUT_CN district education_level_m occupation_m income_orgi d2 marriage_wzx c6_wzxx c9_wz e4_wzx e5_wz hypertesion140yes b3_wzx b2_wzx b5_wzx b6_wzx DepressionGMS DementiaGMS BY fiveP6071followup

 /FORMAT=AVALUE TABLES

 /CELLS= COUNT COLUMN

 /STATISTICS=CHISQ

 /COUNT ROUND CELL.
```

Table 10-7. Numbers of deaths and adjusted HR for all-cause mortality in older adults from urban and rural areas in China: the 4-province cohort study

```
CROSSTABS

 /TABLES=district BY fiveP6071followup

 /FORMAT=AVALUE TABLES

 /CELLS= COUNT ROW

 /STATISTICS=CHISQ

 /COUNT ROUND CELL.


COXREG FT5province1

 /STATUS=fiveP6071followup(2)

 /CONTRAST (sex_rc)=Indicator(1)

 /CONTRAST (province)=Indicator(1)

 /CONTRAST (BMICUT_CN)=Indicator(2)

 /CONTRAST (smoke_wz)=Indicator(1)

 /CONTRAST (drink_wzxx)=Indicator(1)

 /CONTRAST (district)=Indicator(1)

 /CONTRAST (education_level_m_HigLow)=Indicator(1)

 /CONTRAST (occupation_m_HigLow)=Indicator(1)

 /CONTRAST (income_org_HigLow)=Indicator(1)

 /CONTRAST (d2)=Indicator(1)

 /CONTRAST (marriage_wzx)=Indicator(1)
```

```
  /CONTRAST (c6_wzxx)=Indicator(3)
  /CONTRAST (e4_wzxx)=Indicator(1)
  /CONTRAST (hypertesion140yes)=Indicator(1)
  /CONTRAST (b3_wzx)=Indicator(1)
  /CONTRAST (b2_wzx)=Indicator(1)
  /CONTRAST (b5_wzx)=Indicator(1)
  /CONTRAST (b6_wzx)=Indicator(1)
  /CONTRAST (DepressionGMS)=Indicator(1)
  /CONTRAST (DementiaGMS)=Indicator(1)
  /METHOD=ENTER district age_yao sex_rc province BMICUT_CN smoke_wz drink_wzxx
education_level_m_HigLow marriage_wzx c6_wzxx e4_wzxx hypertesion140yes b3_wzx b2_wzx
b5_wzx b6_wzx DepressionGMS DementiaGMS
  /PRINT=CI(95)
  /CRITERIA=PIN(.05) POUT(.10) ITERATE(20).
```

Table 10-8. Numbers of deaths and adjusted HR for all-cause mortality in older adults from low and high SES in China: the 4-province cohort study

```
CROSSTABS
  /TABLES= education_level_m_HigLow occupation_m_HigLow income_org_HigLow d2 BY
fiveP6071followup
  /FORMAT=AVALUE TABLES
  /CELLS= COUNT ROW
  /STATISTICS=CHISQ
  /COUNT ROUND CELL.

COXREG FT5province1
  /STATUS=fiveP6071followup(2)
  /CONTRAST (sex_rc)=Indicator(1)
  /CONTRAST (province)=Indicator(1)
  /CONTRAST (BMICUT_CN)=Indicator(2)
```

```
/CONTRAST (smoke_wz)=Indicator(1)

/CONTRAST (drink_wzxx)=Indicator(1)

/CONTRAST (district)=Indicator(1)

/CONTRAST (education_level_m_HigLow)=Indicator(1)

/CONTRAST (occupation_m_HigLow)=Indicator(1)

/CONTRAST (income_org_HigLow)=Indicator(1)

/CONTRAST (d2)=Indicator(1)

/CONTRAST (marriage_wzx)=Indicator(1)

/CONTRAST (c6_wzxx)=Indicator(3)

/CONTRAST (e4_wzxx)=Indicator(1)

/CONTRAST (hypertesion140yes)=Indicator(1)

/CONTRAST (b3_wzx)=Indicator(1)

/CONTRAST (b2_wzx)=Indicator(1)

/CONTRAST (b5_wzx)=Indicator(1)

/CONTRAST (b6_wzx)=Indicator(1)

/CONTRAST (DepressionGMS)=Indicator(1)

/CONTRAST (DementiaGMS)=Indicator(1)

/METHOD=ENTER district age_yao sex_rc province BMICUT_CN smoke_wz drink_wzxx
education_level_m_HigLow marriage_wzx c6_wzxx e4_wzxx hypertesion140yes b3_wzx b2_wzx
b5_wzx b6_wzx DepressionGMS DementiaGMS

/PRINT=CI(95)

/CRITERIA=PIN(.05) POUT(.10) ITERATE(20).
```

/*Variables of “occupation_m_higlow” “income_higlow” and “d2” were included into the Cox regression model when analysed occupational class, satisfactory income, and financial problems, respectively.

Table 10-9. Numbers of deaths and adjusted HR for all-cause mortality among older adults with HD or stroke in China: the 4-province cohort study

```
USE ALL.

COMPUTE filter_$=(province<5 and fiveP6071followup<3 and education_level_m<>999 and
occupation_m<>999 and a5<>999 and d2<>999 and (b2=1 or b5=1)).
```

VARIABLE LABELS filter_$ 'province<5 and fiveProvinces6071=1 (FILTER)'.

VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.

FORMATS filter_$ (f1.0).

FILTER BY filter_$.

EXECUTE.

/* Repeated above Cox regression analysis (Table 10-8) and analysed the SES variables accordingly, but the variables of “Heart disease” and “Stroke” were not adjusted in the models.

Table 10-10. Numbers of deaths and adjusted HR for all-cause mortality in older adults without heart disease and stroke in China: the 4-province cohort study

USE ALL.

COMPUTE filter_$=(province<5 and fiveP6071followup<3 and education_level_m<>999 and occupation_m<>999 and a5<>999 and d2<>999 and b2<>1 and b5<>1).

VARIABLE LABELS filter_$ 'province<5 and fiveProvinces6071=1 (FILTER)'.

VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.

FORMATS filter_$ (f1.0).

FILTER BY filter_$.

EXECUTE.

/* Repeated above Cox regression analysis (Table 10-8) and analysed the SES variables accordingly, but the variables of “Heart disease” and “Stroke” were not adjusted in the models.

Table 10-11. Number of deaths and adjusted HR for all-cause mortality in older adults with actual income in China: the 4-province cohort study

USE ALL.

COMPUTE filter_$=(province<5 and fiveP6071followup<3 and education_level_m<>999 and occupation_m<>999 and a5<>999 and d2<>999).

VARIABLE LABELS filter_$ 'province<5 and fiveProvinces6071=1 (FILTER)'.

VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.

FORMATS filter_$ (f1.0).

```
FILTER BY filter_$.

EXECUTE.


COXREG FT5province1

  /STATUS=fiveP6071followup(2)

  /CONTRAST (sex_rc)=Indicator(1)

  /CONTRAST (province)=Indicator(1)

  /CONTRAST (BMICUT_CN)=Indicator(2)

  /CONTRAST (smoke_wz)=Indicator(1)

  /CONTRAST (drink_wzxx)=Indicator(1)

  /CONTRAST (district)=Indicator(1)

  /CONTRAST (education_level_m_HigLow)=Indicator(1)

  /CONTRAST (marriage_wzx)=Indicator(1)

  /CONTRAST (c6_wzxx)=Indicator(3)

  /CONTRAST (e4_wzxx)=Indicator(1)

  /CONTRAST (hypertesion140yes)=Indicator(1)

  /CONTRAST (b3_wzx)=Indicator(1)

  /CONTRAST (b2_wzx)=Indicator(1)

  /CONTRAST (b5_wzx)=Indicator(1)

  /CONTRAST (b6_wzx)=Indicator(1)

  /CONTRAST (DepressionGMS)=Indicator(1)

  /CONTRAST (DementiaGMS)=Indicator(1)

  /CONTRAST (income51_4P_higlow)=Indicator(2)

  /CONTRAST (income52_4P_higlow)=Indicator(2)

  /METHOD=ENTER district age_yao sex_rc province BMICUT_CN smoke_wz drink_wzxx
education_level_m_HigLow marriage_wzx c6_wzxx e4_wzxx hypertesion140yes b3_wzx b2_wzx
b5_wzx b6_wzx DepressionGMS DementiaGMS

  /PRINT=CI(95)
```

/*Variables of “income51_4P_higlow” and “income52_4P_higlow” were included into the Cox regression model when analysed personal income and family income, respectively.

Table 10-12. Number of deaths and adjusted HR for all-cause mortality among older adults with heart disease or stroke in China: the 4-province cohort study

USE ALL.

COMPUTE filter_$=(province<5 and fiveP6071followup<3 and education_level_m<>999 and occupation_m<>999 and a5<>999 and d2<>999 and (b2=1 or b5=1)).

VARIABLE LABELS filter_$ 'province<5 and fiveProvinces6071=1 (FILTER)'.

VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.

FORMATS filter_$ (f1.0).

FILTER BY filter_$.

EXECUTE.

/* Repeated above Cox regression analysis (Table 10-11) and analysed the personal income and family income variables accordingly, but the variables of “Heart disease” and “Stroke” were not adjusted in the models.

Table 10-13. Number of deaths and adjusted HR for all-cause mortality among older adults without heart disease and stroke in China: the 4-province cohort study

USE ALL.

COMPUTE filter_$=(province<5 and fiveP6071followup<3 and education_level_m<>999 and occupation_m<>999 and a5<>999 and d2<>999 and b2<>1 and b5<>1).

VARIABLE LABELS filter_$ 'province<5 and fiveProvinces6071=1 (FILTER)'.

VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.

FORMATS filter_$ (f1.0).

FILTER BY filter_$.

EXECUTE.

/* Repeated above Cox regression analysis (Table 10-11) and analysed the personal income and family income variables accordingly, but the variables of “Heart disease” and “Stroke” were not adjusted in the models.

Table 10-14. Pooled HR of all-cause mortality in different SES indicators among participants from the Anhui cohort and the Four-province cohort studies

/*Pooled hazard ratios were analysed using Stata statistical software.

Syntax for meta-analysis through Stata statistical software

```
metan LnRR SeLnRR, label(namevar=RefmanID) random effect (Relative Risk) eform

metan LnRR SeLnRR, label(namevar=RefmanID) fixed effect (Relative Risk) eform


metan LnRR SeLnRR if Study_No ==1, label(namevar=study_id) random effect (Relative Risk) eform

metan LnRR SeLnRR if Study_No ==1, label(namevar=study_id) fixed effect (Relative Risk) eform

metan LnRR SeLnRR if Study_No ==1, label(namevar=study_id) sortby(_WT) by (Case_control) random effect(Relative Risk) eform


metabias LnRR SeLnRR, graph (begg)

metabias LnRR SeLnRR if Study_No ==1, egger

metabias LnRR SeLnRR if Study_No ==1, egger

metafunnel LnRR SeLnRR if Study_No ==1, x label(0.1 0.2 0.4 0.6 0.8 1 2 3 4 5 10 20) xtitle(Relative Risk) eform

metabias LnRR SeLnRR, graph egger
```

APPENDIX 2. Characteristics of Participants with Follow-up and Dropout in the Four-province Cohort Study, China

Variable	All Participants N=4314		Follow-up n=3151	(%)	Dropout n=1163	(%)	P* value
Age (years)							
Mean (SD)	71.4	7.6	71.1	7.3	72.3	8.1	*<0.001*
Sex							
Women	2470	57.3	1763	56.0	707	60.8	*0.004*
Men	1844	42.7	1388	44.0	456	39.2	
Province							
Guangdong	1019	23.6	902	28.6	117	10.1	*<0.001*
Shanghai	1227	28.4	926	29.4	301	25.9	
Heilongjiang	1039	24.1	460	14.6	579	49.8	
Shanxi	1029	23.9	863	27.4	166	14.3	
Smoking							
Never-smoking	2704	62.7	1956	62.1	748	64.3	*0.067*
Ex-smoking	513	11.9	373	11.8	140	12.0	
Current-smoking	1048	24.3	797	25.3	251	21.6	
Missing*	49	1.1	25	0.8	24	2.1	
Alcohol drinking							
Never	3300	76.5	2365	75.1	935	80.4	*<0.001*
Ex-drink	318	7.4	250	7.9	68	5.8	
Current-drink	630	14.6	494	15.7	136	11.7	
Missing*	66	1.5	42	1.3	24	2.1	
BMI (kg/m^2)							
Cut-off point							
<18.5	350	8.1	264	8.4	86	7.4	*0.004*
18.5-<24.0	2435	56.4	1820	57.8	615	52.9	
24.0-<28.0	1145	26.5	805	25.5	340	29.2	
≥28.0	384	8.9	262	8.3	122	10.5	
Socio-economic status							
Urban-rurality							
Urban	2182	50.6	1402	44.5	780	67.1	*<0.001*
Rural	2132	49.4	1749	55.5	383	32.9	
Educational level							
≥High Secondary school	563	13.1	348	11.0	215	18.5	*<0.001*
Secondary school	657	15.2	442	14.0	215	18.5	
Primary school	1326	30.7	977	31.0	349	30.0	
Illiterate	1735	40.2	1377	43.7	358	30.8	
Missing*	33	0.8	7	0.2	26	2.2	

Main occupation							
Official/Teacher	563	13.1	349	11.1	214	18.4	*<0.001*
Business/other	369	8.6	269	8.5	100	8.6	
Manual labourer/housewife	1306	30.3	849	26.9	457	39.3	
Peasant	2044	47.4	1677	53.2	367	31.6	
Missing*	32	0.7	7	0.2	25	2.1	
Satisfactory income							
Very satisfactory	426	9.9	282	8.9	144	12.4	*0.006*
Satisfactory	2019	46.8	1497	47.5	522	44.9	
Average	1514	35.1	1123	35.6	391	33.6	
Poor	312	7.2	232	7.4	80	6.9	
Missing*	43	1.0	17	0.5	26	2.2	
Financial problems in the past two years							
No	4065	94.2	2996	95.1	1069	91.9	*0.048*
Yes	206	4.8	139	4.4	67	5.8	
Missing*	43	1.0	16	0.5	27	2.3	
Social network and support							
Marital status							
Married	3018	70.0	2334	74.1	684	58.8	*<0.001*
Never married/Divorcees	95	2.2	70	2.2	25	2.1	
Widowed	1173	27.2	743	23.6	430	37.0	
Missing*	28	0.6	4	0.1	24	2.1	
Living with							
Somebody	3938	91.3	2888	91.7	1050	90.3	*0.641*
Alone	345	8.0	257	8.2	88	7.6	
Missing*	31	0.7	6	0.2	25	2.1	
Frequency of visiting children or other relatives							
<Yearly or Never	1437	33.3	1018	32.3	419	36.0	*<0.001*
At least Monthly or less often	485	11.2	353	11.2	132	11.3	
At least weekly	1268	29.4	887	28.1	381	32.8	
Everyday	1084	25.1	880	27.9	204	17.5	
Missing*	40	0.9	13	0.4	27	2.3	
Co-morbidities							
Hypertension							
No	2102	48.7	1561	49.5	541	46.5	*0.085*
Yes	2082	48.3	1497	47.5	585	50.3	
Missing*	130	3.0	93	3.0	37	3.2	
Heart disease							

No	3575	82.9	2725	86.5	850	73.1	*<0.001*
Yes	639	14.8	370	11.7	269	23.1	
Don't know	53	1.2	38	1.2	15	1.3	
Missing*	47	1.1	18	0.6	29	2.5	
Diabetes							
No	3966	91.9	2944	93.4	1022	87.9	*<0.001*
Yes	280	6.5	175	5.6	105	9.0	
Don't know	28	0.6	21	0.7	7	0.6	
Missing*	40	0.9	11	0.3	29	2.5	
Activity of daily living (score)							
0	3951	91.6	2920	92.7	1031	88.7	*<0.001*
1-4	181	4.2	131	4.2	50	4.3	
≥5	182	4.2	100	3.2	82	7.1	
GMS-AGECAT diagnosis							
"Well"	3269	75.8	2382	75.6	887	76.3	*0.477*
Depression-subcase	126	2.9	92	2.9	34	2.9	
Depression-case	184	4.3	136	4.3	48	4.1	
Dementia-subcase	347	8.0	266	8.4	81	7.0	
Dementia-case	382	8.9	270	8.6	112	9.6	
Missing*	6	0.1	5	0.2	1	0.1	

*P-value in the Chi-square test was calculated based on available data, not including these "missing" data.