Retirement, Cardiovascular Disease and its Risk Factors in China

Baowen Xue

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Declaration

I, Baowen Xue, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Signature: ………………………………………………

Baowen Xue

Date: ………………………………………………

Abstract

Population ageing and proposals for delaying retirement in many countries have led to greater interest in understanding the potential long-term associations between retirement and cardiovascular disease (CVD) and CVD risk factors. Most relevant studies were conducted in Western countries. The cross-national comparison between China and England conducted by this thesis revealed that China has a much earlier retirement age than England, and the cross-sectional associations of retirement and CVD and CVD risk factors are different in the Chinese context, and these associations are moderated by personal and family characteristics in both countries. It is important to consider reverse causality when investigating the health effects of retirement. Thus, this thesis assessed the longitudinal associations between retirement and CVD risk factors over a 17-year period both before and after retirement among 1,084 people who participated in the China Health and Nutrition Survey at least once prior to and once after the year in which they retired. Piecewise models, centred at the year of retirement, were applied. Retirement was accompanied by a reduction in diastolic blood pressure, a slowdown in the increase of both systolic blood pressure and waist circumference, and a reduction in the probability of being a heavy drinker. Results for heavy smoking mirrored those for heavy drinking, but only reached borderline statistical significance. The association between retirement and blood pressure was stronger for men, for urban dwellers, and for those who have a non-working spouse. No significant association with body mass index was found. The reduced probability of being a heavy drinker after retirement explained some of the association between retirement and blood pressure. This study suggests that retirement may be beneficial in the Chinese context. Better working environment and flexible schedules are needed for an ageing workforce, given plans to raise the retirement age in China.

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Abbreviations

ADL- activities of daily living

AME- average marginal effect

BOISE- Basic Old Age Insurance System for Employees

BOISEE- Basic Old Age Insurance for Enterprise Employees

BMI- body mass index

CHARLS- China Health and Retirement Longitudinal Study

CHNS- China Health and Nutrition Survey

CI- confidence interval

CRP- C-reactive protein

CVD- cardiovascular disease

DBP- diastolic blood pressure

ELSA- English Longitudinal Study of Ageing

HbA1c- glycated haemoglobin

HDL- high-density lipoprotein

HRS- Health and Retirement Study

HSE- Health Survey for England

ISCO- International Standard Classification of Occupations

IV- instrumental variable

LDL- low-density lipoprotein

MAR- missing at random

MCAR- missing completely at random

MEM- marginal effect at the mean

MET- metabolic equivalent of task

MI- multiple imputation

MICE- multiple imputation by chained equations

MID- multiple imputation then deletion

MNAR- missing not at random

NRSPS- New Rural Social Pension Scheme

OR- odds ratio

PMM- predictive mean matching

PPS- probability-proportional-to-size

PSU- primary sampling unit

RRR- relative-risk ratio

SBP- systolic blood pressure

SHARE- Survey of Health, Ageing and Retirement in Europe

SPA- State Pension Age

USPS- Urban Social Pension Scheme

WC- waist circumference

WHO-World Health Organization

Chapter 1: Introduction and Background

1.1 Introduction

Almost every country in the world is experiencing growth in the number and proportion of older persons in their population. On one hand, population ageing is a demographic success story, driven by declines in fertility and increases in longevity that are associated with economic and social development. One the other hand, global population ageing has led to shrinking ratios of workers to pensioners and people are now spending longer in retirement than ever before. This strains social insurance and pension systems and challenges existing models of social support. Some countries have initiated changes in the pension age in order to ease the burden of public spending. For example, in the UK, default retirement ages were fully abolished in 2011, thus most people can now work for as long as they want to. The earliest age at which employees can receive the Basic State Pension, namely the State Pension Age (SPA), was 60 for women and was 65 for men in 2000. The SPA is rising to 65 for women by 2018, and men and women's SPA will increase to 68 in the mid-2030s (HM Treasury, 2013).

The pace of population ageing in many developing countries today is much faster than occurred in developed countries in the past. These developing countries will be old before they will be rich, thus they must act swiftly to establish a strong social system to support the older population. China is a good example of rapid population ageing in developing countries. Its average life expectancy has increased from less than 50 years in the 1950s to more than 73 years in 2015 (United Nations, 2015), and its fertility rate has decreased from 5.9 to 1.7 during this period (UN, 2016). As a result, the share of population aged 65 and above will rise from 7% to 14% within 25 years in China, which took more than 100 years in France and nearly 50 years in the UK (Kinsella and He, 2009). By 2050, 329 million out of the total 1.4 billion Chinese people will be aged over 65 (UN, 2005), and there will be only 1.3 working people to support each pensioner in China, compared to three people for each pensioner today (Ministry of Human Resources and Social Security, 2015). How to support such a big number of older people has become the biggest challenge in China. To reduce the strain on public finances and the social-security system, China is going to formalise a plan in 2017 to raise the official compulsory retirement age (currently 60 years for men, 50 years for blue-collar women, and 55 years for white-collar women) for the first time since the 1950s (Vilela, 2013). There is a huge debate about the economic influences of delaying the mandatory retirement age in China now, with suggestions that rises in the retirement age be implemented gradually, and possibly with different approaches taken for different sectors (Wong, 2015).

Population ageing and proposals for delaying retirement in many countries have led to greater interest in understanding the potential long-term associations between retirement and health. Retirement may change financial resources, psychosocial stressors, health behaviours, social integration, and personal control, and thus may influence older people’s health in different ways (Adams et al., 2002; Barnes-Farrell, 2003). In terms of health outcomes, cardiovascular disease (CVD) is the greatest cause of death among older people in both developing and developed countries. The rapidly ageing population and progressive urbanization in China underlines the increasing importance of both the increased CVD burden and the population relevance of retirement as a life course transition (World Health Organization, 2016). To understand the influence of retirement on the onset of CVD and its risk factors is therefore essential.

China has a much younger compulsory retirement age than many developed countries, and job characteristics, working environments, pension income, the epidemiological transition of CVD, and access to health services also differ between China and most Western countries. Are associations between retirement and cardiovascular health outcomes in China similar to Western countries? If not, what are the potential mechanism and causal processes underlying these associations in China? In addition, within a single country context, such as in China, do the health effects of retirement vary among people with different characteristics? Answering these questions is important before any policy to increase retirement age is implemented in China. However, there are few studies from China, and most of the empirical studies on the health effect of retirement are from Western countries (Behncke, 2012; Dave et al., 2006; Moon et al., 2012). Therefore, this PhD aims to fill this gap in the current knowledge.

1.2 Aims and objectives

This thesis first aims to assess the nature of retirement, the prevalence of CVD and CVD risk factors, as well as the cross-sectional associations between retirement and

CVD/CVD risk factors in both China and England. England has a long history of state pension provision within a public welfare system which has been well managed since World War II. Comparing China with England, may offer insights into whether results from the studies in Western countries are applicable in the Chinese context, and whether there are any lessons that China can learn from Western countries in terms of policy making on population ageing and retirement. When studying the association between retirement and CVD or its risk factors, it is important to consider reverse causality, as poor health may be a determinant of retirement (Disney et al., 2006). Longitudinal studies where CVD risk factors have been measured repeatedly both before and after retirement provide an opportunity to address this problem. There are no previous longitudinal studies of retirement and CVD risk factors in China, so this thesis will test the longitudinal association between retirement and CVD risk factors in China using a 20-year cohort study. More specifically, this PhD project has two aims:

Aim 1

To conduct a cross-national comparison between China and England, in terms of retirement behaviour and factors associated with retirement behaviour, as well as the associations between retirement and CVD/CVD risk factors in these two countries.

Aim 2

To investigate the effects of retirement on CVD risk factors in China, independent of any reciprocal effects of CVD risk factors on retirement, and to test potential mediating and moderating factors.

Objectives

1. To compare the retirement behaviour and its determinants in China and England.

2. To examine the cross-sectional relationships between retirement and self-reports of CVD, and its metabolic, behavioural and biological risk factors in both China and England.

3. To investigate the moderating role of gender, area of residence, spouse's employment status in the relationships between retirement CVD and it risk factors in China and England.

4. To understand the longitudinal association between retirement and objective measures of cardiovascular risk factors, as well as self-reports of behavioural risk factors in China.

5. To examine the moderating role of gender, area of residence, and spouse's employment status in the longitudinal relationships between retirement and CVD risk factors in China.

6. To examine the mediating role of household income, daily nutrient intake, alcohol consumption and total physical activity level in the longitudinal relationships between retirement and CVD risk factors in China.

These research aims and specific objectives will be achieved by empirical studies in the following chapters. In this thesis, Chapter 1 introduces the pension system, retirement policies, and factors affecting older people's retirement decisions as well as the epidemiology of CVD and its risk factors in China. Chapter 2 summarises the common theories regarding health effects of retirement, then current evidence on the potential link between retirement and CVD/CVD risk factors is summarised and critiqued. In Chapter 3, a comparative study of retirement behaviour and CVD and CVD risk factors is presented between China and England, using the first wave of the China Health and Retirement Longitudinal Study (CHARLS) and the sixth wave of the English Longitudinal Study of Ageing (ELSA). The analyses for Chapters 4-7 use data from the China Health and Nutrition Survey (CHNS, 1991-2011). Chapter 4 describes the methods used in examining the longitudinal associations between retirement and CVD risk factors over a 17-year period both before and after retirement. Results of the longitudinal analyses are shown in Chapter 5. Chapter 6 examines the potential moderating effects of gender, area of residence, and spouse's employment status in the longitudinal associations between retirement and CVD risk factors. Chapter 7 further tests the mediating role of household income, nutrition intake, and alcohol consumption as possible explanatory mechanisms in the effect of retirement on CVD risk factors. A discussion of the thesis' key results, alongside its strengths, limitations and policy implications, is provided in Chapter 8.

1.3. The pension system and retirement behaviour in China

1.3.1 Development of the pension system in China

Shortly after the founding of the People's Republic of China in 1949, China's first formal pension scheme, the Basic Old-Age Insurance System for Employees (BOISE), was introduced in 1951, targeting urban employees. This system covered urban employees of state-owned and large collectively-owned enterprises, civil servants and those people working in other public institutions (Hu, 2006). The replacement rate of the BOISE was about 80% of a worker's wage, and the eligibility age to receive this public pension was 60 years for men and 50 years for blue-collar women. For white-collar women, whose jobs are less physically demanding, the eligibility age was 55 years (Vilela, 2013). The eligibility age for BOISE became the statutory retirement age in China and this remains the case today. This pension system mainly relied on contributions from state- and collectively-owned enterprises.

In 1995, the Chinese government formally introduced a new system, the Basic Old-Age Insurance for Enterprise Employees (BOISEE), which requires contributions from individual workers, with the exception of civil servants[1]. Two years later, this system was extended from state- and collectively-owned enterprises to the private sector. Its replacement rate is 59% of the social average wage, in which, 35% is paid by local government-administered funds (social pooling system) and 24% is paid by the individual account system (Hu, 2004). To qualify for this pension, urban employees

[1] In 2015, the pension privileges of civil servants were removed, and civil servants now have the same pension system as urban employees.

have to work for at least 10 years and to reach the statutory retirement age (Giles et al., 2015).

In contrast, rural residents were left to fend for themselves, and have not been included in any substantial government-run retirement system until 2009. In 2009, China established a New Rural Social Pension Scheme (NRSPS), allowing rural residents to make voluntary contributions to individual accounts that are subsidised by local and central governments. The NRSPS rapidly expanded to all counties by the end of 2012 (Vilela, 2013). While the coverage rate of the NRSPS has extended rapidly, the income from NRSPS is much less generous than the scheme for urban workers and is often not enough to make a living. For example, results from the CHARLS pilot revealed that the median pension income of retirees with at least one pension is 1500 Yuan (equal to 230 US dollars) per month for urban retirees, but is only 65 Yuan (equal to 10 US dollars) for rural pensioners (Giles et al., 2012).

In 2011, urban residents who are not employed in the formal sector are allowed to have access to a basic pension scheme- the Urban Social Pension Scheme (USPS), which is similar to the NRSPS (Vilela, 2013).

In terms of the rural-urban migrants, China has a family register system, namely the HuKou, to control the movement of people between rural and urban areas. A worker seeking to move from the rural areas to urban areas only has a temporary residence permit to reside in an urban area, thus is not covered by the USPS. Migrant workers who are working in urban formal sectors are allowed to be covered by the BOISEE, but many of them choose not to participate in the scheme to avoid individual contributions (Asher and Zen, 2016).

1.3.2 Retirement behaviour in China

Urban-rural differences

Long-term urban residents with formal sector employment can expect to receive a generous pension upon retirement, but are faced with mandatory retirement at a relatively young age. The age ceiling in the urban pension system is strictly enforced: men have to retire at age 60, women in blue collar occupations are frequently required to retire at age 50, women in white collar occupations at age 55, with women in some categories (e.g. university professors) are able to work until age 60 if they wish. Anyone who reaches retirement age must process retirement and end employment. The average retirement age of urban residents/workers was 54 in 2015 (Giles et al., 2015; Cooke, 2001). After retirement, some people are allowed to be rehired in the same working place on a temporary contract or to find another job in the informal sector. In contrast, most rural residents work in self-employed agriculture-related activities, with low incomes and pensions, but are not restricted by mandatory retirement ages (Giles et al., 2011; Gong et al., 2012).

Giles et al. (2015) documented the retirement patterns among Chinese aged 45 and older using the first wave of the CHARLS. They found that older urban residents were more than twice as likely (60%) to be retired as their rural counterparts (26%). By age 75-80, few urban residents were still working (only 5% among men and less than 2% among women), but 40% of rural men and nearly 25% of rural women were still working (Giles et al., 2015). Working hours were quite similar between rural and urban older workers, thus the higher labour force participation of rural older people was unlikely to be because of lower work intensity. Giles et al. (2015) also compared retirement rates in China with seven developed countries (France, Germany, Italy, Canada, USA, Japan and South Korea) and two Asian developing countries (India and Indonesia), and found that retirement patterns of China's rural workers were similar to patterns observed in the other two developing countries, but that urban people retired at similar rates to those found in developed countries. In terms of economic resources, this study showed that the wealth of urban people was nearly three times that of the rural people and this urban-rural discrepancy existed for both men and women. About 76% of the urban older population was covered by at least one pension scheme, while the percentage was only 41% for their rural counterparts, and rural pension comes mainly from the NRSPS, which is much less generous. Thus, rural older people overwhelmingly (81%) expected children to support them when they lose the ability to work. Studies by Giles et al. (2011, 2015) showed that older women exited from the labour force earlier than older men in both rural and urban areas in China, and gender differences in the age of exit from work were much greater in urban China than in rural areas.

Early retirement

Even with China's young official retirement age, substantial retirement occurs even earlier. In the first wave of the CHARLS, 41% of urban men aged 55-59 had retired and nearly a quarter of urban women had withdrawn from the labour force by age 45-49 (Giles et al., 2015). The Chinese urban pension system permits early retirement for people with poor health and for those working in hazardous work conditions. The mandatory retirement age may also induce early retirement among urban women, particularly for women who need to find a job in their 40s (Giles et al., 2015). Another special circumstance leading to early exit from work is known as 'internal retirement'. This was a special practice during the 1990s when many companies experienced financial difficulties and faced business transformations. Some employees were laid off before the normal retirement age and received subsidies determined by their firms. Once they reached the official retirement age, they could process formal retirement and thus receive a normal pension (Cai, 2006).

Is retirement a gradual process?

Sometimes retirement does not necessarily mean total and permanent withdrawal from paid work (Feldman, 1994). Evidence in the USA suggests that retirement is often a gradual process: workers may reduce working hours, move to a less demanding job with usually fewer hours, or even transition in and out of retirement (Blau, 1994; Kantarci and Van Soest, 2008). In contrast to the experience in the USA, take-up of gradual retirement is rather low in China, as working hours for older workers in both urban and rural China remain high (Giles et al., 2015). Similarly, for the majority of people in the UK, retirement is not a gradual process of labour market withdrawal, but instead an abrupt transition from full-time work to zero hours (Banks, 2006).

1.3.3 Determinants of retirement in China

There are likely to be a variety of factors influencing an individual's retirement behaviour, including whether and when to exit the workforce. An understanding of these factors is essential if older populations are to be successfully encouraged to remain in the workforce for a longer period, and to guarantee their quality of working life, as well as to help them adapt to the retirement transition. A number of 'push and pull' factors have been identified in the literature as leading to exit from the labour market. Push factors have been defined as negative considerations, such as poor health or an unsatisfying job that induces workers to retire. Pull factors are typically positive considerations, such as the desire for leisure time or volunteer activities, that attract workers toward retirement (Shultz et al., 1998). This section describes several factors that are suggested to influence retirement behaviour in the Chinese context.

Retirement policy

Compulsory retirement age is a major driving force behind the observed retirement behaviour of older workers in China. Retirement occurs much more often at the mandatory administrative retirement ages for both men and women in urban areas, but not for rural men and women (Giles et al., 2015).

Pension availability

Retirement typically marks the end of labour earnings, thus whether a worker has sufficient financial resources often determines if he or she is able to retire at a particular age. In countries where there are pension schemes, pension income is one of the most important sources of retirement income, and the concept of retirement is sometimes synonymous with drawing a pension (Coile, 2004). The incentive of pension eligibility for retirement has been well documented in the literature (Coile and Gruber, 2001; Stock and Wise, 1990). In common with findings from the retirement literature focusing on developed economies, the ability to collect a pension also plays an important role in retirement decision-making among Chinese older workers. For example, Giles et al. (2011) found that in urban China, men and women aged 45 and above who are eligible for a pension are estimated to be 24% and 15% less likely to be working than those not eligible for a pension, after controlling for age, education, health status of respondent and spouse, wealth, and family characteristics. However, in rural areas of China, there was no such relationship, because the rural pension scheme has only been phased in since 2009, and it is not sufficient for meeting a basic living standard after retirement, and does not require exiting from work in order to claim it (Giles et al., 2011). Thus, rural older workers do not have a strong incentive to retire.

The pension income of a spouse may also influence an individual's retirement decision. The study by Giles et al. (2011) also showed that rural women are less likely to be working if their husband is pension eligible, because male pension recipients in rural China tend to be cadres with much higher lifetime savings. There was no effect of husband's pension eligibility on employment of women in urban China, and Giles et al. (2011) stated that this may be because urban women are already out of the labour force due to the younger mandatory retirement age for women.

Health

The link between health and labour market behaviour in the context of developed countries has long been established in the literature. Many studies have found that health is a major determinant of employment rates among older workers (e.g. Disney et al., 2006; García-Gómez, Jones, and Rice, 2010; Humphrey et al., 2003). For example, in the UK, ill health may trigger retirement decisions by reducing people's working ability, as well as by entitling individuals to non-wage income, such as disability benefit. 'Own ill health' is the most commonly cited reason for early retirement among both men and women in the UK (Banks, 2006). Health can be an even bigger factor in a less developed country such as China, especially rural areas, where a greater proportion of jobs involve strenuous labour. Benjamin et al. (2003) describes the work pattern of the rural Chinese older workers as 'ceaseless toil', which means that they keep working at older ages until they are not capable of working any longer. Giles et al. (2015) found that an increase in disability score (measured by activities of daily living together with instrumental activities of daily living) was associated with a 4% decrease in the probability of being employed for older men and women in rural China, and with a 2% decrease in urban China. It seems that health status has a less pronounced effect on work activities of China's urban older residents, which is probably because fewer urban residents engage in manual work, and they tend to reach compulsory retirement age before the onset of marked declines in physical functioning (Giles et al., 2015, 2011).

Education

There is evidence from CHARLS that retirement rate is associated with a respondent's years of schooling (Giles et al., 2015). After controlling for pension receipt and other demographic characteristics, older urban women with a high school education or above were 10% more likely to be employed than those with lower educational attainment. This study explained that this may partially reflect the fact that urban educated white collar women are allowed to work until 55, as opposed to 50 for blue collar women, and this association was not observed in urban men or men and women in rural areas.

Spouse's employment status

In urban China, men and women are 18% and 16% more likely to be working if their spouse is employed. In rural China, an employed spouse is also linked to 17% and 20% increases in probabilities the men and women are working, respectively. A strong association between the employment of husbands and wives suggests that couples may have a preference for retiring together (Giles et al., 2015). Several studies in Western countries also found that wives' employment status can influence husbands' participation in the labour force, but women are less responsive to husbands' labour supply (Banks et al., 2010; Coile, 2004; Goux et al., 2011; Schirle, 2008). For example, one study in the UK showed that having an employed partner in the year prior to retirement reduced the likelihood of retirement for men by around a half. The estimated impact for women was smaller and was not statistically significant, because many women will be retired before their partner due to the earlier SPA (Jones et al., 2010).

Family care provision

Retirement participation decisions may also be influenced by caring responsibilities. Workers in their 50s or 60s may still have parents or a partner with health problems and they may also have grandchildren to care for, hence their identification as the 'pivot generation' (Mooney et al., 2002). A range of Western studies showed that provision of family care is associated with fewer working hours and a higher probability of retirement and exit from the workforce, particularly for women. (Jacobs et al., 2014; Meng, 2012; Van Houtven et al., 2013). Giles et al. (2015) also found that women in China in their 50s contributed significant amounts of time to provision of childcare and eldercare in both urban and rural areas, and the presence of each additional child under the age of six in the household was associated with a significant reduction in the probability of employment among women.

However, when a spouse is ill, older workers in China are more likely to work. Giles et al. (2015) found that a unit increase in the spouse's index of disability was associated with a 2% increase in probability of employment for both men and women in urban areas. This may suggest that the financial burden is increased when a spouse is ill, and older people in China have to work to maintain their standard of living and to pay for medical expenses. A small positive effect of spouse's ill health on employment was also found for men but not for women in the USA (Coile, 2004). However, in the UK, evidence from the British Household Panel Survey suggests that partner's health status does not predict individuals employment status (Disney et al., 2006), which may be because medical treatment is free there.

1.4 CVD and its risk factors in China

While different factors, especially health status, can influence older workers' retirement decisions, retirement may also influence health in turn, both physically and mentally. When talking about the health of older people, CVD affects mostly men and women as they move through their last several decades of life, and has imposed a large burden in many countries. The next section will describe recent trends in CVD and CVD risk factors in China.

1.4.1 The epidemiology of CVD

CVD includes diseases of the heart, vascular diseases of the brain and diseases of blood vessels. CVD due to atherosclerosis includes coronary heart disease (e.g. angina, heart attack/myocardial infarction, and heart failure), cerebrovascular disease (e.g. stroke), and diseases of the aorta and arteries (e.g. hypertension and peripheral vascular disease). In atherosclerosis, fatty material and cholesterol are built up inside the blood vessels. These plaques cause the inner surface of the blood vessels to become irregular and the lumen to become narrow, making it harder for blood to flow through. The plaque can eventually rupture, triggering the formation of a blood clot. Different diseases may develop based on where the blood clot is: if the blood clot develops in a coronary artery, it can cause a coronary heart disease (CHD); if it develops in the brain, it can cause a stroke. CHD and stroke are the most fatal components of CVD which together account for more than 70% of CVD death. Other CVD are congenital heart disease, rheumatic heart disease, cardiomyopathies, and cardiac arrhythmias (WHO, 2011).

Rapid population ageing together with fast economic development has resulted in a considerable rise in the prevalence of CVD in China. Today, every 10 seconds there is a death in China due to CVD. In 1973, CVD only caused about 13% of total deaths in China, and now this figure is 43%. Especially in rural China, which had a much lower CVD morality in the 1990s than urban areas, but now has both a higher proportion of deaths due to CVD (45% vs. 43%) and a higher death rate from CVD (295.6 vs. 262.0 per 100,000) compared with urban areas (Hu et al., 2015). Annual CVD events (combined fatal and non-fatal CVD) are predicted to increase by 50% between 2010 and 2030 in China (National Bureau of Statistics of China, 2014a; Non-communicable Chronic Disease in China, 2013; WHO, 2015). In contrast to China, over the last two decades, CVD mortality has declined in developed countries due to a combination of prevention and control measures (WHO, 2011). Taking the UK as an example, the proportion of people who died from CVD was high in the UK in 1961, at over half of all deaths that year. This situation remained largely unchanged until the early 1980s. After that, both the proportion of deaths caused by CVD and the age-standardised CVD death rate declined (Scarborough et al., 2011; Townsend et al., 2015). In 2012, CVD went from being the first to the second cause of death in the UK, causing 27% of all deaths while cancer caused 29% (Bhatnagar et al., 2015). The UK has an older age-structure than China, and according to the World Health Organization (WHO), the UK had a much lower age-standardised CVD death rate (per 100,000), which was 165.7 for men and was 101.7 for women, compared to 311.5 and 259.6 for men and women in China (WHO, 2014b). This may partially reflect the fact that there is still a big gap between China and more developed countries in terms of access to health services (Peters et al., 2008). As with mortality, China and the UK have experienced opposing trends in CVD incidence since 1980s, which has increased in China (Hu, 2013; National Health and Family Planning Commission, 2003) but has decreased in the UK (Davies et al., 2007; Lee et al., 2011; Scarborough et al., 2011).

In China, CVD prevalence is also increasing rapidly. In 2003, all-age prevalence of CHD and stroke was 4.6‰ and 6.6‰ respectively, and in 2008 these figures increased to 7.7‰ and 9.7‰ (Hu et al., 2015). This increase in prevalence was seen in both urban and rural China, with CVD prevalence is much higher in urban than rural China. For example, the CHD prevalence in 2008 in rural China was only 4.8‰, compared to 15.9‰ in urban China. It is important to note that the current CVD prevalence in rural

China may be underestimated due to the lack of attendance at, or availability of, healthcare services. In the UK, although the declining incidence of CVD had some impact on limiting the increase in prevalence, its effect was offset by improved survival among people with CHD and stroke (Townsend and Wickramasinghe, 2012). In 2008 in the UK, estimated all-age prevalence was 35‰ for CHD and 16‰ for stroke (Townsend et al., 2015), which were much higher than China.

1.4.2 The epidemiology of CVD risk factors

The upward trend of CVD in China are likely to be associated with population ageing, and, more importantly, the increased number of cardiovascular risk factors, including hypertension, smoking, high blood cholesterol, diabetes, overweight or obesity, unhealthy diet and physical inactive (Hu, 2013). In China, except for the prevalence of smoking which had slightly declined since 1996, all remaining risk factors showed a rising trend in prevalence (Li and Ge, 2015).

Hypertension

Hypertension is the most important CVD risk factor. About half of the CVD in China is related to hypertension. In 1979, the prevalence rate of adult hypertension in China was 11% in urban areas and was 6% in rural areas (Li and Ge, 2015). By 2002, the prevalence of hypertension has more than doubled in urban areas (23%) and nearly tripled in rural areas (18%, Wu et al., 2008). In 2009, the prevalence of hypertension further increased to 30%, which corresponded to 325 million patients, and the prevalence was slightly higher in men (31%) than in women (28%), but was similar between those in urban and rural areas (J. Wang et al., 2014). The hypertension prevalence rate in China is already higher than Canada (20%), and at the similar level of England (30%) and the USA (29%). There are important gaps in the management of hypertension between China and developed countries, with consequences on CVD mortality. For example, studies have shown that hypertension awareness, treatment and control among hypertensive participants in China is 43%, 35%, and 9%, respectively (Wang et al., 2014), and corresponding figures in England are 65%, 51%, and 27%, respectively (Joffres et al., 2013).

Smoking

Smoking is a another main risk factor of CVD in China (Hu, 2013), and is a problem for Chinese men in particular. The majority of Chinese adult males (53%), but only 2% of adult females are current smokers (WHO, 2010). In the UK, men were much more likely than women to be smokers in the 1970s, but dramatic gender differences in smoking are not seen now. The percentage of current smokers in the UK was about 22% for men and 17% for women in 2013 (ONS, 2015). Therefore, Chinese men are now facing a much higher smoking rate than the UK, and the high percentage of male smokers in China will be difficult to change in the near future, as the majority of smokers (76%) do not intend to quit smoking and only 23% of Chinese adults believe smoking causes stroke, heart attack, and lung cancer (Jiang et al., 2010). In addition, there is some increase of smokers among women in China (WHO, 2010). Passive smoking is also considered as an independent risk factor for CVD, and more than 60% of non-smoking adults in China are exposed to second-hand smoke both at home and the workplace (WHO, 2010a).

High blood cholesterol

High blood cholesterol is a leading risk factor for CVD in both Western countries (Stamler et al., 2000) and in Asia (Collaborative, 1998). Cholesterol travels to the body's cells through the bloodstream by two kinds of lipoproteins: low-density lipoproteins (LDL) and high-density lipoproteins (HDL). LDL cholesterol is sometimes called 'bad' cholesterol, as a high LDL level can lead to atherosclerosis. HDL cholesterol is called 'good' cholesterol, which carries harmful cholesterol away from the arteries and helps protect from heart attack and stroke. A national study conducted in China between 2007 and 2008 suggested that the mean level of blood total cholesterol of the Chinese aged 20 and above was 4.7 mmol/l, with 32% having borderline high or high total cholesterol (≥5.18 mmol/l), and 20% a raised level (borderline high, high, or very high) of LDL cholesterol (Yang et al., 2012). The current situation of high blood cholesterol in China is better than many developed countries. For example, the mean blood total cholesterol level for men aged 16 and over in England in 2008 was 5.2 mmol/l and for women 5.4 mmol/l, and the proportion of people with raised total cholesterol levels (≥5mmol/l) ranged between 52% and 64% for different regions of England for men, and between 56% and 68% for women. However, generally, total cholesterol levels have fallen in most developed countries (Capewell and Ford, 2011), but there is an average of 0.91 mmol/l increase in the mean blood total cholesterol level in China compared to 5 to 6 years earlier (Wong, 2005). More importantly, among those who have elevated total or LDL cholesterol, the proportions of patients who are aware, treated, and controlled was much lower in China than in Western populations, especially in rural China (Yang et al., 2012).

Diabetes

Average prevalence rate of diabetes (diagnosed and undiagnosed) in the Chinese adult population was 10% between 2007 and 2008 (Yang et al., 2010). In 2010, this prevalence had increased to 12% (12% for men and 11% for women), with higher occurrences in urban areas (14%) than in rural areas (10%). Among patients with diabetes, only 30% were aware of their condition, and 26% received treatment for diabetes, and 40% of those treated had adequate glycemic control (Xu et al., 2013). In England, the estimate prevalence of diabetes (diagnosed and undiagnosed) was only 7% in 2009 (APHO, 2012). The prevalence rate of diabetes in the UK is also rising, but at a much lower speed than in China (González and Johansson, 2009).

Obesity

Overweight and obesity increase the risk of CVD. As well as being an independent risk factor of CVD, obesity is also a major risk factor for hypertension, high blood cholesterol, and diabetes. The adverse effects of excess weight are more pronounced when fat is concentrated in the abdomen, which is known as central or abdominal obesity (Townsend and Wickramasinghe, 2012). China had a history of under-nutrition followed by a rapid increase in obesity during the past decade. During the period of 1993-2009 in China, the age-adjusted prevalence of obesity, which is measured by body mass index (BMI), increased from 3% to 11% among men and from 5% to 10% among women; the age-adjusted prevalence of abdominal obesity, which is measured by waist circumference (WC) increased from 9% to 28% among men and from 28% to 46% among women. General obesity increased more rapidly in urban men, while abdominal obesity increased faster among rural women (Xi et al., 2012). Overweight and obesity are more serious in Western countries. For instance, in England in 2010, 26% of adults were obese, and 40% of adults had a raised waist circumference. Women were significantly more likely than men to have a raised waist circumference (46% and 34%, respectively).

Metabolic syndrome

Metabolic syndrome is a clustering of at least three of the five following medical conditions: abdominal obesity, elevated blood pressure, elevated fasting plasma glucose, high serum triglycerides, and low HDL levels. Some evidence has suggested that metabolic syndrome is associated with increased risk of CVD over and above the independent effects of each risk factor (e.g. Scuteri et al., 2005). Because of the increasing prevalence of obesity, hypertension, diabetes, and high cholesterol in China, the percentage of people with metabolic syndrome has risen. Data show that in 2009 (Xi et al., 2013), the prevalence of metabolic syndrome among Chinese adults was 21%, 18% and 11% based on diagnostic criteria of revised NCEP ATPIII (National Cholesterol Education Program Adult Treatment Panel III), IDF (International Diabetes Federation) and CDS (Chinese Diabetes Society), respectively.

Alcohol consumption

Excessive drinking can lead to stroke and myocardial infarction (Bazzano et al., 2009; Chadwick and Goode, 2007; O'Keefe, Bybee, and Lavie, 2007; Yang et al., 2012). According to the report by the WHO in 2014, alcohol per capita (15 years old and above) consumption was much lower in China (6.7 litres per year) compared to the UK (11.6 litres per year). Eight percent of Chinese adults were classed as having had an episode of heavy drinking (consumed at least 60 grams or more of pure alcohol on at least one occasion) in the previous month, which is only half of the global average (16%), but the percentage in the UK was as high as 28%. The relatively low alcohol consumption level in China is because very few women in China are drinkers. Seventy one percent of Chinese women were abstainers in the past year, compared to only 19% of women in the UK. Female drinkers in China also consumed less alcohol (7.6 litres per year) than their counterparts in the UK (8.5 litres per year), but male drinkers in both countries consumed similar amount of alcohol (18.7 and 18.9 litres per year). In terms of the long-term trend, alcohol consumption is gradually increasing in China but is slowly decreasing in the UK (WHO, 2014a).

Dietary intake

The amount of dietary salt consumed is an important determinant of blood pressure levels and overall CVD risk. The WHO recommends a population sodium intake of less than 2000mg/person/day to help the prevention of CVD, but most of the world's population consumes much more sodium daily. One study found that the mean daily sodium intake per person was 3,990 mg in China, compared to 3,406 in the UK and 3,600 in the USA (Anderson et al., 2010).

High dietary intakes of saturated fat, trans-fats and salt, and low intake of fruits, vegetables and fish are also linked to cardiovascular risk (WHO, 2011). Mean total energy intake increased significantly among older Chinese, but still 36% of Chinese aged 50 and older do not meet recommendations for consumption of fruits and vegetables (Wu et al., 2015). Also, the increased consumption of high-fat, and non-staple high-carbohydrate foods such as plant oil and wheat buns suggests that diet quality of older Chinese adults is becoming less healthy in recent years (Pan et al., 2014).

Insufficient physical activity

Technology and urbanisation tend to discourage activity, and physical inactivity is considered one of the biggest public health problems worldwide, and it also a risk factor for CVD (Kohl, 2001). Insufficient physical activity can be defined as less than 150 minutes of moderate-intensity physical activity per week, or less than 75 minutes of vigorous-intensity physical activity per week, or equivalent. According to the WHO data in 2010, the age-standardised percentage of insufficiently active was 23 and 26 for men and women in China, which were much lower than the men (32%) and women (42%) in the UK (WHO, 2010b). In addition, there have been uneven changes in environments and behaviours across urban and rural areas in China. For example, one study found that total physical activity has been lower for individuals living in more urban areas in the whole observation period from 1991 to 2009. However, these differences narrowed over time, with declines in occupational physical activity for individuals at all levels of urbanicity, but increases in leisure physical activity only among individuals in more urban area and those with higher incomes (Attard et al., 2015).

This chapter reviewed the nature of retirement in China, underlining the urban-rural differences in the pension system and retirement behaviour in China. Considering CVD is the health outcome of interest for this thesis, this chapter also summarised trends in CVD and its risk factors in China, which are increasing dramatically. The next chapter will link these two parts together and review the theoretical perspectives and empirical studies on the association between retirement and health.

Chapter 2: Literature and Systematic Reviews

2.1 Introduction

The relationship between retirement and health is likely to be dependent on a complex set of mechanisms, thus this chapter first provides an overview of principle theoretical perspectives concerning retirement and health, including role theory, continuity theory, stage theory, and a life-course perspective (section 2.2). In section 2.3, a theoretical framework for how retirement might affect CVD is proposed. After that, this chapter discusses empirical studies concerning the effects of retirement on various health outcomes, including psychological well-being, cognitive function, physical functioning, and self-rated health (section 2.4). Because CVD and CVD risk factors are the health outcomes of interest here, a systematic review of empirical evidence on retirement and CVD and CVD risk factors was conducted in section 2.5. This section provides details of the search method used, a summary of the search results, and a critical review of findings.

2.2 Theoretical perspectives on the health effects of retirement

Before examining empirical evidence concerning the health effects of retirement, it is necessary to review the theoretical frameworks for understanding the mechanisms - why and how retirement and health might be related. These theoretical perspectives may provide alternative explanations for the findings in the literature.

2.2.1 Role theory

Role theory (George, 1993) provides a commonly used explanation of adjustment to retirement, which emphasizes the importance of the role transition and the role exit in retirement adjustment. Society is viewed as structured around various roles, and to the extent that one is highly invested in a particular role (e.g. the work role), feelings of self-worth tend to be associated with the ability to carry out that role effectively (Ashforth, 2000). Therefore, being retired can be characterised as a role transition, which involves loss of the critically important work role but potentially strengthening the family member role and the community member role. Role theorists argue that the role loss accompanying retirement can lead to psychological distress, which may lead to low levels of well-being in retirement (Riley and Riley, 1994). This distress may be due to the functional importance of work-related roles, which serve to maintain one's positive self-image (Feldman, 1994).

Role theory could lead itself to an opposite formulation. Retirement from the demands of one's primary occupation may be a major role exit that serves to reduce role strain and overload, therefore enhancing the well-being of retirees (Kim and Moen, 2002). Vandewater et al. (1997) also points to the importance of role quality (e.g. satisfaction with current work), suggesting that circumstances around workplace and retirement should matter. For example, for individuals who find their job burdensome, retiring could be a relief from long-term strains and conflicts. For individuals who would like to engage more in the roles as a family member or a community member, retirement offers opportunities for them to free up time to enjoy the rewards and responsibilities tied to those roles (Wang et al., 2011).

2.2.2 Continuity theory

Contrary to role theory, which points to employment as a fundamental role, continuity theory emphasizes the importance of maintaining consistency of life patterns over time, and the need to accommodate life changes without the experience of stressful disruption (Atchley, 1999). Continuity theorists provide an explanation for the ways in which people approach this life course transitions in an adaptive way, and view retirement as an opportunity for individuals to maintain earlier lifestyle patterns, previous levels of self-esteem, and longstanding values. Continuity can be internal, such as a persistent personal character, or it can be external, such as attempts to maintain familiar environments, role relationships, and activities (Atchley, 1972, 1989). In this perspective, that pre-retirement priorities and activities have more impact on later life than retirement itself, thus retirement is not viewed as leading to maladjustment and distress.

But Covey (1981) and Palmore et al. (1984) criticised continuity theory for being simplistic and argued that while life satisfaction and previous lifestyle patterns are maintained in some instances, a lack of access to adequate resources could lead to difficulty in maintaining continuity. In a major longitudinal analysis of retired men, Palmore et al. (1984) found that individuals' responses to retirement were contingent on resources, social supports, and the circumstances of retirement. Atchley (1989) proposed a more dynamic view of continuity, suggesting that individuals first prefer continuity, but at the same time, they have to adapt to disruptions that happen in life. He suggested that normal ageing occurs when the needs for income, housing, health care, and nutrition are met successfully; if for some reasons, people cannot maintain continuity, 'pathological ageing' occurs. In summary, this theory predicts that there should not be a significant drop in well-being when people transition from work into retirement life, if they are able to maintain continuity.

2.2.3 Stage theory

Stage theory (e.g. Atchley, 1976; Gall, Evans, and Howard, 1997) suggests a changing pattern of adjustment in retirement across time, reflecting different stages or phases of retirement. Early in the transition to retirement, such as in the months immediately following retirement, retirees experience a 'honeymoon' stage. In this stage, people may feel improved satisfaction and health as they lose stressful working roles and pursue new roles and activities. Later on, those retirees who have fewer resources and/or had unrealistic expectations about retirement may experience a 'disenchantment' stage, during which they experience less satisfaction and more distress (Wang et al., 2011). As time goes on, retirees move into a 'reorientation' stage, during which they accept any limitations, re-evaluate their life status, and focus on further adjustment to retirement (Wang et al., 2011). Eventually, retirees enter the 'stability' stage, settling into a predictable and comfortable daily life pattern until they die or become disabled (Wang et al., 2011). Szinovacz and Davey (2004), using the data from the US Health and Retirement Study (HRS), found that being retired for less than one year is significantly associated with lower depression only among men with a nonworking spouse. This indicates that the 'honeymoon' phase of retirement may be contingent on marital context, especially spouses' employment and marital quality. In addition, the literature has recognised that people may experience several job exits and entries using various forms of bridge employment before they fully retire (e.g. Wang and Adams, 2009). Thus, retirement adjustment may constitute an even longer and complex process, and retirees' health may vary during each specific adjustment stage.

2.2.4 The life course perspective

The life course perspective focuses on the characteristics of individuals and environments that foster healthy development at all stages of the life course. When it comes to retirement, the life course model indicates how individual and contextual characteristics can shape the retirement transition and its consequences for health and well-being. This section discusses how these characteristics before, surrounding, and post retirement, can influence the health and well-being of individuals.

Before retirement

<u>Prior occupation and work trajectory</u>

The health effects of retirement may be contingent on the conditions of personal occupation prior to retirement. Jobs that are demanding and provide little sense of control are negatively related to health and well-being, and retirement from such jobs may represent a 'relief', leading to lower stress levels and improved health (Westerlund et al., 2009). Alternatively, persons retired from jobs from which they derive satisfaction may experience stress because of the loss of a position or status in society (Moen, 1996). Role theory is often applied in this life course perspective, stating that retirement can be viewed either as 'roleless' or as a reduction in role-strain (Kim and Moen, 2002).

In addition, work trajectories, such as duration and patterning of labour force participation throughout the adult years, may have implications for the extent to which an individual's identity is tied up with work and success as well as pensions and other resources available after retirement, thus, influencing health and well-being. For example, men and women often have different attachments to the labour force which are likely to lead to different experiences of retirement. When men leave their jobs, they are exiting from a role that has typically dominated their whole adulthood. Women, however, commonly experience greater discontinuity, moving in and out of the labour force and part-time jobs, together with shifting household responsibilities (Lacey et al., 2015; Levy et al., 2013). Given their less stable employment histories and occupational segregations by gender, women are also less likely than men to be covered by a pension, and those with pensions will have incomes far lower than men's. Therefore, retirement may well have different health impacts on men and women.

Other personal circumstances

Other personal circumstances, such as education, marital status, family composition, and finance status, may have an impact on an individual's retirement timing and health following retirement (Kim and Moen, 2002). For example, high socioeconomic status reflects resources that promote health throughout the life course, including following retirement, and the life course perspective hypothesizes that income adequacy is an important mediator between retirement and health (Moen, 1996). This point is consistent with the continuity theory.

Institutional environments

Individuals' responses to retirement are also related to features of the institutional environment shaping those choices (Riley and Riley, 1994). For example, the institutionalisation of age-related social security payments and pensions may necessitate a later retirement transition than desired or anticipated, and other policies such as contingent work, downsizing, and retirement incentive packages may fundamentally change the retirement behaviour and the health effects of retirement (Moen, 1996).

Retirement and well-being can be also put in the broader institutional context of historical circumstances. For example, the first old age pension act was introduced in the UK in 1908, but retirement as a part of the life course is a relatively recent phenomenon in many other countries. In the USA, retirement was institutionalised with the Social Security Act of 1935 (Meyer, 1986). In China, retirement was not institutionalised until 1978, when the state council in China issued a temporary measure on providing financial supports for old cadres and workers. Subsequent policy developments regarding pensions and social security have gradually made retirement a normative life stage for Chinese cadres and workers in the last 20 or 30 years. In rural China, retirement is still not considered as a universal event occurring in later adulthood as many rural residents do not have access to sufficient pension support, and have to keep working into older age until they are no longer capable of working. Therefore, different historical contexts and current institutional circumstances of retirement may shape retirement behaviour, attitudes toward retirement, as well as health and well-being after retirement.

Surrounding retirement

<u>Exigencies</u>

A health crisis can be considered as an individual exigency, and poor health is one of the most important determinants of retirement. Importantly, the life-course approach places retirement in the larger context of both current individual exigencies and other life pathways (e.g. whether one's children are grown or one's spouse is about to retire; Elder 1995). Non-work life (e.g. marital life) pathways play an important role in retirement adjustment because they provide retirees with alternative salient identities after retirement and offer opportunities for retirees to engage in meaningful and desirable activities (Wang et al., 2011). A simple example is that individuals who are married have more positive experiences in retirement (Calasanti, 1996; Mutran et al., 1997).

<u>Timing of retirement</u>

It has been suggested that planned or expected changes in roles and resources are more easily adapted to, and having little ability to influence significant events can produce feelings of anxiety, futility, and despondency (Bandura, 1982; Moen, 1996). As such, when making the choice of whether and when to retire, perceived control, such as whether retirement is voluntary or not, is crucial to retirement adjustment (Henkens et al., 2008).

Cultural and individual norms and expectations about the appropriate time for a life transition also influence the meaning of the transition for both the individual and others (Settersten, 1998). When a transition occurs 'off time', individuals may not go through 'anticipatory socialisation', or the individual may lack peers with whom he or she can share transition experiences and who can provide social support. In the literature, some have found early retirement to have more negative effects than retirement at SPA, and retirees may perceive retirement as involuntary if the transition was 'off time' from his or her perspective (Szinovacz and Davey, 2005; Van Solinge and Henkens, 2007).

Post-retirement

The life-course perspective also points out that the effects of retirement may change over time, and post-retirement behaviour is one reason. For example, there is evidence that persons who were active in leisure activities after retirement have the highest life satisfaction, and, for those who experienced limited leisure activity prior to retirement, experiencing new activities can help in the process of adapting to retirement (Nimrod, 2007). Other studies also have shown that social participation in activities in the later years of adulthood can promote both psychological and physical health (McMunn et al., 2009; Menec, 2003; Silverstein and Parker, 2002).

Gender remains a key factor in shaping the behaviours of older adults. For example, women are more likely to be active in caregiving after retirement (Dentinger and Clarkberg, 2002), and high levels of care provision may damage the health of older people (Lee and Colditz, 2003; Schulz and Beach, 1999). There is also some suggestion that community participation is especially beneficial for the well-being of men post-retirement (Moen and Fields, 2002).

This section described individual and environmental characteristics before, surrounding, and after retirement that may influence the effects of retirement on health and well-being of elders. However, it should be noticed that the characteristics at a specific life stage are not only restricted to that stage, and many can last for a very long time in one's life course, influencing both the decision of retirement and the health and well-being of individuals at both before and after retirement.

2.2.5 Discussion

In summary, role theory, continuity theory, and stage theory are not mutually exclusive from each other. Each of them provides insight into a specific aspect of the process of retirement and provides some reasonable explanations regarding the health effects of retirement from different perspectives. However, these theories often simplify the process of retirement, and do not take account other factors that may interfere with the health consequences of retirement. For example, role theory highlights the importance of work role and the impact of 'role exit' and being 'roleless', but it does not take account of the possibility that one may have different feelings of retirement at different stages. In addition, some people may make multiple role transitions, as they take up other works or move into and out of work. Continuity theory underscores one's ability to continue one's previous lifestyle even after retirement, and views retirement as not leading to difficulties if 'continuity' in lifestyle is maintained. However, it does not acknowledge the potential detrimental effect of retirement if the work role is very important to someone, which is the idea of role theory. Stage theory focuses on adjustment to retirement over time, and highlights the 'honeymoon' period after retirement, but it does not take into account different work characteristics, such as job quality before retirement or the reason for retirement, which may largely change the trajectory of post-retirement adjustment. The life course perspective integrates these theoretical frameworks and defines retirement as a life-course transition, whereby the individual and contextual characteristics before, during, and after retirement can interact to influence the ways in which retirement affects aspects of health and wellbeing. The life course perspective points out that retirement can be either beneficial or detrimental to an individual's health and development depending on the personal and environmental situation, and the effects can change over time depending on post-retirement environment and activities.

Most of the theoretical perspectives described above have been developed in order to better understand the effect of retirement on mental health, but none of them has been used in studying CVD. This is probably because the impact of retirement on CVD is likely to be more complex than the impact on mental health, because CVD can develop through a variety of potentially interacting behavioural, biological and psychosocial pathways. A theoretical framework, which is based on the life course perspective and integrates other theoretical perspectives described above, is proposed in the next section.

2.3 Life course theoretical framework of retirement and CVD

This framework is specific to CVD/CVD risk factors, and focuses on the underlying mechanisms through which retirement may impact cardiovascular health. A main difference between the effect of retirement on mental health and that on cardiovascular health is that mental health itself is on the proposed pathway between retirement and cardiovascular health.

Specifically, as illustrated in Figure 2.1, this framework hypothesizes that the retirement transition may affect CVD/CVD risk factors through two main possible pathways. First, retirement may influence the development of CVD through behavioural pathways, such as changes in smoking, alcohol consumption, physical activity, and diet. These health behaviours themselves are risk factors of CVD (e.g. Bazzano et al., 2009; Hu, 2013; Kohl, 2001; WHO, 2011), and can affect other biological risk factors of CVD, such as diabetes and hypertension (Roerecke et al., 2017; Will et al., 2001). Second, retirees' CVD risk may be influenced by changes in mental and physical health as well as health indicators as a result of retirement. Each of these health conditions are closely related to CVD risk (e.g. Buckley et al., 2009; Elderon and Whooley, 2013; Saquib et al., 2013; Williams et al., 2012), thus retirement could affect CVD through changing these non-CVD health outcomes. These two possible pathways are also likely to interact with each other in the development of CVD. On one hand, non-CVD health outcomes may influence the health behaviour of retirees, therefore influencing CVD. On the other hand, health behaviours may influence non-CVD health outcomes. For example, physical inactive (Strawbridge et al., 2002), smoking (Luger et al., 2014), and excessive alcohol consumption (Boden and Fergusson, 2011) are associated with subsequent poor mental health, and conversely, people with poor mental health may be more likely to turn to heavy drinking (Dixit and Crum, 2000), smoking (Bonnet et al., 2005), and physical inactivity (Penninx et al., 2000).

In this framework, retirement is considered as a life course transition. Even early life conditions may have an impact on one's retirement decision and post-retirement cardiovascular health (Clark et al., 2017; Hayward and Gorman, 2004). Similar to the life course perspective described above, this framework is constituted with three sections: before, around, and after retirement. Factors at any of these sections can interact to influence the two possible pathways in which retirement affects CVD/CVD risk factors. In addition, social context factors, such as the overall economy, urbanisation, retirement policy, welfare benefit, and the social normal towards retirement could always influence individuals' retirement behaviour and their health behaviours and health conditions after retirement

This framework also integrates role theory to in understanding the effect of retirement on CVD/CVD risk factors. According to the role theory, retirement can be either a good or bad influence depending on whether retirees view this transition as ‘role loss’ or ‘role exit’ (Kim and Moen, 2002). This framework includes several factors that may determine whether the role transition in retirement is desirable. As shown in Figure 2.1, work domain factors, such as high job demands, low decision latitude, long work hours, and low work support, may make the working role stressful (Bakker and Demerouti, 2007). Retirement provides an opportunity to exit this role, and thus may lead to better biological and psychosocial health as well as healthier behaviours, contributing to better cardiovascular health. On the contrary, for those who enjoy their working role but have to stop working due to some exigencies (e.g. caring responsibilities), and those who retired involuntarily, retirement may be a stressful ‘role loss’ and be detrimental for their mental health (Gallo et al., 2000). This, in turn, may lead to increases in smoking and alcohol consumption to cope such stress, eventfully increasing the likelihood of developing CVD. In addition, for people who are less attached to their working roles, such as those who derive a strong sense of identity from family-related roles and those who were working part-time during most of their career stages, they may not experience a major role transition during retirement. Thus, retirement may have minimal or no effect on the development of CVD for this group of people.

The continuity perspective underscores one’s ability to continue one’s earlier lifestyle patterns even after retirement, and does not view retirement as leading to distress and poor mental if ‘continuity’ in lifestyle is maintained (Atchley, 1999). This framework acknowledges that individuals may first prefer continuity, but at the same time, it views retirement as an important disruption in this continuity. This framework highlights the potential changes of resources, demands, stress, and role relationships after retirement, and retirees who are not able to adapt to these changes may develop CVD thought the proposed behavioural and non-CVD health pathways.

This framework suggests that the effect of retirement on CVD/CVD risk factors is a longitudinal process, and relaxes the sequential assumption regarding the stages in retirement adjustment (e.g., as specified in stage theory). This framework contends that years since retirement are less important in describing the process of developing CVD/CVD risk factors. There may not be a ‘honeymoon period’ when retirees have the best cardiovascular health condition, instead, retirees' cardiovascular health could fluctuate up and down at any given time point, following the variation in individual and environmental factors.

In summary, this proposed theoretical framework ties the theories that have been used in the study of mental health to CVD, when feasible. This framework provides a more dynamic perspective on the potential effects of retirement on CVD, and it will be applied in explaining the results from empirical studies on retirement and CVD.

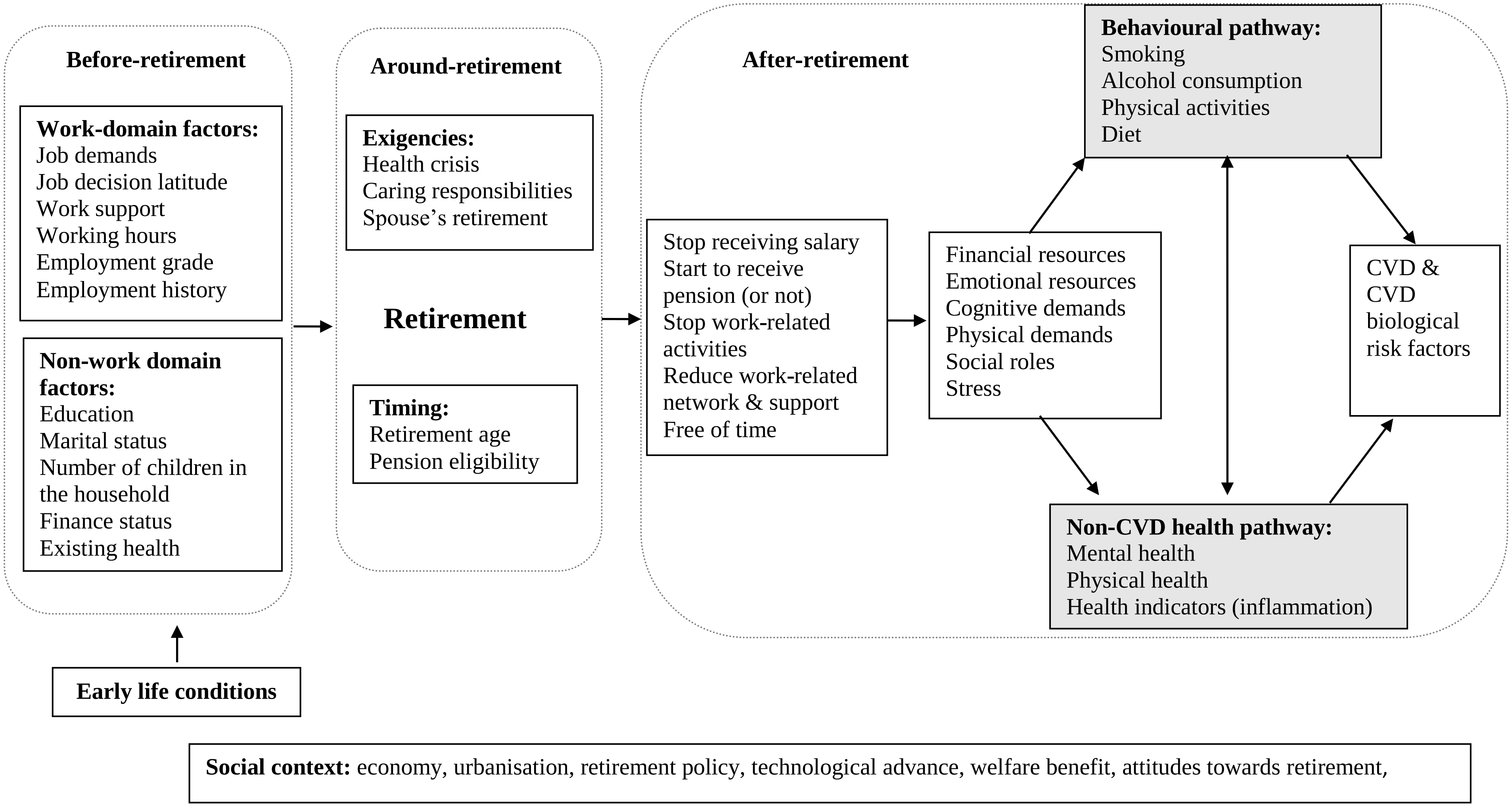

Figure 2. 1 Theoretical framework of retirement and CVD.

2.4 Empirical studies on the association between retirement and non-CVD health outcomes

This section provides a literature review of empirical evidence on associations between retirement and non-CVD health outcomes. Commonly examined outcomes, including mental health, cognitive function, physical functioning, and self-rated health, are discussed. This section first compared the study designs used in different studies, and then discussed the study results of each health outcome. A key focus is placed on longitudinal studies.

2.4.1 Comparing study designs in investigating associations between retirement and non-CVD health outcomes

A key issue in studying associations between retirement and health is the healthy worker effect, in that people who continue to work are likely to be healthier than those who choose to retire. Inappropriate handling of this problem could lead to biased results. Several studies investigating the relationship between retirement and health are cross-sectional in nature. The cross-sectional design can only measure the prevalence of disease of retired group and working group, rather than incident cases; therefore, cross-sectional studies cannot demonstrate the direction of effects of retirement on health. For example, using a cross-sectional design, Buxton et al. (2005), found that early retirees had a higher prevalence of common mental disorder compared to those still in work. This result can be interpreted either as mental disorder is a determinate of retirement, or that retirement can lead to poor mental health.

Longitudinal studies with repeated measures provide an opportunity to investigate the direction of effects. One common method is to choose a sample who are free of the disease of interest, and to adjust for other baseline characteristics that may confound the association between retirement and health. This method can reduce heterogeneity between retirees and those who are still working. However, this method cannot fully take account of the healthy worker effect, as individuals' characteristics, especially health conditions, may change over time. Those with deteriorating health in the follow-up may be more likely to choose retirement, but this cannot be controlled by adjusting baseline characterises.

There some other methods applied in longitudinal studies which seek to take account of this issue. For example, Jokela et al. (2010) compared the trajectories of physical functioning before and after the statutory retirement age among the same group of people, so called piecewise regression. This method can largely reduce the healthy worker effect, because retirees were compared with themselves rather than with those still working. This method may perform better than other standard regression techniques in handling reverse causality. Similar to other standard regression techniques, piecewise regression assumes no correlation exists between the model regressors and its error terms, but such an assumption might be problematic when there are other unobserved differences of sample characteristics before and after retirement. Therefore, this piecewise method still cannot eradicate the possibility of biased results.

The third method, instrumental variable (IV) analysis, has been commonly used in the field of economics. IV analysis controls for confounding factors through the use of an IV related to the exposure (i.e. retirement) but not to the outcome measure and error terms (i.e. individual's unobserved characteristics) (Greenland, 2000). The IV approach usually has two stages. In the first stage, retirement status is regressed on the IV and other covariates. In the second stage, retirement status is replaced with its predicted value from the first stage, and is regressed on the health outcomes. Discontinuous incentives in retirement schemes, such as the SPA, is often used as an IV. For example, if reaching SPA could be a strong incentive for retirement, then SPA will be strongly associated with individual's retirement behaviour. Also, SPA itself is not related to the health outcomes, as it is decided by the government. Therefore, this kind of IV provides an 'exogenous' shock to retirement behaviour, which is better able to take account of healthy worker effects when studying the health effect of retirement than other methods described previously, such as adjusting baseline characterises or piecewise regressions, which may not be able to fully remove the 'endogenous' problem, that prior health may influence retirement behaviour rather than the other way around. Therefore, the IV method may provide less biased results than standard regression techniques and piecewise method used in longitudinal analysis.

The next sections will present the strength of current evidence on the (non-CVD) health effects of retirement in light of these study designs. We will see that most research in this area has relied on IV analysis and standard regression techniques, and fewer studies have used piecewise method.

2.4.2 Retirement and mental health

A considerable body of literature has examined the impact of retirement on mental health, especially on depression. Several cross-sectional (Drentea, 2002) and longitudinal studies have found retirement to be associated with fewer depression symptoms (Fernandez et al., 1998; Jokela et al., 2010; Oksanen et al., 2011; Reitzes et al., 1996; Westerlund et al., 2010).

When it comes to IV analysis, four longitudinal studies which used IVs did not show any significant effect of retirement on mental health (Behnke, 2012; Calvo et al., 2013; Coe and Lindeboom, 2008; Coe and Zamorro, 2011). As described previously, the IV methods are able to provide less biased results than other longitudinal methods. However, these IV studies did not differentiate group differences which are likely to influence the effect of retirement on mental health. For example, Mandal & Roe (2007), which also used IV analysis, found voluntary retirement to be significantly associated with a reduction in depression symptoms, yet showed an increase among those whose retirement was involuntary. Therefore, it is possible that combining voluntary and involuntary retirement creates a balance between opposing effects which cancel one another and result no significant effects.

Several other factors that may modify in the associations between retirement and mental health have been suggested in the literature. Using longitudinal data from the Whitehall II study in the UK, Mein et al. (2003) showed that mental health functioning improved only among those civil servants who retired from high grade employment, but not for those retired from lower grades. Another longitudinal study from the US HRS shows that depressive symptoms increase when retirement is abrupt and perceived as too early or forced (Szinovacz and Davey, 2004). Buxton et al. (2005) and Butterworth et al. (2006) also found that early retired people are more likely to have mental disorder, especially for men, although the cross-sectional nature of their data cannot explore the directions of the association. In addition to these work-domain factors, family contexts may also play an important role in post-retirement well-being. One longitudinal study showed that retirement is associated with relatively fewer depressive symptoms among individuals who reported high levels of work stress interfering with family life in late midlife (Coursolle et al., 2010). This is probably because retirement provides an opportunity to reduce work demands interfering with family life. Another longitudinal study found that making the transition to retirement within the last 2 years is associated with less depressive symptoms for men compared to those continuously working, and this study showed a positive interaction effect of having a nonemployed wife in terms of reduced depressive symptoms (Kim and Moen, 2002).

On balance, the evidence suggests that retirement does not generally have a negative influence, if not always as a positive influence, on mental health, as long as retirement was not perceived as too early or involuntary. Both work-domain factors and family contexts may interact the effects of retirement on mental health.

2.4.3 Retirement and cognitive function

Relatively fewer studies have examined the effects of retirement on cognitive function. In contrast to the potential beneficial effect of retirement in terms of depression, most longitudinal studies have shown that retirement may have some negative effects on cognitive function of elders (Bonsang et al., 2012; Roberts et al., 2011; Wickrama and O'Neal, 2013). One longitudinal study estimated that every one extra year increase in retirement age was associated with on average 0.13 years delay in the onset of Alzheimer's disease among British men (Lupton et al., 2010).

Using cross-national survey data from the US (HRS), England (ELSA), and Europe (SHARE) in 2004, Rohwedder and Willis (2010) used IV analysis and also found that early retirement had a significant negative on the cognitive ability of people in their early 60s.

These findings generally support the 'use it or lose it' hypothesis, which proposes keeping mentally active will maintain individual's cognitive functioning level, and possibly prevent cognitive decline and the onset of dementia, whereas a lack of mentally challenging activities might exacerbate loss of cognitive function (Coyle, 2003; Hultsch et al., 1999). However, a recent longitudinal study in the USA found that those who had retired voluntarily or for family reasons had improved abstract memory scores, although those who had retired for health reasons had both lower verbal memory and verbal fluency scores (Denier et al., 2017). The results suggest that retirement may have inconsistent effects on cognitive ageing across cognitive domains. More importantly, this study suggests that the conditions surrounding the retirement decision may modify the effect of ‘use it or lose it’.

2.4.4 Retirement and physical functioning

In terms of the effects of retirement on physical functioning, most studies have been conducted in the USA and Europe, but their results are mixed. First, longitudinal studies in Europe have found either non-significant or beneficial effects of retirement on physical functioning. For example, a longitudinal study in Finland (Salokangas and Joukamaa, 1991) found a non-significant effect of retirement on self-rated physical health. Mein et al. (2003) using the Whitehall II cohort study in the UK, also found that physical functioning measured by the SF-36 questionnaire decreased with age regardless of retirement status. However, Jokela et al. (2010) using the same outcome in the same British cohort showed that physical functioning was improved after statutory retirement, but not early retirement. This study used a piecewise approach to evaluate whether retirement had different effects before and after age 60. As discussed previously, this piecewise method can better reduce the likelihood of reverse causality than other standard regression methods (e.g. Mein et al., 2003) thus provide relatively reliable evidence.

Longitudinal studies in the USA also showed mixed results. For example, Dave et al. (2006) applied the IV method in the US HRS data, and found that retirement worsened mobility by 34% and led to a 61.6% increase in difficulties with activities of daily living (ADL). Using the same survey, Stenholm et al. (2014), using standard regression analyses, also suggest that physical functioning declined faster in retirement than for those in full-time work amongst those aged 65 years and above. However, Luoh and Herzog (2002), using the Asset and Health Dynamics among the Oldest Old Study, suggest that both paid and volunteer work were associated with lower levels of self-reported poor functioning among Americans who were 70 years and above. People who remain in work after age 70 are likely to be physically healthier and enjoy their working roles more, thus this result may be not comparable to those from the HRS. An earlier study in the USA (Ekerdt et al., 1983) found a non-significant result on physical health. Its results may be less comparable to more recent studies due to technical developments in the workplace.

There are several reasons that effects of retirement on physical functioning are likely to vary on the basis of sample characteristics. For example, for those working in manual jobs, work might be a key source of exercise and is protective of physical decline, thus retirement may lead to physical functioning decline (Gall and Parkhouse, 2004). On the other hand, exit from the workforce might lead to an increased leisure physical activity, leading to improvements in, or protection from decline of, physical functioning. Such ideas tie in with activity theories of successful ageing and role continuity, thus the effects of retirement on physical functioning may depend on the lifestyle both before and after retirement (Herzog and House, 1991).

2.4.5 Retirement and self-rated health

Self-reported health is another commonly used variable the in the literature to assess the health effects of retirement. When respondents are asked to rate their general health, they tend to incorporate aspects of both physical and mental health (Singh-Manoux et al., 2006). Thus, self-rated general health may provide a more complete picture of one's overall well-being, and it has been shown to be an important predictor of mortality (Idler et al., 2004) and physical health (Kaplan and Baron-Epel, 2003). A study by Dave (2006), which used longitudinal data from the HRS in the USA showed that retirement was associated with increased occurrence of poor self-rated health. In contrast, some longitudinal studies indicate that retirement has a primarily positive effect. For example, Latif (2012) found that retirement had a positive but non-significant impact on self-reported health status among Canadians. Mojon-Azzi et al. (2007) suggested that retirement in Switzerland was not significantly associated with self-rated health in the short-term, but for those individuals whose health status did change, retirement had a primarily positive effect. Solinge (2007), using panel data on Dutch older workers, found that self-related health after retirement was improved compared to pre-retirement period, but deteriorated if retirement was perceived as involuntary.

Self-rated health might be particularly prone to issues of selection bias arising from the increased likelihood of those with poorer levels of health retiring for health reasons. Therefore, interpretation of analyses using methods such as IV which seeks to test causal effects is especially important here. However, results produced by means of IV analyses are also mixed. Behnke et al. (2012) found retirement was associated with worse self-assessed health in England, while Coe and Zamarro (2011), using the SHARE data in Europe, showed retirement to be associated with a 35% decrease in the probability of reporting in fair, bad, or very bad health. Calvo et al. (2013), using data from the US HRS, suggested that retirement happening ‘on time’ generated the best self-rated health. Workers who began their retirement transition before the SPA experienced the worst self-rated health outcomes, and continued employment after traditionally expected retirement age also offered no health benefits. Conflicting results may be due to different retirement policies, social welfare systems and social norms in specific countries. Additionally, the IVs used to assess relationships between retirement and health varied by study: Calvo et al. uses early retirement opportunity windows, Behnke et al. uses attainment of SPA and Coe & Zamarro uses country-specific early and state pension retirement ages. On the basis of this, it is unsurprising that even studies using the same methods of analysis produce widely differing results. Therefore, the impact of retirement on self-rated health is unclear, and differentiation may be dependent on prior working conditions and post-retirement experiences.

2.4.6 Summary

In summary, in studies of the associations between retirement and health outcomes, the most researched and most consistent evidence in relation to the impact of retirement is on mental health, in which retirement does not generally have a negative influence on mental health, particularly when retirement was not perceived as too early or involuntary. Findings are less consistent for physical health and self-rated health, and less research has been done on cognitive function.

Most studies support the idea that retirement leads to relief from stressful working roles, resulting in better mental health. However, the ability to enjoy personal pursuits in retirement may rely on adequate financial resources and fewer family duties after retirement, as the beneficial effects of mental health are less obvious for women, and those who retired from a low-grade job or retired involuntarily or early. These findings support the continuity theory that there should not be a significant drop in health when people transit from work into retirement life, if they have sufficient resources to maintain continuity. These results also partly provide evidence for role theory, that role transition during retirement can be a good or bad influence, depending on whether this transition is desirable. Additionally, findings that personal characteristics, such as gender, employment grade, and retirement timing, can affect the mental health after retirement fit well with the life course perspective. Stage theory expects a changing stage of adjustment in retirement across time, especially a 'honeymoon' stage immediately after retirement, but none of the studies found a changing association, thus cannot support stage theory.

In terms of cognitive function, less research has been done, but most studies propose keeping working will maintain levels of cognitive function, and retirement is associated with cognitive decline and the onset of dementia. These findings support the 'use it or lose it' hypothesis, but do not support any of the theories reviewed in the above sections in terms of the health effects of retirement. Further research is needed to understand the linkages between retirement and cognition, as well as the potential moderating role of specific career context.

For physical functioning and self-rated health, results from the empirical studies are less consistent. Differences in findings are likely to be due to heterogeneity inherent in the study designs, such as the definitions of work and retirement varied, in that some use employment status and others use the SPA. A broad set of analytical techniques were used, such as survival analysis, piecewise regression, and IV methods. These methods have different ways of handling selection bias when studying the association between retirement and health, and thus may estimate different results. In addition, each study takes into account a different list of covariates, although the majority of analyses accounted for age, gender and indicators of socio-economic status. Despite the differences in study designs, findings within countries were less heterogeneous. For instance, longitudinal studies in the USA often found retirement to be associated with poor physical functioning and self-rated health, while studies in Europe often suggest less detrimental associations. It is possible that more generous social support systems in European countries may result in better health conditions for retirees. In addition, social norms between different countries can influence the subjective feeling of health and wellbeing, subsequently leading to differences in self-rated health outcomes. These findings underscore the importance of the institutional environment on retirement, which is mentioned in the life course perspective.

2.5 Systematic review of the associations between retirement and CVD and CVD risk factors

The previous section has shown that the health effects of retirement tend to vary depending on study designs and especially what the health outcome is. Considering CVD is the area of interest for this thesis, a systematic review of empirical evidence on retirement and CVD and CVD risk factors was conducted. This systematic review is carried out according to the PRISMA guidelines (Moher et al., 2009).

2.5.1 Search method

The primary objective of this systematic review was to assess the current state of evidence for the impact of retirement on CVD and CVD risk factors. This review searched studies published before May 2016 in the following electronic databases: Medline, Embase, Social Science Citation Index, PsycINFO, and Social Policy and Practice. The reference list of the eligible papers was hand searched. No language restrictions were applied, as long as there was an English abstract. Indexing terms in combination with text words were used in searching. Indexing terms included ‘retirement’, ‘cardiovascular diseases’ and a range of CVD risk factors. Indexing terms vary between Social Science Citation Index and other databases, so two slightly different sets of search terms were used (Appendices 2.1a and 2.1b). When searching text words, wildcard characters were applied to search efficiently for alternative terms. The wildcard character can be thought of as a special character that means 'replace me with zero or more occurrences of any other character'. The dollar and question mark are frequently used in this way. For example, 'ischemi$' can stand for ischemia, ischemic, ischemical, and so on.

Included studies had to meet all the following criteria: 1) types of participants: general population, irrespective of gender, race or ethnicity; and 2) exposures of interest: retirement, regardless of whether it was normal, early, old age retirement. The operational definition of retirement was not restricted, which could be self-reports of economic activities as retired, being eligible for a public pension, or stopping work at the SPA. Outcomes of interest included: CVD, CVD metabolic risk factors, CVD behavioural risk factors, and CVD biomarkers. In this review, definitions of CVD could be any diseases of the heart and circulation except for congenital heart disease. According to the British Heart Foundation recommendations, high blood pressure, high cholesterol, diabetes and being overweight or obesity/central obesity were all considered as metabolic risk factors of CVD. In addition, physical inactivity, smoking, alcohol drinking and poor diet were considered as behavioural risk factors of CVD. Biomarker risk factors of CVD included lipid blood levels, low-density lipoprotein (or low level of high-density lipoproteins), glycated haemoglobin, C-reactive protein and any other inflammatory biomarkers.

Studies were excluded if they met one or more of the following criteria: 1) does not evaluate the relationship between retirement and CVD or CVD risk factors (e.g. using retirement status as a demographic characteristic in the descriptive results and did not provide statistical significance); 2) CVD or CVD risk factors are the determinants of retirement, rather than the effects of retirement; 3) exposure is disability retirement; 4) studies among patient populations (e.g. survivors of stroke) or people in special occupations (e.g. athletes); 5) retirement is an effect modifier rather than an exposure; 6) assess surgeries or therapies of CVD; 7) study on congenital heart disease or non-modifiable CVD risk factors, such as family history or genes; 8) non-English abstract; and 9) small sample size (less than 50).

2.5.2 Results

The numbers of studies identified from each database are shown in Figure 2.2. After removing duplicates, database searches identified a total of 4,898 titles, and 104 papers were eligible after reading titles and abstracts. Most studies were excluded because they did not evaluate the relationship between retirement and CVD/CVD risk factors. For example, some of them were based on retirement surveys (e.g. HRS), but they did not talk about a relevant topic. After that, the reference list search on these eligible papers identified three additional papers. After examining the full texts of the remaining 107 studies, five studies were excluded based on exclusion criteria1, and a total of 102 studies were included in this literature review. Some of the studies examined more than one outcome of interest; 19 studies focused on CVD, 15 on adiposity measures, 22 on other metabolic chronic conditions, 31 on physical activity, 10 on smoking, 19 on alcohol consumption, and seven on diet. Study designs, analytic methods, and findings of the included studies are presented in Appendix 2.2.

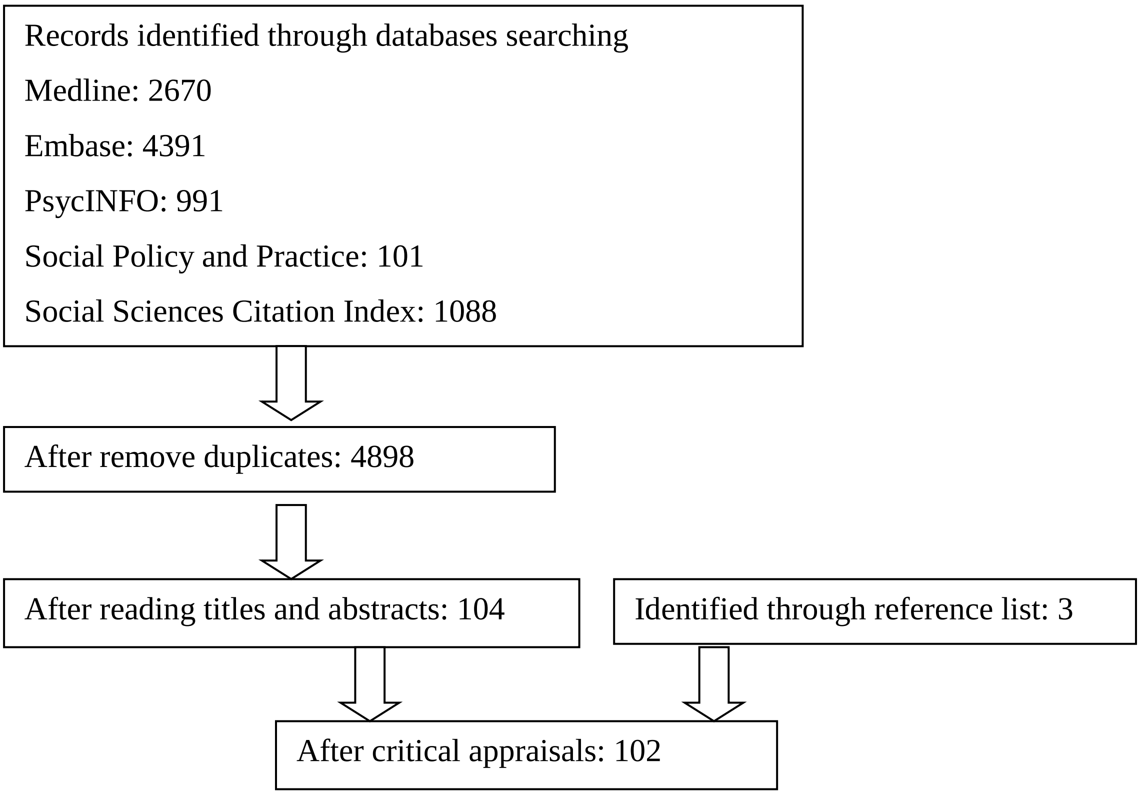

Figure 2. 2 Numbers of studies identified in the literature.

2.5.3 Key findings of the systematic review

Retirement and CVD

The results of 19 studies concerning the association between retirement and CVD are summarised in Appendix 2.2.a. Among the included studies, 15 were longitudinal studies, two were cross-sectional studies and the other two were case-control studies. Mortality from CVD or circulatory disease and self-reported physician diagnosed heart disease or stroke were often used as the measures of CVD in the included studies. Definitions of retirement were either self-reported employment status or reaching SPA.

Longitudinal studies in the US and Europe

Most of the included longitudinal studies are conducted in the US and Europe. It is worth noticing that the effects of retirement on CVD found in the studies tend to depend on the country of origin. Longitudinal studies in the US showed no significant effect of retirement on CVD incidence, at least in the long term. There were four longitudinal studies came from the US, which were all based on the HRS, a representative survey of Americans over the age of 50, but different analytic methods have been applied. To elaborate, Dupre et al. (2012) used survival analyses and adjusted for socio-demographic characteristics, health behaviours, baseline health conditions and health insurance. They did not find any significant differences between retired and working people regarding myocardial infarction incidence. Dave et al. (2006) took individual's fixed effects into account and reported that retirement was associated with an increased incidence of heart disease and stroke, but not once samples were restricted to those consistently insured in all waves. Coe et al. (2008) used early retirement window as the IV, which is related to retirement but not to an individual's background characteristics, therefore is better able to estimate causal effects of retirement on CVD. This study again did not find any significant effects of early retirement on myocardial infarction either in the short run (within 2 years) or long run (within 4 years). Moon et al. (2012) echoed the ideas of short and long-term effects of retirement, and using survival analyses found that the risk of occurring CVD (myocardial infarction or stroke) within the first year of retirement was modestly increased (HR=1.55), but it reduced to nonsignificant from the second year post-retirement.

Unlike the studies in the US, the vast majority of European longitudinal studies found detrimental effects of retirement regarding CVD. Morris et al. (1994) stated that men who retired earlier than 60 years old for reasons other than illness were more likely to die from circulatory disease during the 5.5 years' follow-up in the British Regional

Heart Study. Increased fatal and non-fatal CVD incidence associated with retirement were also found in longitudinal studies in Denmark (Olesen et al., 2014), Greece (Bamia et al., 2008), Italy (Petrelli et al., 2006), and the Netherlands (Méjean et al., 2013). The study in the Netherlands also looked into the mediators and estimated that dietary factors and lifestyle factors (physical activity, smoking status and alcohol consumption) explained 15% and 30% of the increased risk for CHD in the retired group, respectively. Considering CVD may be a determinate of exit from work, it is possible that the above associations between retirement and CVD have been overestimated due to the healthy worker effect. However, Behncke (2012) applied the IV method in the first three waves of English ELSA also found retirees had a higher risk of being diagnosed with CVD than working people, and this effect of retirement on CVD can be considered as causal. One exception of the European country is France, as none of the French studies reported any significant results between retirement and CVD. Westerlund and colleagues (2009) used the French GAZEL study to calculate the cumulative prevalence of self-reported CVD from seven years before to seven years after retirement. This piecewise method has shown that the CVD prevalence increased with age, and without a break in the trend around or after retirement. Another longitudinal French study found that retired men had similar CVD incidence to working men (Vallery-Masson et al., 1981). This study was conducted in the early 1980s in Paris, so its results might not be comparable to other more recently published studies, as the health effects of retirement are possibly contingent on current retirement policies and social norms.

Cross-sectional studies and case-control studies in the US and Europe

There was only one cross-sectional study from Europe which used the second wave of the English ELSA (Bound and Waidmann, 2007). CVD prevalence by age was plotted separately before and after the SPA for men and women, respectively, and this study found that women had significantly higher likelihood of diagnosis of heart disease and diabetes after SPA than what would be predicted by preretirement levels, but this pattern was not observed in English men. However, its cross-sectional design cannot demonstrate the direction of effects of retirement on CVD.

In the relatively older literature, two case-control studies were conducted among American married men. Casscells et al. (1980) found retirees were more likely to die from CHD, but Siscovick (1990) found no association between retirement and primary cardiac arrest (cardiac arrest is usually caused by cardiac arrhythmia). The results of case-control studies may subject to selection bias of the sample, and similar to cross-sectional studies, they do not allow calculation of incidence, thus cannot demonstrate the direction of associations.

Studies from other countries

There was only one study form China. Using a national representative longitudinal study in China, Mao et al. (2010) found that, among men, unemployed individuals and farmers had the highest CVD incidence, followed by manual workers and retirees, and men working in other occupations had the lowest risks, after adjusting for relevant covariates. This study did not find any occupational difference among Chinese women. An important limitation of this study is using unemployed people as the reference group, thus it is impossible to evaluate the significance of the differences between retirees and working people. Evidence from Asian countries may be more relevant to the situation in China because of similar social norms, but again there was only one study. This longitudinal study used a Korean cohort aged 45 years and above, and distinguished involuntary retirement from voluntary retirement (Kang and Kim, 2014). This study defined involuntary retirement as retired before scheduled or regular retirement age due to business closure, layoff, or family problems. It showed that voluntary retirement increased the risk for CVD among both men and women. For men, involuntary retirement was more closely associated with the development of CVD than voluntary retirement, but this was not true for women. This is likely that, for men, the nature of involuntary job loss is more close to unemployment than retirement, thus it is more detrimental.

The remaining two included studies came from the Middle East. One cross-sectional study in Kuwait found retired people had a higher prevalence of CVD (Shah et al., 2010), and the other longitudinal study in Iran found retirement was not associated with CVD incidence (Masoudkabir et al., 2012).

Summary

To summarise, most of the studies on retirement and CVD were conducted in the US and Europe. Studies in the US often found no significant effect of retirement on CVD, while research in Europe (with the exception of France) showed consistent increased CVD events among retirees. Many factors, such as different retirement policies and social-welfare legislation between these countries are likely to be one of the factors influencing the differing results by country. This will be discussed together with other CVD outcomes later in the chapter. No clear pattern emerged in other regions due to the small number of relevant studies.

Retirement and CVD metabolic risk factors

Thirty-five studies have tested the relationship between retirement and metabolic CVD risk factors, and their key findings and study designs are summarised in Appendices 2.2.b and 2.2.c. This section discusses the study findings of cross-sectional and longitudinal studies, respectively.

Cross-sectional studies

Fifteen of the included studies were cross-sectional, and 12 of these suggested that retired people were more likely to have metabolic CVD risk factors, including: hypertension (Ke et al., 2015; Seow and Subramaniam, 2015; Shah et al., 2010; Sivén and Niiranen, 2015; Roberts et al., 2012), diabetes or impaired fasting glucose (Azimi-Nezhad, 2008; Müller et al., 2013; Shamshirgaran, 2013; Shah et al., 2010; Zhang et al., 2013), obesity or high adiposity measures (Lahmann et al., 2000), and metabolic syndrome (Al-Daghri, 2014; Madani Larijani, 2012). Only three cross-sectional studies from Canada (Kong, 2011), Spain (Martín et al., 2008), and Portugal (Kowalkowska and Poínhos, 2016) did not find any significant association between retirement and obesity. However, reverse causality is a concern for the cross-sectional findings. For example, diabetes may influence an individual’s ability to work, and thus increases the likelihood of retirement (Vijan et al., 2004). Besides, overweight and obese workers may have disadvantages in the labor market (Brunello and D’Hombres, 2007) and, therefore, a stronger incentives to retire than normal weight people (Burkhauser and Cawley, 2006).

Longitudinal studies where CVD risk factors have been measured repeatedly both before and after retirement, provide an opportunity to reduce the selection bias to some extent. The metabolic risk factors of CVD have been researched in the longitudinal retirement studies are adiposity measures, diabetes, hypertension, and metabolic syndrome. The following paragraphs will discuss the study findings of each risk factor.

Longitudinal studies on retirement and adiposity measures

Four longitudinal studies based on the HRS study in the USA found consistent results that retirement was associated with higher adiposity measures among those retired from physically demanding jobs. The most recent HRS study conducted by Gueorguieva et al. (2011) showed that those in service and other blue-collar occupations had a significant increase in BMI trajectory after retirement, whereas individuals in white-collar occupations exhibit no change. IV estimations in Chung et al. (2009) also supported that BMI was only increased with retirement from physically demanding occupations. The other two studies based on the HRS further tested the effects of retirement by gender. Zheng (2008) found weight gain among men retired from strenuous jobs, while Forman-Hoffman et al. (2008) found this association among blue-collar women. The inconsistent results between the two are likely because of different analytic methods applied, where Forman-Hoffman et al. (2008) compared retired people with those who continued to work, and Zheng (2008) used eligibility ages of the USA Social Security and Medicare as IVs. Using IV approach in the European SHARE data (age discontinuities in social security incentives as IVs), Godard (2016) also showed that retirement caused an increase in the probability of being obese among men retiring from strenuous jobs, and no significant results were found among women. Nooyens et al. (2005) compared Dutch men who remained employed with those retired either voluntarily or mandatorily, finding that retired men gained more weight and the weight gain was greater among retirees from physically active jobs. This result echoed the findings of retiring from strenuous jobs can be detrimental for men, although did not include a group of female retirees against which to compare this result.

Three longitudinal studies were conducted in the UK, but their results are mixed, and may be limited by methodologic weaknesses. First, Monsivais et al. (2015) found that weight gain for those who entered retirement was equivalent to those who had remained employed, suggesting no effect of retirement. This study again has the issue of selection bias when comparing retirees with workers. Morris and colleagues (1992) stated that non-continuously employed men were more likely to either gain or lose weight, compared to continuously employed men. This study compared a broad category of non-continously employed, thus there was heterogeneity within the group. For example, temporary job loss may change health but do so differently from retirement. Last, Patrick et al. (1982) found body fat was increased after retirement. This study did not adjust for any covariates and the sample size was only 73, thus may have serious bias in their results.

Longitudinal studies on retirement and diabetes/hypertension/metabolic syndrome

In the literature, eight longitudinal studies assessed the associations between retirement and diabetes or hypertension, and five of them found no association. To elaborate, Westerlund et al. (2010) compared the cumulative prevalence of self-reported diabetes before and after retirement in the French GAZEL cohort and found that its prevalence increased with age, with no break in the trend around retirement. Oksanen et al. (2011) used purchases of diabetes medication to avoid potential response bias from self-reported questionnaires, finding that purchases of diabetes medication in Finland were not altered by retirement; regardless of whether it was statutory retirement or early retirement. The remaining five longitudinal studies were all based on the HRS in the USA. Three of them did not find any significant effects of retirement on self-reported diabetes or hypertension (i.e. Horner and Cullen, 2016; Zheng, 2008; Coe and Lindeboom, 2008). In contrast to these non-significant results, Insler (2014) suggested that retirement decreased the onsets of diabetes and hypertension, but Dave et al. (2006) found retirement was associated with increased self-reported diabetes, even after limiting the study samples to healthy workers prior to retirement. These five studies focus on the same country and, therefore, the conflicting findings cannot be explained by differences in the institutional setting or culture. The possible explanation is that these studies used different analytic methods, where Dave et al. (2006) used individual fixed effects to control for time-invariant heterogeneity across individuals, and Insler (2014) used workers' self-reported probabilities of working past ages 62 and 65 as the IV, whereas others used earliest ages of pension or health insurance scheme as the IVs.

One limitation of studies on diabetes and hypertension is that most of them used self-reported physician-diagnoses diseases, thus the results may be biased due to the unawareness of disease. Only one longitudinal study used objectively measured blood pressure, and showed a significant increase in blood pressure (an average of 3.44 mmHg in systolic blood pressure, 1.62 mmHg in diastolic blood pressure) for retirees compared with workers over a three-year span in the US Normative Aging Study (Ekerdt et al., 1984). This study also found a non-significant increase (5.56 mg/dl) in blood cholesterol. However, this study was conducted in the 1980s, thus its result may be less comparable to more recent studies, and its analytic method is less able to handling healthy worker effect.

There is only one longitudinal study used objective biological measures of metabolic syndrome[2] and found that retirement increased the risk of having metabolic syndrome only at the 10% significance level (Behncke, 2012).

Summary

On balance, the majority of cross-sectional studies suggest retirement is associated with increased metabolic CVD risk factors, but their results are likely to be overestimated because of the healthy worker effect. For longitudinal studies, results vary by different health outcomes. Results from the US and several European countries consistently show that retirement may increase adiposity measures only among those retired from physically demanding jobs, especially for men. However, findings in the UK are less consistent on adiposity measures, which is probably because of limitations in study designs. In terms of diagnosed diabetes and hypertension, five out of eight longitudinal studies suggest no effect of retirement. Despite the relatively consistent findings, results may be biased due to self-reports of outcomes in most of the studies.

Retirement and physical activity

Retirement is often accompanied by changes in lifestyles, and physical activity is one of the most researched health behaviours. Among the included studies, 29 examined the effects of retirement on physical activity, and 20 of them were longitudinal. The effects of retirement on leisure-time physical activity and total physical activity are discussed

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[2] Having a BMI>30 plus any two of the following four factors: 1. Raised triglycerides $\geqslant$ 150 mg/dL (1.7 mmol/L) 2. Reduced HDL cholesterol: < 40 mg/dL (1.03 mmol/L) in males; < 50 mg/dL (1.29 mmol/L) in females 3. Raised blood pressure: SBP $\geqslant$ 130 or DBP $\geqslant$ 85 mm Hg 4. Raised fasting plasma glucose: $\geqslant$ 100 mg/dL (5.6 mmol/L). This definition is provided by the International Diabetes Federation.

respectively in this section. Findings and study designs of included studies are also shown in Appendix 2.2.d.

Cross-sectional studies on retirement and leisure-time physical activity

The absence of work activities provides an opportunity for free time; thus, it is not surprised to see that many studies found an increase in leisure-time physical activity after retirement. Cross-sectional results from the UK (Godfrey et al., 2013), Germany (Steindorf, 2010), and Canada (Wister, 1996) found that retired people were more likely to participate in leisure-time physical activity than their working counterparts. Among 74,942 Chinese women aged 40 to 70 years, Jurj et al. (2007) found that being non-employed (combined retirees and housewives) was associated with an increased participation in exercise or sports and higher levels of housework. Retired women may have different behaviour from housewives, but this study did not test the association for retirees alone.

Longitudinal studies on retirement and leisure-time physical activity

Longitudinal studies also provided similar evidence in terms of leisure activities after retirement. A Dutch longitudinal study found that people reported more exercise after retirement, regardless of whether retirement was perceived as voluntary or not (Henkens et al., 2008). In the French GAZEL cohort, walking at least 5 km/week increased by 36% among men and 61% among women during the transition to retirement, and this increase was also observed among people at a higher risk of physical inactivity, such as smokers and those with elevated depressive symptoms (Sjösten et al., 2012). Increased moderate to vigorous leisure-time physical activity with retirement was also found in two Finnish cohort studies (Lahti and Laaksonen, 2011; Kuvaja-Köllner et al., 2013), a German cohort study (Eibich, 2015), and a longitudinal study in the Netherlands (Koeneman et al., 2012), Beyond Europe, beneficial effects on leisure-time physical activity were also observed in cohort studies in Australia (Brown et al., 2009) and the USA (Midanik et al., 1995).

While significant evidence of increased leisure-time physical activity following retirement was found in the literature, retirees were also more likely to have sedentary behaviour at the same time. A longitudinal study among French participants showed that retirement was associated with about an 2 hours/week increase in leisure-time physical activities, especially with an increased duration of moderate activities and walking, but retirees increased about 2 hours per week on TV watching as well (Touvier et al., 2010). Similar results were found among Americans (Evenson et al., 2002) and French people (Menai et al., 2014), which were characterised by increasing in both leisure-time physical activity and sedentary behaviour. These longitudinal studies point out that 'sedentary' is not simply the opposite of 'active'.

When only looking at vigorous physical activity, such as sports and heavy housework, there is consistent evidence form longitudinal studies that there was no significant difference between retirees and employee (Zheng, 2008; Nekuda, 2009; Insler, 2014), which is probably because it is more difficult for older people to pick up vigorous physical activities after retirement.

Cross-sectional studies on retirement and total physical activity level

Although retirement has been repeatedly linked to increasing leisure-time physical activity, retirement may reduce work- and transport-related physical activity in turn. When it comes to total physical activity level, several studies showed a decreased trend following retirement. Cross-sectional results from Ireland (Murtagh et al., 2015) and Morocco (Najdi et al., 2011) showed that retirees were more likely to have lower total physical activity level, and one cross-sectional study in Australia highlighted that only recently retired men were more likely to report a decreased total physical activity, but not for those long-term retired (Wells and Kendig, 1999). There is only one cross-sectional study in Portugal which found no change in total physical activity after retirement (Fonseca and Paúl, 2003), but this study may be limited by small sample size (n=100).

Longitudinal studies on retirement and total physical activity level

Longitudinal results from Slingerland and colleagues (2007) showed that although Dutch retirees participated in leisure activity more often than employees, this was not enough to compensate for the cessation of work-related transportation activity, leading to a reduction in total physical activity among retirees. Less walking for transportation was also found among Australian retirees (Turrell et al., 2014). Two longitudinal studies were conducted among British people. Berger et al. (2005) found that Scottish retirees less often met the physical activity recommendations due to the loss of work-related activity. Barnett et al. (2013) found a decline in overall physical activity among British retirees, especially for men and women retired from manual social class occupations. An even stronger moderating effect of pre-retirement occupation was found in Chung et al. 's (2009) work in the HRS study, in that total physical activity decreased with retirement from a physically demanding job, but increased with retirement from a sedentary job. Fixed-effects regression models were used in this study to account for confounders. However, findings from Kämpfen and Maurer (2016), which was also based on the HRS, stand in contrast to this evidence. This study used early (62 years) and normal (65 years) state pension ages as IVs to take account of the likely endogeneity of retirement status. It estimated 20% to 40% increases in compliance with physical activity guidelines in response to retirement, and beneficial effects were larger for better educated individuals and persons with higher levels of household wealth. As mentioned previously, these results using the IV method are likely to be less biased by the healthy worker effects than Chung et al.'s (2009) study. Nevertheless, both studies suggest that total physical activity level is increased after retirement for socially advantaged Americans, which may reflect differences in initial levels of work-related physical activity and differences in opportunity to participate in leisure-time physical activity. Increased total physical activity levels were also found among retired civil servants in the UK, and this benefit was evident amongst those who retired from higher employment grades (Mein et al., 2005). Civil servants held less physically demanding jobs before retirement, thus it is possible that the loss of working activities is compensated by increased leisure-time activates. Another longitudinal study (Patrick et al., 1986) in the UK reported an increase in total physical activity among men but a decrease among women. This study may be limited by the measures of heart rates and physical activity used as well as other methodologic weaknesses, such as a small sample size (*n*=72) and no adjustment for confounders.

Summary

In summary, the studies on leisure-time physical activity and retirement conclude that retirement was associated with an increase in leisure-time physical activity, which is possibly related to an increase in light or moderate intensity activities, but not vigorous activities. At the same time, retired people are also more likely to increase sedentary behaviour, such as sitting to watch TV. No clear pattern emerged with regard to total physical activity. Some studies state that increased leisure-time physical activities are unlikely to replace the ending of work and transportation-related physical activities, thus suggesting a negative effect of retirement on total physical activity, whereas, other studies document a positive effect. Social class seems to moderate the association, in that individuals retired from low employment grades and physically demanding jobs, and those with lower education and less wealth, experience a less beneficial effect or a bigger adverse effect on total physical activity in response to retirement.

Retirement and smoking status

Smoking is an important risk factor of CVD. In the literature, 10 studies tested the association between retirement and smoking. Seven of them are longitudinal and three are cross-sectional. Findings of the included studies are discussed in the following paragraphs, and details of specific results and study designs are summarised in Appendix 2.2.e.

Longitudinal studies on retirement and smoking status

Two longitudinal studies using the US HRS data showed contradictory results. Insler (2014) suggested that retirement was linked with decreased probability of smoking, but Ayyagari (2014) showed an increased probability. The conflicting results are most likely due to the different IVs used, where Insler (2014) used workers' self-reported probabilities of working past ages 62 and 65 as an IV for retirement, and Ayyagari (2014) used the state pension age of 62. It highlights the importance of selecting a proper IV in the study design, but it is not always easy to do so in practice. A third US longitudinal study using Kaiser Permanente Retirement Study found no difference between working and retired people in the probability of smoking (Midanik, 1995). Two longitudinal studies were conducted among British participants, which found some benefits of retirement with respect to smoking, although not all of them were statistically significant. One following up 5 to 6 years of the ELSA cohort found that those aged 55-70 who retired were more than twice as likely to quit smoking as those who continued to work. Results were robust when those who retired for reasons of ill-health were excluded (Lang et al., 2007). Another longitudinal study based on the British Regional Heart Study found that 31% retirees quit smoking compared to 26% of workers, but this difference did not reach a statistically significant level (Morris et al., 1992). Similar to findings in the UK, a longitudinal study among more than 20,000 German participants found that retirement reduced the probability of smoking by about 5% points. The effect on smoking was almost zero for individuals with low job strain, whereas individuals with high physical and mental strain were less likely to smoke after retiring (Eibich, 2015). This study used a regression discontinuity design, which is very similar to IV strategies, since both approaches rely on SPA as a source of exogenous variation in retirement status. The only difference is that IV approach often specifies a quadratic age trend over the whole age range, but this regression discontinuity design allows the age trends to differ (Eibich, 2015). Therefore, these two approach should have the same ability to resolve the reverse causality. A Dutch cohort study differentiated involuntary retirement from voluntary retirement, and found that during the 6-year follow-up, the involuntarily retired people had both a higher risk of increased smoking and a lower risk of decreased smoking, and voluntary retirement was not associated with smoking status (Henkens et al., 2008).

Cross-sectional studies on retirement and smoking status

In terms of cross-sectional studies, a reduced risk of smoking associated with retirement was reported by Wister (1996) among Canadians, and UK cross-sectional study found that retirement was significantly associated with decreased smoking among women, but the effect on men did not reach a statistically significant level (Cox, 1987). The third cross-sectional study was conducted in the Black Belt region of the USA, which is characterised by a predominantly African American population with relatively high poverty rates. This study found that retirement was associated with an increased risk of smoking (Shuaib et al., 2011).

Summary

In summary, the majority of studies (seven out of 10) included in the review suggested that retirement did not increase smoking, and two studies suggested that retirement may increase smoking if it is involuntary or companied with poverty.

Retirement and alcohol consumption

Nineteen studies have assessed the relationship between retirement and drinking behavior or alcohol problems, and they are all longitudinal studies. This section compares the results of each of these studies. Their key findings and study designs are also summarised in Appendix 2.2.f.

Increased alcohol use associated with retirement

Some retirees may turn to alcohol to fill leisure time and cope with the stresses associated with retirement as a major life change. A number of studies support this idea that retirement increases alcohol consumption and the incidence of drinking problems. Two French studies based on the GAZEL cohort suggested that retirement increased the risk of excessive alcohol consumption, temporarily (1 year before and after retirement) in most people and permanently in the small group of women managers (Tamers et al., 2014; Zins et al., 2011). One longitudinal study in Germany found retirement to decrease the probability of abstaining from alcohol, although no significant impact of retirement on the probability of regular alcohol consumption was found (Eibich, 2015). Using 2 years of panel data among blue-collar Americans, Bacharach et al. (2004) suggested that retirement generally heralds no great shift in alcohol consumption or drinking patterns; however, taking into account the effects of periodic heavy drinking history, individuals opting to retire were twice as likely to engage in periodic heavy drinking as those who continued to work. This finding is consistent with that of Ekerdt et al. (1989) among American men born between 1884 and 1945. Perreira and Sloan (2001) and Wang et al. (2014) using data from the US HRS also found retirement to be associated with increased alcohol consumption, particularly among those with a preretirement history of problem drinking.

Decreased alcohol use associated with retirement

Other researchers, however, argue that workplace risk factors, such as work stress and job-based drinking cultures, represent a greater risk to workers' drinking behaviour than retirement does. If this is the case, retirement may provide a chance to eliminate these risk factors from workers' lives. For example, a study among older people (60-96 years) in Japan suggested that alcohol consumption tends to drop significantly among non-working people (retired and unemployed combined), and the authors ascribed the use of alcohol as a 'social lubricant' within Japanese work culture (Gee et al., 2007). Neve et al. (2000) conducted an analysis of a 9-year longitudinal study in the Netherlands and found retirement to be associated with a decrease in alcohol consumption and alcohol-related problems. Using six waves of the US HRS, Bob et al. (2013; 2011) estimated 10-year drinking trajectories and suggested that retired women were more likely to decrease their alcohol consumption compared to working women, but retirement was not associated with the alcohol consumption trajectories among men. While Rodriguez and Chandra (2006), utilizing data from the US National Survey of Families and Households, found that retired men were more likely to reduce drinking, but not retired women.

No association with retirement

Other studies in the UK (Iparraguirre, 2015; Morris et al., 1992), and the USA (Glynn et al., 1988; Platt et al., 2010; Brennan et al., 2010) suggested no association between retirement and alcohol consumption or drinking problems.

Summary

In aggregate, the evidence did not show a clear conclusion on the effect of retirement on drinking behaviours or alcohol problems. This is probably because of the different study designs applied. For example, the measures of drinking outcomes vary between studies, with some using risk of problem drinking or periodic heavy drinking, some using the risk of non-drinking, some using drinking trajectories (increased/declined/stable/other), and others using average alcohol consumption. In addition, the study samples were from different countries, and results observed in one study could differ from studies from other cultural settings. For example, the French have one of the highest alcohol consumption rates among industrialised nations, and alcohol is often consumed daily by a majority of the French population, thus results from the France might not be comparable to the USA where has much lower alcohol consumption level. Besides, individual attributes, such as having a history of problem drinking, may be more of a determinant in the context of retirement. Perriera and Sloan's (2001) longitudinal study of retirement and drinking patterns revealed that retirees with a problem drinking history were significantly less likely to decrease drinking than not retired people. In addition, pre-retirement conditions, such as high job satisfaction or workplace stress, may also influence the overall use of and problems with alcohol. In an analysis of blue-collar retirees (Bacharach et al., 2008), the moderating impact of pre-retirement job satisfaction on retirement was explored, and those who had higher pre-retirement job satisfaction demonstrated greater alcohol consumption and more problems related to drinking in retirement. The conditions of the workplace exit itself, such as whether the decision is voluntary, may also impact drinking behaviours. For instance, Henkens et al. (2008) explored voluntariness of retirement as a mediator of retirement's impact on health outcomes in the Netherlands, and concluded that involuntary retirees may use alcohol to cope with stress of sudden change in their employment status.

Retirement and diet

High dietary intake of saturated fat, trans-fats and salt, and low intake of fruits, vegetables and fish are linked to cardiovascular risk (World Heart Federation, 2016), but changes in food habits after retirement have been investigated in only a few studies. Only four longitudinal and three cross-sectional studies were included in this systematic review.

<u>Longitudinal studies</u>

All the longitudinal studies were based on European population, but their results are mixed. A British longitudinal study on changes in fiber intake after retirement reported minor changes at the food item level (Davies et al., 1986). A Swedish longitudinal study found that people were more likely to have unhealthy habits after retirement, such as increased consumption of pastry, potato chips and similar food items (Steen et al., 1988). A French longitudinal study reported that the amount of dietary nutrients consumed remained the same before and after retirement (Lauque et al., 1998). The most recent longitudinal study on retirement and diet is Hellda´n et al.’s (2012) work using the Helsinki Health Study cohort. A food frequency questionnaire with eight items formed according to dietary recommendations was asked. Their results suggested that the transition to retirement led to healthier food habits among women, but for men, a similar trend was not found, and men’s food habits remained at a clearly unhealthier level.

<u>Cross-sectional studies</u>

Cross-sectional studies in the US (Teufel-Shone et al., 2015) and Brazil (Fisberg et al., 2006) also suggest that retired people were more likely to consume healthy foods. Irz et al. (2014) compared the diet of pensioners and employees in the UK, Italy, and Finland, and their cross-sectional results suggested that effects of retirement might vary between countries. In the UK, currently employed managers adopted relatively healthier diets than pensioners, but there is no statistically significant difference in diet quality between pensioners and the other socio-professional categories. A different relationship was observed in the Italian sample, where managers were found to consume diets of relatively poorer quality than pensioners, and in Finland, no association between employment status and diet quality was found.

Summary

No clear pattern emerged from reviewed studies, and most of the diet data was derived from self-reported survey responses and are prone to response bias. In addition, the definition of healthy diet based on dietary recommendations can vary from country to country that may contribute to inconsistent results across studies.

2.5.4. Discussion of the systematic review and identifying gaps in current evidence

This section systematically reviewed the empirical studies in the literature regarding the effects of retirement on CVD and CVD risk factors. The results showed that the effect of retirement varies according to the health outcomes studied. However, even these studies using the same health outcome suggest different effects of retirement. A number of factors may underlie the inconsistency in these research findings. First, inconsistencies may stem from the way in which researchers conceptualise retirement, with some using self-reported employment status, while others use state pension ages. Other sources of inconsistency may be that the study samples vary with respect to age ranges, gender, country of origin, measures of health outcomes, study designs and statistical methodologies.

Among the sources of inconsistency, country of the study population seems to play an important role in the results. For example, empirical studies in the USA often found no significant effect of retirement on CVD, while studies in Europe, except France, showed consistent detrimental effect of retirement on CVD. As suggested by the life-course perspective, individuals' responses to retirement are often related to features of the institutional environment shaping their choices of retirement (Riley and Riley, 1994). Thus, different retirement policies and social-welfare legislation between the USA and European countries are likely to be one of the factors influencing the health and well-being of individuals after retirement. For instance, there is no statutory retirement age in the USA, while there are statutory retirement ages in European countries, although some European countries have recently outlawed compulsory retirement. These findings support the idea of the life-course model that institutional characteristics between countries can shape the decision of retirement and influence the health and well-being after retirement. However, it is worthwhile to note that the health services accessibilities between countries may make their results less comparable. For example, it is interesting to see that empirical studies in the USA consistently found no significant effect of retirement on CVD, but showed increased adiposity measures associated with retirement. Most studies use diagnosed CVD as the outcome of study. It is possible that the effect of retirement on CVD has been underestimated in the USA due to more unawareness of CVD compared to European countries.

Asian participants are likely to have different social norms in terms of working and retirement, but due to the limited number of Asian studies found in the literature, it is difficult to identify a pattern in study findings. Also, very few studies were conducted among less developed countries, where participants are likely to have very different retirement behaviour and social-welfare provision after retirement, compared to developed countries. For example, only five studies (i.e. one longitudinal and four cross-sectional), were based on the Chinese population. The longitudinal study used unemployed Chinese people as the reference group, so it is not possible to evaluate the significance of the differences between retirees and working people (Mao et al., 2010). One cross-sectional study investigated the patterns and correlates of physical activity in middle-aged and older women from urban Shanghai in China (Jurj et al., 2007), but it compared non-working women with working women rather than looking at the role of retirement. Two additional cross-sectional Chinese studies were conducted in Hong Kong (Chung et al., 2015) and Macau (Ke et al., 2015), which were Western colonies for a very long time, thus their results are likely to be different from the population in mainland China. The last study was based on Tianjin in China, which showed that retired people were more likely to have impaired fasting glucose, diagnosed and undiagnosed Type 2 diabetes (Zhang et al., 2013). However, it was a cross-sectional study and results may be overestimated due to the healthy work effect. In addition, none of these Chinese studies have tested the whether the association between retirement and CVD/CVD risk factors differs between urban and rural Chinese populations, despite the urban-rural differences in China in terms of retirement ages and social welfare provision.

The life course perspective also underscores gender differences in retirement behaviour and post-retirement activities and health conditions. However, many of the reviewed studies fail to consider differences between the genders with regards to the health effects of retirement. For example, only three longitudinal studies (Kang and Kim, 2014; Olesen et al., 2014; Petrelli et al., 2006) and one cross-sectional study (Bound and Waidmann, 2007) have examined the effects of retirement on CVD for men and women separately. For studies that tested gender differences, some suggested that retirement is more detrimental for men, while others found the opposite result. One possible reason for this, as suggested by the life course perspective, is that the association between retirement and health also interacts with other personal and environmental characteristics which differ by gender. For instance, a study sample with higher proportion of female manual workers may find a smaller gender difference regarding retirement and adiposity measures, compared to studies with fewer female manual workers. The inconsistent gender differences found in the included studies may partly support role theory in that the role transition during retirement may lead to either beneficial or detrimental effects on individuals, depending on whether this role transition is desirable.

It is also important to note that, regardless of heterogeneity, none of the included studies have found any beneficial effects of retirement on CVD, and only a few of them suggest retirement reduced metabolic risk factors of CVD. The general finding regarding retirement and CVD and metabolic diseases is contrary to the potential relief effect of retirement on mental health found in the literature (section 2.3), and does not support continuity theory, which highlights retirement as not being detrimental in continuing one’s previous lifestyle even after retirement. The underlying mechanisms through which retirement influences the development of CVD and other metabolic diseases might be more complicated than that of mental health. Yet, it remains unclear whether deterioration in cardiovascular health can be explained by factors such as the loss of a highly valued working role, negative changes in lifestyle, or by insufficient economic resources. Thus, the mechanisms potentially linking retirement and CVD need to be further explored. There is only one study (Méjean et al., 2013) which tested potential mediators in the effects of retirement on CHD, and found that dietary factors and lifestyle factors (physical activity, smoking status and alcohol consumption) explained 15% and 30% of the increased risk for CHD in the retired group, respectively. In terms of the stage theory, only two studies assessed both short and long-term effects of retirement on CVD, and none of them support the idea of a 'honeymoon' period in which retirees experience an improvement in health early in the transition to retirement as they lose stressful working roles and pursue new roles and activities (Atchley, 1989).

Another common limitation of reviewed studies is inappropriate handling of missing data. Only six out of the 102 included studies had multiply imputed missing data in the analysis (Forman-Hoffman et al., 2008; Henkens et al., 2008; Gee et al., 2007; Iparraguirre, 2015; Rodriguez and Chandra, 2006; Teufel-Shone et al., 2015), and the remaining studies all used complete case analysis. When analysing the health effect of retirement, many personal characteristics need to be adjusted for; thus, this kind of study often faces a relatively higher percentage of missing data, and complete case analysis could lead to biased estimations and reduced the statistical power.

Reverse causality may also have contributed to the results seen in the studies reviewed, especially for non-longitudinal studies. CVD and metabolic diseases are important determinants of retirement, thus people who stay in the labour market are generally healthier than retirees. Most of the included studies assessed the health effects of retirement by comparing retired people with employed people which may over-estimate the detrimental effect of retirement. But some of the longitudinal analytic methods used in some of the studies reviewed might be particularly useful in terms of reducing bias. For instance, the study by Behncke (2012) considered newly diagnosed CVD as an outcome variable only if it occurred after retirement, and simulated retirement dates for working people. It applied two statistical methods: propensity score matching and IV analysis. A propensity score is calculated for each individual, representing the probability of retiring on the basis of background characteristics. Based on this propensity score, employed individuals are 'matched' to retired individuals, so matched pairs will have a similar probability of retiring. Propensity score matching is a useful technique to control for selection biases in observational studies, but this method requires a large enough sample size to process matching, and in the case of retirement, detailed information of the working environment and other job characteristics as well as eligibility for pension and health insurance. The second method employed is using the SPA as an IV for retirement. As mentioned in section 2.4.6, this method controls for confounding through the use of an IV related to the exposure but not to an individual's background characteristics, therefore is better able to estimate causal effects of the exposure on outcomes. However, a limitation of the IV analysis is that its results only apply to the subsample who retired induced by the IV (i.e. SPA here). In this study, the results from IV estimation showed a stronger association between CVD health risk and retirement than that achieved by propensity score matching (7.3% vs 3.9%), but only the results from the matching method reached a statistically significant level (at 5%). This is because those individuals retired at SPA was much smaller than the population of retirees. Another disadvantage of IV analysis is that an instrument with a strong association with the exposure is difficult to be identified, and failure to do so will immediately result in biased results (Martens et al., 2006). A good example is Insler (2014) and Ayyagari (2014) who chose different IVs in their models, and showed contradictory results on the effects of retirement and smoking using the same US HRS data. Studies by Westerlund et al. (2010), Gueorguieva et al. (2011), and Oksanen et al. (2011) limited their study samples to retirees whose health outcomes had been measured repeatedly both before and after retirement, and compared the trajectories of outcomes of interest before and after retirement among retirees. This piecewise method largely circumvented the probability of reserve causality.

This PhD thesis will integrate the approaches used in the literature in an attempt to fill some of the gaps in evidence described above regarding the nature of the relationship between retirement and CVD and CVD risk factors.

Chapter 3: Retirement and its Cross-sectional Associations with CVD and CVD Risk Factors in China and England

3.1 Introduction of the chapter

As most developed countries have entered population ageing several decades earlier than China (UN, 2016), can China learn lessons from Western countries in policy making on population ageing and retirement? To answer this question, this chapter presents a cross-national comparison between China and the UK. The UK is chosen as an example of a developed country with a long history of pension provision and a public welfare system. The UK's first state pension system, known as the 'Old Age Pension', was introduced in 1908, when most countries did not has a government-run pension system (Gilbert, 1966). In 1948, a modern state pension was introduced and became prevalent (Bozio et al., 2010). In addition, the UK has a relatively large older age population, with 18% aged 65 and over (ONS, 2016) compared with 10% in China (World Bank, 2015), and the UK SPA is gradually increasing for women from 60 to 65, and will start to increase for both men and women to reach 66 by 2020 (HM Treasury, 2013). Policies and research on encouraging older workers to remain in the workplace are also relatively mature and thorough, such as increasing training and career development opportunities and adapting job design for older workers (POST, 2011). Comparing China with the UK could help to answer whether policies on retirement and working environment in the UK are applicable in China, and, thus, can help to inform plans for dealing with population ageing in China.

In a cross-national analysis, it is important to use datasets and methods that are as similar as possible. This chapter uses the first wave of the China Health and Retirement Longitudinal Study (CHARLS) in China and the sixth wave of the English Longitudinal Study of Ageing (ELSA) in England. These two surveys are sister studies which are designed to be used for the investigation of a broad set of topics relevant to understanding the ageing process, and many of the objective and subjective data collected are comparable to each other.

This chapter first compares retirement behaviour, the prevalence of CVD and CVD risk factors, and their determinants in these two countries. Then cross-sectional associations between retirement and CVD/CVD risk factors are examined and compared. A description of the datasets and selection of the analytic sample is shown in section 3.2.

The measures of retirement and CVD/CVD risk factor outcomes as well as covariates are described in section 3.3. Analytic technique and missing data handling is presented in section 3.4. Results of the main analysis are presented in sections 3.5.

In both China and England, men have to retire at an older age than women do, as the compulsory retirement age in China is 5 to 10 years later for men than for women, and the SPA in the UK is up to 5 years later for men than for women for those born before 1950. Compared to women, men are more likely to die from CVD, and are also more likely to be exposed to CVD risk factors, such as hypertension (Wang et al., 2014), diabetes (Xu et al., 2013), smoking and excessive drinking (WHO, 2010). The gender differences in both retirement age and health may moderate the main associations between retirement and CVD/CVD risk factors. Therefore, the moderating role of gender is examined in section 3.6. In addition to gender differences, urban-rural disparity in both retirement behaviour and health conditions described in Chapter 1 makes it another potential moderator. Besides, marital life may be important for retirement adjustment, because it provides retirees with alternative salient roles after retirement and offers opportunities for retirees to engage in meaningful and desirable activities after retirement. Given the importance of marital life, a spouse's employment also plays a key role (Kim and Moen, 2002; Szinovacz and Davey, 2004). Having a working spouse after retirement may not be able to provide the companionship expected by some of the retirees. Therefore, the moderating role of spouse's employment status/no spouse is tested in section 3.6. Sensitivity analyses to investing the effects of adjusting for medication use and using a different definition of retirement are shown in Appendix 3.3. Results are then discussed in section 3.7.

3.2 Data and analytic sample

3.2.1 Data

China Health, Aging, and Retirement Longitudinal Study (CHARLS)

This chapter used two datasets. One is the China Health, Aging, and Retirement Longitudinal Study (CHARLS) in China, and the other is the English Longitudinal

Study of Ageing (ELSA). CHARLS is a panel study of a representative cohort of men and women in China aged 45 years and above. It assesses the social, economic, and health circumstances of community residents. The first national baseline wave was fielded from June 2011 to March 2012, and individuals were followed up every two years. Baseline samples were chosen through multistage probability sampling (Zhao et al., 2014). At the first stage, all county-level units with the exception of Tibet were sorted by region, within region by urban district or rural county, and by gross domestic product per capita. After this sorting, 150 county-level units were randomly chosen using a 'probability-proportional-to-size' (PPS) sampling method. This PPS sampling method makes larger clusters have a bigger probability of being sampled, and the 150 counties fell within 28 provinces[3]. In the second stage, using the PPS method, CHARLS randomly chose three community level units (villages in rural areas and urban communities in urban areas) within each county-level unit as primary sampling units (PSUs), and 450 PSUs were selected. The third step was the household-level sampling. Collective dwellings such as military bases, schools, dormitories, nursing homes, and domestic helpers living in the homes of their employer were excluded before choosing households. At this step, 23,590 households were randomly chosen (on average 52.4 households per PSU). Among them, 12,740 households were age-eligible, and final interviews were conducted on 10,257 households, so the household contact rate was 81%. Of the 19% of nonresponsers, 9% was due to refusal to respond, 8% to the inability of interviewers to contact sample residents, and 2% to other reasons (Zhao et al., 2014). If the chosen household had more than one person who are at least 39 years old, one person was randomly chosen. If the chosen person was between 39 and 45 years old, then this person was not interviewed but was designated for inclusion in a future refreshment sample. If the selected person was 45 years old or above, then he/she became an age-eligible respondent and his/her spouse was interviewed. A total of

[3] China has 34 provincial-level administrative units: 23 provinces, 4 municipalities (Beijing, Tianjin, Shanghai, Chongqing), 5 autonomous regions (Guangxi, Inner Mongolia, Tibet, Ningxia, Xinjiang) and 2 special administrative regions (Hong Kong, Macau).

17,708 individuals were interviewed in wave 1, with 10,069 were main respondents and 7,639 were spouses of main respondents. Among all study participants, 13,978 individuals (79%) participated in the nurse visit, and 12,122 (69%) provided blood samples. A follow-up survey was conducted in the summer of 2012, and 93% of wave 1 respondents participated in wave 2 (Zhao et al., 2014).

CHARLS is part of a set of longitudinal ageing surveys that include surveys in the United States, England, 19 countries in continental Europe, Korea, Japan, and India. These surveys were designed as sister studies, and were harmonised with each other to facilitate international comparisons. ELSA is one of them.

English Longitudinal Study of Ageing (ELSA)

ELSA, which commenced in 2002, involves the collection of economic, social, psychological, cognitive, health, biological and genetic data. For wave 1, participants were recruited from households who had previously responded to the Health Survey for England (HSE) in 1998, 1999 and 2001, all of which were nationally representative. Eligible participants need to be aged 50 years or older (born before 1 March 1952) and living in a private household in England at the time of the first wave of fieldwork. The original sample consisted of 11,391 members. Their mean age was 65 years, ranging from 50 to 100 years (Steptoe et al., 2013). The sample has been followed up every 2 years, and a nurse visit carried out for every 4 years. Eighty two percent of wave 1 age-eligible 'core' respondents participated in wave 2, 74% in wave 3, 69% in wave 4, 69% in wave 5, and 66% in wave 6 (Bridges et al., 2015). In addition to the age-eligible 'core' members, 636 younger partners aged <50 years and 72 new partners aged $\geqslant 50$ years were interviewed at wave 1 and were followed up in subsequent waves. At waves 3, 4, and 6, the study was replenished with new study participants from HSE to maintain the size and representativeness of the cohort (Steptoe et al., 2013).

Harmonised CHARLS and Harmonised ELSA

Harmonised versions of data from several international ageing and retirement studies are developed by the RAND Corporation. Harmonised CHARLS and Harmonised ELSA are in the list of harmonised studies[4]. Using the RAND HRS as a model, these harmonised data sets allow users to compare identically defined variables across countries. Where possible, harmonised data were used in this chapter.

3.2.2 Analytic sample

Wave 1 (2011/2012) of the CHARLS was used as the Chinese data in this chapter. To make it comparable with ELSA, all analyses in CHARLS were restricted to 13,649 interviewed participants (both main and spouse) who were aged 50 or older. Among these age-eligible people, 128 did not report their employment status and 815 were in other employment statuses other than working or retired (details in section 3.3.1). The 128 people missing employment status were not included in the analytic sample, as benefits of multiple imputation are likely to be minimal when data are missing in the exposure variable of interest (K. Lee and Simpson, 2014). This study only compared retired people with working people, so those 815 people in other employment status were excluded. The final sample size of the CHARLS is 12,706. When modelling the association between retirement and blood biomarkers, only individuals who provided blood samples were included (*n*=8,714).

To date, seven waves of ELSA are publicly available. When choosing which wave to use, there are two factors that need to be considered. First, several health outcomes which will be analysed in this chapter were collected during nurse visits, and nurse visits were only carried out in waves 2, 4, and 6. Second, the Chinese data was conducted in 2011/2012, so the collection year of ELSA should be as close as possible to the Chinese collection year. Therefore, wave 6 which was conducted in 2012/2013 and included a nurse visit was used in this chapter. In wave 6, 10,601 participants were

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[4] In addition to the RAND HRS, this project includes and Harmonised ELSA, Harmonised SHARE (Europe + Israel), Harmonised KLoSA (South Korea), Harmonised JSTAR (Japan), Harmonised CHARLS (China), Harmonised LASI (India), Harmonised MHAS (Mexico), Harmonised TILDA (Ireland), and Harmonised CRELES (Costa Rica) data.

interviewed, of which 9,169 were ‘core’ participants. The ‘core’ sample included 5,659 individuals who have remained in the study from the start, plus refreshment cohorts first interviewed in wave 3 (2006-07), wave 4 (2008-09) and wave 6 (2012-13). The nurse visited the respondent to carry out a series of measurements and a blood sample was collected. Partners of core members were not eligible for the nurse visit, and they are not the representative samples of English population age 50 and above, so analyses in this chapter were only restricted to the 9,169 ‘core’ respondents. In addition, 926 people in a labour force status other than retired or working were excluded. Thus, the final sample size is 8,243. When modelling the association between retirement and blood biomarkers, only individuals who provided blood sample were included (*n*=5,628).

3.3 Measures

3.3.1 Exposure variable: retirement status

There are multiple overlapping criteria by which someone might be called retired, including stopped working, reduced work effort, pension receipt, or self-report (Denton and Spencer, 2009). Operationalising retirement in different ways may yield different findings. This thesis is interested in the potential health effects of retirement as a later life transition, possibly through the changes in exposure to stress, health behaviours, social networks, and resources after older people exit from paid work. In this case, retirement should be a relatively permanent stage of later life, and retirees by this definition should be those who are not working, not looking for work, and not intending to work again.

The operational definition of retirement as the receipt of pensions is prominent in the field of economics (Beehr and Bowling, 2012). Most people who can access retirement income are retired. However, some retirees are still working for pay in addition to receiving these pensions, and in countries where state pension is not universal, such as in China, some retirees do not have access to any pension (Giles et al., 2011). Thus, the receipt of pensions may not be the best operationalisation of retirement for this study. Non-participation in the labour force, sometimes called full retirement, is a traditional and one of the most commonly used operational definitions of retirement (e.g. Shannon and Greirson, 2004; Shimizutani and Oshio, 2010). However, some people may be temporally out of the labour force because of illness or family issues, but they are not in a stable later life stage, thus are not the targeted population of this thesis. Therefore, combination of labour force participation with other measures (e.g. self-assessed retirement/ have completed retirement procedures/ age of stop working/ currently not looking for a new job/ not on sick or other leave) was used in this thesis to capture the target population of retired people.

Self-assessed retirement is relatively convenient and flexible, thus has been widely used in household surveys (Bowlby, 2007). In ELSA, both self-assessed retirement (reason of currently not working) and whether the respondent participated in a paid work in the last month were both asked. Individuals in ELSA who considered themselves to be 'retired' and were not 'in paid work' in the last month were included as retired in the analytic sample. An individual was considered as working if 'paid work' was one of his/her economic activities in the last month. Seeking work, sick and unoccupied were considered as 'other employment status'.

Participants in CHARLS were asked 'Did you engage in agricultural work (including farming, forestry, fishing, and husbandry for your own family or others) for more than 10 days in the past year?' and 'Did you work for at least one-hour last week? We consider any of the following activities to be work: earn a wage, run your own business and unpaid family business work, et al. Work does not include doing your own housework or doing activities without pay, such as voluntary work.' As farming is seasonal, respondents were considered to be 'working' if they answered 'Yes' to at least one of these two questions. In addition, participants were also asked whether they completed retirement procedures (including early retirement or internal retirement). In China, people who retired through the 'formal system' have to complete retirement procedures in order to claim the pension. Thus, if a respondent is currently not working and mentions having completed retirement procedures, they were classified as 'retired'. However, people who retired from the informal sector (e.g. self-employed, farmers) are often unable to completed retirement procedures, thus if a respondent is currently not working and stopped the most recent job at or after age 45, and is not searching for a new job or on sick/other leave, they were classifies as 'retired' as well. The reason for choosing age 45 is that the current statutory retirement age in China is 60 years for men, and 50 to 55 years for women, and some companies offer early retirement up to 5 years before the statutory age, in which case age 45 would be the earliest statutory retirement age. Although those who are self-employed or working in the informal sector do not have to wait until statutory retirement age, retiring before age 45 is rare and would most likely be due to poor health (Giles et al., 2011). A sensitivity analysis using 'completed retirement procedures and not working' as the definition of retirement was conducted. Participants were classified as 'other employment status' and were excluded if they were not working and met any of the following conditions: searched for a new job in the last week, never worked for more than three months during the lifetime, have a job but currently on sick or other leave, and stopped most recent main job before age 45.

Under these definitions of employment status, 32.2% of the CHARLS members and 58.5% of the ELSA members are retired. Number and percentage of each employment status are shown in Table 3.1.

Table 3. 1 Employment status in CHARLS and ELSA.

Employment status	**CHARLS**		**ELSA**	
	n	**%**	***n***	**%**
Working	8314	60.9	2880	31.4
Retired	4392	32.2	5363	58.5
Other	815	6.0	926	10.1
Missing	128	0.9	0	0.0

3.3.2 Outcome variables

The research in this chapter centres on four types of key measures of cardiovascular health, including self-reports of CVD (heart disease and stroke), objectively measured metabolic risk factors for CVD (blood pressure, BMI, and WC), blood-based biomarker risk factors for CVD (total cholesterol, C-reactive protein, glycated haemoglobin) and behavioural risk factors for CVD (smoking status and drinking frequency). Diet may be linked to CVD and other CVD risk factors (WHO, 2011), but it was not measured in either survey. Low level of physical activity is another risk factor of CVD (Kohl, 2001). Self-reported physical activity was only collected among half of the sample in CHARLS, thus it was not included as an outcome in the CHARLS analysis. To make the results of two studies comparable, physical activity was not included in the ELSA analysis either, although physical activity was assessed in ELSA.

Self-reported heart disease and stroke

In CHARLS, participants were asked whether they had ever been diagnosed with a heart attack, coronary heart disease, angina, congestive heart failure, or any other heart problems. If participants responded 'yes' to any of these, they are considered to have heart disease. Participants were also asked about whether they had ever been diagnosed with stroke and are considered to have stroke if they responded 'yes'.

In ELSA, if the respondent reported ever having a condition of heart disease or stroke at a previous wave of data collection, then he/she was first asked to confirm this. Then a show card was given to participants to detect newly diagnosed conditions. Respondents were considered to have stroke if they newly or previously reported this condition, and to have heart disease if they newly or previously reported being diagnosed with any of the following conditions: angina/a heart attack (including myocardial infarction or coronary thrombosis)/congestive heart failure/a heart murmur/an abnormal heart rhythm/any other heart trouble.

Systolic blood pressure (SBP) and diastolic blood pressure (DBP)

Participants from rural China are likely to have more undiagnosed hypertension due to limited access to health services, and there is increasing evidence that risk of having CVD or dying from CVD are not confined to people who have high blood pressure (Lewington et al., 2002; MacMahon et al., 1990). So self-reported diagnosed hypertension or using cut-offs to define hypertension are less informative, and continuous values of SBP and DBP were used in this research.

In both CHARLS and ELSA, three measurements of blood pressure were taken, in the right arm, with the subjects seated. SBP and DBP were calculated in this research using the mean of the last two measurements (Godet-Mardirossian et al., 2012). The first reading was not used as blood pressure value could be raised due to feeling nervous at the beginning. Blood pressure data had been cleaned by the CHARLS team before it was released, with SBP ranging from 63 to 230 mm Hg, and the DBP ranged from 34 to

142 mm Hg. In ELSA, SBP ranged from 69 to 224 mmHg, and the DBP ranged from 34 to 122 mm Hg.

Body mass index (BMI) and waist circumference (WC)

Being overweight or obese, is associated with with a number of conditions that interfere with health and well-being in both Western and Chinese populations. These include metabolic syndrome (obesity, insulin resistance, hypertension, high blood cholesterol), diabetes, and CVD (Stevens, 2002; Wilson et al., 2002; Zhou et al., 2002). BMI (kg/m^2), which is calculated as weight divided by height squared, has been traditionally used to measure body size, but some studies have suggested that central adiposity or abdomial obesity, which is usually measured by WC or waist-hip ratio, is superior to BMI in predicting CVD risk (Bigaard et al., 2005; Janssen et al., 2004; Welborn and Dhaliwal, 2007). There is also some evidence that joint measurement of BMI and WC is more predictive of CVD risk than either alone (Ardern et al., 2003; Wildman et al., 2005; Zhu et al., 2004). Thus, this study used continuous measures of BMI and WC as health outcomes.

Harmonised BMI variables were available in both surveys and thus were used in the analysis. In ELSA, one measurement of height using a stadiometer was taken, and the reading was recorded to the nearest millimetre. In CHARLS, height was measured in either meters or centimetres, and every measure was converted to centimetres in the harmonised CHARLS. In both surveys, weight was measured using electronic scales, without participant's shoes, and a single measurement was recorded to the nearest 0.1 kg. In the Harmonised CHARLS, it was considered as an invalid measurement if the weight value was 20 kgs or less. After looking into the distribution of BMI, one person with a BMI of less than 10 and three people with a BMI higher than 60 were considered as outliers, and were recoded to missing. The BMI (ranges from 15.1 to 59.4) given for respondents in ELSA excluded invalid reports of height and weight in the data.

In CHARLS, WC was measured once around the middle, levelled with a subject's belly button. In ELSA, WC was defined as the midpoint between the lower rib and the upper margin of the iliac crest, and measurements were taken three times using the same tape. Measures in both datasets were recorded to the nearest millimetre. In ELSA, mean of three measures was used, and invalid measures were exluded. The WC ranged from 57.7 to 155.2 cm. When looking into the distribution of WC in CHARLS, 163 people's WC was lower than 40 cm, with 144 people lower than 30 cm. When comparing WC with BMI, people with an extreme low WC value did not have a corresponding low BMI, so these exterme low values of WC are likely to be measurement errors. One possible source of error is that some of the field workers measured only half way of the wasit rather than all the way around, and another possible reason is that WC was recorded in the Chinese cun, a widely used measure of WC in China, which equals to 3.33 cm. In the analysis, WC less than 40 cm was as considered as an invalid measurement and was recoded as missing. The WC ranged from 42 to 131 cm in the analytic sample of CHARLS.

Total blood cholesterol, C-reactive protein (CRP), and glycated haemoglobin (HbA1c)

Blood-based biomarker risk factors data are available in both surveys. Cholesterol is a type of fat present in the blood which is related to diet, and too much cholesterol in the blood increases the risk of heart disease and stroke. Both datasets have measures of high-density lipoprotein (HDL), low-density lipoprotein (LDL), triglycerides and total cholesterol. HDL cholesterol is 'good' cholesterol, which is protective for heart disease. LDL cholesterol is 'bad' cholesterol and a risk factor for CVD. Triglyceride is another type of fat (lipid) in the blood. Total blood cholesterol is a measure of the total amount of cholesterol in the blood, including LDL cholesterol, HDL cholesterol, and other lipid components. Raised total blood cholesterol is often considered as a risk factor for CVD, so total blood cholesterol (mg/dL) was used as the health outcome in this chapter.

The level of CRP (mg/L) in the blood gives information on inflammatory activity in the body and is also associated with risk of heart disease. In the analysis, CRP values were log transformed to get a normal distribution.

HbA1c is an objective measure of blood glucose. It develops when haemoglobin, a protein within red blood cells that carries oxygen throughout body, joins with glucose in the blood, becoming glycated. HbA1c (mmol/mol) reflects time-averaged blood glucose during the previous 8-12 weeks, and it is often used as a diagnostic test for diabetes, which is associated with an increased risk of heart disease. In CHARLS, the value of

HbA1c is shown in old units (%), and it was transformed to mmol/mol using the formula: (Old number-2.15) ×10.929. In the analysis, HbA1c values were log transformed to get a normal distribution.

Smoking status

There is much epidemiologic evidence to link smoking with increased risk of CVD events and CVD mortality (Ambrose and Barua, 2004; Ezzati and Lopez, 2003; Huxley and Woodward, 2011). Possible pathophysiological pathways between smoking and CVD may include vasomotor dysfunction, atherogenesis, thrombosis in multiple vascular beds, and insulin resistance (Ambrose and Barua, 2004; Tsiara et al., 2003). Current smoking status (yes/no), ever smoking (yes/no), and the number of cigarettes smoked per day were asked in both surveys. In CHARLS, about 70% of the participants are current non-smokers (about 60% are never-smokers, and about 10% are ex-smokers) and the self-reported number of cigarettes smoked per day tended to be grouped at 10 cigarettes (half pack) and 20 cigarettes (a pack). Thus, it is not appropriate to use number of cigarettes smoked per day as a continuous variable. Smoking status was divided into never smoker, ex-smoker, current light/moderate smoker (<20 cigarettes per day), and current heavy smoker (>=20 cigarettes per day) (Barua et al., 2002). Light and moderate smokers were combined because of small percentages. Same categories of smoking status were used for the ELSA sample.

Drinking frequency

There is evidence that heavy drinking is associated with increased risk of having CVD and death from CVD (Bazzano et al., 2007; Britton, 2000), while some argue that moderate or light alcohol consumption may be associated with reduced risk of CVD (Britton, 2000; Rimm et al., 1999).

ELSA asked participants whether had an alcoholic drink during the last 12 months as well as the number of days having an alcoholic drink in the last seven days. CHARLS participants were asked whether they had an alcoholic drink during the last 12 months and the frequency of drinks consumed, but not the number of days of drinking in the past year. The frequency of drinks consumed (once a month/2-3 times a month/once a week/2-3 times a week/4-6 times a week/once a day/twice a day/more than twice a day) was asked for beer, wine, and liquor separately in CHARLS. So the highest frequency of drinking behaviour during the last year that the respondent reports for any one of the three types of alcohol is used. To make the definition of alcohol consumption as similar as possible between the two surveys, drinking frequency in the analysis was defined as ‘non-drinkers’, ‘not every day of the last week’ and ‘every day of the last week’.

CHARLS also asked how much respondent drank the last time in the last year, separately for beer, wine, and liquor. This question cannot provide an average level of alcohol consumption, and thus was not used.

3.3.3 Covariates

Socio-demographic characteristics, including age in years, gender, spouse working status/no spouse, highest education level, occupation skill level, household total income, household total wealth and area of residence were included as covariates in this analysis. These covariates are most probably linked to each individual's retirement decision and are closely related to CVD and the CVD risk factors of interest, and yet are not on the hypothesised causal pathway between retirement and outcomes (except for household income). They may confound the associations between retirement and the risk factor outcomes, thus are often adjusted in the literature (e.g. Behncke, 2012; Dupre et al., 2012; Godard, 2016; Gueorguieva, 2011; Olesen et al., 2014). Smoking status, alcohol consumption and depressive symptoms were also included as covariates in the fully adjusted model, except when they themselves were outcomes of interest.

Age at interview

A harmonised version of age at interview was used. In both CHARLS and ELSA, respondent’s age was calculated by respondent’s birth year and month minus the interview year and month; furthermore, self-reported age was used if there is a missing value of calculated age. In the case that the respondent’s birth month is missing, age was calculated assuming that the respondent’s birth month is month 6 (June). In ELSA, respondent’s age is top-coded at 90 years old. To make two surveys comparable, all respondents in CHARLS who report an age of 90 or older were also given a value of 90. Age was used as a continuous variable in the analysis. Sometimes, the relationship between age and CVD/CVD risk factors may be non-linear. Adding age-squared improved the model fit of most outcomes, thus both age and age squared were kept as covariates.

Spouse working status/no spouse

In both CHARLS and ELSA, marriage status was asked in the questionnaire. A harmonised version of marriage status was used, and it was categorised into ‘have a spouse’ (married or cohabiting) and ‘no spouse’ (separated, divorced, widowed, or never married). This study adjusted for whether respondents had a spouse and, if they had one, the spouse’s working status, with three categories ‘having a working spouse’, ‘having a non-working spouse’, and ‘have no spouse’.

Area of residence

In CHARLS, urban/rural area of residence was measured by the current residential area. Whether the residential region is rural or urban was defined according to the National Bureau of Statistics of the People's Republic of China. An area is defined as urban if it is located in a city, suburb of a city, a town, suburb of a town, or other special areas where non-farm employment constitutes at least 70% of the work force, such as a special economic zone and state-owned farm enterprise (Yang, 2016).

In ELSA, an urban/rural indicator was generated by the Department of the Environment, Food and Rural Affairs according to the National Statistics Postcode Directory in the UK. Geographical identifiers, including this urban/rural indicator in wave 6 is not public available in the UK Data Archive. I have the urban/rural indicator of wave 4, and use it instead of wave 6[5].

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[5] Non-archive data charges on a rate per day basis with a minimum cost of £1000. This charging is a new policy and I applied for the wave 4 indicator before charges were in place.

Highest level of education

In the CHARLS and ELSA questionnaire, the highest level of educational qualification that respondents have attained was asked. To account for the high prevalence of lower education levels, CHARLS provides additional education categories below elementary school. In the second wave of the CHARLS, what is the highest level of education in the first wave was double checked. A harmonised education variable which combined the answers from both waves was used in the analysis, and it was categorised into: low, middle, and high. The corresponding education qualification in CHARLS were 'did not finish elementary school', 'finished elementary school', and 'secondary school or above'. As expected, the average education level in China is much lower than in England. For example, 51.7% of the CHARLS participants did not finish elementary school. In order to make the low, middle and higher education classification to be as comparable as possible between the two datasets, education levels in ELSA were classified as 'less than O-level or equivalent', 'O-level, A-level or equivalent' and 'higher than A-level'.

Occupation skill level

During the CHARLS interview, occupation and sector were described in words by the respondents. This was done so that the interviewers did not have to classify the occupation themselves. After the survey, the descriptions were coded into the 2-digit classification of the International Labour Organization's International Standard Classification of Occupations, 2008 (ISCO-08). There are nine major unit groups in the ISCO, and they can be further combined into four skill levels (Level 1: elementary occupations. Level 2: clerical support workers, service and sales workers, skilled agricultural, forestry and fishery workers, craft and related trades workers, plant and machine operators, and assemblers. Level 3: technicians and associate professionals. Level 4: managers and professionals). Farmers were not asked about their ISCO, and in the analysis they were classified as level 1: elementary occupations. ISCO of most recent job was used for retired people, and the ISCO of the main job was used for people who had more than one job at the same time.

Standard Occupational Classification 2000 (SOC-2000) was measured in ELSA. SOC is a common classification of occupational information in the UK. To make ELSA comparable to CHARLS, SOC-2000 was first transferred to SOC-2010, and then to ISCO-08, using official cross-walks provided by the International Labour Organization. Some minor groups (2 digits) which cannot be matched to the ISCO were converted according to the major groups (1 digit) they belong to.

Total household income and total household wealth

To make the wealth measures in CHARLS (RMB) and ELSA (GBP) as similar as possible, harmonised wealth and income data was used. Total family income is the sum of all income at the household level including earnings, pension income, income from government transfer, other income, and capital income.

Total household wealth in CHARLS was derived by adding the different sources of wealth minus 'individual value of other debt' and 'household value of mortgage of primary residence'. Sources of wealth include the value of cash and saving accounts, stocks and mutual funds, government bonds, and other savings for each individual in the household as well as the household value of the primary residence and other properties, vehicles, non-financial assets, fixed capital assets, irrigable land, and agricultural assets. In the harmonised ELSA, a similar method was used in calculating the household total wealth, except that total family wealth in ELSA does not include the value of vehicles whereas in CHARLS does include the net value of vehicles.

In the harmonised ELSA, the household income and wealth were constructed at the benefit unit level, which is a couple or a single person with any dependent children they may have, but these variables in CHARLS were constructed at the household level.

Because the wave 6 household roster in ELSA has not been made available in the index file at this time, per capita income and per capita wealth cannot be estimated. Household income and wealth were skewed in their distribution, thus were log transformed to achieve normal distributions. People with zero or negative income (*n*=584 in CHARLS, *n*=20 in ELSA) or with zero or negative wealth (*n*=637 in CHARLS, *n*=333 in ELSA) were given a value of 0.001 before the log transformation. Log transformed income and wealth were kept as continuous covariates in the analysis, and adding quadratic terms did not improve their model fits.

Depressive symptoms

In CHARLS, respondents were asked to rate how often they experienced each of the depressive symptoms of the ten-item Center for Epidemiologic Studies Depression Scale (CESD-10) in the past week. CESD items are shown in the following text boxes, and each item was scored on a four-point scale ranging from 0 (rarely or none of the time) to 3 (most or all of the time) with the total possible summary score of 0 to 30. Two positively worded items (hopeful and happy) were reverse-coded. Thus, higher scores indicate higher levels of depressive symptoms. In ELSA, an eight-item CESD scale was provided. Participants are asked whether they had experienced any of the symptoms in the past 4 weeks. The total number of 'yes' responses to questions 1, 2, 3, 5, 7, 8, and the 'no' responses to questions 4 and 6 were summed to arrive at a total depressive symptom score ranging from 0 to 8, and higher scores indicate higher levels of depressive symptoms. The individual CESD-10 and CESD-8 items are shown in the following text boxes. The CESD score of the CHARLS sample ranged from 0 to 30, with a mean at 8.7, and that of ELSA ranged from 0 to 8, with a mean at 1.4. Their distributions were a bit left skewed. Transformations did not make them closer to a normal distribution, and using a binary variable may lose useful information. Therefore, the original CESD scores were used as continuous in the analysis, and adding quadratic terms did not improve the model fits.

CESD-10 in CHARLS

1) being bothered by things that do not usually bother
2) having trouble concentrating
3) feeling depressed
4) feeling that everything you did was an effort
5) feeling hopeful about the future
6) feeling fearful
7) being sleepless
8) feeling happy
9) feeling lonely
10) inability to 'get going'

CESD-8 in ELSA
1) felt depressed
2) felt everything I did was an effort
3) sleep was restless
4) happy
5) felt lonely
6) enjoyed life
7) felt sad
8) could not 'get going'

Medication/treatment

In both datasets, respondents who were ever diagnosed with hypertension, diabetes or high blood cholesterol were asked whether they were currently taking any medication/treatment to control of these disease. Whether taking medication/treatment for hypertension was adjusted when modelling SBP and DBP in the analysis, whether taking medication/treatment for diabetes was adjusted when modelling HbA1c, and whether taking medication/treatment for high blood cholesterol was adjusted when modelling blood total cholesterol.

3.4 Analytic technique

3.4.1 Statistical methods

In both CHARLS and ELSA, Wilcoxon rank-sum test was used to test the differences in median age at retirement. Logistic regression was used to assess the associations between covariates and retirement status. Linear regression was used to test the associations between covariates and continuous CVD related outcomes, and logistic regression was used for binary health outcomes.

Multivariate logistic regression was used to test the association between retirement and binary CVD outcomes (heart disease and stroke), and multivariate linear regression was used for continuous CVD risk factors (BMI, WC, SBP, DBP, CRP, HbA1c, and total cholesterol). Multivariate multinomial logistic regressions were used for categorical behavioural risk factors (smoking status and drinking frequency) with results from multinomial logistic regressions shown in relative risk ratios (RRR). A RRR equal to one suggests no difference in risk, and a RRR less than one suggests a reduced risk, while a RRR larger than one means an increased risk. A detailed description of the mechanisms of multinomial logistic regressions is shown in section 4.4.1 in the next chapter.

There were three adjustment models in this analysis. Model 1 adjusted for age and gender to reduce the influence of biological factors that may confound the association between retirement and CVD/CVD risk factors. Model 2 further adjusted for spouse employment status/no spouse, highest education, occupation skill level, household total income, household total wealth and area of residence. Comparing model 2 and model 1 could provide a sense of how much of the associations between retirement and CVD/CVD risk factors may be explained by socio-economic factors. Model 3 further adjusted for smoking status, drinking frequency, and depressive symptoms. These covariates were adjusted in a separate model, because they may be confounders in the associations between retirement and CVD/CVD risk factors, but also may be intermediate variables (mediators) on a causal path from retirement to outcome. For example, people with raised depressive symptoms may be more likely to choose retirement (e.g. Karpansalo et al., 2005), and are more likely to develop CVD (e.g. Ariyo et al., 2000), so depression needs to be adjusted for as a baseline confounder. After retirement, relief from work stress may reduce depressive symptoms amongst retirees (e.g. Westerlund et al., 2010), thus leading to lower CVD risk. In this case, depressive symptom is a mediator between retirement and CVD. The cross-sectional design of this study cannot distinguish confounders from mediators, so caution must be taken when drawing conclusions from Model 3.

Omitting weights from the analysis may result in biased estimations, and sampling weights also play an important role in estimating standard errors. In CHARLS, weights with corrections for both household and individual non-response are available (households that were sampled but did not respond to the baseline survey; individual non-response for the main questionnaire, given that the household did respond). Only 68.6% of the CHARLS individuals provided blood samples. So, for the blood sample data, additional individual weights are provided to correct for the non-participation of individuals. Similar to CHARLS, ELSA provides cross-sectional individual weights to correct for non-response amongst key sub-groups of individuals. In addition, the calculation of the cross-sectional weights in ELSA involved computing a scaling factor to ensure that the original sample and refreshment samples were represented in the same proportions, with respect to age, in which they appear in the population. Additional individual blood sample weights are also provided in ELSA. All the analyses in this chapter were weighted by the cross-sectional weights provided by both datasets, and when modelling blood-based biomarker risk factors, blood sample weights were applied.

3.4.2 Handling missing data

Researchers are often faced with the problem of non-response, and inappropriately handling missing data can lead to biased estimates of parameters and standard errors, resulting in incorrect confidence intervals and significance tests (White et al., 2011). This section first describes the percentage of missing data in this study. After that, an overview of missing data mechanisms and handling was provided and the approach to deal with missing data in this study was described.

Percent missing in CHARLS and ELSA

Percent missing for each health outcome and covariate in both CHARLS and ELSA is shown in Table 3.2. The percent missing for heart disease and stroke was 0.7% and 0.4% respectively in CHARLS, and there was no missing data for these variables in ELSA. SBP, DBP, BMI, and WC were collected in the nurse visit in both datasets, thus had more incomplete cases. 22.3% of CHARLS respondents and 15.7% of those in ELSA were missing blood pressure values. The percent missing of BMI and WC in CHARLS was 21.1% and 21.3% respectively, and the corresponding percent missing in ELSA was 18.5% and 16.7%. Blood total cholesterol, CRP, and HbA1c were only modelled among people who provided blood samples, and the percent missing blood biomarkers based on those in these samples was about 1% in CHARLS, and was about 5% to 6% in ELSA. 12.3% of CHARLS respondents did not report their smoking status. In ELSA, the answer to the respondent’s first question on smoking behaviour is fed-forward in subsequent waves, and thus ELSA had lower percent missing (3.5%) with regard to smoking. In addition to a face-to-face interview, ELSA carried out a self-completion questionnaire, but fewer people participated in the self-completion section.

Drinking frequency was asked in the self-completion questionnaire in ELSA, so the percent missing (15%) was higher than other variables. The percent missing drinking frequency in CHARLS was 7.2%.

Table 3. 2 Percent missing in CHARLS and ELSA.

	% Missing in CHARLS (*n*=12,706)	% Missing in ELSA (*n*=8,243)
Outcome variables		
Heart disease	0.7	0.0
Stroke	0.4	0.0
SBP	20.3	15.7
DBP	20.3	15.7
BMI	21.1	18.5
WC	21.3	16.7
Total cholesterol[a]	1.6	5.2
CRP[a]	1.5	5.2
HbA1c[a]	1.1	6.4
Smoking status	12.3	3.5
Drinking frequency	7.2	15.0
Covariates		
Age	0.0	0.0
Gender	0.0	0.0
Spouse’s employment status	2.8	4.0
Urban/rural	0.0	13.1
Education qualification	0.0	0.7
ISCO skill level	2.4	1.0
Household total income	15.9	2.2
Household total wealth	28.3	2.1
Depressive symptoms	8.4	4.1
Medication for blood pressure	0.6	0.1
Medication for blood cholesterol	1.0	0.0
Medication for blood glucose [b]	2.1	0.1
Total	57.8	49.0

[a] Missing percentage based on the people who provided a blood sample.
[b] Taking medication or taking insulin injection.

The percent missing of covariates ranged from zero to 28.3% in CHARLS, with the most missing data found in household wealth. In ELSA, the urban/rural indicator had the highest percent missing (13.1%) among covariates. Because the wave 4 indicator was used here for wave 6, this variable was necessarily missing for replenishment samples that were newly recruited at wave 6. Individual level income and wealth in

ELSA were already imputed by the ELSA team using the conditional hot-deck method. For each missing or banded case, this imputation procedure involved choosing and assigning a random observation from all observations with matching characteristics in a number of dimensions (the conditioning variables). The ELSA team did not impute values for non-responding spouses, so couple-level household financial variables are left missing when spouse information is missing.

Mechanisms of missing data

Missing data is often caused by unit non-response, item non-response, and wave non-response, and there are three main patterns of missing data: univariate, monotone, and arbitrary. A detailed explanation of these sources and patterns of missing data is showed in Appendix 3.1. There is no clear rule about how much is too much missing data in analysis, as potential bias is inherent whenever there is a non-response (Schafer and Graham, 2002). Therefore, it is useful to understand the mechanisms of missing data. Little and Rubin's (2002) framework is commonly used and it classifies three mechanisms: missing completely at random (MCAR), missing at random (MAR), and missing not at random (MNAR). With MCAR, 'the observed data can be thought of as a random sample of the complete data' (Molenberghs and Fitzmaurice 2009: 397), so there is no systematic difference between observed and missing data, thus would not lead to bias (Musil et al., 2002). MCAR data occurs, for example, when respondents accidentally skipped a question on a questionnaire or accidentally discarded a questionnaire. With MAR, the observed data cannot be viewed as a random sample of the complete data (Molenberghs and Fitzmaurice, 2009), but its missing data mechanism depends only on the observed data and not on the missing data (Little and Rubin, 2002). For example, say, older participants are more likely than younger people to have their blood pressure measured. If age is an observed variable, then age can predict the pattern of missingness (White et al., 2011). There is still some randomness to the occurrence of missing data, so this missingness is termed 'missing at random' (Musil et al., 2002). Under MCAR and MAR, the missing data mechanism does not need to be modelled, so MCAR and MAR are referred to as 'ignorable' missingness, but MNAR is 'non-ignorable'(Allison, 2001; Molenberghs and Fitzmaurice, 2009). MNAR occurs when the probability of data being missing depend on the unobserved data (White et al., 2011). Using the blood pressure as another example, blood pressure data are MNAR if individuals with high blood pressures are more likely to have their blood pressure recorded than other individuals of the same age.

Comparing methods in dealing with missing data

Under different mechanisms of missing data, different approaches can be used in handling missing data. For example, complete-case analysis, also known as listwise deletion, confines attention to subjects with no missing data. It is easy to conduct and is a standard option in statistical software packages. This method can yield unbiased estimates of parameters and confidence intervals under MCAR (Enders, 2010). However, the MCAR assumption is often over restrictive for most studies, and even when MCAR is plausible, excluding cases from an analysis still reduces the statistical power (Enders, 2010). Therefore, current methodological literature does not favour deletion methods. Some researchers point out that complete-case analysis may be appropriate only when the proportion of missing data is minimal, for example less than 5% (Graham, 2009).

When data are MAR, but not MCAR, analyses based on complete cases will lose precision and cause bias. Other methods, such as multiple imputation (MI), can allow individuals with incomplete data to be included in analyses, thus can overcome the bias of complete-case analysis when data is MAR. MI is an increasingly popular statistical technique for handling missing data because of its generality and recent developments in software (Harel and Zhou, 2007; Horton and Kleinman, 2007). It does not predict missing values as close as possible to the true values, but handles missing data in a way resulting in valid statistical inference (Rubin, 2012). It uses the distribution of the observed data to estimate a set of ($m>1$) plausible values for the missing data, and random components are included in these estimations to reflect uncertainty. Once the multiple data sets have been generated, each imputed data set is analysed separately. The last step is to combine these estimates from multiply imputed data sets (White et al., 2011). If the proportion of missing values is minimal (say, $<5\%$), then single imputation ($m=1$) may be reasonable. Otherwise, without special corrective measures, such as the methods of Schafer and Schenker (2000), single imputation tends to overstate precision due to omitting the between-imputation variance. In modern computing environments, the effort required to produce good single imputation is not less than doing multiple imputation (Schafer, 1999), so multiple imputation is preferred. Another commonly used technique in handling non-response under MAR is the maximum likelihood method. This method is ideal for analyses with incomplete outcome variables, but it is less flexible when the independent variables are incomplete. In contrast, MI is ideal for this situation, because it makes no distinction between independent and dependent variables. MI's process simply predicts the missing data from the observed data without regard to each variable's role in the subsequent analysis (Enders, 2013). Other methods, such as a full Bayesian analysis, could also be used to handling missing data under MAR, but these methods are not computationally straightforward in general, thus are less popular than MI among researchers (Carpenter and Kenward, 2013).

MNAR is the most difficult condition to model, and dealing with MNAR is still an open research area. In the MNAR setting, it is difficult to know the appropriate model for the missingness. Statistical techniques for MNAR such as selection model and pattern-mixture model, are substantially sensitive to the assumptions of the missing process specified in modelling (Allison, 2001), thus have not been widely used in the current methodological literature.

Both CHARLS and ELSA have collected detailed information that may be linked to missing data, such as social-demographic characteristics, chronic diseases, area of residence, sampling weights, and so on, therefore, it is reasonable to assume the reason for observations being missing only depends on the observed variables, i.e. MAR. MI is an appropriate method in handling missing data under MAR. As mentioned above, MI is more general and flexible compared to other methods, and its processes are straightforward to be applied in many software packages, thus MI method was used in this study.

Multiple imputation (MI) for missing data in the analysis

This research applied the MI method in Stata to handle the missing data in covariates and outcome variables (SBP, DBP, WC, BMI, smoking status, drinking frequency) of the 12,706 participants from CHARLS and the 8,243 individuals from ELSA. When modelling blood biomarkers (total blood cholesterol, CRP, and HbA1c), only people who provided a blood sample were used (*n*=8,714 in CHARLS, *n*=5,628). Missing blood biomarkers among people who provided a blood samples were multiply imputed, and the analysis was weighted using the blood sample weights to correct for the non-response in blood sample.

In the imputation model, usually all variables which will be used in analysis models or are predictive of missingness should be included (Schafer, 1997; Karpansalo et al., 2004). Thus, the imputation procedure in this chapter included the independent variables, outcome variables, and covariates, as well as moderators, which will be used in analysis models. In addition, weights (Stata command: [pweight=weight]) were also included.

Imputing missing data in MI can be carried out using one of two approaches. One is assuming a joint multivariate normal distribution, but this approach is not appropriate for a large data set with many different types of variables as CHARLS and ELSA. Another approach is specifying a univariate imputation model of each incomplete variable, which is known as multiple imputation by chained equations (MICE). An important feature of MICE is its ability to handle different variable types (continuous, binary, unordered categorical and ordered categorical), because each variable is imputed using its own imputation model (Azur et al., 2011). Therefore, MICE was used in this research. Detailed mechanisms of MICE can be found in Appendix 3.1.

In every cycle of MICE, similar to the analysis of complete data, different regression models were specified for different types of missing variables: linear regression was for continuous missing variables; logistic regression was for binary variables; ordered logistic regression was for ordinal variables; and multinomial logistic regression was for nominal variables. In order to stabilise the results, the MICE procedure is usually repeated for several cycles to produce one imputed data set. A low number of cycles, say 10 to 20, is often sufficient (White et al., 2011). In this chapter, each imputation was drawn every 20 cycles (the default is 10). The whole procedure is then repeated *m* times to produce *m* imputed data. The number of imputations (*m*) should be large enough so as not to impact the conclusions or inhibit analysis reproducibility. White et al.'s (2009) simple rule of thumb is that the number of imputed datasets should be at least equal to the percentage of incomplete cases. The proportion of missing data was 57.8% in CHARLS and was 49% in ELSA, so 60 imputed data sets were generated in this chapter.

Once the *m* imputations have been generated, each imputed data set is analysed separately. This is the second step of MI. Complete-data methods were performed in this step. Regression coefficients were estimated from each imputed data set, together with their variance-covariance matrices. The results of these *m* analyses differ because the missing values have been replaced by different imputations (White et al., 2011). In the final MI step, the *m* estimates were combined into an overall estimate and variance-covariance matrix using Rubin's rules.

There are two common techniques for handling missing data on the outcomes. The first is the standard imputation that imputes the outcomes and retains the imputed values in the analysis. The second technique is a multiple imputation, then deletion (MID) method. The MID method first imputes outcomes, but then deletes the cases with imputed values on the outcomes prior to analysis (Hippel, 2007). Some studies suggest that both standard MI and MID produced negligible bias when estimating regression parameters, with standard MI being more efficient in most settings (Sullivan et al., 2015; Young and Johnson, 2010). In this study, retaining imputed values of outcomes can give an identical sample size for several health outcomes, thus making results more comparable within each survey. Therefore, standard MI was used in the subsequent analysis.

3.4.3 Testing moderators

The moderating role of gender (men/women), residential area (urban/rural), and spouse's employment status (working spouse/non-working spouse/no spouse) in the associations between retirement and outcomes were examined.

For moderators, a reference category should not be a category with few cases, for reasons related to sample size and error. Therefore, men, urban dwellers, and people with a working spouse, who have the most cases, were chosen as the reference categories (coded as 0). Then women, rural dwellers, having a non-working spouse were coded as 1, and having no spouse was coded as 2. Retired was coded as 0, and working was coded as 1. This chapter tested the potential moderators by adding them as an interaction term (i.e. retirement status × gender; retirement status × area; retirement status × spouse's employment) in the regression. If the interaction term is statistically significant at the 10% level ($P<0.1$), a stratified analysis by the moderator was conducted.

3.5 Results

3.5.1 Descriptive results

Table 3. 3 Sample characteristics in CHARLS and ELSA.

Characteristics	**CHARLS (*n*=12,706)**	**ELSA (*n*=8,243)**
Age at interview (%)		
50-54	19.3	16.6
55-59	24.9	16.3
60-64	19.5	16.5
65-69	13.2	16.1
≥70	23.1	34.5
Mean age, years	62.9	65.9
Women (%)	49.6	50.9
Spouse's working (%)		
Working spouse	52.0	30.8
Non-working spouse	30.2	38.4
No spouse	17.8	30.9
Rural dwellers (%)	52.6	14.4
Education (%)		
Low	51.7	40.6
Middle	21.0	27.8
High	27.3	31.6
ISCO skill level (%)		
1 (lowest)	63.2	13.2
2	24.7	46.3
3	2.0	10.4
4 (highest)	10.1	30.1
Median annual household income, RMB/GBP	1940.0	22474.1
Median household wealth, RMB/GBP	6355.4	212500.0
Smoking status (%)		
Never smoker	66.2	40.8
Ex-smoker	11.0	50.0
Current light/moderate smoker	9.8	6.6
Current heavy smoker	13.0	2.6
Drinking frequencies (%)		
Non-drinkers	72.1	34.6
Less than everyday	16.9	54.8
Every day or more	11.0	10.6

Characteristics	CHARLS (*n*=12,706)	ELSA (*n*=8,243)
Elevated depressive symptoms (%)[b]	36.5	12.2
Ever had heart disease (%)	13.1	18.9
Ever had stroke (%)	3.0	4.4
Mean SBP, mm Hg	132.5	131.9
Mean DBP, mm Hg	76.0	74.3
Mean BMI, kg/m^2	23.3	28.3
Mean WC, cm	85.5	96.5
Median CRP, mg/L [c]	1.1	1.6
Median HbA1c, mmol/mol [c]	32.2	39.0
Mean blood total cholesterol, mg/dL [c]	192.7	214.6

[a] %, mean and median values were weighted, and were based on people with the complete information for that variable.
[b] CESD-10 score >=10 for CHARLS and CESD-8 score >=4 for ELSA.
[c] Value based on the people who provide blood sample.

Table 3.3 shows the sample characteristics in CHARLS and ELSA. Percentages and mean or median values were weighted. CHARLS data had a younger age structure than ELSA, with a mean age of 62.9 years compared to 65.9 years in ELSA. 49.6% of the CHARLS participants and 50.9% of the ELSA participants were women. Compared to CHARLS participants, those in ELSA were less likely to have a spouse (no spouse: 17.8% in CHARL, 30.9% in ELSA), especially a working spouse (52% in CHARLS, 30.8% in ELSA), which is likely because of the older age structure of ELSA. The ELSA participants were socially advantaged in urbanicity, education and occupation skills compared to CHARLS respondents. 52.6% of CHARLS participants were living in rural areas compared to only 14.4% of ELSA participants. 51.7% of the CHARLS participants were classified to the lowest education level, which is 'did not finish elementary school', and 40.6% of the ELSA participants were classified to the lowest education level, which is 'less than O-level or equivalent'. 63.2% of the CHARLS participants had the lowest ISCO skill level, compared to only 13.2% in ELSA. The biggest differences between the two datasets are participants' financial resources. Compared to CHARLS, the median household total annual income in ELSA was more than ten times higher, and was more than 30 times higher in terms of the median household wealth.

Compared to ELSA, CHARLS had a higher percent of non-smokers (66.2% vs. 40.8%), but a lower percent of ex-smokers (11% vs. 50%) and a higher percent of heavy smokers (13% vs. 2.6%). In addition, 72.1% of the CHARLS individuals did not have any alcohol drink during the last 12 months, but this figure in ELSA was only 34.6%. The percent of people drinking every day was similar between the two datasets (11% and 10.6%). In terms of the depressive symptoms, participants with ≥10 on the CESD-10 in CHARLS (Boey, 1999) or with ≥4 on the CESD-8 in ELSA (Stevens et al., 2008) were considered as having elevated depressive symptoms in the descriptive results. According to these cut-off scores, 36.5% of CHARLS respondents and 12.2% of ELSA respondents had elevated depressive symptoms. 13.1% of the CHARLS respondents and 18.9% of the ELSA respondents had ever been diagnosed with heart disease, and 3.0% and 4.0% of them ever been diagnosed with stroke. The average blood pressure level was similar between the two datasets (76.0/132.5 mm Hg for CHARLS, 74.3/131.9 mm Hg for ELSA), but the CHARLS participants had a much lower BMI (23.3 kg/m^2 vs. 28.3 kg/m^2) and WC (85.5 cm vs. 96.5 cm) than the ELSA participants. The three blood biomarkers were lower in CHARLS than in ELSA as well. The median value of CRP, HbA1c, and total blood cholesterol was 1.1 mg/L, 32.2 mmol/mol, and 192.7 mg/dL respectively in CHARLS, and was 1.6 mg/L, 39.0 mmol/mol, and 214.6 mg/dL in ELSA. In summary, ELSA participants are older and more socially advantaged, but less likely to be non-smokers and non-drinkers, and less healthy than CHARLS participants, with the possible exception of depressive symptoms.

Table 3.4 shows the retirement age in CHARLS and ELSA. Retirees in CHARLS retired earlier than the ELSA retirees. The mean retirement age was 57.7 years in CHARLS, and was 59.1 year in ELSA. Considering the distribution of retirement ages tend to cluster at the compulsory retirement ages or at the SPA, median retirement age may be more useful in representing the average level of retirement age. The median retirement age was 55 years in CHARLS, and was 60 years in ELSA. In both datasets, women retired earlier than men, but the gender differences were bigger in CHARLS. The median age for men was 6 years older than women in CHARLS, compared to only 1-year difference in ELSA. 22% of the CHARLS women and only 8.3% of the ELSA women retired before age 50, which is probably because it is difficult for Chinese women to go back to labour force at age 40s due to the early compulsory retirement age for women in China. Despite the average retirement age is earlier in CHARLS, 11.3% of the CHARLS retirees retired at age 70 or older, and the percent in ELSA was only

2.7%. The reason for the higher proportion of CHARLS respondents retired at a very old age was that 22.9% of rural dwellers retired at age 70 or older. The median retirement age was 60 years for rural dwellers and was 54 years for urban retirees in CHARLS. In ELSA, the median retirement age was 60 for both urban and rural retirees.

Table 3. 4 Retirement age in CHARLS and ELSA by gender and residential areas [a].

	CHARLS (*n*=4,392)					ELSA (*n*=5,363)				
Retirement age, years	**Total**	**Men**	**Women**	**Urban**	**Rural**	**Total**	**Men**	**Women**	**Urban**	**Rural**
<50 (%)	15.9	7.7	22.0	19.6	8.1	6.3	3.9	8.3	5.9	7.0
50-54 (%)	24.5	19.7	28.2	28.8	15.6	10.4	9.6	11.0	9.8	12.0
55-59 (%)	22.7	28.0	18.6	24.6	18.7	22.5	20.6	24.0	22.4	23.9
60-64 (%)	17.3	25.0	11.5	16.1	19.7	38.6	32.5	43.6	40.0	33.5
65-69 (%)	8.3	7.7	8.9	5.2	14.9	19.5	30.0	11.1	19.5	19.9
≥70 (%)	11.3	11.9	10.8	5.8	22.9	2.7	3.5	2.1	2.6	3.6
Mean	57.7	59.2	56.6	55.7	62.0	59.1	60.6	57.9	59.3	58.6
Median	55.0	58.0	52.0	54.0	60.0	60.0	61.0	60.0	60.0	60.0

[a] %, mean and median values were weighted and only based on those who are retired.

Table 3. 5 Unadjusted and adjusted model for factors related to retirement [a].

Characteristics	CHARLS (n=12,706)				ELSA (n=8,243)			
	Univariate OR (95% CI)	***P***	**Adjusted OR[b] (95% CI)**	***P***	**Univariate OR (95% CI)**	***P***	**Adjusted OR[b] (95% CI)**	***P***
Age, years	1.123(1.115,1.131)	<0.001	1.151(1.037,1.278)	0.008	1.354(1.333,1.376)	<0.001	3.123(2.597,3.755)	<0.001
Age^2, $years^2$	1.001(1.001,1.001)	<0.001	1.000(0.999,1.001)	0.690	1.002(1.001,1.003)	<0.001	0.993(0.992,0.995)	<0.001
CESD score	1.010(1.002,1.019)	0.015	1.025(1.014,1.037)	<0.001	1.098(1.063,1.135)	<0.001	1.055(1.013,1.099)	0.009
Women(vs. men)	1.800(1.616,2.007)	<0.001	2.739(2.262,3.315)	<0.001	1.490(1.342,1.654)	<0.001	1.775(1.522,2.071)	<0.001
Rural (vs. urban)	0.276(0.247,0.309)	<0.001	0.330(0.288,0.379)	<0.001	0.806(0.675,0.964)	0.018	0.796(0.639,0.992)	0.042
Spouse status:								
Working	Reference		Reference		Reference		Reference	
Not working	8.880 (7.689,10.256)	<0.001	4.429 (3.714, 5.282)	<0.001	14.432 (12.385,16.818)	<0.001	3.568 (2.956,4.306)	<0.001
No spouse	9.125 (7.785,10.695)	<0.001	3.105 (2.559, 3.767)	<0.001	9.520 (8.142,11.131)	<0.001	1.877 (1.492,2.362)	<0.001
Education:								
Low	Reference		Reference		Reference		Reference	
Middle	0.840(0.729,0.968)	0.016	1.193(0.991,1.435)	0.063	0.411(0.360,0.469)	<0.001	1.057(0.881,1.267)	0.552
High	1.226(1.080,1.392)	0.002	2.067(1.718,2.485)	<0.001	0.381(0.336,0.432)	<0.001	1.076(0.888,1.304)	0.454
ISCO skill level:								
1 (lowest)	Reference		Reference		Reference		Reference	
2	2.094(1.839,2.384)	<0.001	2.027(1.680,2.445)	<0.001	0.858(0.721,1.021)	0.085	1.081(0.858,1.363)	0.509
3	3.060(1.756,5.333)	<0.001	2.179(1.437,3.304)	<0.001	0.482(0.387,0.601)	<0.001	0.764(0.560,1.043)	0.090

Characteristics	CHARLS (*n*=12,706)				ELSA (*n*=8,243)			
	Univariate OR (95% CI)	*P*	Adjusted OR[b] (95% CI)	*P*	Univariate OR (95% CI)	*P*	Adjusted OR[b] (95% CI)	*P*
4 (highest)	2.170(1.718,2.740)	<0.001	1.302(0.924,1.833)	0.131	0.567(0.474,0.679)	<0.001	1.177(0.899,1.540)	0.236
Income, log RMB/ log GBP	0.983 (0.969,0.996)	0.013	0.968 (0.951,0.985)	<0.001	0.454 (0.375,0.550)	<0.001	0.792 (0.690,0.909)	0.001
Wealth, log RMB/ log GBP	1.041 (1.025,1.058)	<0.001	1.022 (1.003,1.040)	0.021	0.997 (0.983,1.011)	<0.001	0.988 (0.970,1.006)	0.200
Smoking:								
Never	Reference		Reference		Reference		Reference	
Ex-smoker	0.910(0.762,1.086)	0.291	1.230(0.969,1.562)	0.089	1.605(1.433,1.796)	<0.001	0.957(0.816,1.123)	0.589
Light/moderate	0.639(0.531,0.770)	<0.001	1.058(0.829,1.349)	0.648	0.713(0.569,0.892)	0.003	0.673(0.500,0.906)	0.009
Heavy	0.383(0.316,0.465)	<0.001	0.926(0.700,1.224)	0.589	0.710(0.505,0.996)	0.048	0.738(0.477,1.143)	0.173
Drinking:								
Non-drinkers	Reference		Reference		Reference		Reference	
< everyday	0.478(0.398,0.574)	<0.001	0.612(0.493,0.759)	<0.001	0.575(0.507,0.652)	<0.001	1.065(0.896,1.265)	0.474
≥ everyday	0.395(0.332,0.471)	<0.001	0.599(0.465,0.772)	<0.001	0.821(0.672,1.003)	0.054	1.123(0.849,1.485)	0.417

[a] Missing data were multiply imputed, and analyses were weighted.

[b] All variables were included in each mutually adjusted model.

Table 3.5 shows the unadjusted and mutually-adjusted model (included all variables) for factors related to retirement status in CHARLS and ELSA. In the unadjusted models, all covariates were associated with retirement in both datasets. In the mutually adjusted model, people who were older, female, had more depressive symptoms were more likely to be retired at interview in both datasets. Age squared was negatively associated with retirement in ELSA, which means that the speed of increased likelihood of retirement with ageing slowed down at older ages. The association between gender and retirement was stronger in CHARLS (OR=2.739) than ELSA (OR=1.775), which is probably because China has a much earlier compulsory retirement age for women working in formal sectors. In CHARLS, urban dwellers and those who were advantaged in education and occupation skill level were more likely to be retired. However, in ELSA, rural dwellers were only slightly less likely (OR=0.796) to be retired compared to urban dweller, and it was borderline significant (*P*=0.042). Education and occupation were not significantly related to the retirement status in ELSA either. Perhaps because their associations with retirement has been explained by household income, as ELSA respondents with higher household incomes were less likely to be retried (OR=0.792). Household wealth was not associated with retirement in ELSA. In CHARLS, household income (OR=0.968) and household wealth (OR=1.022) were inversely associated with retirement, that higher wealth and lower income were associated with higher likelihood of being retired. This probably because the cross-sectional association actually reflect the fact that people in China have lower income after retirement, rather than lower income triggers retirement. Compared to never-smokers, light/moderate smokers in ELSA were less likely to be retired (OR=0.673). While in CHARLS, only drinking was associated with retirement, that drinkers, no matter how often they drink (OR=0.612 for less than every day, OR=0.599 for every day), were less likely to be retired than non-drinkers.

The mutually-adjusted models for factors related to health outcomes are shown in Appendices 3.2.a to 3.2.e. The covariates used in the analysis were associated with at least some of the interested outcomes.

3.5.2 Multivariate results of the associations between retirement and CVD

Table 3.6 shows the multivariate results of the associations between retirement and heart disease and stroke. In both CHARLS and ELSA, retired participants had higher ORs of heart disease and stroke than working people. This table first shows the results with only adjusting for age, age^2 and gender (Model 1). In this model, the OR of heart disease was 2.436 in CHARLS, and was 1.425 in ELSA. The OR of stroke was 3.458 in CHARLS, and was 1.770 in ELSA.

Further adjusting for socio-economic characteristics (spouse status, highest education, occupation skill level, household total income, household total wealth and urban/rural) in Model 2 reduced the OR of heart disease to 2.124, and increase the OR of stroke to 3.779 in CHARLS, but the results in ELSA were only slightly changed.

In Model 3, smoking status, drinking frequency, and depressive symptoms were further adjusted. All ORs were attenuated to some extent in this fully adjusted model, but retired people still had statistically significantly higher risk of ever had heart disease (OR=1.959 in CHARLS, OR=1.405 in ELSA) and stroke (OR=3.221 in CHARLS, OR=1.662 in ELSA). The associations between retirement and CVD (heart disease and stroke) seemed to be stronger in CHARLS than in ELSA across all three models.

Table 3. 6 Multivariate analyses on the associations between retirement and CVD.

	CHARLS (*n*=12,706)						ELSA (*n*=8,243)					
	Heart disease			Stroke			Heart disease			Stroke		
	OR	**95% CI**	***P***	**OR**	**95% CI**	***P***	**OR**	**95% CI**	***P***	**OR**	**95% CI**	***P***
Model 1	2.436	2.094, 2.832	<0.001	3.458	2.541, 4.708	<0.001	1.425	1.182, 1.719	<0.001	1.770	1.173, 2.672	0.007
Model 2	2.124	1.787, 2.526	<0.001	3.779	2.690, 5.308	<0.001	1.437	1.177, 1.753	<0.001	1.700	1.093, 2.643	0.019
Model 3	1.959	1.649, 2.327	<0.001	3.221	2.312, 4.487	<0.001	1.405	1.149, 1.718	0.001	1.662	1.055, 2.617	0.028

Model 1: Adjusted for age, age^2 and gender.
Model 2: model 1 + spouse status, highest education, occupation skill level, household total income, household total wealth and urban/rural.
Model 3: model 2 + smoking status, drinking frequency, and depressive symptoms (fully adjusted model).

3.5.3 Multivariate results of the associations between retirement and adiposity measures

Table 3.7 shows the multivariate results of the associations between retirement and BMI and WC. When only adjusting for age, age^2 and gender (Model 1), the coefficients of BMI and WC were 1.239 and 3.855 in CHARLS. These positive coefficients suggest that retired CHARLS respondents had higher values of BMI and WC than working people ($P<0.001$). In this model, BMI and WC were not significantly associated with retirement in ELSA.

Further adjusting for socio-economic characteristics (spouse status, highest education, occupation skill level, household total income, household total wealth and urban/rural) in Model 2 reduced the coefficients of BMI and the coefficient of WC in CHARLS, but their associations with retirement were still statistically significant.

Full adjustment in Model 3 only slightly changed the coefficients, and did not change the significant associations with BMI and WC in CHARLS, nor the non-significant associations in ELSA. Therefore, retired people had higher values of BMI and WC than working people in CHARLS, but not in ELSA.

Table 3. 7 Multivariate analyses on the associations between retirement and adiposity measures.

	CHARLS (*n*=12,706)						ELSA (*n*=8,243)					
	BMI, kg/m²			WC, cm			BMI, kg/m²			WC, cm		
	β	95% CI	*P*	β	95% CI	*P*	β	95% CI	*P*	β	95% CI	*P*
Model 1	1.239	0.955, 1.523	<0.001	3.855	3.116, 4.594	<0.001	0.261	-0.123, 0.645	0.182	0.680	-0.286, 1.646	0.168
Model 2	0.522	0.230, 0.813	<0.001	1.788	1.007, 2.569	<0.001	0.188	-0.145, 0.553	0.195	0.522	-0.480, 1.524	0.307
Model 3	0.540	0.252, 0.829	<0.001	1.860	1.081, 2.640	<0.001	0.109	-0.285, 0.503	0.589	0.367	-0.622, 1.356	0.467

Model 1: Adjusted for age, age^2 and gender.
Model 2: model 1+ spouse status, highest education, occupation skill level, household total income, household total wealth and urban/rural.
Model 3: model 2+ smoking status, drinking frequency, and depressive symptoms (fully adjusted model).

3.5.4 Multivariate results of the associations between retirement and blood pressure measures

Table 3.8 shows the multivariate results of the associations with SBP and DBP. In CHARLS, none of the three models showed any statistically significant (<5%) associations between retirement and blood pressure. Only one result reached a 10% significance level (*P*=0.087), that retired people had on average 1.460 mm Hg lower SBP level than working people in CHARLS, after adjusting for age, age^2, gender, taking antihypertensive medications, and other socio-economic characteristics. But its *P* value reduced to 0.166 after further adjusting for smoking status, drinking frequency, and depressive symptoms.

However, in ELSA, retired people had significantly lower levels of both SBP (β=-1.503) and DBP (β=-1.164) than working people, after adjusting for age, age^2, gender and antihypertensive medications. With further adjustment for other socio-economic covariates in Model 2, the coefficients of SBP and DBP were reduced to -1.146 and -0.826, and the *P* value for SBP reduced to 0.074. Full adjustment only slightly changed the results. In summary, compared to working people, retired ELSA respondents had a significantly lower level of DBP and a borderline significantly lower level of SBP than working people. No such associations were found in CHARLS.

Table 3. 8 Multivariate analyses on the associations between retirement and blood pressure measures.

	CHARLS (*n*=12,706)						ELSA (*n*=8,243)					
	SBP, mm Hg			DBP, mm Hg			SBP, mm Hg			DBP, mm Hg		
	β	95% CI	*P*	β	95% CI	*P*	β	95% CI	*P*	β	95% CI	*P*
Model 1	-0.484	-1.945, 0.976	0.515	0.416	-0.474, 1.307	0.359	-1.503	-2.700,-0.305	0.014	-1.164	-1.889,-0.439	0.002
Model 2	-1.460	-3.133, 0.213	0.087	-0.067	-1.020, 0.885	0.891	-1.146	-2.403, 0.111	0.074	-0.826	-1.587,-0.066	0.033
Model 3	-1.177	-2.842, 0.489	0.166	0.084	-0.863, 1.032	0.861	-1.149	-2.406, 0.109	0.073	-0.838	-1.600,-0.075	0.031

Model 1: Adjusted for age, age^2, gender, and taking antihypertensive medications.
Model 2: model 1 + spouse status, highest education, occupation skill level, household total income, household total wealth and urban/rural.
Model 3: model 2 + smoking status, drinking frequency, and depressive symptoms (fully adjusted model).

3.5.5 Multivariate results of the associations between retirement and blood biomarker measures

Tables 3.9 and 3.10 show the multivariate results of the associations between retirement and three blood biomarker CVD risk factors, including blood total cholesterol, CRP and HbA1c. Neither CHARLS nor ELSA showed a significant association with blood total cholesterol in any of the adjustment models (Table 3.9).

Table 3. 9 Multivariate analyses on the associations between retirement and blood total cholesterol.

	CHARLS (*n*=8,714)			ELSA (*n*=5,628)		
	Blood total cholesterol, mg/dL			Blood total cholesterol, mg/dL		
	β	95% CI	*P*	β	95% CI	*P*
Model 1	0.084	-2.544, 2.713	0.950	-1.154	-4.502, 2.193	0.499
Model 2	1.299	-1.480, 4.078	0.360	-0.920	-4.397, 2.557	0.604
Model 3	1.610	-1.137, 4.356	0.251	-0.995	-4.452, 2.461	0.572

Model 1: Adjusted for age, age^2, gender, and taking medications for lower blood cholesterol.
Model 2: model 1 + spouse status, highest education, occupation skill level, household total income, household total wealth and urban/rural.
Model 3: model 2 + smoking status, drinking frequency, and depressive symptoms (fully adjusted model).

Retired CHARLS respondents showed a raised level of CRP than their working counterparts in all three models, and the coefficient was 0.233 in Model 1, 0.212 in Model 2, and 0.210 in Model 3 (Table 3.10). However, ELSA respondents did not show significant differences on CRP between those retired and those working. In ELSA, retire people had significantly lower level of HbA1c than working people in all three models, and the coefficient was -0.019 in Model 1, -0.017 in Model 2, and -0.018 in Model 3. No association between retirement and HbA1c was found among the CHARLS participants.

Table 3. 10 Multivariate analyses on the associations between retirement and blood biomarker measures.

	CHARLS (*n*=8,714)						**ELSA (*n*=5,628)**					
	CRP, log mg/L			**HbA1c, log mmol/mol [a]**			**CRP, log mg/L**			**HbA1c, log mmol/mol [a]**		
	β	**95% CI**	**P**	**β**	**95% CI**	**P**	**β**	**95% CI**	**P**	**β**	**95% CI**	**P**
Model 1	0.233	0.162,0.304	<0.001	-0.0004	-0.012,0.013	0.949	0.037	-0.048, 0.123	0.389	-0.019	-0.029, -0.008	0.001
Model 2	0.212	0.117,0.308	<0.001	0.0020	-0.012,0.016	0.795	0.022	-0.066, 0.110	0.627	-0.017	-0.030, -0.007	0.001
Model 3	0.210	0.114,0.305	<0.001	0.0001	-0.014,0.014	0.989	0.023	-0.064, 0.111	0.600	-0.018	-0.029, -0.007	0.001

[a] Adjusted for taking medications for diabetes in all models.
Model 1: Adjusted for age, age^2, gender.
Model 2: model 1 + spouse status, highest education, occupation skill level, household total income, household total wealth and urban/rural.
Model 3: model 2 + smoking status, drinking frequency, and depressive symptoms (fully adjusted model).

3.5.6 Multivariate results of the associations between retirement and health behaviours

Tables 3.11 and 3.12 show the multivariate multinomial logistic regression results of the associations between retirement and smoking and drinking. A RRR less than one suggests a reduced risk, while a RRR larger than one means an increased risk. In Model 1 of smoking, where only age, age^2, and gender were adjusted, retired people in CHARLS were less likely to be a current heavy smoker versus a never smoker than working people (RRR=0.737). This association became not statistically significant after further adjusting for social-demographic characteristics in Model 2 and in the full adjustment in Model 3. But in ELSA, the association between retirement and smoking status existed in all three models, that compared to working people in ELSA, retired people were more likely to be a never smoker rather than a current light/moderate smoker. The RRR in the fully adjusted model was 0.626, which means that the ratio of the probability of being a current light/moderate smoker over the probability of being a never-smoker was 37.4% (1-0.626) lower among retired people than working people. However, no association between retirement and heavy smoking was found in ELSA.

In CHARLS, retirement was associated with drinking frequency in all models (Table 3.12), that retired people were less likely to be a drinker versus a non-drinker (P<0.001). In the fully adjusted model, the ratio of the probability of being a less than everyday drinker over the probability of being a non-drinker was 38.1% (1-0.619) lower among retired people than working people, and ratio of the probability of being an everyday drinker over the probability of being a non-drinker was 40% (1-0.600) lower among retired people than working people. No association between retirement and drinking frequency was found in ELSA.

Table 3. 11 Multivariate analyses on the associations between retirement and smoking.

	CHARLS (n=12,706)			ELSA (n=8,243)		
	RRR	95% CI	P	RRR	95% CI	P
Model 1						
Never smoker	Reference			Reference		
Ex-smoker	1.041	0.831, 1.304	0.728	0.948	0.813, 1.106	0.500
Light/moderate	0.924	0.733, 1.165	0.503	0.667	0.505, 0.880	0.004
Heavy smoker	0.737	0.570, 0.953	0.020	0.924	0.607, 1.406	0.711
Model 2						
Never smoker	Reference			Reference		
Ex-smoker	1.106	0.868, 1.408	0.415	0.952	0.811, 1.117	0.546
Light/moderate	0.953	0.740, 1.227	0.708	0.627	0.464, 0.849	0.003
Heavy smoker	0.832	0.633, 1.094	0.188	0.761	0.472, 1.228	0.264
Model 3						
Never smoker	Reference			Reference		
Ex-smoker	1.156	0.912, 1.466	0.230	0.945	0.803, 1.112	0.493
Light/moderate	1.029	0.801, 1.321	0.825	0.626	0.462, 0.849	0.003
Heavy smoker	0.913	0.693, 1.203	0.517	0.768	0.475, 1.242	0.281

Model 1: Adjusted for age, age^2, gender.
Model 2: model 1 + spouse status, highest education, occupation skill level, household total income, household total wealth and urban/rural.
Model 3: model 2 + drinking frequency and depressive symptoms.

Table 3. 12 Multivariate analyses on the associations between retirement and drinking frequency.

	CHARLS (n=12,706)			ELSA (n=8,243)		
	RRR	95% CI	P	RRR	95% CI	P
Model 1						
Non-drinkers	Reference			Reference		
< everyday	0.689	0.561, 0.846	<0.001	0.938	0.796, 1.105	0.442
≥Every day	0.552	0.448, 0.681	<0.001	0.957	0.734, 1.248	0.745
Model 2						
Non-drinkers	Reference			Reference		
< everyday	0.612	0.490, 0.764	<0.001	1.122	0.947, 1.330	0.183
≥Every day	0.579	0.451, 0.744	<0.001	1.240	0.948, 1.623	0.117
Model 3						
Non-drinkers	Reference			Reference		
< everyday	0.619	0.498, 0.770	<0.001	1.069	0.896, 1.276	0.460
≥Every day	0.600	0.465, 0.775	<0.001	1.141	0.856 1.520	0.369

Model 1: Adjusted for age, age^2, gender.
Model 2: model 1 + spouse status, highest education, occupation skill level, household total income, household total wealth and urban/rural.
Model 3: model 2 + smoking status and depressive symptoms.

3.6 Moderating results

3.6.1 Gender as a moderator

Gender was tested as a moderator in the association between retirement and health outcomes, and the *P* values for the interaction term are shown in Table 3.13. In CHARLS, there was a significant gender × retirement interaction (*P*<0.1) for blood total cholesterol (*P*=0.08), smoking (light/moderate vs. non *P*=0.003, heavy vs. non *P*=0.009), and drinking (drinking<everyday vs. non *P*=0.067). In ELSA, there was a significant gender × retirement interaction for SBP (*P*<0.001), DBP (*P*<0.001), blood total cholesterol (*P*<0.001), and smoking (ex-smoker vs. non *P*<0.001). For those *P* values less than 0.1, gender stratified analyses were conducted.

Table 3. 13 Gender as a moderator in the association between retirement and health outcomes.

Health outcomes	**CHARLS**	**ELSA**
	***P* for retire × gender**	***P* for retire × gender**
Heart diseases	0.629	0.573
Stroke	0.437	0.450
BMI	0.262	0.084
WC	0.614	0.277
SBP	0.569	<0.001
DBP	0.629	<0.001
Total cholesterol	0.080	<0.001
CRP	0.597	0.487
HbA1c	0.734	0.657
Ex-smoker[a]	0.203	<0.001
Light/moderate smoker[a]	0.003	0.706
Heavy smoker[a]	0.009	0.624
Drinking <everyday[b]	0.067	0.602
Drinking ≥ everyday[b]	0.380	0.358

[a] Never smokers are the baseline group.
[b] Non-drinkers are the baseline group.

Tables 3.14 and 3.15 show the gender-stratified results in CHARLS. Retired men in CHARLS did not show a significant different level of blood total cholesterol compared with working men (Table 3.14). However, retired women showed an on average 4.280

mg/dL higher blood total cholesterol compared with working women (*P*=0.022). In terms of smoking status, retired men in CHARLS did not show any significant differences from working men. Retired women in CHARLS seem to be more likely to be light/moderate smokers rather than non-smokers compared to working women (RRR=1.486), although its *P* values was 0.073. Retirement was not associated with heavy smoking or ex-smoking among women in CHARLS. For drinking frequency, retired men and women in CHARLS were less likely to drink, compared to their working counterparts. The coefficient of being a less than everyday drinker versus a non-drinker was 0.698 for men, and was 0.504 for women, so the probability of being a less than everyday drinker over the probability of being a non-drinker was 30.2% (1-0.698) lower for retired men than working men, and 49.6% (1-0.504) lower for retired women than working women. Similarly, the probability of being a frequent drinker (≥ everyday) over a non-drinker was 34.3% (1-0.657) lower for retired men than working men, and 59.8% (1-0.402) lower for retired women than working women. Therefore, the association between retirement and drinking was stronger for women than for men in CHARLS.

Table 3. 14 Gender-stratified results of the association between retirement and blood total cholesterol in CHARLS [a].

	Men in CHARLS(*n*=4,337) retired vs. working			**Women in CHARLS(*n*=4,377) retired vs. working**		
	β	**95% CI**	***P***	**β**	**95% CI**	***P***
Total cholesterol, mg/dL	-1.123	-5.004, 2.758	0.571	4.280	0.605, 7.955	0.022

[a] Adjusted for age, age^2, spouse status, highest education, occupation skill level, household total income, household total wealth and urban/rural, smoking status, drinking frequency, depressive symptoms, and medication.

Table 3. 15 Gender-stratified results of the association between retirement and behavioural risk factors in CHARLS.

	Men in CHARLS(*n*=6,469) retired vs. working			**Women in CHARLS(*n*=6,237) retired vs. working**		
	RRR	**95% CI**	***P***	**RRR**	**95% CI**	***P***
Ex-smoker[a]	1.254	0.952,1.651	0.107	0.800	0.498,1.286	0.357
Light/moderate smoker[a]	1.010	0.751,1.358	0.948	1.486	0.964,2.291	0.073
Heavy smoker[a]	0.939	0.691,1.277	0.690	0.878	0.510,1.511	0.637
Drinking< everyday[b]	0.698	0.526,0.925	0.012	0.504	0.369,0.689	<0.001
Drinking≥ everyday[b]	0.657	0.496,0.870	0.003	0.402	0.232,0.695	0.001

[a] Adjusted for age, age^2, spouse status, highest education, occupation skill level, household total income, household total wealth and urban/rural, drinking frequency, and depressive symptoms. Non-smokers are the reference group.

[b] Adjusted for age, age^2, spouse status, highest education, occupation skill level, household total income, household total wealth and urban/rural, smoking status, and depressive symptoms. Non-drinkers are the reference group.

Tables 3.16 and 3.17 show the gender-stratified results in ELSA. In Table 3.16, men and women showed different associations between retirement and DBP, in that retired men had significantly lower DBP level than working men (β=-1.296), but no significant association was found among women. For SBP and blood cholesterol, no significant association with retirement was found in either men or women. In Table 3.17, retired men and women showed a significantly lower likelihood of being a light/moderate smoker, compared to their working counterparts. This association was slightly stronger for men, as retired men showed 43.6% (1-0.564) lower probability of being a light/moderate smoker, and retired women showed 32.3% (1-0.677) lower probability. Besides, retired men also had 51.7% (1-0.483) lower probability of being a heavy smoker, compared to working men, but no such association was found among women.

Table 3. 16 Gender-stratified results of the association between retirement and CVD risk factors in ELSA [a].

	Men in ELSA (*n*=3,802) retired vs. working			Women in ELSA (*n*=4,441) retired vs. working		
	β	**95% CI**	***P***	**β**	**95% CI**	***P***
SBP, mm Hg	-1.392	-3.116, 0.333	0.114	-1.041	-2.890, 0.808	0.270
DBP, mm Hg	-1.296	-2.383, -0.209	0.019	-0.488	-1.577, 0.601	0.380
Total cholesterol, mg/dL[b]	-2.213	-7.222, 2.795	0.386	-0.849	-5.578, 3.880	0.725

[a] Adjusted for age, age^2, spouse status, highest education, occupation skill level, household total income, household total wealth and urban/rural, smoking status, drinking frequency, depressive symptoms, and medication.

[b] *n*=2,607 for men, *n*=3,021 for women.

Table 3. 17 Gender-stratified results of the association between retirement and smoking status in ELSA [a].

	Men in ELSA (*n*=3,802) retired vs. working			Women in ELSA (*n*=4,441) retired vs. working		
	RRR	**95% CI**	***P***	**RRR**	**95% CI**	***P***
Ex-smoker	1.007	0.795, 1.274	0.956	0.872	0.698, 1.089	0.226
Light/moderate smoker	0.564	0.349, 0.908	0.019	0.677	0.452, 1.013	0.058
Heavy smoker	0.483	0.250, 0.935	0.031	1.446	0.705, 2.963	0.314

[a] Adjusted for age, age^2, spouse status, highest education, occupation skill level, household total income, household total wealth and urban/rural, drinking frequency, and depressive symptoms. Non-smokers are the reference group.

3.6.2 Living in urban or rural areas as a moderator

Living in a rural or urban area was tested as a potential moderator the association between retirement and CVD risk factors, and the P values for the interaction term are shown in Table 3.18. In CHARLS, area of residence was a significant moderator (P<0.10) in the associations between retirement and heart diseases (P= 0.022), SBP (P=0.001), DBP (P<0.001), blood total cholesterol (P=0.037), CRP (P=0.022), and drinking less than everyday (P=0.057). In contrast, in ELSA, area of residence was not a moderator for the association between retirement and any CVD risk factor. Area-stratified analyses on the associations between retirement and health outcomes were conducted in CHARLS.

Table 3. 18 Area of residence as a moderator in the association between retirement and health outcomes.

Health outcomes	**CHARLS**	**ELSA**
	P for retire × area	***P for retire × area***
Heart diseases	0.022	0.829
Stroke	0.716	0.443
BMI	0.293	0.886
WC	0.664	0.760
SBP	0.001	0.908
DBP	<0.001	0.565
Total cholesterol	0.037	0.541
CRP	0.022	0.387
HbA1c	0.426	0.518
Ex-smoker[a]	0.206	0.845
Light/moderate smoker[a]	0.163	0.403
Heavy smoker[a]	0.719	0.716
Drinking <everyday[b]	0.057	0.385
Drinking ≥ everyday[b]	0.615	0.804

[a] Never smokers are the baseline group.
[b] Non-drinkers are the baseline group.

Tables 3.19 and 3.20 show the area-stratified results of the association between retirement and CVD related health outcomes in CHARLS. Table 3.19 shows that retired urban and rural dwellers in CHARLS had significantly higher ORs of heart disease than their working counterparts, and this association was stronger for urban dwellers (OR=2.067) than for rural dwellers (OR=1.809). Table 3.20 shows that the coefficients for SBP (β=-3.594, *P*=0.015) and DBP (β=-1.369, *P*=0.084) were negative for urban dwellers, but were positive for rural dwellers (SBP: β=1.333, *P*=0.113; DBP: β=1.767, *P*<0.001). This suggests that retirement may be associated with lower blood pressure for urban dwellers, but the opposite for rural dwellers, although not all the *P* values were significant at the 5% level. Retirement was not associated with blood total cholesterol or CRP among urban dwellers, but was associated with increased blood total cholesterol (β=2.493, *P*=0.088) and CRP (β=0.288, *P*<0.001) among rural dwellers, although its *P* value for total cholesterol was only at borderline significance.

Table 3. 19 Area-stratified results of the association between retirement and heart diseases in CHARLS [a].

	Urban in CHARLS (*n*=4,853) retired vs. working			**Rural in CHARLS (*n*=7,853) retired vs. working**		
	OR	**95% CI**	***P***	**OR**	**95% CI**	***P***
Heart diseases	2.067	1.544, 2.767	<0.001	1.809	1.480, 2.211	<0.001

[a] Adjusted for age, gender, spouse status, highest education, occupation skill level, household total income, household total wealth, smoking status, drinking frequency, and depressive symptoms.

Table 3. 20 Area-stratified results of the association between retirement and CVD risk factors in CHARLS [a].

	Urban in CHARLS (*n*=4,853) retired vs. working			**Rural in CHARLS (*n*=7,853) retired vs. working**		
	β	**95% CI**	***P***	**β**	**95% CI**	***P***
SBP, mm Hg	-3.594	-6.498,-0.691	0.015	1.333	-0.315, 2.980	0.113
DBP, mm Hg	-1.369	-2.924, 0.186	0.084	1.767	0.805, 2.730	<0.001
Total cholesterol, mg/dL [b]	0.891	-4.031, 5.812	0.723	2.493	-0.369, 5.356	0.088
CRP, log mg/L [b]	0.126	-0.059, 0.312	0.181	0.288	0.198, 0.378	<0.001

[a] Adjusted for age, gender, spouse status, highest education, occupation skill level, household total income, household total wealth and urban/rural, smoking status, drinking frequency, depressive symptoms, and medication.
[b] *n*= 2,991 for urban, *n*=5,723 for rural.

3.6.3 Spouse's employment status as a moderator

Tables 3.21 tested the moderating effect of spouse's working status/no spouse in the association between retirement and health outcomes. In CHARLS, spouse's working status may moderate the association between retirement and drinking, in that there was a significant difference in the association between retirement and the probability of drinking every day when comparing retirees with a non-working spouse to those with a working spouse (P=0.012).

In ELSA, spouse's employment status may influence the associations between retirement and WC, smoking, and HbA1c. Compared to people with a working spouse, people without a spouse showed different associations between retirement and WC (P=0.032) and HbA1c (P=0.030), and people with a non-working spouse showed a different association between retirement and risk of being an ex-smoker (P=0.042).

Table 3. 21 Spouse employment status as a moderator in the association between retirement and health outcomes.

Health outcomes	CHARLS		ELSA	
	***P* for retire × non-working spouse**[a]	***P* for retire × no spouse**[a]	***P* for retire × non-working spouse**[a]	***P* for retire × no spouse**[a]
Heart diseases	0.925	0.827	0.149	0.427
Stroke	0.562	0.706	0.758	0.119
BMI	0.526	0.473	0.854	0.241
WC	0.386	0.118	0.384	0.032
SBP	0.810	0.853	0.344	0.632
DBP	0.709	0.619	0.720	0.419
Total cholesterol	0.647	0.445	0.828	0.458
CRP	0.494	0.425	0.836	0.420
HbA1c	0.558	0.379	0.122	0.030
Ex-smoker[b]	0.454	0.977	0.042	0.797
Light/moderate smoker[b]	0.344	0.328	0.418	0.686
Heavy smoker[b]	0.902	0.828	0.861	0.771
Drinking<everyday[c]	0.219	0.926	0.749	0.238
Drinking≥ everyday[c]	0.012	0.224	0.993	0.148

[a] Having a working spouse is the reference group.
[b] Never smokers are the baseline group.
[c] Non-drinkers are the baseline group.

Table 3.22 shows the stratified results of the association between retirement and drinking frequency by spouse employment status in CHARLS. Among people with a working spouse, retired people were less likely to drink, either less than every day (RRR=0.528) or more frequently (RRR=0.400), compared to working people. Similar beneficial association between retirement and drinking frequency was also found among people without a spouse, with a RRR equals to 0.477 for drinking less than every day (*P*=0.001), and a RRR equals to 0.635 for drinking every day (*P*=0.093). Among people with a non-working spouse, retirement seems to be also associated with less drinking (RRR=0.854 for <everyday, RRR=0.868 for ≥everyday), but this association was not statistically significant (*P*>0.4).

Table 3. 22 Stratified results of the association between retirement and drinking frequency by spouse's employment status in CHARLS [a].

	Working spouse in CHARLS (*n*=1,918) retired vs. working			Non-working spouse in CHARLS (*n*=3,373) retired vs. working			Without a spouse in CHARLS (*n*=2,622) retired vs. working		
	RRR	**95% CI**	***P***	**RRR**	**95% CI**	***P***	**RRR**	**95% CI**	***P***
Drinking<everyday	0.528	0.360, 0.773	0.001	0.854	0.586, 1.245	0.411	0.477	0.307, 0.742	0.001
Drinking≥everyday	0.400	0.274, 0.585	<0.001	0.868	0.539, 1.400	0.560	0.635	0.374, 1.079	0.093

[a] Adjusted for age, age^2, spouse status, highest education, occupation skill level, household total income, household total wealth and urban/rural, smoking, and depressive symptoms. Non-drinkers are the reference group.

Table 3.23 shows the stratified results of the associations between retirement and WC and HbA1c by spouse's employment status in ELSA. The coefficient of WC among those not living with a spouse was 1.786, and was negative for other groups (β=-0.397 for having a working spouse, β=-0.182 for having a non-working spouse), which suggested that retirement may be linked to higher WC only for people without a spouse, but none of the associations were statistically significant. Retirement was significantly associated with lower HbA1c level among those with a non-working spouse (β=-0.035, *P*=0.001) and those without a spouse at the 10% significance level (β=-0.021, *P*=0.085), but not among those with a working spouse.

Table 3.24 shows the stratified results of the associations between retirement and smoking status by spouse's employment status in ELSA. Retirement seemed to be associated with lower probability of being an ex-smoker versus a never smoker among people with a working spouse (RRR=0.784) or those without a spouse (RRR=0.773), but was associated with higher probability among people with a non-working spouse (RRR=1.211). This may be the reason why the interaction term of spouse employment was 0.042 in Table 3.21. However, none of the above associations were statistically significant at the 5% level for any group. Retirement was significantly associated with lower probability of being a light /moderate smoker (versus being a never smoker) only among those with a non-working spouse (RRR=0.454, *P*=0.003). Other groups of people seemed to have similar reduced probability of being a smoker after retirement (RRR<1), but they did not reach a statistically significant level.

Table 3. 23 Stratified results of the association between retirement and WC and HbA1c by spouse's employment status in ELSA.

	Working spouse in ELSA retired vs. working (*n*=1,918)			Non-working spouse in ELSA retired vs. working (*n*=3,373)			Without a spouse in ELSA retired vs. working (*n*=2,622)		
	β	**95% CI**	***P***	**β**	**95% CI**	***P***	**β**	**95% CI**	***P***
WC, cm [a]	-0.397	-2.101,1.307	0.648	-0.182	-1.655,1.291	0.809	1.786	-0.383,3.956	0.107
HbA1c, log mmol/mol [b]	-0.005	-0.021, 0.011	0.544	-0.035	-0.055,-0.014	0.001	-0.021	-0.045,0.003	0.085

[a] Adjusted for age, age^2, highest education, occupation skill level, household total income, household total wealth and urban/rural, smoking, drinking, and depressive symptoms.
[b] Further adjusted for taking medications for diabetes. Sample size for each group is 1,419, 2,320, and 1,680.

Table 3. 24 Stratified results of the association between retirement and smoking status by spouse's employment status in ELSA[a].

	Working spouse in ELSA retired vs. working (*n*=1,918)			Non-working spouse in ELSA retired vs. working (*n*=3,373)			Without a spouse in ELSA retired vs. working (n=2,622)		
	RRR	**95% CI**	***P***	**RRR**	**95% CI**	***P***	**RRR**	**95% CI**	***P***
Ex-smoker	0.784	0.588, 1.045	0.097	1.211	0.939, 1.562	0.140	0.773	0.550, 1.087	0.139
Light/moderate smoker	0.652	0.374, 1.136	0.131	0.454	0.272, 0.759	0.003	0.910	0.550, 1.506	0.714
Heavy smoker	0.697	0.249, 1.930	0.482	0.633	0.277, 1.448	0.279	0.673	0.289, 1.567	0.358

[a] Adjusted for age, age^2, highest education, occupation skill level, household total income, household total wealth and urban/rural, drinking, and depressive symptoms. Never smokers are the baseline group.

3.7 Discussion of the chapter

The cross-national comparison between China and England in this chapter found that there are some similarities and differences between the two countries in terms of retirement and CVD/CVD risk factors. In both datasets, women retired earlier than men. The median retirement age in the Chinese data was 5 years earlier than the English data, and the gender and urban-rural differences in retirement age were larger in China. Compared to the Chinese participants, the English participants are less likely to be never-smokers and non-drinkers, and less healthy, with the possible exception of depressive symptoms.

The multivariate results show that, in both datasets, retired people had a higher risk of heart disease and stroke than their working counterparts did, and effects of these associations seemed to be stronger in China. No association between retirement and blood total cholesterol was found in either country. Several country-level differences in the association between retirement and CVD risk factors were also found. In CHARLS, retired people had higher levels of BMI, WC, and CRP compared to those in paid work. However, in ELSA, retired people had lower levels of blood pressure and HbA1c than their working counterparts. Therefore, it seems that retired people in China had higher levels of CVD risk factors than those in paid work, but the contrary is the case in England. One general limitation of the cross-sectional study design is that results can be biased because of reverse causality. People are more likely to choose retirement when their health deteriorates, especially when they had a heart disease or a stroke, so when comparing retired people with those in paid work, the association between retirement and disease is likely to be overestimated. Thus, the cross-sectional results here can lend itself to two opposite formulations. One is that retirement may be associated with having more CVD risk factors in China, but with fewer risk factors in England. On the other hand, the results may partly reflect that poor health condition plays a more important role in retirement decision in the Chinese context. To better understand the association between retirement and CVD related health outcomes, longitudinal study design will be applied in later chapters of this thesis.

In terms of behavioural risk factors, retirement was associated with a reduced likelihood of being a smoker in ELSA, and was associated with a reduced likelihood of being a drinker in CHARLS. Reverse causality may be less of a problem in this case, as healthier behaviours are unlikely to trigger retirement. Thus, the results here indicate that retirement may provide an opportunity for healthier lifestyle in both China and England. It is interesting to see that retirees chose different healthy behaviours in different countries, that Chinese retirees were less likely to drink, and English retirees choose to smoke less. This may be due to different social norms about smoking and drinking in these two countries. It has been described in the background section that only 23.2% of Chinese adults believe smoking causes stroke, heart attack, and lung cancer, and the majority of smokers (75.6%) do not intend to quit smoking (Jiang et al., 2010); therefore, retirees in China may not choose to quit smoking because of the poor public awareness of health risks of smoking. As for drinking, a study among older people (60-96 years) in Japan suggested that alcohol consumption tends to drop significantly with non-working people, and the authors ascribed the use of alcohol as a 'social lubricant' within Japanese work culture (Gee et al., 2007). China shares a drinking culture similar to that in Japan. Alcohol is commonly used, particularly by Chinese men, in business meetings and at social events to initiate business partnerships, or to establish good networks between employees (Cochrane et al., 2003; Hao and Young 2000). Thus, it is possible that Chinese are less likely to drink alcohol after retirement.

This study also tested the moderating role of several important characteristics, including gender, area of residence, and spouse's employment status. In CHARLS, compared to men, women had a stronger detrimental association with blood total cholesterol, but also a stronger beneficial association with drinking frequency. In ELSA, men had stronger beneficial associations with DBP and smoking than women. Results from this cross-national comparison study indicate that gender differences in associations between retirement and CVD risk factors may differ in the two countries. It is still unclear about the underlying social-demographic mechanisms of these country-level differences. However, in terms of drinking, it is possible that some Chinese women only drink in the workplace, but they may want to reduce or stop drinking after retirement, because they do not want to break established norms and values imposed on women in China regarding drinking, but this is less the case for English women. Urbanisation played a key role in China, as retirement had stronger detrimental associates with SBP, DBP, CRP, and blood total cholesterol among rural dwellers than among urban dwellers, and retirement was even associated with lower blood pressure for urban dwellers. One possible exception is the result of heart disease, which was stronger for urban dwellers, but this result may be biased due to lack of access to health services compared with urban dwellers. In contrast to China, urban-rural differences were not observed in ELSA. Spouse's employment status also moderated the association with drinking frequency in CHARLS, in that retirees with a working spouse or without a spouse had significantly lower probability of being a drinker than their working counterparts, but this was not observed among retirees who lived with a non-working spouse. One possible explanation is that retirees in China may be more likely to drink with non-working spouse than retirees with a working spouse or without a spouse. In ELSA, the retirees had lower level of HbA1c and were less likely to be a light/moderate smoker than their working counterparts, and these associations were stronger for people with a non-working spouse. This is likely because a non-working spouse may provide companionship and social supports, thus improve health of retirees. In summary, gender and spouse's employment could influence the association between retirement and health outcomes in both China and England, but urbanisation and seemed to be only important in the Chinese retirement context.

In terms of adjusting for the treatment effects of hypertension, diabetes, or high blood cholesterol, this study included medication/treatment as a binary covariate in the regression. Whether this method can effectively take into account of the treatment effects is still unclear. So this study conducted a sensitivity analysis without adjusting for medication/treatment, and the results show that the general conclusion was the same as main analysis, despite that some of the coefficients have changed (Appendix 3.3a). Some research has suggested other possible methods for adjusting for those on medication (Tobin, 2005). For example, the addition of a sensible constant to the observed BP in treated subjects has been widely used in the literature (e.g. Cui et al., 2003). However, this method has been mainly based on antihypertensive therapy, and there are no standard values to add for adjusting for diabetes and high blood cholesterol treatment. Another possible method is to assume right censoring on the observed readings for treated individuals (Tobin, 2005). This method avoids the need to make assumptions about the size of the treatment effect. These methods might be useful in regular regressions, and how well will it perform in a piecewise multilevel model with imputed dataset is unknown, but it will certainly make the current model in this study more complex.

Another sensitivity analysis was conducted in CHARLS by comparing those in paid work with those who completed retirement procedures. The detrimental associations with heart diseases and stroke become stronger, and the beneficial association with drinking frequency become less strong, but the general conclusion was the same as main analysis (Appendices 3.3b to 3.3d).

Smoking status, alcohol consumption and mental health were also included as covariates in the fully adjusted model. These variables are likely to be associated with the decision of retirement, but also may be influenced by retirement. Adjusting for these variables may lead to overadjustment, so the associations found in the fully adjusted model maybe underestimated. However, in this study, the coefficients in the fully adjusted model are often close to those in Model 2 (adjusted for socio-demographic covariates), thus did not largely changed the *P* values.

To sum up, the main purpose of this cross-sectional study was not to test the effect of retirement on health outcomes, but rather this chapter aims to understand the similarities and differences between China and Western countries, more specifically England, in terms of retirement and CVD/CVD risk factors. Of course, a single dataset from England cannot really represent all Western countries, but it can point to which factors may influence the decision to retire and the health effects after retirement in a specific domestic context, and can provide useful information for the longitudinal analysis in the later chapters.

Chapter 4: Methods in Testing the Longitudinal Associations between Retirement and CVD Risk Factors in China

4.1 Introduction

When studying the association between retirement and CVD or its risk factors, it is important to consider healthy worker effects, as poor health may be a determinant of retirement (Disney et al., 2006), especially early retirement (Karpansalo et al., 2004). So cross-sectional designs, such as that used in Chapter 3, cannot demonstrate the direction of effects of retirement on CVD outcomes, and results can be seriously biased due to reverse causality. Longitudinal studies with repeated measures provide an opportunity to investigate the direction of effects. To our knowledge, there is no longitudinal study in China that has examined the effects of retirement on CVD risk factors. Therefore, this chapter aims to examine the longitudinal associations between retirement and objective measures of cardiovascular risk factors, as well as self-reports of behavioural risk factors (Aim 2).

Standard methods used in the longitudinal studies, such as comparing retirees with those continued to work and adjusting for baseline health conditions, cannot fully take account of the healthy worker effects, as health conditions of individuals may change over time. In the literature, there are three methods applied in longitudinal studies seeking to take account of this issue. First, IV analysis has been used in investing the effects of retirement on CVD (section 2.5.3) and other non-CVD health outcomes (section 2.4.6). This method controls for confounding through the use of an IV related to the exposure but not to an individual's background characteristics, and is therefore is better able to take account of healthy worker effects and to estimate causal effects of retirement on health outcomes. As mentioned in section 2.5.4, a limitation of the IV analysis is that its results only apply to the subsample who retired induced by the IV. The SPA is widely used as the IV in the literature. In the Chinese context, rural residents who mainly work in self-employed agriculture-related activities are not restricted by the statutory retirement ages. More importantly, there is no state pension age for them. Thus, there is no appropriate IV related to retirement in rural China. Understanding the urban-rural difference is a key reach aim of this thesis, thus IV analysis was not used in this thesis. The second method is propensity score matching, which has been used in investigating the effect of retirement on CVD in the literature (e.g. Behncke, 2012). This method controls for selection bias by 'matching' similar individuals on the basis of a set of observable background covariates. Detailed information of factors that may lead to retirement, such as working environment and other job characteristics as well as eligibility for pension and health insurance are needed for inclusion in a propensity score approach in order to better control the confounding factors. However, such information is not collected in the longitudinal survey in China. The third method is to compare the trajectories of health outcomes before and after the statutory retirement age among the same group of people, so called piecewise regression. Using this method, one French study found that coronary heart disease and stroke were not influenced by retirement (Westerlund et al., 2010); a Finnish study showed that purchases of diabetes medication were not altered by retirement (Oksanen et al., 2011); and an American study showed that post-retirement BMI did not change in white-collar employees, but increased in blue-collar workers (Gueorguieva et al., 2011). This method can largely reduce the healthy worker effects because retirees are compared with themselves rather than with those still working. One limitation of this piecewise method is that there may be still some unobserved differences of sample characteristics before and after retirement that are not controlled for in this method. Therefore, this method may perform less well in handing the healthy worker effects and other bias compared to IV analysis. However, considering IV analysis is not suitable to answer the research questions of this study in this particular sample, piecewise regression was used in this chapter.

Analyses were carried out in a 20-year prospective population study in China (section 4.2). Continuous outcome risk factors included objectively measured SBP, DBP, BMI, and WC. Categorical outcome risk factors included self-reports of current smoking status and alcohol consumption. These risk factors were chosen based on their ability to predict CVD, and the measures of risk factors are described in section 4.3. Using two-segment piecewise regressions, we tested whether the trajectories of risk factors differ before and after retirement to understand the potential long-term associations between retirement and risk factors (section 4.4). Missing outcomes and missing covariates of the included participants were multiply imputed in R software using multivariate imputation by chained equations (section 4.5), and results from the imputed data are shown in section 4.6. Two sensitivity analyses were conducted in section 4.7. The first sensitivity analysis excluded participants who went back to work after retirement, and the second sensitivity analysis added participants who move from working to doing housework. Results are summarised and discussed in section 4.8.

4.2 Data and analytic sample

4.2.1 Data: The China Health and Nutrition Survey (CHNS)

Analyses in this chapter were conducted using the CHNS. This cohort survey included residents of any age from nine provinces (Heilongjiang, Liaoning, Shandong, Henan, Jiangsu, Hubei, Hunan, Guizhou and Guangxi) from north to south in China (Map 4.1), which vary substantially in economic development, public resources, and health indicators. The baseline wave was conducted in 1989, and eight further waves were conducted in 1991, 1993, 1997, 2000, 2004, 2006, 2009 and 2011. Heilongjiang province was not included in the first three waves (1989, 1991, and 1993), and Liaoning province did not participate the survey in 1997 due to a natural crisis. Both Liaoning and Heilongjiang were followed on all subsequent waves. In the most recent wave in 2011, three mega cities (Beijing, Shanghai, and Chongqing) were added into the survey (Zhang et al., 2014). Questionnaires and anthropometric data were collected in each wave, but biomarker data were only collected in 2009.

The CHNS provides a good opportunity to understand how socio-economic factors affected health and health behaviours under different environments in China. It used a multistage, random cluster design: two cities (usually the provincial capital and a lower-income city) and four rural counties (one high-income, two middle-income, and one low-income) were randomly selected in each province. A total of 190 sampling units, including 32 urban communities and 30 suburban communities within cities, and 32 townships and 96 rural villages within counties, were randomly selected in 1989. Within every sampling community, 20 households were randomly selected, and all individuals in each household were interviewed (Popkin et al., 2010). So 15,462 individuals from 3,790 households were selected in 1989, with an average of four people (2.8 adults) in each household. In 1997, 24 sampling units from Heilongjiang province were included, and replenishment samples were recruited then if a primary sampling unit had less than twenty households or if participants had formed a new household or separated from their family into a new place in the same sampling unit (Popkin et al., 2010). In the most recent wave in 2011, the sampling units have increased to 288 after the three mega cities (Beijing, Shanghai, and Chongqing) were added (Zhang et al., 2014).

Map 4. 1 Participating provinces in the CHNS.

In the CHNS, 60% of individuals who participated in 1989 remained in the ninth wave in 2011, and the response rate was 80-88% across all waves relative to the previous round of data collection (Zhang et al., 2014).

Survey proposals and the process for obtaining informed consent for the CHNS were approved by the institutional review committees of the University of North Carolina at Chapel Hill, the National Institute of Nutrition and Food Safety, and the China Center for Disease Control and Prevention. Written informed consent was obtained from each participant before any data were collected.

4.2.2 Analytic Sample

The purpose of this study is to observe change in health outcomes before and after retirement in the CHNS longitudinally. The three newly added mega cities in 2011 were not eligible for this longitudinal purpose, thus were not used. The 1989 wave was not used either, as it only collected anthropometric data from people aged 20 to 45 due to constraints of funding.

Among 22,861 adult participants, I identified 1,121 people who moved from 'working' to 'retired' between 1991 and 2011. In other words, they participated in the study at least once prior to and once after the time of retirement. Thirty-seven people who retired before age 45 were excluded. As mentioned in previous chapters, the current statutory retirement age in China is 60 years for men, and 50 to 55 years for women. Some companies offer early retirement up to 5 years before the statutory age, in which case the earliest possible statutory retirement age is 45 years in China (Giles et al., 2011). Although those who are self-employed or working in informal sectors do not have to wait until statutory retirement age, retiring before age 45 is rare and would most likely be due to poor health. Therefore, the analytic sample included 1,084 people (636 men and 448 women) with 5,921 observations. WC and alcohol consumption were collected from 1993 onwards (see details in 4.3.2), and missing outcomes in 1991 were not multiply imputed (see details in 4.5.3). When modelling these two outcomes, only 970 individuals who retired in 1997 or later were included. This ensured that included individuals had information of WC and alcohol consumption at least once before and once after retirement.

4.3 Measures

This section describes the measures of the exposure variable, outcome variables and covariates, respectively.

4.3.1 Exposure variable: Year centred on retirement

'Year centred on retirement' was used as the key exposure variable of interest in this chapter, and it was calculated as the interview year minus the year of retirement.

To generate this variable, a very important stage was to ensure the definition of 'retirement' was precise. In each interview, participants were asked whether they were currently working. If currently not working, participants were asked to give the reason with optional categories of ‘seeking work’, ‘doing housework’, ‘disabled’, ‘student’, ‘retired’, and ‘other’. In this chapter, ‘retirement’ was defined as those individuals who give ‘retired’ as the reason for currently not working.

In every wave from 1997 onwards, year of retirement was asked among retirees. The first answer after retirement was used to reduce recall bias. The mid-year between the working wave and the retired wave was used for 49 individuals who did not report their year of retirement, and for 36 individuals who only participated in 1991 and 1993.

4.3.2 Outcome variables

This study assessed six cardiovascular risk factors: SBP, DBP, WC, BMI, current smoking status, and alcohol consumption. Stroke and myocardial infarction were not included as outcomes because of the small number of people who had ever been diagnosed with. In the CHNS, WC and alcohol consumption status were collected from 1993 onwards, and other outcomes were collected from 1991 onwards. (In 1991, the frequency of drinking alcohol was measured, but the amount of alcohol consumed was not.)

SBP and DBP

In this chapter, values of SBP and DBP were used as two continuous outcomes. In the CHNS, blood pressure was taken on the right arm after a 10 minutes seated rest by trained health workers using mercury sphygmomanometers with appropriate cuff sizes. SBP was measured at the first appearance of a pulse sound and DBP at the disappearance of the pulse sound. For each participant, blood pressures were measured three times (Yan et al., 2012; Tuan et al., 2010). Consistent to the cross-sectional analyses in previous chapters, SBP and DBP were calculated using the mean of the last two measurements (Godet-Mardirossian et al., 2012). The first measurement was not used, as participants' blood pressure could be raised due to feeling nervous at the beginning. No outlier was found in the blood pressure data, as it had been cleaned before it was released. The SBP ranged from 70 to 232 mm Hg, and the DBP ranged from 42 to 146 mm Hg.

BMI and WC

This study used BMI to measure general obesity and chose WC as an indicator of central obesity. BMI (kg/m^2) was calculated as weight divided by height squared. In the physical examinations, weight (kg) was measured without shoes and in lightweight clothing to the nearest 0.1 kg on a calibrated SECA 880 scale. Height (m) was measured without shoes to the nearest 0.1 cm using a SECA 206 wall-mounted metal tape (Yan et al., 2012; Popkin et al., 1995; Tuan et al., 2010). WC (cm) was measured using a non-elastic tape at the point midway between the iliac crest and the lower border of the costal margin and in a horizontal plane (Tuan et al., 2010). BMI and WC were kept as continuous variables in this chapter, as using cut-offs for obesity cannot capture the effects of retirement if they did not reach a clinical level.

After looking into their distributions, BMI values less than 10 or bigger than 60 were considered as outliers, and were recoded to missing (*n*=8). WC values less than 40 cm were recoded to missing (*n*=5), so WC ranged from 40 to 130 cm in the data.

Smoking status

Current smoking status (yes/no) and the number of cigarettes smoked per day were asked in the CHNS questionnaire. Between 1991 and 2011, 68% of the observations are non-smokers. In addition, the self-reported number of cigarettes smoked per day tended to be grouped at 10 cigarettes (half pack) and 20 cigarettes (a pack). As a result, it was not appropriate use number of cigarettes smoked per day as a continuous variable. In addition, self-reports of smoking history were not consistent across waves. For example, some people said they never smoked, but reported being current smokers in previous waves. So, current smoking status at each wave was used in the analysis. Using the same cut-off points applied in the cross-sectional analysis in the previous chapter, smoking status was divided into current non-smoker (combined ex-smoker and never smoker), current light/moderate smoker (<20 cigarettes per day), and current heavy smoker (>=20 cigarettes per day) (Barua et al., 2002). Light and moderate smokers were combined because of small numbers.

Alcohol consumption

In the questionnaire from 1993 onwards, participants were asked how much they drank on average each week in the last year, separately for beer, wine, and liquor. A total amount of pure alcohol consumed per week was calculated assuming the following alcohol content by volume (v/v): 4% for beer, 15% for wine, and 53% for liquor (Yang et al., 2012). As the distribution of alcohol consumption was highly skewed (77% are non-drinkers between 1993 and 2011), it was categorised into: non-drinker, light/moderate drinker (<60 g/day for men, <40 g/day for women), and heavy drinker (≥60 g/day for men, ≥40 g/day for women) (Rehm et al., 2004). Eight grams of pure alcohol are equal to one UK unit (Department of Health, 1995), thus light/moderate drinker would be those who consume less than 7.5 units/day among men and less than 5 units/day among women. Heavy drinkers are those drinking more than this level.

4.3.3 Covariates

Gender, highest educational qualification, and province were included as covariates. Other time-fixed covariates based on the last response before retirement were spouse's working status/no spouse in the household, occupation skill level, physical activity level in the workplace, and household income. Smoking status, alcohol consumption, and BMI were also included as time-fixed covariates based on the pre-retirement time point, except when they themselves were the key outcomes of regressions. Time-varying community urbanisation index was included as well. When modelling blood pressure as an outcome variable, an indicator of whether participants were taking antihypertensive medicines was included as a time-varying covariate. Age at retirement was used to adjust for the age effects at each time point, and age at 1991 was used to control for the period effects.

These covariates are most probably linked to each individual's decision to either keep working or retire at the year of interview, and are closely related to the risk factors of interest, and yet are not on the hypothesised causal pathway between retirement and outcomes. They may confound the associations between retirement and the risk factor outcomes, thus are often adjusted in the literature. This section describes the reason for choosing each covariate and the measures of each covariate.

Gender

Due to the compulsory retirement age in China, women on average retire much earlier than men (cross-sectional results in Chapter 3). Also, men are suggested to have greater risk of CVD than pre-menopausal women (Finegold et al., 2013). While some studies have argued that some CVD risk factors, such as diabetes and hypertension carry a greater risk for CVD in women than in men (Regitz-Zagrosek et al., 2007; Van Lennep et al., 2002). Considering men and women differ in both retirement behaviour and the development of CVD and CVD risk factors, it is thus important to include gender as a covariate in the analysis.

Age at retirement

Age can influence health, for example, in the process of ageing, our bodies accumulate changes in the vascular wall, which lead to a loss of arterial elasticity and compliance and may subsequently lead to CVD (Jani and Rajkumar, 2006). Age is also one the most important determinants of retirement, especially in China where retirement age is compulsory.

This chapter included retirement age as a covariate to adjust for the age effects at each time point. This is because all the analyses in this chapter were centred at the year of retirement (see details in section 4.4), and including retirement age as a covariate can effectively adjust for the age differences between participants at each time point.

Age at 1991

Different birth cohorts may have different retirement behaviour. More importantly, fast economic development in a relatively short period is accompanied by rapidly increasing prevalence of conventional CVD risk factors in China (Yusuf et al., 2001). This chapter included age at 1991 as a covariate to control for the possibility of period effects that may be influential for particular age cohorts.

So far, both ‘age at 1991’ and ‘age at retirement’ were included as covariates, and ‘year centred on retirement’ is our exposure variable. So we will know ‘age at each wave’ from the following equations:

age at 1991= 1991-birthyear

age at retirement= retirement year-birth year

year since retirement= wave-retire year

age at each wave= wave-birth year

Thus, age as a time varying variable has been effectively included with the inclusion of the terms above.

Highest educational qualification

Education level has been linked to both retirement behaviour (Banks, 2006) and CVD risk factors in both the literature (Mensah et al., 2005; Winkleby and Jatulis, 1992) and the cross-sectional results in Chapter 3.

This chapter included participants' highest educational qualification as a covariate, with six categories: no school completed, primary school completed, middle school completed, high school diploma, technical degree, and university degree or higher. If the last answer of the education level is not the highest education level arcoss all waves, it was treated as an error and the most frequenct answer was used.

Household income

Results from Chapter 3 suggest that associations exist between people’s financial situation, their retirement behaviour and their health in later life. This is also seen in the literature (Banks and Casanova, 2002). The CHNS did not collect information about household wealth, but it collected detailed information about household income. So the last measure of household income before retirement was used as a covariate in the analysis. There are questions about nine potential sources of income in the questionnaire: business, farming, fishing, gardening, livestock, non-retirement wages, retirement income, subsidies, and other income. In each source of income, the amount of revenue and expenses was collected. A derived household income variable was calculated as the sum of all sources of revenue and minus expenditures. Per capita household income was applied to account for the household size, and per capita household income was deflated by the yearly consumer price index in China (in 1991 RMB) to control for price inflation during the 20-year data collection period (National Bureau of Statistics of China, 2014b).

The inflated per capita household income was skewed, thus was log transformed to achieve a normal distribution. Twenty four people with zero or negative income were given a value of 0.001 before the log transofrmation.

Urbanicity

China has large urban-rural differences in retirement ages and as well as the prevalence of CVD risk factors. Thus, it is necessary to adjust the level of urbanicity. The CHNS has a unique measure of urbanicity that captures 12 dimensions: population density; economic activity; traditional markets; modern markets; transportation infrastructure; sanitation; communications; housing; education; diversity; health infrastructure; and social services. This chapter included the community urbanisation index as a time-varying covariate in the model.

Provinces

As mentioned previously, the nine provinces in the CHNS vary substantially in geography, economic development, public resources, and health indicators. For example, one cross-sectional survey in a nationally representative sample of 15,540 Chinese found that the prevalence of the metabolic syndrome and overweight was higher in northern than in southern China (Gu et al., 2005). In addition, different provinces in China tend to have different local policies that can influence individual retirement decisions. Thus, residential province may be linked to both retirement behaviour and CVD, and was included as a covariate in the model.

Occupation skill level & workplace physical activity level

There is considerable evidence that workplace characteristics are important for health and wellbeing across the life course, and employment grade and type are commonly used for measuring workplace characteristics (McFadden et al., 2008; Warr et al., 2004; Broersen et al., 1996; Chandola et al., 2007). For instance, Marmot et al. (1997) found men and women in the lowest grade of occupation (clerical and office-support staff) were about 1.5 times more likely to develop new coronary heart disease, compared to those in the highest grade of occupation class (administrators). Seitsamo et al. (2007) found that manual older workers had the lowest levels of both mental and functional wellbeing. Alongside expected occupational differences in health and wellbeing, a relationship between job characteristics and retirement decisions might exist, with those in manual jobs less inclined to continue working due to stressful and physically demanding roles, and those in less physically demanding occupations may be more likely to delay retirement independent of income (Banks and Casanova, 2002). The compulsory retirement age at 50 years for blue-collar women in China also triggers retirement at an early age for female manual workers. This study included occupation skill level and workplace physical activity level at the time point before retirement as two covariates to adjust for the effects of workplace characteristics.

The CHNS asked about occupation at each wave, but so far, China does not have a standard socio-economic classification of occupation. In this chapter, occupation was classified into four groups according to the skill level in the International Standard Classification of Occupations (ISCO). ISCO is one of the main international classifications for which International Labour Organization is responsible, and it provides a basis for the international reporting and comparison. It categorizes occupations into 10 major groups and combines these 10 groups into four skill levels, from high to low are: 'managers and professional', ' technicians and associate professionals', 'clerical support workers, services and sales workers, skilled agricultural, forestry and fishery workers, craft and related trades workers, plant and machine operators, and assemblers', and 'elementary occupations' (ILO, 2012).

The CHNS data also measured self-reported workplace physical activity level at each wave, with five binary categories ‘very light’, ‘light’, ‘moderate’, ‘heavy’, and ‘very heavy’. In this chapter, ‘heavy’, and ‘very heavy’ were combined due to small number.

Partner’s employment status/no partner

Living with a partner is important for one's health. A large body of literature suggests that marriage promotes health and increases longevity, especially for men (Kiecolt-Glaser and Newton, 2001; Rendall et al., 2011; Waite, 1995), although these benefits may not extend to maintaining a healthy body weight (Fitzgibbons Shafer, 2010; Wilson, 2012). Widowhood is the main reason for living without a partner for the participants in this chapter, and losing a partner can undermine one's health and increase risk behaviours (Williams, 2004).

Sometimes retirement is a joint household decision rather than an individual decision. Older people who have a partner are more likely to continue to work than those without a partner in the household (Whiting, 2005; Szinovacz and Davey, 2004). This is likely to be because people desire to retire at the same time as their partner (Humphrey et al., 2003; Whiting, 2005). For example, women in the UK, who have a younger SPA than men, are more likely to wait until their partner leaves the workforce before doing so (Banks et al., 2006). Similarly, in the Chinese context, people are more likely to work if their spouse is also working (Giles et al., 2011). This study adjusted for whether respondents had a spouse or partner and, if they had a spouse or partner, the spouse or partner's working status, with three categories 'having a working spouse', 'having a non-working spouse', and 'have no spouse in the household'.

Smoking status, alcohol consumption, & BMI

On one hand, smoking status, alcohol consumption status, and BMI are important CVD risk factors, and this thesis aims to test their changes before and after retirement (section 5.3.2). On the other hand, they can be important covariates in the association between retirement and CVD risk factors. For example, compared to non-smokers smokers, current smokers are more likely to be drinkers (Falk et al., 2006), to have lower body weight (Huot et al., 2004; Molarius et al., 1997), and to have higher risk of having CVD and CVD risk factors (Lakier, 1992; Price, 1999), and to take disability retirement or early retirement (Koskenvuo et al., 2011; Lund et al., 2001; Rothenbacher et al., 1998).

This chapter includes the last measure before retirement of smoking status, alcohol consumption and BMI as covariates, except when they themselves were the key outcomes of regressions. The detailed measures of these three variables were already shown in section 4.3.2.

Taking antihypertensive medicines

The CHNS has an indicator of whether participants were currently taking antihypertensive medicines. When modelling blood pressure as an outcome variable, this indicator was included as a time-varying covariate to adjust for the treatment effect.

4.4 Analytic techniques

This section first describes the piecewise regression. After that, it documents the potential clustering of the data, and how multilevel modelling was used to take account of clustered data in this longitudinal study. In addition, this section describes the how the trajectories of each risk factor both before and after retirement were generated, and how the missing data was multiply imputed.

4.4.1 Piecewise regression

Piecewise regression is a method in regression analysis in which the independent variable is partitioned into intervals and a separate line segment is fit to each interval. Therefore, it is also known as segmented regression, spline regression or broken-stick regression. The points which joint the segments are referred to as 'break points' or 'knots'.

This study applied piecewise linear regression for continuous outcomes and piecewise logistic regression for categorical outcomes in Stata, with two splines separated at the year of retirement. Piecewise linear regression with two segments separated by a 'knot' is the most basic piecewise regression, but it very useful to test a change of the response function (*Y*) of a varying independent variable (*X*) (Roebuck, 2012; Weisberg, 2005). By testing the differences in the slopes of regression lines before and after retirement, we can evaluate whether CVD risk factors are associated with retirement. This method assumes the regression lines can change directions but not intercepts at the joint point. We tested this assumption by including a dummy variable (0 before retirement, 1 after retirement) into the model. No significant result for this variable was found for any of the CVD risk factors (results are shown in Table 4.1), suggesting there was no intercept change.

Table 4. 1 Intercept changes of CVD risk factors at the year of retirement in the CHNS.

	β of intercept change	**95% CI**	***P***
SBP	-0.393	-1.690,0.904	0.55
DBP	-0.227	-1.055,0.600	0.59
WC	-0.233	-0.819,0.352	0.44
BMI	-0.008	-0.189,0.174	0.94
Smoking status			
Light/moderate versus Non	0.077	-0.219,0.373	0.61
Heavy versus Non	-0.035	-0.078,0.009	0.12
Alcohol consumption			
Light/moderate versus Non	-0.170	-0.425,0.084	0.19
Heavy versus Non	-0.200	-0.659,0.259	0.39

In this chapter, we tested whether trajectories of risk factors follow different paths prior to- and following- retirement by examining differences in the slopes of the trajectories segmented at retirement (i.e. the ‘knot’). All the trajectories were centred at the year of retirement (i.e. year 0). This piecewise method can reduce the likelihood of reverse causality, as it looks at the slope change before-and-after retirement rather than the values themselves. If someone is retired due to increased cardiovascular risk factors, it would increase the mean values of trajectories but not the slopes. Using a 20-year follow up from 1991 to 2011 allows an up to 19-year observation period both before (i.e. years -19 to -1) and after (i.e. years +1 to +19) retirement. However, because of the small sample size at the first and last two years of observation, I only analysed -17 to +17 years. The number of observations in each year is shown in Appendix 4.1. This 34-year observation period was then converted to a positive variable by adding 17. In order to aid visualization of the results, Stata’s *marigns* command was used to draw the graphs of results, and the *marigns* command does not work when the independent variables have negative values.

After that conversion, the observation period was partitioned into two variables, i.e. X_1 and X_2, by using Stata's *mkspline* command, with the *marginal* option. This option allows examining the retirement related slope changes (i.e. post-retirement slope minus pre-retirement slope), rather than the slopes themselves. For each risk factor, I report coefficients for slope before retirement (X_1) and for slope change post retirement (X_2). A statistically significant coefficient of X_2 suggests trajectories of risk factors follow significantly different paths before and after retirement at the 5% level. The coding of X_1 and X_2 are shown in Table 4.2.

Table 4. 2 Coding of the piecewise exposure variables in the CHNS.

Years centred on retirement	X_1	X_2
-17	0	0
-16	1	0
-15	2	0
-14	3	0
-13	4	0
-12	5	0
-11	6	0
-10	7	0
-9	8	0
-8	9	0
-7	10	0
-6	11	0
-5	12	0
-4	13	0
-3	14	0
-2	15	0
-1	16	0
0	17	0
1	18	1
2	19	2
3	20	3
4	21	4
5	22	5
6	23	6
7	24	7
8	25	8
9	26	9
10	27	10
11	28	11
12	29	12
13	30	13
14	31	14
15	32	15
16	33	16
17	34	17

These health outcomes may not grow with years linearly, so quadratic terms for the two segments were included in the model, if Wald tests (Stata command is *test*) showed a better fit with them.

For continuous outcomes, including SBP, DBP, BMI, and WC, piecewise linear regression was used. For nominal outcomes, including smoking status and alcohol consumption status, piecewise multinomial logistic regression was used.

In multinomial logistic models, a set of coefficients were estimated for each category of the outcome. For example, when alcohol consumption is the outcome *y*. $\beta^{(1)}$, $\beta^{(2)}$, and $\beta^{(3)}$ are the coefficients corresponding to non-drinkers (*y*=1), light/moderate drinkers (*y*=2), and heavy drinkers (*y*=3). The following equations show how the probability of each drinking status was calculated.

$$\Pr(y=1) = \frac{e^{X\beta^{(1)}}}{e^{X\beta^{(1)}} + e^{X\beta^{(2)}} + e^{X\beta^{(3)}}}$$
$$\Pr(y=2) = \frac{e^{X\beta^{(2)}}}{e^{X\beta^{(1)}} + e^{X\beta^{(2)}} + e^{X\beta^{(3)}}}$$
$$\Pr(y=3) = \frac{e^{X\beta^{(3)}}}{e^{X\beta^{(1)}} + e^{X\beta^{(2)}} + e^{X\beta^{(3)}}}$$

One category will be chosen as the reference group. Here, we chose non-drinkers as the reference, and its $\beta^{(1)}$ was set to 0. So the equations become:

$$\Pr(y=1) = \frac{1}{1 + e^{X\beta^{(2)}} + e^{X\beta^{(3)}}}$$
$$\Pr(y=2) = \frac{e^{X\beta^{(2)}}}{1 + e^{X\beta^{(2)}} + e^{X\beta^{(3)}}}$$
$$\Pr(y=3) = \frac{e^{X\beta^{(3)}}}{1 + e^{X\beta^{(2)}} + e^{X\beta^{(3)}}}$$

The relative probability of being a light/moderate drinker versus a non-drinker is:

$$\frac{\Pr(y=2)}{\Pr(y=1)} = e^{X\beta^{(2)}}$$

This ratio is called the relative risk. Assume that X and $\beta^{(2)}_k$ are vectors equal to (x_1, x_2, . . . , x_k) and ($\beta^{(2)}_1$, $\beta^{(2)}_2$, . . . , $\beta^{(2)}_k$), respectively. The relative risk becomes

$$\frac{\Pr(y=2)}{\Pr(y=1)} = e^{\beta_1^{(2)}x_1+\cdots+\beta_i^{(2)}x_i+\cdots+\beta_k^{(2)}x_k}$$

The ratio of the relative risk of being a light/moderate drinker versus a non-drinker for a one-unit change in x_i is then

$$\frac{e^{\beta_1^{(2)}x_1+\cdots+\beta_i^{(2)}(x_i+1)+\cdots+\beta_k^{(2)}x_k}}{e^{\beta_1^{(2)}x_1+\cdots+\beta_i^{(2)}x_i+\cdots+\beta_k^{(2)}x_k}} = e^{\beta_i^{(2)}}$$

Thus, the exponentiated value of a coefficient is the relative-risk ratio for a one-unit change in the corresponding variable. By specifying *rrr*, Stata will display the results in relative-risk ratio (RRR) rather than in coefficient. All the results in this chapter from multinomial logistic regressions are shown in RRR. A RRR equals to one suggests no difference in risk, and a RRR less than one suggests a reduced risk, while a RRR larger than one means an increased risk.

4.4.2 Multilevel modelling

Principles of multilevel modelling

Multilevel analysis was first developed for educational research in analysing the performance of students (Twisk, 2006). The researchers found that the observations of students in the same class were not independent of each other. In the case of assessing students' performance, it is reasonable to assume that the characteristics of a population of students belonging to a particular class differ from those of the population of students belonging to another class. This situation is known as a two-level data structure: the first level is the students and the second level is the classes. Standard statistical methods assume that observations (students in this example) are independent, but ignoring this non-independence will underestimate the standard errors of regression coefficients and overstate statistical significance. This clustering can be corrected by creating a dummy variable for every class in the linear regression to give each class a different intercept, but the number of dummy variables depends on the number of classes, so this method becomes inefficient when the number of clusters is large. Instead, multilevel modelling is a powerful and efficient way to correct for these clustering by estimating only the variance of the intercepts. This is also referred to as random intercept (Twisk, 2006).

Therefore, in general, the aim of multilevel modelling is to take account of the dependency of the observations. It takes this hierarchy into account in the analysis by dividing the variance to be explained across the levels (Snijders and Bosker, 2012), thus multilevel modelling is also referred to as hierarchical modelling.

In longitudinal data, outcomes observed at different occasions on the same person (e.g. repeated measurement of blood pressure), are not independent and errors will be correlated within person. In this situation, just as in multilevel modelling for clustered data, the measurement occasions are nested within individuals. Thus, level-1 units are the repeated measures for each individual, and the level-2 units are the individuals. This application of multilevel modelling is also referred to as growth curve modelling. If there are unobserved variables in the current multilevel model and these unobserved variables are correlated with the variables in the model, then this could cause bias. Multilevel modelling can be composed by both fixed and random effects. Fixed effects models could provide means to controlling for omitted variable bias, as long as these omitted variables have the same or ‘fixed’ effect across time. This is also called a multilevel mixed-effects model. For example, in a linear mixed-effects model, the fixed effects are the mean intercept and mean slope of the entire sample; in contrast, the random effects are the variability in the individual intercepts and slopes (Hoffman and Rovine, 2007). In this case, an overall growth of the sample over a specific period of time is described. Its growth can be linear, quadratic, cubic etc., and its slope and intercept are allowed to vary (Hox and Stoel, 2005).

Multilevel modelling in this chapter

To take account of the clustering of the data, mixed-effects models with repeated measures, individuals, and households as the three random-effects levels were conducted in Stata. Mixed models are characterised as containing both fixed and random effects. The fixed effects are analogous to standard regression coefficients and are estimated directly. The random effects are not directly estimated but are summarised in terms of their estimated variances and covariances. Multilevel mixed liner regressions were used for continuous outcomes (SBP, DBP, BMI and WC), and the Stata command is *mixed*. For categorical outcomes (smoking and alcohol consumption), multilevel mixed multinomial logistic regressions were used. Missing data were multiply imputed (see section 4.5), but Stata's default *mi estimate* command does not support mixed multinomial logistic regression with imputed data. So a user-written command *mim* in Stata was used, which can perform post estimation tests on models based on multiply imputed data, and this command can be used with another user written command *gllamm* for mixed multinomial logistic regressions.

Likelihood-ratio tests were performed to check whether including these three random-effects levels improved the model fit. Random intercepts at the individual level were first tested. The null hypothesis is that the intercept of the outcome is identical for everyone, which means that the variance of the intercept is zero. This null hypothesis lies on the boundary of the parameter space, as a variance is always non-negative. Therefore, this kind of likelihood-ratio test does not have a chi-square distribution, and their *P*- values are not correct. Fortunately, the correct *P*-values can be obtained ' by dividing the naive *P*-value from the likelihood-ratio test by 2' (Rabe-Hesketh and Anders, 2008: 159). In the data, the naive *P*-value was <0.05 for all outcomes, so the correct *P*-values were <0.025. This suggests that a random-intercept model is better than a fixed-effects model. In addition to the dependency of outcomes observed at different occasions on the same person, people living in the same household are also likely to be correlated. Likelihood-ratio tests have shown that adding a random intercept at the household level improves the model fit (correct *P*-values were <0.025). In addition, a random-coefficient model, which allows health outcomes to differ in their overall rate of growth with time at the individual level, is likely to make the model more realistic. Likelihood-ratio tests were performed to test whether the random-coefficient model fits better than the random-intercept model. For continuous outcomes, the correct *P*-values were <0.0005, suggesting that random-coefficient model is better than the random-intercept model. Therefore, the models in this chapter allowed for between individual variance in both level (i.e. random intercept) and rate of change (i.e. random slope) for each continuous outcome. Implementing mixed multinomial logistic regressions in an imputed data can be very slow. It takes about four to ten days for a single random-intercept regression using the current data, and random-coefficients need much more time. Therefore, random-coefficients were not included in the models of categorical outcomes.

Assumptions in multilevel modelling

Multilevel modelling is an extension of standard regression analysis, so all assumptions for standard regression analysis also hold for multilevel analysis. The continuous outcome variable should be normally distributed, which means that the residuals are normally distributed. After dropping outliers (section 4.3.2), all continuous outcomes in this chapter were generally normal distributed. Multilevel multinomial logistic modelling does not have to assume normality, linearity, or homoscedasticity.

Another assumption is that the residuals are uncorrelated. In most multilevel studies this should not be a big problem, as the reason for conducting a multilevel analysis in the first place to take correlated observations (i.e. correlated residuals) into account. So the problem of these correlated residuals is more or less solved in multilevel modelling (Twisk, 2006).

An additional assumption that is typical for multilevel modelling is that the random intercepts and the random slopes should be normally distributed. This assumption can be tested by analysing the different groups separately. However, it should be realised that this is not always possible, especially when many groups are involved (Twisk, 2006). In this chapter, this assumption was not tested due to the large number of groups.

4.4.3 Predicting trajectories of risk factors using marginal effects

To visualise the results from regressions, trajectories of each risk factor both before and after retirement, after adjusting for covariates, are shown.

If we have only one predictor in the model, the *predict* command in Stata will give a predicted value of *Y* at each level of a predictor. If we have additional predictors in the model, the *predict* command will not adjust for the other predictors in the model. The *margins* command (introduced in Stata 11) is very helpful in this situation. The *margins* command is designed to compute the marginal effects (MEs). A ME measures the expected 'instantaneous change' in the dependent variable as a function of a change in a certain explanatory variable while all other variables are held constant. In the linear regression model, the ME equals the relevant slope coefficient. In using the *margins* command, the *at* () option specifies values for variables to be treated as fixed, and computes the predicted values of Y adjusting for other covariates. As piecewise models were used in this chapter, where the years centred on retirement were expressed as X_1 and X_2. I specified the values of both X_1 and X_2 in the *at* () option. For example, to compute the adjusted mean of BMI at 1 year before retirement adjusting for other covariates, we specified *at* (X_1=16, X_2=0). For multiply imputed data, the Stata command *mimrgns* was used, which runs *margins* after *mi estimate*.

Trajectories of adjusted means from piecewise linear models are shown. By default, the adjusted means are adjusted for covariates by averaging across all values of covariates in the sample. An adjusted mean computed in this fashion is called the 'average marginal values', and the difference between the adjusted means is the average marginal effect (AME) in the linear models. In a linear model, holding covariates at their means can obtain the same results in adjusted means, and the difference between the adjusted means is also called the marginal effect at the mean (MEM).

For categorical outcomes, results from piecewise multinomial logistic regressions are RRRs. RRRs were transformed into the predicted probabilities of each alcohol consumption status. In nonlinear models, AME and MEM will generate different results, because the predicted probabilities vary depending on other covariates. In an AME method, Stata computes a predicted probability with the observed values of covariates, and then average the predicted values. In a MEM method, Stata uses the mean values for covariates when computing the probabilities. The MEM is popular, but many think that AME is superior. The means used during the calculation of MEM might refer to either nonexistent or inherently nonsensical observations, such as someone is 1.2 married and has 2.3 children. Therefore, AME is more appropriate for providing a realistic interpretation of estimation results. This chapter applied the AME method to predict the probabilities of categorical risk factors.

In addition to trajectories predicted from piecewise models, where the exposure variable (year centred on retirement) was treated as continuous, predicted adjusted means or probabilities at each year are shown. Predicted values at each year were generated using year centred on retirement as a categorical variable in the regression, so each year will have their own coefficients, and thus, have their own predicted values of risk factors. Predicted values at each year are shown as points in the figures. By comparing the trajectories before and after retirement with the points at each year, we can evaluate how well the piecewise models fit the data.

4.4.4 Handling missing data

Percent missing in the CHNS sample

The percent missing for health outcomes and covariates is shown in Table 4.3. Only retirees who had participated in the survey at least once prior to and once after the time at which they retired were included in the analysis (*n*=1,084; observations=5,921). Missing data was not handled if analytic samples were not present at that wave. Among the 5,921 observations, the percent missing was 6.9% for SBP and DBP, 7.6% for BMI, and 4.7% for smoking status. Alcohol consumption and WC were collected from 1993 onwards, and only individuals who retired after 1993 were used when modelling these two outcomes. The percent missing was 5.5% for alcohol consumption, and 6.6% for WC, based on the 5,431 observations of those who retired after 1993. The percent missing of covariates ranged from 0 to 11.5%, with the most missing data found in pre-retirement alcohol consumption. The household income had only 0.3% missing. Because the incomplete data of this derived variable had already handled by the CHNS team, that missing data was filled by, in order of preference, the household's previous and subsequent waves, the mean of households in the community, or the mean in the city/county. If fewer than three households supplied data at any of these levels, the missing data was left missing.

Table 4. 3 Percent missing in the CHNS.

	% Missing in CHNS [a]
Outcomes	
SBP&DBP	6.9
BMI	7.6
WC [b]	6.6
Smoking status	4.7
Alcohol consumption [b]	5.5
Covariates	
Gender	0.0
Retirement age	0.0
Age in 1991	0.0
Spouse's working status	0.0
Province	0.0
Urbanisation index	0.0
Education qualification	0.2
Pre-retirement household income	0.3
Occupation skill level	2.1
Workplace physical activity	4.4
Taking antihypertensive medicines	5.3
Pre-retirement BMI	6.1
Pre-retirement smoking status	6.2
Pre-retirement alcohol consumption	11.5
Total	23.5

[a] Missing percentage is based on the 5,921 observations of the 1,084 analytic samples.
[b] Missing percentage is based on the 5,431 observations of those who retired after 1993.

MI for missing data

The CHNS has collected detailed information that may be linked to missing data, thus MAR is a suitable assumption for this study, where missing data mechanism depends only on the observed data. Then, appropriate methods in handling missing data under MAR are MI and maximum likelihood estimation. As described in Chapter 3, MI is more flexible than maximum likelihood estimation when the independent variables are also incomplete. In the data, both outcomes and covariates have missing values, and, therefore MI was used to handling missing data in this chapter.

MICE was used to specify a univariate imputation model of each incomplete variable. All the covariates, exposure variable, outcome variables, potential moderators (gender, urbanisation, and retire together), and potential mediators (household income, nutrient intake, physical activity) were put into to the imputation. Missing values of time-fixed pre-retirement covariates (BMI, smoking, household income) were not included in the imputation and were constructed from imputed time-varying values. Missing values for alcohol consumption and WC in 1991 were not included in the imputation, as their missing pattern was missing for all rather than MAR. Only individuals who retired after 1993 were used when modelling these two outcomes.

In every cycle of imputation, different regression models were specified for different types of missing variables: linear regression was for continuous missing variables; logistic regression was for binary variables; ordered logistic regression was for ordinal variables; and multinomial logistic regression was for nominal variables. Predictive mean matching (PMM) method is also a method available for continuous variables. For each missing value, PMM draws an observation randomly from a set of observed values whose predicted values are closest to the predicted value for the missing value from the simulated regression model (Schenker and Taylor, 1996). The PMM method ensures that imputed values are plausible and might be more appropriate than the regression method if the normality assumption is violated (Horton and Lipsitz, 2001). So PMM was used when the distributions of continuous variables are non-normal (nutrient intake, physical activity, and interaction terms) or non-zero (urbanisation index). In this chapter, each imputation was drawn every 20 cycles. The whole procedure was then repeated 25 times to produce 25 imputed data, as White et al.'s (2009) suggests that the number of imputed datasets should be at least equal to the percentage of incomplete cases (23.5%).

The data is clustered, but imputation of multilevel data is still an open research area. R software includes the *mice.impute.2L.pan()* function, which was used to impute missing continuous data under a linear 2-level model. The imputation was performed in a wide format, and used individual's ID as the 'class variable' to specify that repeated measures belonged to the same person. Higher levels of the data structure were not incorporated into the imputation.

This chapter described the detailed methods which were used in testing the longitudinal associations between retirement and CVD risk factors in China. The next chapter will show the results from the longitudinal analysis.

4.4.5 Sensitivity analyses

Models in this longitudinal analysis assume individuals enter retirement once and do not return to paid work, but retirement does not always mean permanent withdrawal from the labour force. For example, one study based on the HRS in the USA found that approximately 15% of older people return to the labour force after having retired (Cahill et al., 2011). Thus, a sensitivity analysis which excludes observations from retirees who return to work was conducted.

In addition, there were fewer women than men in the analytic sample (636 men and 448 women), as more women work in informal sectors, especially in rural China, and thus cannot take formal retirement. Therefore, they may report the reason for stopping work as doing housework rather than retirement. A sensitivity analysis in which participants who moved from working to doing housework are included in as 'retired' was also conducted.

Results from these sensitivity analyses will be discussed in the next chapter.

Chapter 5: Results of the Longitudinal Associations between Retirement and CVD Risk Factors in China

This section first describes the sociodemographic characteristics, health behaviours, and health conditions of the sample before retirement. After that, coefficients from piecewise regressions and trajectories of each health outcome before and after retirement are shown.

5.1 Descriptive results

Table 5.1 describes sociodemographic characteristics, health behaviours, and health outcomes of the 1,084 individuals before retirement. For time-varying characteristics, the last answer before retirement was selected.

The mean retirement age of participants was 57.1 years, and their mean age at 1991 was 46.4 years. The median household income was 6,158 RMB per year (equals to 947 US dollars).

Because many women look after the home full-time or work in informal sectors, they made up only 41% of the analytic samples. Half of the adults in the CHNS were from urban areas, but 83% of the selected sample lived in urban areas. This is probably because retirement in our sample was concentrated among urban dwellers, while rural dwellers in China are often unable to take true retirement (Pang et al., 2004). Fifty eight percent of the analytic sample have highest education qualification that is lower than high school degree, and 54% had a working spouse, and only 7% did not have a spouse. About 70% of the participants were doing light or very light jobs before retirement. The majority of the samples were non-smokers (66%) and non-drinkers (62%).

This table also shows the age adjusted mean level of CVD risk factors at the last wave before retirement, which was 126.6 mm Hg for SBP, 81.9 mm Hg for DBP, 23.7 kg/m^2 for BMI, and 83.4 cm for WC.

Table 5. 1 Descriptive characteristics of the analytic sample in the CHNS.

Characteristics (*n*= 1,084) [a]	
Retirement age, years [b]	57.1 (6.9)
Age in 1991, years [b]	46.4 (9.1)
Median annual household income, RMB	6158.1
Women (%)	41.3
Urban residents (%)	83.2
Education qualification (%)	
No school completed	14.8
Primary school degree	16.7
Middle school degree	26.2
High school degree	16.6
Technical degree	13.9
University degree/higher	11.8
Spouse's employment status (%)	
Working spouse	54.9
Not working spouse	37.9
No spouse	7.2
Occupation skill level (%)	
Lowest	11.5
2	40.1
3	21.3
Highest	27.1
Workplace activity (%)	
Very light	35.7
Light	34.0
Moderate	18.5
Heavy/very heavy	11.8
Smoking status (%)	
Non-smoker	66.3
Light/moderate smoker	16.3
Heavy smoker	17.3
Alcohol consumption (%)	
Non-drinker	62.3
Light/moderate drinker	31.2
Heavy drinker	6.5
SBP, mm Hg [c]	126.6 (0.6)
DBP, mm Hg [c]	81.9 (0.4)
BMI, kg/m^2 [c]	23.7 (0.1)
WC, cm [c]	83.4 (0.4)

[a] % for alcohol consumption and mean of WC are based on a smaller sample (*n*=970)
[b] Values are mean (standard deviation).
[c] Values are age adjusted mean (standard error)

5.2 Results of piecewise regressions on blood pressure

For each risk factor, I reported slope before retirement and slope change post retirement. Table 5.2 shows results of piecewise regressions on SBP and DBP. Adding quadratic terms did not improve their model fits (Wald test $P>0.1$), so results from linear trajectories are reported. Positive pre-retirement slopes (0.791 for SBP, 0.410 for DBP) suggest that SBP and DBP increased with years before retirement. The coefficients for slope change were negative for both SBP ($\beta=-0.463$) and DBP ($\beta=-0.557$), suggesting that the increasing pre-retirement slopes were reduced after retirement.

Figures 5.1 to 5.2 show the trajectories of adjusted means for SBP and DBP centred at the year of retirement. The straight lines were the predicted trajectories from piecewise linear regression, where year centred on retirement was used a continuous variable and was separated at the year of retirement. The connected dots were the predicted adjusted means of blood pressure at each year, using year centred on retirement as a categorical variable. Dots were evenly distributed around the predicted lines, suggesting the models fit the data well. In Figure 5.1, the trajectory of SBP increased over time both before and after retirement, but its growth rate was reduced after retirement. In Figure 5.2, DBP increased over time before retirement, but decreased after retirement.

Table 5. 2 Results of piecewise regressions on blood pressure in the CHNS [a].

	SBP, mm Hg (*n*=1,084)			DBP, mm Hg (*n*=1,084)		
	β	**95% CI**	***P***	**β**	**95% CI**	***P***
Pre-retirement						
Linear slope	0.791	0.657, 0.925	<0.001	0.410	0.325, 0.494	<0.001
Post-retirement change						
Linear slope change	-0.463	-0.663, -0.264	<0.001	-0.557	-0.682, -0.433	<0.001

[a] Fully adjusted model, including gender, provinces, age at retirement, age at 1991, highest educational qualification, pre-retirement characteristics (spouse's working status/no spouse, household income, occupation skill level, workplace physical activity level, smoking status, alcohol consumption, and BMI), time-varying urbanization and taking antihypertensive medicines.

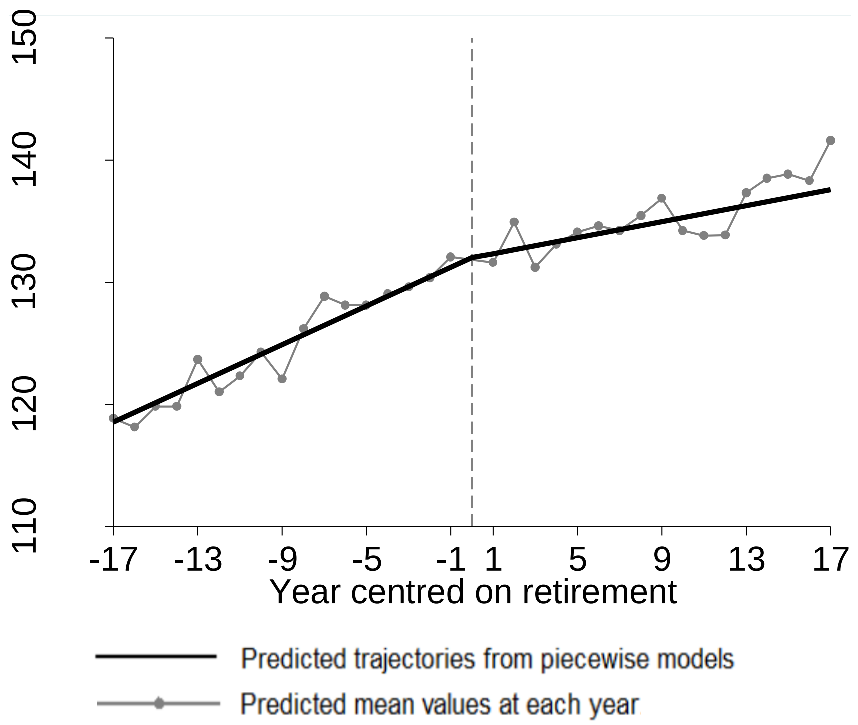

Figure 5. 1 Trajectories of SBP before and after retirement in the CHNS.

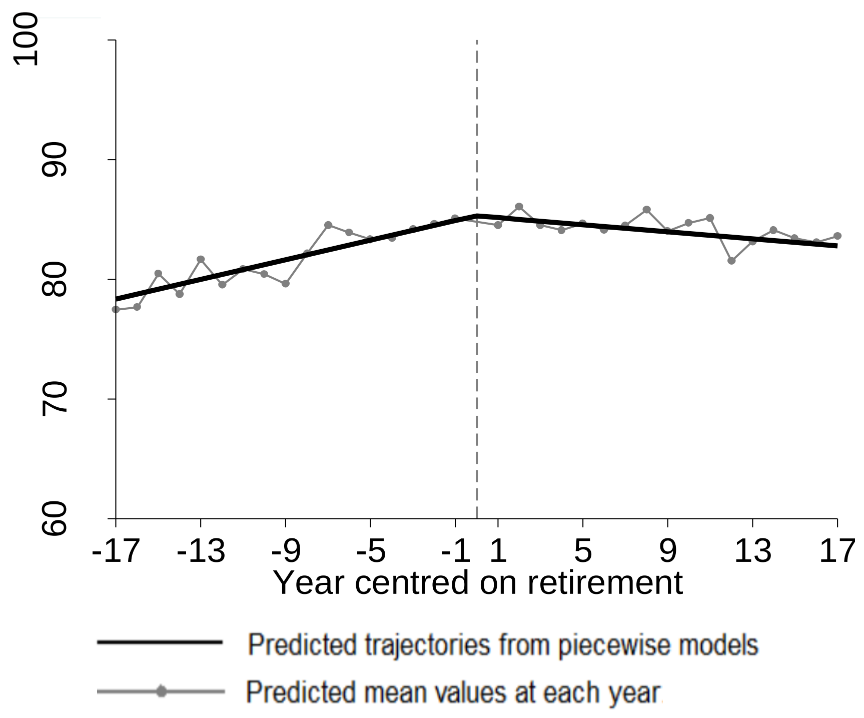

Figure 5. 2 Trajectories of DBP before and after retirement in the CHNS.

5.3 Results of piecewise regressions on adiposity measures

Table 5.3 shows results of WC and BMI these two adiposity measures. BMI changed with years before retirement in a quadratic shape (Wald test $P<0.01$). The joint *P*-value (assuming both linear and quadratic post-retirement slope changes are zero) was 0.84, suggesting that the shape of the pre-retirement BMI curve did not change after retirement.

Adding quadratic terms did not improve the model fit for WC (Wald test $P=0.25$). WC increased linearly with years before retirement ($\beta=0.377$), and the increasing pre-retirement slope decreased by 0.142 each year after retirement ($P<0.01$).

Table 5. 3 Results of piecewise regressions on adiposity measures in the CHNS.

	BMI, kg/m² (*n*=1,084)[a]				WC, cm (*n*=970)[c]		
	β	**95% CI**	***P***	**Joint *P*** [b]	**β**	**95% CI**	***P***
Pre-retirement							
Linear slope	0.194	0.124, 0.264	<0.001		0.377	0.305, 0.448	<0.001
Quadratic slope	-0.004	-0.007, -0.001	<0.01				
Post-retirement change							
Linear slope change	0.011	-0.055, 0.077	0.75	0.84	-0.142	-0.249, -0.035	<0.01
Quadratic slope change	0.001	-0.002, 0.004	0.64				

[a] Fully adjusted except for taking antihypertensive medicines and pre-retirement BMI.

[b] Joint P-value assuming both linear and quadratic post-retirement slope changes are zero.

[c] Fully adjusted except for taking antihypertensive medicines.

Trajectories of BMI and WC are shown in Figures 5.3 to 5.4. Again, the connected dots (predicted mean at each year) were evenly distributed around the predicted lines, suggesting the models fit the data well. BMI grew quadratically every year in the whole observation period, and its curve did not change before and after retirement. WC increased in the whole observation period, but the increasing pre-retirement slope decreased after retirement.

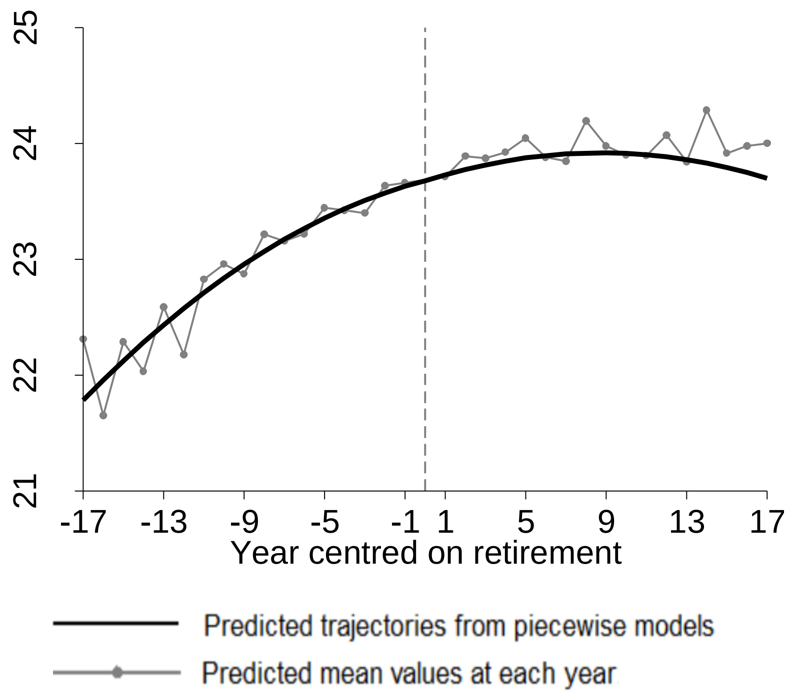

Figure 5. 3 Trajectories of BMI before and after retirement in the CHNS.

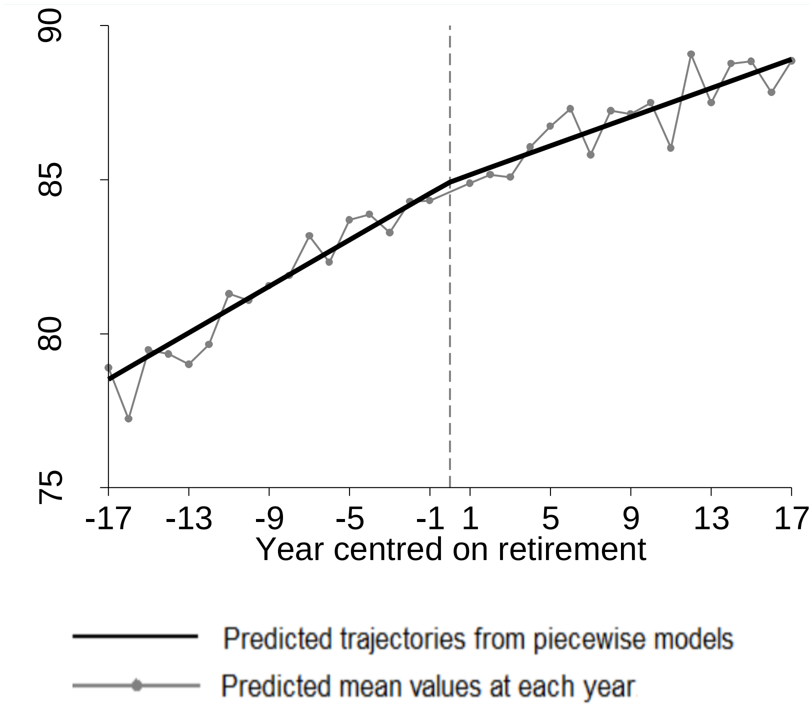

Figure 5. 4 Trajectories of WC before and after retirement in the CHNS.

5.4 Results of piecewise regressions on categorical behavioural risk factors

RRRs (i.e. exponential coefficients) from piecewise multinomial logistic regressions for smoking and alcohol consumption are shown in Table 5.4. Adding quadratic terms did not improve the model fits of categorical risk factors.

Table 5. 4 Results of piecewise multinomial logistic regressions on categorical behavioural risk factors in the CHNS.

	Alcohol Consumption (*n*=970) [a]			Smoking Status (*n*=1,084) [b]		
	RRR [c]	**95% CI**	***P***	**RRR [c]**	**95% CI**	***P***
Light/moderate versus Non						
Pre-retirement	0.912	0.882,0.942	<0.001	0.950	0.927,0.974	<0.001
Post-retirement change	1.005	0.957,1.057	0.83	1.003	0.965,1.042	0.89
Heavy versus Non						
Pre-retirement	0.955	0.918,0.995	0.03	0.960	0.935,0.985	<0.01
Post-retirement change	0.919	0.862,0.982	0.01	0.963	0.923,1.005	0.08

[a] Fully adjusted except for taking antihypertensive medicines and pre-retirement alcohol consumption.
[b] Fully adjusted except for taking antihypertensive medicines and pre-retirement smoking status.
[c] Relative risk ratio.

The relative risk of being a light/moderate drinker versus a non-drinker was 0.912 with every year increase before retirement. In other words, the ratio of the probability of being a light/moderate drinker over the probability of being a non-drinker decreased by 8.8% (1-0.912) every year before retirement. The change of RRR after retirement compared to before retirement was 1.005, as this value is very close to 1, the pre-retirement reduction (8.8% per year) was not changed significantly after retirement (P=0.83). For heavy drinkers, the ratio of the probability of being a heavy drinker over the probability of being a non-drinker decreased by 4.5% (1-0.955) every year before retirement, and further decreased by 8.1% (1-0.919) every year after retirement (P=0.01). In short, retirement was associated with a decreased relative risk of being a heavy drinker versus a non-drinker, but was not associated with the relative risk of being a light/moderate drinker versus a non-drinker.

However, RRR can only provide the relative results, but cannot directly show the effects of retirement on the probabilities of being a certain type of drinker. Using ME, RRR were transformed into predicted probabilities for each drinking status (Figure 5.5). The probability of being non-drinkers increased from 48% at the beginning to 61.3% at the year of retirement, and to 79.6% at 17 years after retirement. The probability of being light/moderate drinkers decreased from 42% to 25.5% at the year of retirement, and further decreased to 16.6% at 17 years after retirement. The probability of being heavy drinkers increased from 10% at the beginning to 13.2% at retirement, but decreased to 4.4% in the end.

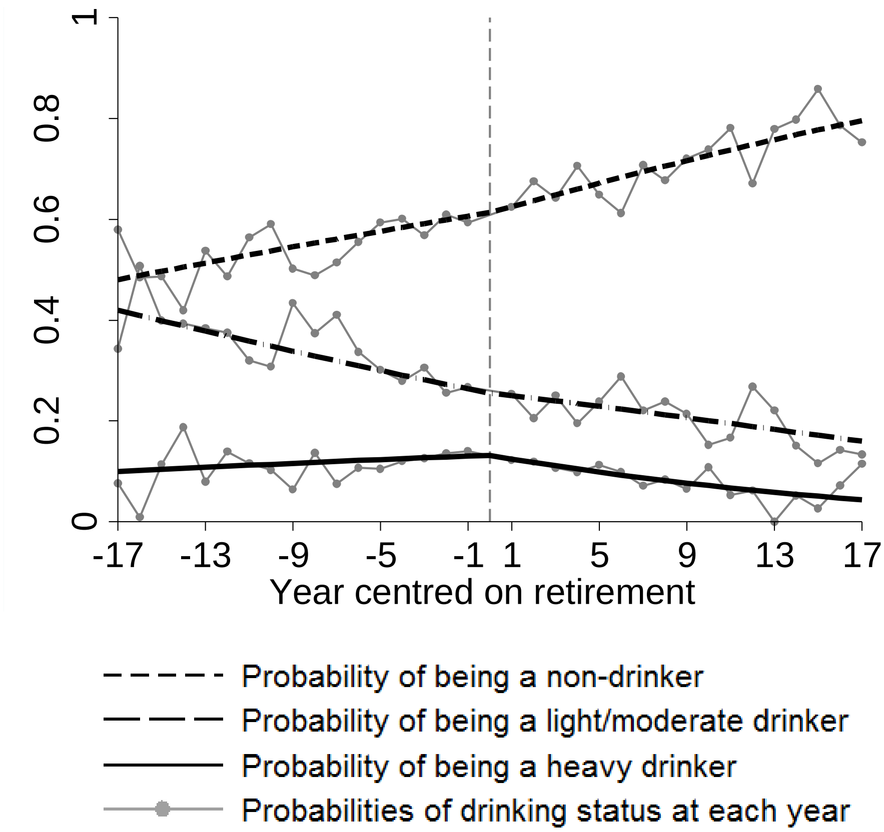

Figure 5. 5 Trajectories of the probability for each alcohol consumption status before and after retirement in the CHNS.

It can be seen in Figure 5.5 that the probability of heavy drinking after retirement is a curve. ME measures the instantaneous rate of change, which often, if not always, provide a good approximation to the amount of change in *Y* that will be produced by a 1-unit change in *X*. When *Y* is a continuous variable, the ME is the same as the slope coefficient. When *Y* is a categorical variable, like results for drinking, ME is the slope of the probability curve. Therefore, AMEs are shown in Table 5.5 to give an average rate of change. The AME was -0.008 (P<0.001) for post-retirement change on heavy drinkers, which means that a 1-year increase after retirement was approximately associated with an 0.008 reduction on the probability of being heavy drinkers compared to pre-retirement pattern. Thus, retirement was associated with reduced probability of being heavy drinkers. The AMEs on the probability of other drinking status were not statistically significant (*P*=0.17 for non-drinkers, *P*=0.24 for light/moderate drinkers).

Table 5. 5 Average marginal effects of retirement on drinking and smoking in the CHNS.

	Alcohol Consumption (*n*=970)			Smoking Status (*n*=1,084)		
	AME [a]	**95% CI**	***P***	**AME [a]**	**95% CI**	***P***
Pre-retirement						
Non	0.007	0.004,0.011	<0.001	0.006	0.003,0.009	<0.001
Light/moderate	-0.009	-0.012,-0.005	<0.001	-0.004	-0.007,-0.002	<0.01
Heavy	0.001	-0.001,0.004	0.33	-0.002	-0.0047,0.0032	0.09
Post-retirement change						
Non	0.004	-0.002,0.010	0.17	0.002	-0.002,0.007	0.34
Light/moderate	0.003	-0.002,0.009	0.24	0.002	-0.002,0.006	0.38
Heavy	-0.008	-0.012,-0.003	<0.001	-0.004	-0.0084,0.0001	0.06

[a] Average marginal effect

The relative risk ratios of being a smoker over a non-smoker were not significantly changed after retirement (Table 5.4), although borderline significance was found for heavy smoking (RRR=0.963, *P*=0.08). Again, RRRs can only provide the relative results, but cannot directly show the effects of retirement on the probabilities of being a certain type of smoker. Table 5.5 shows the result of AME. The AME was -0.004 for post-retirement change on heavy smokers, which means that a 1-year increase after retirement was approximately associated with an 0.004 reduction on the probability of being heavy smokers compared to pre-retirement pattern. The reduction for heavy smokers was only at borderline significance (*P*=0.06). Trajectories in the probabilities of smoking are shown in Figure 5.6.

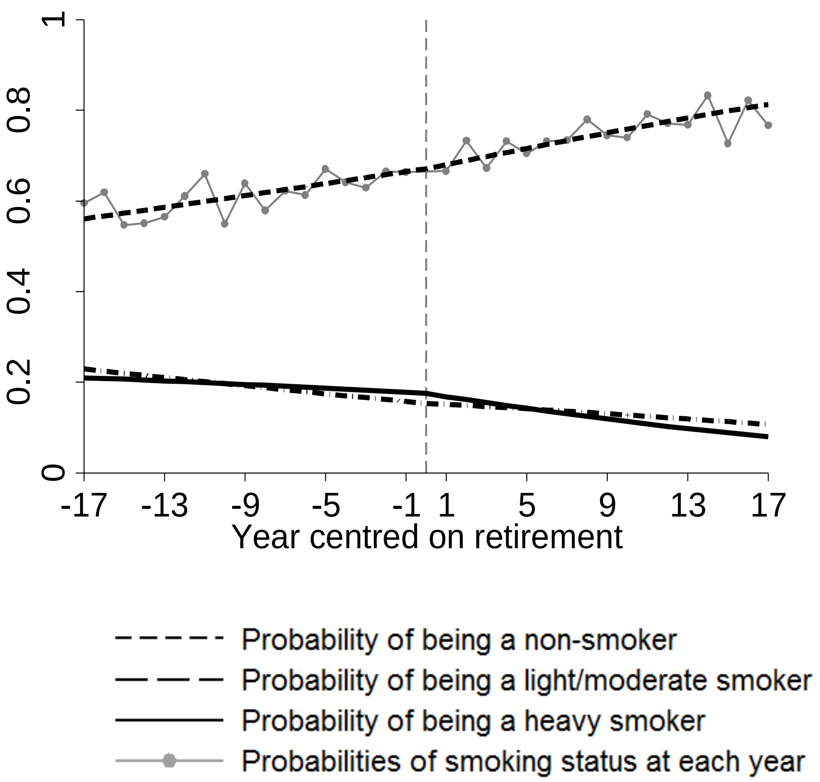

Figure 5. 6 Trajectories of the probability for each smoking status before and after retirement in the CHNS.

5.5 Sensitivity analyses

Two sets of sensitivity analysis were conducted to take account of potential returns to work post-retirement and labour market exits to look after the home.

5.5.1 Sensitivity analysis by excluding observations since go back to labour force after retirement

The previous models in this chapter assume individuals enter retirement once for all, but in our data, 156 out of 1,084 retirees went back to work after retirement (i.e. reported currently working after retirement). 423 observations since these people went back to work were excluded from the sensitivity analysis. This did not change the original conclusions and results of the sensitivity analysis are shown in Appendices 5.1 to 5.3.

Appendix 5.1 shows results of the sensitivity analysis for SBP and DBP. The retirement associated slope change was -0.480 for SBP and -0.560 for DBP, which are close to those of original analysis (β=-0.463 for SBP and β=-0.557 for DBP). *P*-values of blood pressure in the sensitivity analyses were less than 0.05, so these sensitivity analyses did not change the original conclusion that retirement was accompanied by a slowdown in the increase of both SBP and DBP with years.

Appendix 5.2 shows results of the sensitivity analysis for BMI and WC. The coefficients and *P*-values in the sensitivity analysis were also very similar to those in original analysis, suggesting that the increase of WC with years before retirement reduced after retirement, but BMI was not changed after retirement.

Appendix 5.3 shows results of the sensitivity analysis for smoking status and alcohol consumption. Similar to the original analysis, this sensitivity analysis did not found any significant association between retirement and smoking status and the probability to be a heavy drinker was reduced after retirement.

5.5.2 Sensitivity analysis by including participants who moved from working to doing housework

A different definition was applied in this sensitivity, which moving from working to doing housework also counts as retirement, as long as they were at least 45 years old when moved from working to doing housework. The sample size of this sensitivity analysis was 2,845, which was composed of the original sample (*n*=1,084) and the housework sample (*n*=1,761). Alcohol consumption and WC were collected from 1993 onwards. When modelling these two outcomes, only 2,589 individuals who retired after 1993 were included.

Unlike retirement, participants were not asked the exact time of moving from work to doing housework, so the mid-year between working wave and doing housework wave was used for the housework sample. Analytic methods used in this section were the same as those used in the original analysis. Missing data of outcomes and covariates were multiply imputed in R, using the same imputation method as that of Chapter 4. Results of this sensitivity analysis are shown in Tables 5.6 to 5.8.

Table 5.6 shows the results of piecewise regressions on blood pressure. Retirement was still associated with a slowdown in the increase of both SBP and DBP with years ($P<0.001$), but these relationships were attenuated compared to the original analysis. For example, in the original analysis the negative post-retirement coefficient ($\beta=-0.557$) has a bigger value than the positive pre-retirement coefficient ($\beta=0.410$), so DBP was reduced after retirement. However, in the sensitivity analysis, the negative post-retirement coefficient ($\beta=-0.327$) has a smaller value than the positive pre-retirement coefficient ($\beta=0.381$), thus DBP still increased with time after retirement, but with a slower speed.

Table 5. 6 Results of piecewise regressions on blood pressure after including doing housework in the CHNS [a].

	SBP, mm Hg (*n*=2,845)			DBP, mm Hg (*n*=2,845)		
	β	**95% CI**	***P***	**β**	**95% CI**	***P***
Pre-retirement						
Linear slope	0.839	0.783, 0.895	<0.001	0.381	0.340, 0.421	<0.001
Post-retirement change						
Linear slope change	-0.218	-0.324,-0.113	<0.001	-0.327	-0.402, -0.252	<0.001

[a] Fully adjusted model, including gender, provinces, age at retirement, age at 1991, highest educational qualification, pre-retirement characteristics (spouse’s working status/no spouse, household income, occupation skill level, workplace physical activity level, smoking status, alcohol consumption, and BMI), time-varying urbanization and taking antihypertensive medicines.

Table 5.7 shows the results of piecewise regressions on WC and BMI. Retirement was associated with a slowdown in the increase of WC with years, but this relationship was less strong compared to the original analysis. Similar to the original result, this sensitivity analysis did not find any significant association between retirement and BMI.

Table 5.8 shows the results of piecewise multinomial logistic regressions for alcohol consumption and smoking status. The relative risk of being a heavy drinker versus a non-drinker decreased by 6.1% (1-0.939) every year after retirement. In the original analysis, the relative risk of being a heavy drinker versus a non-drinker decreased by 8.1% (1-0.919) every year after retirement. So the result here was also attenuated. This sensitivity analysis did not find any association between retirement and smoking status, which was similar to the original conclusion.

In summary, this sensitivity analysis, which combined both the original sample and the housework sample, showed a similar pattern on associations between retirement and CVD risk factors, although results were less pronounced compared to the original analysis.

Table 5. 7 Results of piecewise regressions on adiposity measures after including doing housework in the CHNS.

	WC, cm (*n*=2,589) [a]			BMI, kg/m^2 (*n*=2,845) [b]			
	β	**95% CI**	***P***	**β**	**95% CI**	***P***	**Joint *P* [c]**
Pre-retirement							
Linear slope	0.459	0.425,0.492	<0.001	0.158	0.124,0.192	<0.001	
Quadratic slope				-0.002	-0.004,-0.001	<0.001	
Post-retirement change							
Linear slope change	-0.084	-0.144,-0.024	<0.01	0.010	-0.030,0.050	0.63	0.88
Quadratic slope change				-0.0002	-0.002,0.002	0.84	

[a] Fully adjusted except for taking antihypertensive medicines
[b] Fully adjusted except for taking antihypertensive medicines and pre-retirement BMI.
[c] Joint P-value assuming both linear and quadratic post-retirement slope changes are zero.

Table 5. 8 Results of piecewise multinomial logistic regressions on behavioural risk factors after including doing housework in the CHNS.

	Alcohol Consumption (*n*=2,589) [a]			**Smoking Status (*n*=2,845) [b]**		
	RRR [c]	**95% CI**	***P***	**RRR [c]**	**95% CI**	***P***
Light/moderate versus Non						
Pre-retirement	0.960	0.948,0.974	<0.001	0.970	0.957,0.983	<0.001
Post-retirement change	0.991	0.966,1.016	0.48	1.007	0.979,1.034	0.76
Heavy versus Non						
Pre-retirement	0.987	0.968,1.005	0.15	0.969	0.956,0.983	<0.001
Post-retirement change	0.939	0.904,0.974	<0.01	1.003	0.973,1.034	0.85

[a] Fully adjusted except for taking antihypertensive medicines and pre-retirement alcohol consumption.
[b] Fully adjusted except for taking antihypertensive medicines and pre-retirement smoking status.
[c] Relative risk ratio.

5.6 Discussion of the chapter

5.6.1 Summary

This longitudinal analysis found that retirement was accompanied by a reduction in DBP, a slowdown in the increase of SBP, and a reduction in the probability of being a heavy drinker in China. Results for heavy smoking mirrored those for heavy drinking but were weaker and only reached borderline statistical significance. Retirement was also found to slowdown the increase of WC with years, but no significant effect of retirement on BMI was found.

Our results suggest, then, that retirement has a beneficial association with blood pressure, central obesity and alcohol consumption, at least in the Chinese context. Hypertension and central obesity are important risk factors for CVD (Gu et al., 2005; Lewington et al., 2002; Yusuf et al., 2005; Zhou et al., 2008). For example, a meta-analysis has shown that a 20 mm Hg increase in SBP or a 10 mm Hg increase in DBP is associated with more than a doubling in the CVD death rate in people aged 40-69, and an even stronger association in older people (Lewington et al., 2002). Another study using participants from 52 countries found that WC was strongly related to myocardial infarction risk, even after adjustment for BMI and height (Yusuf et al., 2005). There is evidence that heavy drinking is associated with increased risk of having CVD and death from CVD (Bazzano et al., 2007; Ronksley et al., 2011). In addition, a 15-year prospective cohort study of 220,000 men aged 40-79 years from 45 areas in China has shown that CVD mortality increased linearly with alcohol consumption (Yang et al., 2012).

The reduced likelihood of heavy drinking after retirement found in this longitudinal study echoed the cross-sectional results from CHARLS, which retired people are less likely to be a drinker than those in paid work. The consistent results may be related to the drinking culture in the workplace in China (Cochrane et al., 2003; Hao and Young 2000), and retirement offers an opportunity to stop using alcohol. Both longitudinal and cross-sectional results in this thesis did not find any statistically significant effect of retirement on smoking, which is probably because of the unawareness of the hazard of smoking among elder Chinese. However, it is possible that some people only reduce the number of cigarettes smoked after retirement, and it is likely that this reduction was not captured by smoking status with a three category variable. Thus, this is may be a limitation in the analysis. However, considering 68% of the observations were non-smokers, and the number of cigarettes smoked per day was tended to be grouped at half pack or a pack, using number of cigarettes smoked per day as a continuous variable may not meet the assumptions of linear regressions can lead to biased estimations.

This study found retirement to slowdown the increase of WC with years, but no significant effect of retirement on BMI was found. The reason remains unclear, but WC may be influenced more by sitting behaviour than BMI. In the CHNS, about 70% of the participants reported their physical activity level in the workplace before retirement as light or very light. After retirement, these participants do not have to sit in the office all the time, and thus may have a slowdown in the increase of WC with years. Excess body fat can increase the risk of type 2 diabetes and CVD. Because direct measures of body fat are not easy to obtain, BMI and WC are often used as alternatives for assessing general adiposity and central adiposity, respectively. Recent studies and meta-analyses have recommended WC as a better predictor of CVD than BMI (Bigaard et al., 2005; Janssen et al., 2004; Welborn and Dhaliwal, 2007). Therefore, the results here still support the ideal that retirement might be beneficial for cardiovascular health in the Chinese context. Maybe BMI responds less well to the benefits of retirement than WC does, but it is also possible that retirement influences WC and BMI differently.

5.6.2 Comparison with previous studies

There are no previous longitudinal studies of retirement and CVD risk factors in China with which to compare, but our findings differ from several recent longitudinal studies from Western counties, which did not find any beneficial association between retirement and metabolic risk factors. For example, several studies based on the HRS in the USA, either compared to those in paid work or pre-retirement level, found retirement was associated with increased BMI, weight and illness conditions (Dave et al., 2006; Forman-Hoffman et al., 2008; Gueorguieva et al., 2011). Another study using the ELSA reported that retirement increased the risk of having higher body mass index and hypertension (Behncke, 2012). A French study using annual self-reported measures of alcohol intake from 5 years before to 5 years after retirement, did not find any beneficial effect of retirement on heavy drinking during the 5-year post-retirement observation, but found an increase in the proportion of heavy drinkers around retirement (Zins et al., 2011).

There are four possible reasons for the inconsistencies with Western results. First, exposure to adverse working environments, in particular work stress, has been linked with an increased risk of hypertension (Vrijkotte et al., 2000) and CVD (Chandola et al., 2008; Kivimäki et al., 2006). Thus, if a job is perceived as less satisfying or more stressful, retirement may, instead, lead to better cardiovascular health outcomes. The working environment in China is generally less favourable than that in developed countries, and, therefore, retirement in China may have beneficial effects.

Second, although people who work in informal sectors in China hardly have any pension after retirement, people who retire from formal sectors usually can receive a very generous financial support (Giles et al., 2011). For example, according to the OECD report (2014), the net pension replacement rate was 81% in China, which was much higher than the OECD average level (63%) and many Western countries (e.g. UK 38%, USA 45%). Long-term residents in urban China usually work in formal sectors, and 84% of the participants in this study lived in urban areas, so they may benefit from the high pension system. Chinese retirees with sufficient pension income may view retirement as a less burdensome transition, thus are more likely to have better mental health and higher life satisfactions, subsequently contributing to better cardiovascular health.

Third, the notion of 'filial piety' is more salient in Chinese culture. Adult children in China are highly motivated to care for and support their parents financially and emotionally (Lin and Yi, 2011; Löckenhoff et al., 2015), and the proportion of living with ageing parents in China is higher than that in Western countries (Kincannon et al., 2006; Isengard and Szydlik, 2012; Silverstein et al., 2006). These strong family ties may buffer the impact of potentially stressful events in retirement for Chinese retirees.

Last, men and women in China retire much earlier than people in Western countries do. Early retirement has suggested to be linked to poorer health after retirement in some Western studies (Morris et al., 1992, 1994; Kuhn et al., 2010), but it might have different health impact when retiring at an early age is the social norm. Retire at an early age in combination with increases in longevity, makes retirement in China become more of a midlife transition, rather than a transition to old age. People who retire at an early age in China can acquire new roles (e.g. taking care of grandchildren), continue in other roles (e.g. friend or spouse), and develop new self-identities (Kim and Moen, 2001).

5.6.3 Strengths and limitations

This study is the only longitudinal study in China to examine the association between retirement and cardiovascular risk factors. The study benefits from a 17-year observation period both before and after retirement and objectively measured blood pressure and adiposity outcomes. A multilevel framework was used to account for between and within-cluster effects (Neuhaus and Kalbfleisch, 1998). Missing values in the covariates have been multiply imputed, which allows for the use of information from all cases. An advantage of this study is the longitudinal analyses on the same individual both before and after retirement that largely reduces the likelihood of reverse causality. We look at the slope change before-and-after retirement rather than the values themselves. If someone was retired due to increased cardiovascular risk factors, it would increase the mean values of trajectories but not the slopes.

In addition, two sensitivity analyses tested the robustness of the results, and results from the sensitivity analyses did not change the conclusions from the original analysis. The sensitivity analysis, which combined both the original sample and the housework sample, showed a similar pattern on associations between retirement and CVD risk factors, although results were less pronounced compared to the original analysis. One possible explanation is that moving from work to doing housework may be not beneficial for people's health, due to no pension support and the stress from housework. Another possible explanation is that there are more women, especially more rural women are in this sensitivity analysis sample, so it is possible that the beneficial effects of retirement on blood pressure is less strong for women than for men, for rural residents than for urban residents. Therefore, gender and area specific analyses were conducted in the next chapter.

However, this analysis may be subject to several limitations. First, this study did not include heart disease and stroke as health outcomes in the longitudinal analysis. The effects of retirement on CVD can be measured by the cumulative prevalence of CVD before and after retirement, but this method may subject to selection bias, as CVD can be fatal, especially in a developing country, such as China, with limited access to health services. People who die from CVD drop out of the survey and the cause of death is not collected in this dataset. If the data could be linked to mortality data, then piecewise survivor analysis could be used to test the effect of retirement on CVD mortality.

Second, the response rate of the CHNS is 80-88% across all waves relative to the previous wave, and 60% of individuals who participated in 1989 remained in 2011. We only include retired people with repeated measurement both before and after retirement, so potential loss-to-follow up bias is a general limitation in this study, as individuals who have CVD are more likely to drop out, and people who die of CVD are lost in the follow up. Thus selected samples might be healthier than those who dropout. Rural-to-urban migrant workers are also lost to follow-up, but their numbers should be very small. Because rural-to-urban migration usually happens in younger labor force, and migration was rare at the time when the samples in this study were young (Fan, 2008).

Another limitation is that the CHNS data was not weighted to take account of the sampling design, as the sampling frame was not available in the baseline, thus the results may not be generalised to the population from which the sample was selected.

In conclusion, this chapter suggests that retirement may be beneficial for blood pressure, central obesity and alcohol consumption in China. Understanding the health impacts of retirement is essential if changes to retirement policy to be cost-effective to the economy and beneficial to the health of China’s older population.

Chapter 6: Moderators in the Longitudinal Associations between Retirement and CVD Risk Factors in China

6.1 Introduction

Chapter 5 found that retirement was accompanied by a lower DBP, a slowdown in the increase of both SBP and WC with years, and a reduction in the probability of being a heavy drinker in China. These beneficial associations with retirement may differ depending on particular characteristics and retirement behaviour of participants.

6.1.1 Potential gender differences in associations between retirement and CVD

Life course models suggest that retirement is a gendered experience (Moen, 1996). Gender serves to shape one's occupation, the pattern and duration of employment, and can affect the barriers, resources, and opportunities that shape the life quality of individuals surrounding retirement, as do retirement and postretirement expectations and behaviours. Several empirical studies from developed countries have found gender differences with regards to the effects of retirement on CVD or CVD risk factors. For example, Godard (2016) employed an IV approach based on age discontinuities in social security incentives across different European countries and found that retirement caused an increase in the probability of being obese among men retiring from strenuous jobs, but not for women, no matter what job they retired from. This is probably because women are more likely to be physical active, as Sjösten et al. (2012) found using the French GAZEL cohort, showing that, during the transition to retirement, the percentage of women who walked at least 5 km/week increased by 61%, but only increased by 36% among men. Some studies also suggested that women were more likely to have healthier life style after retirement. For example, a cross-sectional study found retirement was associated with a decreased risk of smoking among women, but the effect on men did not reach a statistically significant level (Cox, 1987). Bob et al. (2013; 2011) estimated 10-year drinking trajectories and suggested that retired American women were more likely to decrease their alcohol consumption compared to working women, but retirement was not associated with alcohol consumption trajectories among American men. In contrast, some studies found retirement to be more detrimental for women. Bound and Waidmann (2007) did a cross-sectional analysis using the second wave of ELSA, finding that women had a significantly higher likelihood of being diagnosed with heart disease or diabetes after SPA than what would have been predicted by preretirement levels, but this pattern was not observed in English men. A longitudinal study (Patrick et al., 1986) in the UK reported an increase in total physical activity among men but a decrease among women. Rodriguez and Chandra (2006) found that retired American men were more likely to reduce drinking, but not retired American women. Two French studies based on the GAZEL cohort suggested that retirement increased the risk of excessive alcohol consumption, temporarily in men and permanently in the small group of women managers (Tamers et al., 2014; Zins et al., 2011).

Although several studies have tested the gender differences in the associations between retirement and health outcomes, their results are disparate. Some studies suggest that, compared to men, women were more likely to drink less, smoke less, and to be physical active after retirement, while others found the opposite for women, including decreased physical activity, increased drinking, and a higher risk of having CVD. Again, this is likely due to the non-comparability of their study designs. Among the many factors which may lead to heterogeneity, country-level factors are likely to be important. In the literature, there has been no study in China investigating gender differences in the effects of retirement, although men and women in China differ in both retirement behaviour and health conditions. As described in the background chapter, the compulsory retirement age in China for men is 5 to 10 years later than women. Men are more likely to die from CVD, and are also more likely to experience CVD risk factors, such as hypertension (Wang et al., 2014), diabetes (Xu et al., 2013), smoking and excessive drinking (WHO, 2010). These gender differences were also observed in the CHNS analytic sample. The differences between men and women on socio-demographic characteristics and retirement behaviour as well as health outcomes may well influence the associations between retirement and CVD risk factors found in the last chapter. Thus, the moderating role of gender will be tested in this chapter.

6.1.2 Potential urbanisation differences in associations between retirement and CVD

China is characterised by extreme urban-rural disparity. Long-term residents in urban China usually work in formal sectors, and, therefore, have formal wages, and retire at mandatory ages, while most rural residents work in self-employed agriculture-related activities, with low incomes and pensions, but are not restricted by mandatory retirement ages.

In the literature, the moderating role of urban-rural disparity is not well understood, which is probably because most studies are from Western countries, where retirement policy and welfare support do not differ between urban and rural areas. Several American studies found retirement-related increases in body weight to be greater among people from physically demanding jobs than those from sedentary jobs (Chung et al., 2009; Forman-Hoffman et al., 2008; Gueorguieva et al., 2011; Zheng, 2008;). However, in the Chinese context, urban-rural differences exist, in not only the physical demands of occupations, but also in retirement policy and welfare supports as well as the availability of health services. Thus, urbanisation may play an even more important moderating effect in the associations between retirement and CVD risk factors in the Chinese context. Results in Chapter 3 in this thesis showed significant urban-rural differences in the cross-sectional associations between retirement and several CVD related health outcomes, and this chapter will test the urban-rural differences in the longitudinal association.

6.1.3 Potential spousal influences on associations between retirement and CVD

The life course perspective also emphasizes the idea that the experiences in work life are influenced by experiences in other life spheres, such as marital life. According to this concept of interdependent life spheres, marital life is important for retirement adjustment because it provides retirees with alternative salient roles after retirement and offers opportunities for retirees to engage in meaningful and desirable activities. Supporting this idea is evidence that individuals who are married have more positive experiences in retirement (e.g. Calasanti, 1996), and higher levels of retirement satisfaction (e.g. Pinquart and Schindler, 2007) than do unmarried adults.

Given the importance of marital life, a spouse's employment also plays a key role. Wang (2007) found that married retirees whose spouse was present and working did not differ from retirees whose spouse was not present in terms of their chances in experiencing minimum changes in psychological well-being. This is likely because a working spouse may not be able to provide the companionship expected by the retiree. On the other hand, preferences for shared leisure may induce couples to retire together. American research has produced considerable evidence for joint retirement, namely that, in the absence of major shocks such as ill-health or job loss, many couples choose to retire at the same time or at least within a year or 18 months of each other (Ho and Raymo, 2008; Moen et al., 2005). Compared to those couples who do not retire together, these retirees may have different post-retirement experiences and health conditions because of the companionship from a spouse. For example, Szinovacz and Davey (2004) fount that longer-retired men who retired jointly with their spouses had the least depressive symptoms but fared less well if their wives either remained employed or were already nonworking prior to the husband’s retirement. Whether a spouse’s employment has the same moderating role on the effects of retirement on CVD risk factors in the Chinese context is still unclear in the literature.

Thus, this chapter aims to assess whether having a spouse and a spouse’s employment can moderate the longitudinal associations between retirement and CVD risk factors found in the last chapter. The moderating roles of gender and urban-rural disparity are also examined. The measures of potential moderators are shown in section 6.2, and analytic methods are shown in section 6.3. Results of moderation effects are shown in section 6.4, and are then discussed in section 6.5.

6.2 Analytic sample and measures of potential moderators

Gender, living in an urban/rural area, and a spouse’s employment/no spouse were the three moderators tested in this chapter. The CHNS collected the information of gender, area of residence, and marriage status, and the year of retirement for both main interviewer and his/her spouse. Gender was defined as men or women. People were categorised as living in urban areas if they lived in an urban community, a suburban community, or a town, and the remaining (e.g. rural villages) were classed as rural areas[6].

Spouse's employment was classified into: continuously working spouse, jointly retired spouse based on moving from working to retired in the same wave as spouse, already nonworking spouse, and having no spouse.

This chapter used the same individuals as that used in Chapter 5, that are those who moved from 'working' to 'retired' between 1991 and 2011 in the CHNS (*n*=1,084). Because many women look after the home full-time or work in informal sectors, they made up only 41.3 % of the analytic samples (46% in urban areas and 20% in rural areas). Among the selected sample, 83.2% lived in urban areas. This figure is much higher than the actual urban residents in China (51% in 2011) (Ma et al., 2012). Actually, half of the adults in the whole CHNS cohort were from urban areas. The higher proportion of urban analytic in the analytic sample is probably because retirement in our sample was concentrated among urban dwellers, while rural dwellers in China are often unable to take true retirement (Pang et al., 2004). 38.2% of retirees had a spouse who was continuously working during his/her transition into retirement (i.e. spouse is working at the last wave before retirement and the first wave after retirement). 16.7% of retirees moved from working to retired in the same wave as his/her spouse, and these couples were counted as jointly retired. 37.9% of retirees had a spouse already non-working before he/she was retired. 7.2% of retirees have no spouse.

The sample size was 1,084 for SBP, DBP and BMI. WC was collected since 1993, so the sample size was 970 for WC. Smoking and drinking are not common among elders in China. Among 356 participants who were drinkers at the time before retirement, only 49 were women, 60 were living in rural areas, and 59 retired at the same time as spouse. The numbers among smokers were even smaller. Such small number of people may not

[6] This definition is slightly different from the current definition from the National Bureau of Statistics of the People's Republic of China, which classifies towns with county governments or village committees as urban areas, and the remaining towns are classified as rural areas. The CHNS lacks the detailed information of official classification of urbanisation for towns, and all 32 sampled towns (out of 190 sampled communities) in the baseline and other newly added towns in the follow-up were classified as urban areas in the analysis.

provide reliable estimations when testing the moderators, so moderating effects were not tested for alcohol consumption and smoking status.

6.3 Analytic methods in testing moderators

To test whether gender, area of residence, and spouse's employment could modify associations between retirement and CVD risk factors, interaction terms were added into each piecewise model from Chapter 5. Potential moderators were multiplied by post-retirement slope change (i.e. gender×X2; area of residence ×X2; spouse status×X2). Participants may also have different trajectories of CVD risk factors by these moderators before retirement. Therefore, a pre-retirement interaction, where moderators multiplied by pre-retirement slope (i.e. gender×X_1; area of residence ×X_1; spouse status×X_1) was also added, to see if it improved the model fit. When choosing for each moderator, a reference category should not be a category with few cases, for reasons related to sample size and error. So men (58.7%), urban retirees (83.2%), and retirees with a working spouse (38.2%) were chosen as the reference categories (coded as 0). Missing data in the outcomes, covariates and moderators were already multiply imputed in section 4.4.4 in Chapter 4.

6.4 Results of moderators

6.4.1 Descriptive results

Table 6.1 describes sociodemographic characteristics, health behaviours, and health outcomes by gender and area of residence of the 1,084 analytic individuals. For time-varying characteristics, the last answer before retirement was described. Results have shown that men retired on average 5.8 years later than women, and were socially advantaged in education and occupation skills, and were also more likely to retire from physically demanding jobs, but were much more likely to be smokers and drinkers. It is interesting to see that, although men were advantaged in education and occupation, men had lower per capita household income than women. This is likely because that 71.5% of women had a working spouse compared to only 42.3% of men. In terms of health outcomes, men had higher mean values of blood pressure and WC before retirement than women, after adjusting for age at the measurement. Compared to rural retirees, urban retirees retired on average 4.2 years earlier, were more socially advantaged in every aspect, and were less likely to be smokers or drinkers, but urban residents had higher values of BMI and WC, after adjusting for age at the measurement.

Table 6. 1 Descriptive characteristics of the analytic sample in the CHNS [a].

Characteristics	Men *n*= 636	Women *n*= 448	*P* [b]	Urban *n*= 902	Rural *n*= 182	*P* [c]
Mean retirement age, years	59.5	53.7	<0.001	56.4	60.6	<0.001
Mean age in 1991, years	49.2	42.6	<0.001	45.7	50.1	<0.001
Median annual household income, RMB	5598.6	7483.0	<0.001	6718.6	4167.9	<0.001
Education qualification (%)			<0.001			<0.001
No school completed	13.7	16.4		12.9	24.3	
Primary school degree	19.2	13.3		15.7	22.1	
Middle school degree	26.1	26.3		25.7	28.7	
High school degree	15.3	18.4		18.0	9.4	
Technical degree	12.0	16.6		14.1	12.7	
University degree/higher	13.8	9.0		13.7	2.8	
Spouse's working status (%)			<0.001			<0.001
Working spouse	27.6	51.2		34.2	53.6	
Spouse jointly retired	14.6	20.3		18.7	8.2	
Not working spouse	52.5	18.3		40.2	29.2	
No spouse	5.3	10.2		6.9	9.0	
Occupation skill level (%)			<0.001			<0.001
Lowest	14.4	7.3		5.6	40.8	
2	33.3	49.8		42.5	27.9	
3	19.4	24.1		22.1	17.3	
Highest	33.0	18.8		29.8	14.0	
Workplace activity (%)			<0.001			<0.001
Very light	36.1	35.2		40.1	13.5	
Light	29.8	39.8		34.3	32.2	
Moderate	18.7	18.3		19.1	15.8	
Heavy/very heavy	15.4	6.7		6.5	38.6	
Smoking status (%)			<0.001			<0.001
Non-smoker	43.1	97.3		69.3	50.6	
Light/moderate smoker	27.1	2.1		15.9	18.5	
Heavy smoker	29.8	0.7		14.8	30.9	
Alcohol consumption (%)			<0.001			0.01
Non-drinker	41.8	88.4		63.9	54.4	
Light/moderate drinker	47.7	10.1		30.6	34.4	
Heavy drinker	10.5	1.4		5.6	11.3	
Mean SBP, mm Hg [d]	130.7	120.9	<0.001	126.4	127.8	0.21
Mean DBP, mm Hg [d]	83.6	79.4	<0.001	81.9	81.6	0.23
Mean BMI, kg/m^2 [d]	23.6	23.8	0.51	23.8	23.1	0.03
Mean WC, cm [d]	85.0	80.8	<0.001	83.4	82.4	0.02

[a] % for alcohol consumption and WC are based on a smaller sample (*n*=970)
[b] P value for gender differences.
[c] P value for urban-rural differences.
[d] Values are age adjusted mean before retirement.

6.4.2 Gender as a moderator

Results of including gender as a moderator in the associations between retirement and CVD risk factors are shown in Table 6.2. Adding pre-retirement interaction terms with gender did not improve the model fit of any health outcome (Wald test P>0.1). Thus, pre-retirement interaction terms were not included. The coefficients of the post-retirement interaction term were positive for SBP and DBP (0.300 for SBP and 0.145 for DBP). In Chapter 5, retirement was accompanied by a lower DBP (β=-0.557) and a slowdown in the increase of SBP (β=-0.463) with age, so the positive post-retirement interaction terms here suggest that retirement related blood pressure changes were weaker for women than for men (P for SBP<0.01 and P for DBP=0.03). Trajectory graphs of SBP and DBP for men and women are shown in Figures 6.1 to 6.2.

There were no significant gender differences in the association between retirement and WC (P=0.23). BMI changed with years in a quadratic shape, so a joint P-value of the linear and quadratic interaction terms are presented. According to the joint P-value (0.51), gender was not a significant moderator for the association between retirement and BMI.

Table 6. 2 Moderation effect of gender in the associations between retirement and risk factors in the CHNS.

	β	95% CI	*P*	Joint *P*
SBP (*n*=1,084) [a]				
Post-retirement change × Women	0.300	0.090,0.509	<0.01	
DBP (*n*=1,084) [a]				
Post-retirement change × Women	0.145	0.014,0.276	0.03	
WC (*n*=970) [b]				
Post-retirement change × Women	0.065	-0.041,0.172	0.23	
BMI (*n*=1,084) [c]				
Post-retirement linear change × Women	-0.007	-0.074,0.060	0.84	0.51
Post-retirement quadratic change × Women	-0.001	-0.006,0.004	0.68	

[a] Fully adjusted model including gender, provinces, age at retirement, age at 1991, highest educational qualification, pre-retirement characteristics (spouse's working status/no spouse, household income, occupation skill level, workplace physical activity level, smoking status, alcohol consumption, and BMI), time-varying urbanization and taking antihypertensive medicines.

[b] Fully adjusted except for taking antihypertensive medicines.

[c] Fully adjusted except for taking antihypertensive medicines and pre-retirement BMI.

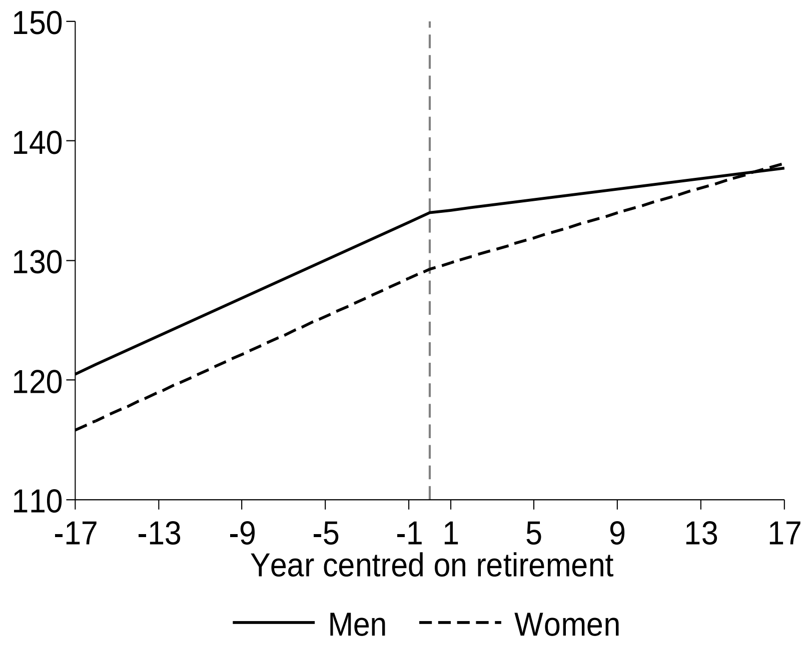

Figure 6. 1 Trajectory of SBP by gender.

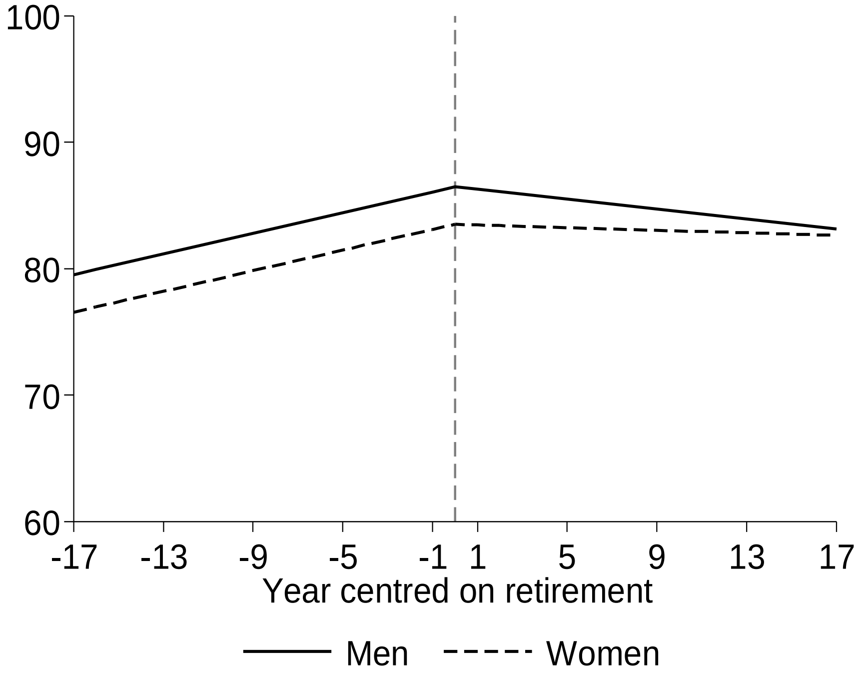

Figure 6. 2 Trajectory of DBP by gender.

6.4.2 Living in urban or rural areas as a moderator

Table 6.3 shows the results after including area of residence as a moderator. Adding pre-retirement interaction with area of residence did not improve the model fit of any health outcome. Thus, pre-retirement interaction terms were not included. The coefficients of the post-retirement interaction term were positive for SBP (β=0.385) and DBP (β=0.170), suggesting the retirement related blood pressure changes were weaker for rural dwellers than for urban dwellers (*P* for SBP<0.01 and *P* for DBP=0.04). Trajectory graphs of SBP and DBP for urban and rural residents are shown in Figures 6.3 to 6.4. There were no significant urban-rural differences in the association between retirement and WC (*P*=0.28) or BMI (joint *P*=0.19).

Table 6. 3 Moderation effect of area of residence in the associations between retirement and risk factors in the CHNS.

	β	95% CI	*P*	Joint *P*
SBP (*n*=1,084)[a]				
Post-retirement change × Rural	0.385	0.118,0.652	<0.01	
DBP (*n*=1,084)[a]				
Post-retirement change × Rural	0.170	0.008,0.332	0.04	
WC (*n*=970)[b]				
Post-retirement change × Rural	0.072	-0.058,0.202	0.28	
BMI (*n*=1,084)[c]				0.19
Post-retirement linear change × Rural	-0.032	-0.120,0.055	0.47	
Post-retirement quadratic change × Rural	0.005	-0.002,0.011	0.14	

[a] Fully adjusted model.
[b] Fully adjusted except for taking antihypertensive medicines.
[c] Fully adjusted except for taking antihypertensive medicines and pre-retirement BMI.

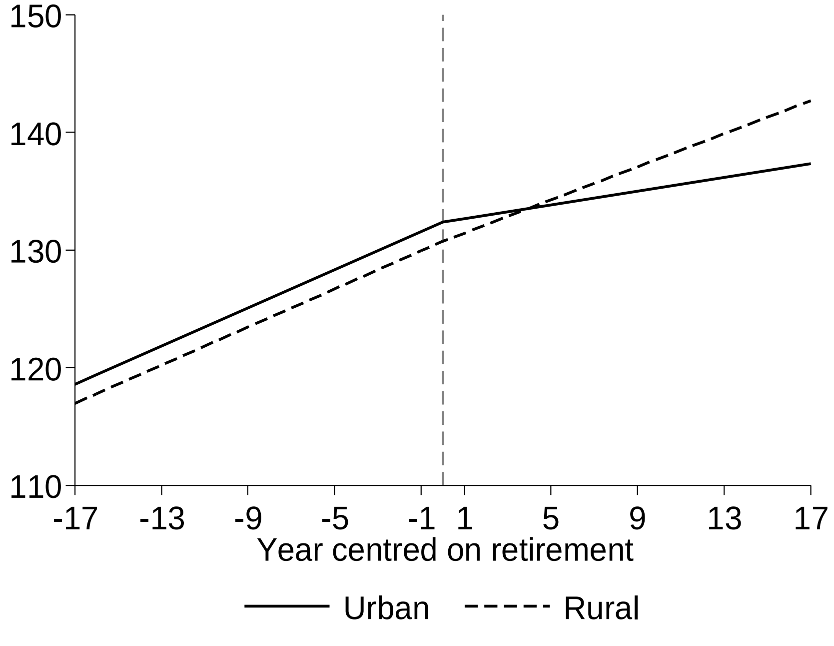

Figure 6. 3 Trajectory of SBP by area of residence.

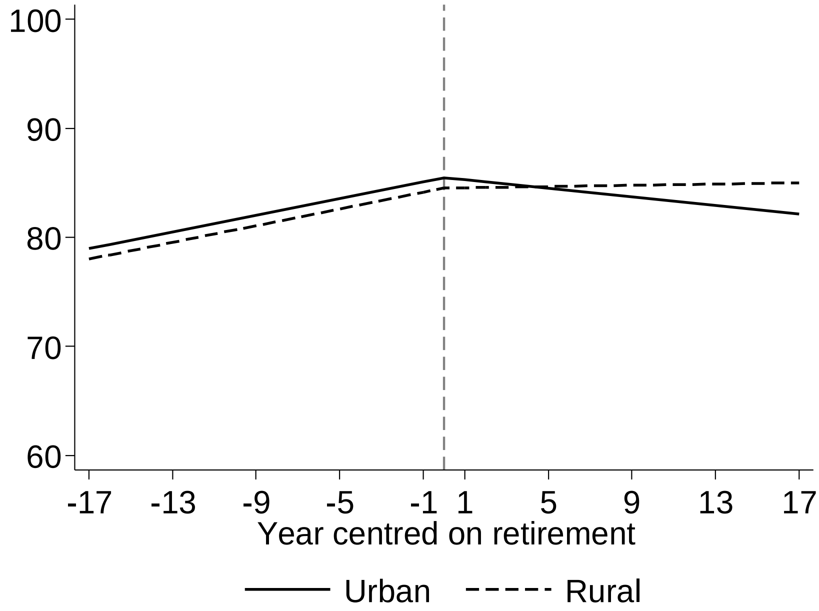

Figure 6. 4 Trajectory of DBP by area of residence.

6.4.3 Spouse's employment status as a moderator

Adding pre-retirement interaction terms with spouse's employment did not improve the model fit of SBP and DBP, but improved the model fit of WC at a borderline significance level. Thus, pre-retirement interaction terms were not included in analysis of blood pressure, but were included in WC models. Table 6.4 shows results of including spouse's employment as a moderator. In Chapter 5, retirement was accompanied by a lower DBP (β=-0.557) and a slowdown in the increase of SBP (β=-0.463) with age. So the significant negative interaction terms for SBP (β=-0.459, *P*<0.01) and DBP (β=-0.241, *P*<0.01) here suggest that, compare to retirees with a continuously working spouse (reference group), retirement had a stronger effect on blood pressure for people who had an already nonworking spouse before his/her retirement. While had a jointly spouse retired or had no spouse did not moderate the effects of retirement on blood pressure. Trajectory graphs of SBP and DBP for retirees with a continuously working spouse and retirees with an already nonworking spouse are shown in Figures 6.5 to 6.6. For WC, retirees with a jointly retired spouse showed a slightly lower increase (β=-0.163) of WC with years before retirement (pre-retirement interaction) compared to retirees with a working spouse, but its *P* value was 0.09. For post-retirement interaction, spouse's employment status did not moderate the association with WC.

Table 6. 4 Moderation effect of spouse's employment status in the associations between retirement and risk factors in the CHNS.

	β	95% CI	*P*
SBP (*n*=1,084) [a]			
Post-retirement slope change × Spouse jointly retired	-0.061	-0.381,0.259	0.71
Post-retirement slope change × Spouse nonworking	-0.459	-0.736,-0.181	<0.01
Post-retirement slope change × No spouse	-0.356	-0.910,0.198	0.21
DBP (*n*=1,084) [a]			
Post-retirement slope change × Spouse jointly retired	-0.048	-0.242,0.145	0.63
Post-retirement slope change × Spouse nonworking	-0.241	-0.407,-0.075	<0.01
Post-retirement slope change × No spouse	-0.031	-0.367,0.306	0.86
WC (*n*=970) [b]			
Pre-retirement slope × Spouse jointly retired	-0.163	-0.351, 0.026	0.09
Pre-retirement slope × Spouse nonworking	-0.128	-0.280, 0.024	0.10
Pre-retirement slope × No spouse	-0.019	-0.272, 0.234	0.88
Post-retirement slope change × Spouse jointly retired	0.183	-0.111, 0.477	0.22
Post-retirement slope change × Spouse nonworking	0.099	-0.143, 0.341	0.42
Post-retirement slope change × No spouse	-0.208	-0.634, 0.218	0.34

[a] Fully adjusted model.
[b] Fully adjusted except for taking antihypertensive medicines.

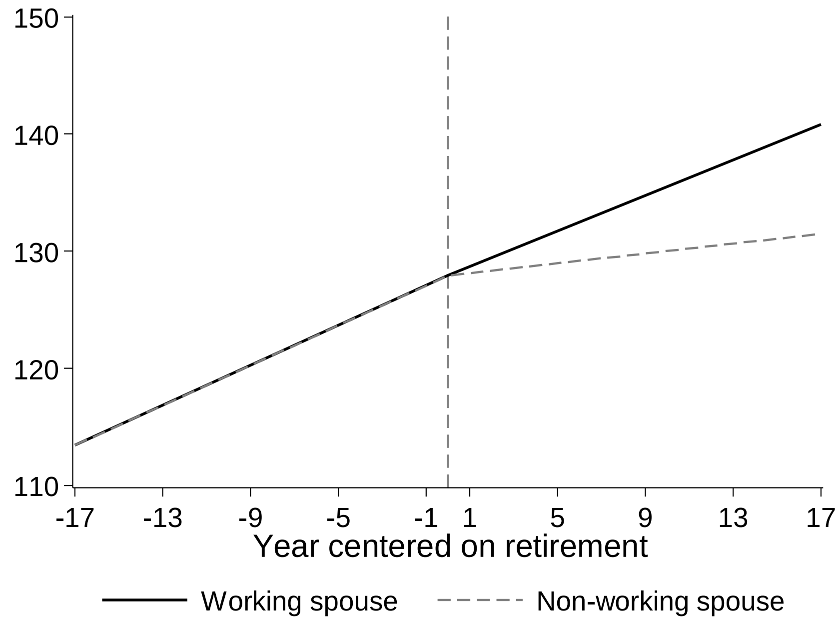

Figure 6. 5 SBP for retirees with a working spouse and those with a non-working spouse.

Figure 6. 6 DBP for retirees with a working spouse and those with a non-working spouse.

In Chapter 5, BMI increased quadratically with years, and no effect of retirement on BMI was found. When taking spouse's employment status as a moderator, the effect of retirement did not differ between those with a working spouse (reference group) and those have a spouse already nonworking before his/her retirement (joint *P*=0.48) or have no spouse (joint *P*=0.41). However, the effects of retirement on BMI differ between retirees with a jointly retired spouse (joint *P* for interaction=0.04) and those with a continuously working spouse. The results for BMI are shown in Table 6.5. Before retirement, the trajectory of BMI is the same for everyone, which BMI increased quadratically with years. After retirement, the pre-retirement trend of BMI did not change for retirees with a continuously working spouse (post-retirement linear change β=0.004, post-retirement quadratic change β=0.001), but BMI was increased for retirees with a jointly retired spouse (liner interaction term β=0.103). The linear coefficient decided the initial direction of BMI trajectory after retirement, and the quadratic coefficient decided the curve of the trajectory. A negative quadratic coefficient of the interaction term (β=-0.009) means that the initial increase for retirees with a jointly retired spouse will become weaker and weaker as time goes on, and eventually their BMI will be lower than those with a jointly retired spouse. To visualise the results, trajectory graph of BMI is shown in Figure 6.7. It can be seen from this figure that the

BMI of retirees with a jointly retired spouse only temporarily increased after retirement, but started to decrease from 7 years after retirement. Retirees with a jointly retired spouse started to have a lower BMI than those with a continuously working spouse from 12 years after retirement onwards.

Table 6. 5 Moderation effect of spouse's employment status in the associations between retirement and BMI in the CHNS.

BMI	**β**	**95% CI**	***P***	**Joint *P***
Pre-retirement				
Linear slope	0.196	0.126,0.266	<0.001	
Quadratic slope	-0.004	-0.007,0.001	<0.01	
Post-retirement change				
Linear slope change	0.004	-0.072,0.079	0.93	
Quadratic slope change	0.001	-0.003,0.006	0.50	
Linear slope change × Spouse jointly retired	0.103	0.008,0.197	0.03	0.04
Quadratic slope change × Spouse jointly retired	-0.009	-0.016,-0.002	0.01	
Linear slope change × Spouse already nonworking	-0.036	-0.112,0.040	0.36	0.48
Quadratic slope change × Spouse already nonworking	0.003	-0.002,0.009	0.23	
Linear slope change × No spouse	0.106	-0.112,0.040	0.18	0.41
Quadratic slope change × No spouse	-0.007	-0.020,0.006	0.27	

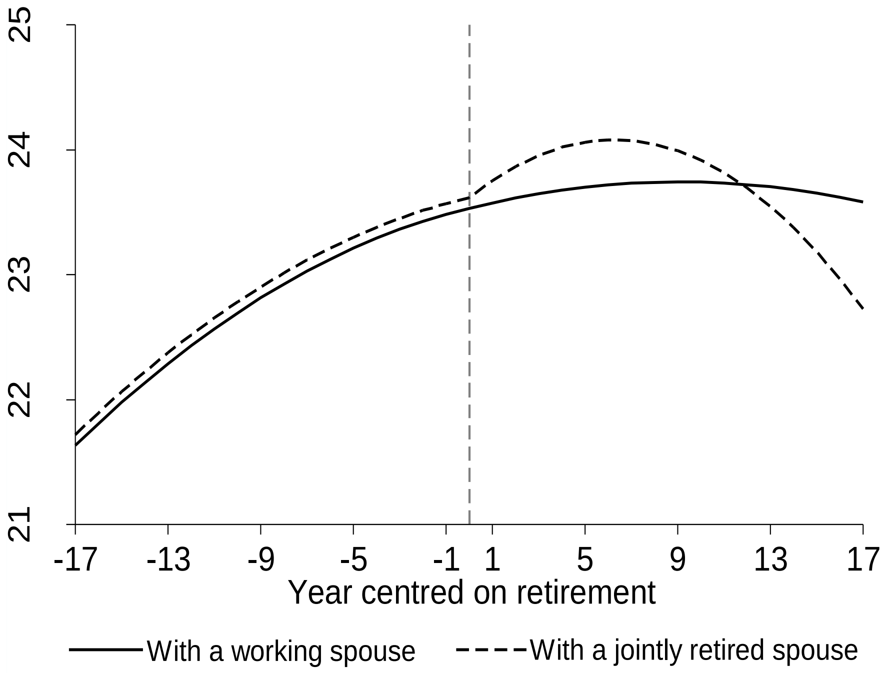

Figure 6. 7 Trajectory of BMI for retirees with a working spouse and retirees with a jointly retired spouse

6.5 Sensitivity analysis

In section 5.5.2, a sensitivity analysis was conducted using different definitions where moving from working to doing housework also counts as retirement, as long as they were at least 45 years old when this is occurred. The sample size of this sensitivity analysis was 2,845, which was composed of the original sample (*n*=1,084) and the housework sample (*n*=1,761). The housework sample is predominantly female. So the moderating role of gender was also tested for these 2,845 people. WC were collected from 1993 onwards. When modelling these outcome, only 2,589 individuals who retired after 1993 were included.

Table 6.6 shows the results for moderators. The coefficients of the interaction term were positive for SBP and DBP (0.525 for SBP and 0.309 for DBP). Retirement was accompanied by a slowdown in the increase of SBP and DBP with age, so the positive interaction terms here suggest that retirement related blood pressure changes were weaker for women than for men. Gender was also a moderator in retirement and adiposity measures, which was not found in the main analysis. The coefficient of interaction was positive (β=0.146), suggesting that retirement related slowdown in the WC growth was weaker for women than for men. The moderating role of BMI was decided by both linear and quadratic integration terms, and their joint P value was 0.005, suggesting that gender is a moderated for BMI. The trajectories of BMI by gender are shown in Figure 6.8. So after retirement, men and women had reserved trajectories, where men experienced a decreased in BMI in the first few years, and women had a increased in BMI. After years after retirement, men's BMI started to increase a little bit, and women's BMI was decreased since then.

Table 6. 6 Moderation effect of gender in the associations between retirement and risk factors in the sensitivity analysis sample.

	β	**95% CI**	***P***	**Joint *P***
SBP (*n*=2,845)[a]				
Post-retirement change× Women	0.525	0.373, 0.676	<0.001	
DBP (*n*=2,845)[a]				
Post-retirement change× Women	0.309	0.203, 0.416	<0.001	
WC (*n*=2,589)[b]				
Post-retirement change× Women	0.146	0.060, 0.232	<0.001	
BMI (*n*=2,845)[c]				
Post-retirement linear change× Women	0.064	0.019, 0.108	0.005	0.005
Post-retirement quadratic change× Women	-0.003	-0.007,0.0002	0.063	

[a] Fully adjusted.
[b] Fully adjusted except for taking antihypertensive medicines.
[c] Fully adjusted except for taking antihypertensive medicines and pre-retirement BMI.

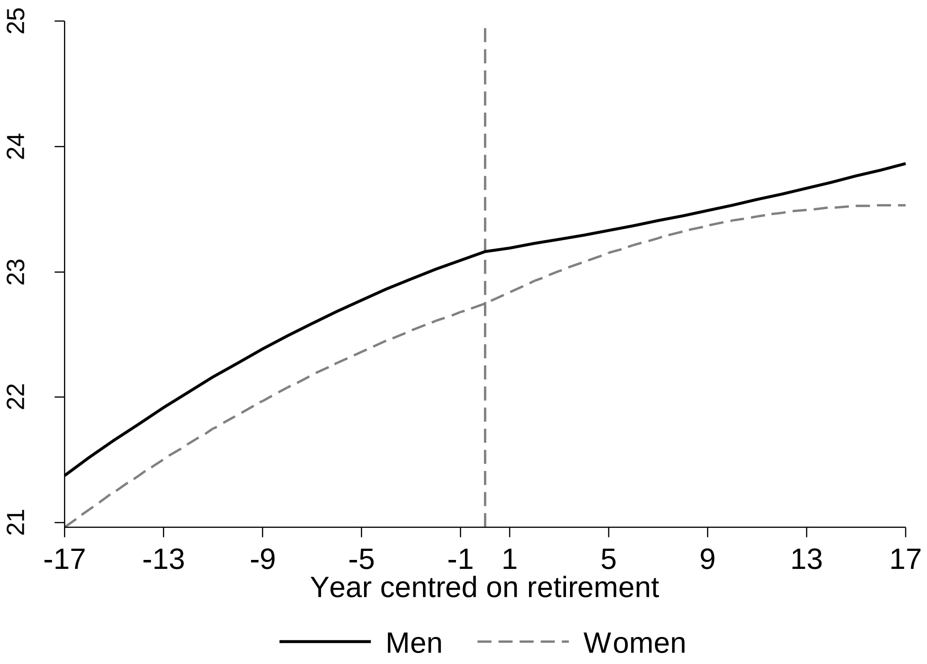

Figure 6.8 Trajectory of BMI for by gender (including people moved from working to doing housework).

6.6 Discussion of the chapter

This chapter found that the association between retirement and blood pressure was stronger for men, for urban dwellers, and for people with an already non-working spouse, but those retired jointly with their spouse tend to have a temporarily increased BMI.

Men are historically likely to have a stronger attachment to their working role than women, and, therefore, they may find exit from the labour force more stressful than women. In contrast, this chapter found that the beneficial associations between retirement and blood pressure were stronger for men than for women. Women's compulsory retirement age is 5 to 10 years earlier than men in China and traditional gender role expectations emphasize women's role as housewives, so it is likely that women are tied to family-related labour burden to a greater extent than men after retirement. For example, Talaga and Beehr (1995) found that the number of dependents in the household decreased the likelihood of men being retired, but it increased the likelihood of women being retired. Also, women are more likely than men to give family reasons for early retirement in the UK (Humphrey et al., 2003; Phillipson and Smith, 2005). High levels of family obligation, such as care giving, have been suggested to be associated with increased CVD (Lee and Colditz, 2003; Lee et al., 2003), which might reduce the beneficial association between retirement and blood pressure for women. To test this explanation, a sensitivity analysis with housewives (and a few men who stopped working for housework) was conducted. The gender differences in blood pressure remained, and the non-significant interactions with WC and BMI in the main analysis became statistically significant in the sensitivity analysis.

In addition, men are more likely to have unhealthy dietary and drinking habits in coping with job stress (Lindquist et al., 1997). Alcohol is considered as an important tool of social communication in the workplace in Chinese culture, especially for men. Retirement may lead to lower job stress and fewer drinking opportunities, thus stronger beneficial effects of retirement for men may be linked to their healthier lifestyle after retirement.

China has a large rural-urban disparity in both retirement behaviour and post-retirement financial supports. Long-term residents in urban China usually work in formal sectors, and, therefore, have formal wages, retire at mandatory ages, and receive generous pensions. In contrast, most rural residents work in self-employed agriculture-related activities, with low incomes and pensions, and are not restricted by mandatory retirement ages (Giles et al., 2011; Gong et al., 2012). For example, one study using a nationally based sample of Chinese age 60 years showed that 14% of rural dwellers and 42% of urban dweller reported bank savings, whereas urban elders were about 12 times more likely than rural elders to be pension eligible (Zimmer and Kwong, 2004). This chapter found a stronger beneficial association between retirement and blood pressure for urban dwellers than for rural dwellers. One possible explanation is that post-retirement financial stress in rural areas has offset some of the beneficial associations with retirement. There is evidence that deterioration in financial strain was associated with an increase in blood pressure (Georgiades et al., 2009) and financial stress may increase the risks of incident CVD and all-cause mortality (Carlsson et al., 2014). In addition, access to health services is particularly important for elders, but it is difficult for rural retirees with inadequate financial resources to afford proper health care treatment for chronic diseases, such as antihypertensive medication. Therefore, retirement may be less beneficial for rural residents in terms of blood pressure. Second, 'role theory' suggests that being retired may include the processes of losing or weakening work roles, while strengthening the family and community member roles (Barnes-Farrell, 2003). This role transition could lead to either positive or negative adjustment consequences, depending on whether it is desirable (Adams et al., 2002). Urban dwellers retire much earlier than rural dwellers because of the compulsory retirement age, and it may be easier for urban retirees to acquire new roles at a younger age. Besides, with no access to pension income, many rural retirees have to rely on adult children's financial support. These rural retirees experience a role transition from a 'breadwinner' to a 'dependent' in the household, which may lead to less positive adjustment consequences. Rural residents may unaware of some diseases due to the lack of availability of health services. The use of objectively measured cardiovascular risk factors as well as adjusting for taking hypertension medication have largely accounted for this problem when testing the moderation effect of living in rural or urban areas.

Retiring at the same time as one's spouse is often observed in the literature (Moen et al., 2005; Ho and Raymo, 2008), and some studies have suggested that couples do this because they want to spend their leisure time together (Coile, 2004; Banks et al., 2010). Joint retirement seems to benefit mental health (Szinovacz and Davey, 2004). This chapter found that joint retirement could lead to a temporary moderate increase on BMI in the first few years after retirement, but followed by a sharper decrease in the longer time after retirement. This may reflect different stages or phases of joint retirement (e.g. Atchley, 1976; Gall, Evans, and Howard, 1997). Early in the transition to joint retirement, such as the months immediately following retirement, couples may experience a 'honeymoon' stage. In this stage, retired couples may feel improvement in life satisfaction and marriage. Cross-sectional analysis in Chapter 3 has shown that, people with higher depressive symptoms (measured by CESD-10) had significantly lower BMI and WC. Then, improved satisfaction in the 'honeymoon' stage may be linked to higher body weight. Jointly retired couples may be willing to spend more time to cook together and eat together, and thus possibly eat more than usual. Later on, those retirees who have fewer resources and/or had unrealistic expectations about joint retirement may experience a 'disenchantment' stage, during which they eat less and lose some weight. As time goes on, retirees accept any limitations, re-evaluate their life status, and eventually settling into a stable daily life pattern until they are dead or disabled (Wang et al., 2011). The current model only has pre and post retirement two phase. Modelling more phases after retirement may provide an insight into the procedure of retirement adjustment. It is interesting that the association between retirement and WC was not altered by joint retirement, but without a spouse reduce the retirees' WC at a borderline significant level (*P*=0.07). It is possible that BMI and WC response to the life-style change after retirement differently, that BMI is more sensitive to the temporary change, while WC may reflect a long-term effect. Linear model fits the WC best, but quadratic model fits the growth of BMI best. The temporary increase of BMI for joint retirement cannot be captured by the linear model, because the first increase then decrease balance off each other in a linear model.

Another limitation in this research is that couples who are observed to retire at the same time do not necessarily do so because they want to spend their retirement time together. In the Chinese context in particular, it could simply be because both of them reached the compulsory retirement age, or it might instead reflect that there is some other third factor influencing both of them in the same way, such as another family member needing care. In cases where retirement is taken and unfavourable roles are assumed, such as care giver, health may be negatively affected (Evandrou and Glaser, 2004). There is no information about the reason for retirement in the CHNS, so further studies that distinguish those who want to retire together from those who happen to retire together would be helpful in understanding the moderating role of retirement together. In addition, this study found that retirees benefit more in terms of SBP and DBP when they have an already non-working spouse before their retirement. It is likely that, joining with the spouse in a non-working life can reduce marital conflict (Moen et al., 2012) and thus improves the health and well-being of elders.

Chapter 7: Mediators in the Longitudinal Associations between Retirement and CVD Risk factors in China

7.1 Introduction

Retirement is a very important life transition, involving changes in many aspects, such as life style, financial resources, psychosocial stressors, social integration, and personal control (Adams et al., 2002; Barnes-Farrell, 2003). These changes may influence health in different ways. Chapter 5 using the CHNS found that retirement was accompanied by a reduction in DBP, a slowdown in the increase of both SBP and WC, and a reduction in the probability of being a heavy drinker. This chapter seeks to explain the mechanisms that underlie the observed relationships between retirement and CVD risk factors via the inclusion of a hypothetical variable, known as a mediator variable. To account for the relationship between retirement and CVD risk factors, a mediator variable has to change after retirement, and can reduce or slowdown the increase of CVD risk factors with ageing.

Household income, daily fat intake, daily total calories intake, alcohol consumption and total physical activity level were selected as potential mediators, because they are likely to change after retirement and there is empirical evidence on their associations with CVD risk factors. Each variable will be discussed in detail in the following paragraphs.

Most rural retirees in China have minimum pension income after retirement, and have to rely on household savings or support from other household members. For most urban retirees, pension income is the main source of income. Reduced household income following retirement may make some retirees less able to buy alcohol and meat (meat is much more expensive than vegetables in China), thus to some extent may become a mediator to better cardiovascular health for Chinese retirees.

Diet intake, such as high consumption of saturated fat, trans-fats and salt, is linked to increased CVD risk. Although the change in eating habits following retirement are not well understood in the literature, several cross-sectional studies have suggested that retirees are more likely to consume healthy food than those in paid work (Fisberg et al., 2006; Teufel-Shone et al., 2015), and results from a Finnish longitudinal study showed that the transition to retirement led to healthier eating habits among women, but not among men (Helldán and Lallukka, 2012). Chung et al. (2007) found that retirement reduced monthly spending on eating out by $10 and $7 on average, among individuals and their spouses. So, it is likely that retirement enables more time being used in cooking thus possibly improving the opportunity to prepare healthy home-cooked food. If the Chinese retirees also spend more time on cooking healthier food after retirement, then improved eating habits may explain the improved cardiovascular health after retirement found in the CHNS. As a nutrition survey, the CHNS collected high quality dietary data for each participant, and derived daily dietary carbohydrate, fat, protein, and total calories are available. Low-calorie and low-fat food have been suggested to reduce CVD risk factors in some studies (Hooper, 2001; Walford et al., 1992), thus dietary fat intake and total dietary calories were included as potential mediators in this chapter.

In Chapter 5, alcohol consumption was used as a behavioural outcome, and the probability of being a heavy drinker reduced significantly after retirement. Besides being an important behaviour CVD risk factor, alcohol consumption may be a potential mediator in the association between retirement and other CVD risk factors. For instance, heavy drinking has been associated with increased blood pressure in epidemiological studies (Chadwick and Goode, 2007; Marmot et al., 1994), and a meta-analysis of 15 randomised controlled trials found that alcohol reduction was associated with a significant reduction in mean SBP and DBP of 3.31 mm Hg and 2.04 mm Hg, respectively (Xin et al., 2001). Thus, the mediating role of alcohol consumption was tested in this chapter.

Evidence from a systematic review suggested that physical activity appears to be inversely associated with the risk of CVD and specifically CHD in a dose-response fashion. The absence of work activities and restrictions provides an opportunity for free time. Thus, retirement often leads to an increase in leisure-time physical activity (e.g. Henkens et al., 2008; Koeneman et al., 2012; Kuvaja-Köllner et al., 2013), but could reduce job-related physical activity level in turn. In the literature no clear pattern emerges with regard to the effects of retirement on total physical activity; if total physical activity increases among Chinese retirees, then it may explain some of the association between retirement and blood pressure and central obesity. However, if total physical activity decreases, then it cannot be considered as a mediator.

The analytic sample and measures of potential mediator variables are presented in the next section 7.2, and the analytic method is shown in section 7.3. The changes of these potential mediator variables before and after retirement are shown in section 7.4. Only variables changed in a direction that can possibly explain the association between retirement and CVD risk factors are kept in the following analyses. Results of testing mediators are shown in section 7.5. Results are then discussed in section 7.6.

7.2 Analytic sample and measures of potential mediators

This chapter used the same analytic sample used in Chapter 5: people who moved from 'working' to 'retired' between 1991 and 2011 in the CHNS (n=1,084). The sample size was 1,084 for SBP, DBP and BMI. WC and alcohol consumption were only collected since 1993, so the sample size was 970 for these two outcomes. Besides being an important health outcome, alcohol consumption was also used as a potential mediator. When testing the mediating role of change of alcohol consumption, only the 970 participants were used. Full information on total physical activity was only collected from 1997 onwards, thus an even smaller analytic sample (i.e. individuals who retired after 1997) was used when testing the mediating role of total physical activity level (n=754).

Household income

A derived total household income variable at each wave was constructed by the CHNS team, which summed all income and revenue minus expenditures in the following nine sources: business, farming, fishing, gardening, livestock, non-retirement wages, retirement income, subsidies, and other income. Missing data in this variable had been imputed before it was released. The detailed percentage of missingness was not provided in the CHNS guidebook, but steps of MI was described, that in order of preference, imputation was based on the household's previous and subsequent waves, the mean of households in the community, or the mean in the city/county.

In this chapter, per capita household income was generated using the constructed total household income divided by family size. Per capita household income was then divided by the yearly consumer price index in China (National Bureau of Statistics of China 2014b) to control for the price inflation during the 20-year data collection. The inflated per capita household income ranged from 0.001 to 326807.3 (RMB), with 90% people with an income lower than 22151.27. The distribution of inflated per capita household income was skewed, and thus it was log transformed to achieve a normal distribution.

Daily nutrient intake

Individual dietary data was collected by asking individuals each day to report all food consumed over three consecutive days, whether at home or away from home. The three consecutive days during which food consumption data have been collected were randomly allocated from Monday to Sunday and are almost equally balanced across the seven days of the week for each household (Carolina Population Center, 2011). All food and beverage was recorded for each individual, and household cooking oil and condiment consumption was calculated to individual level using a weighted method (Wang et al., 2014). The individual food consumption data is self-reported and may subject to errors and bias. Thus during the same daily interview, objectively measured household food consumption data have been collected by field workers. Household food consumption has determined by examining changes in inventory from the beginning to the end of each day, in combination with a weighing and measuring technique. Whenever foods have been brought into the household unit, they have been weighed by trained field workers, and preparation waste has been estimated when weighing was not possible. The collection of both household and individual dietary intake allowed the CHNS team to check the quality of data collection by comparing the two. If there were significant differences between the food consumption calculated from individual level and that from the household level, the survey was revisited by field workers to resolve these discrepancies (Xu et al., 2015).

Constructed daily dietary carbohydrate, fat, energy, and protein for each individual in the household were available at each wave in the CHNS. The 1991 Food Composition Table for China was utilised to calculate nutrient values for the dietary data of 2000 and previous years, and a newer version of Food Composition Table (2002) was used for the 2004 survey and the latest version (2004) was used for the 2006 to 2011 survey

(Carolina Population Center, 2011). Values of dietary nutrient intake in the sample were skewed, with some people have very high nutrient intake, and thus values were log transformed to get a normal distribution in the analyses.

Frequent consumption of high-energy foods promotes obesity, and high dietary intake of saturated fat and trans-fats are linked to cardiovascular risk (Reddy and Katan, 2007; Swinburn et al., 2009; Van Aerde et al., 2013). It is still unclear about whether dietary carbohydrate and protein are associated with CVD, so this chapter only tested the mediating roles of individual dietary fat and energy intake.

Alcohol consumption

This chapter used the same cut-off points of alcohol consumption applied in the previous analyses. The measures of alcohol consumption have been already described in section 4.3.2

Total physical activity level

Information about time spent on occupation, housework, leisure activities, and transportation was asked separately for participants in the CHNS. This chapter used the metabolic equivalent (MET) hours per week to measure total physical activity level at each wave, which was calculated as the value of MET per hour multiplied by average hours spent on each of the activities per week. Specific values of METs per hour were assigned according to Ng et al. (2009), which measured the total physical activity level in the CHNS.

Occupational activity

MET hours per week from occupational activity was measured by self-reported occupation and the average hours spent on working per week for market-sector job plus average hours worked from home in the last year (working on a farm, in a garden or orchard, raising livestock or poultry, fishing, and working on craft/small business). In detail, six METs per hour were assigned to farmers, fishermen, hunters, and those who worked from home, except that four METs per hour was assigned to working on craft/small business at home. Four METs per hour were assigned to skilled workers, non-skilled workers, and service workers, and two METs per hour were assigned to those working as senior or junior professionals, administrators, executives, managers or office staff, drivers, and army or police officers. For individuals who reported having more than one job, their total occupational MET hours per week were derived by summing across all occupations.

Participants were also asked about their physical activity level in the workplace, with optional categories of 'very light', 'light', 'moderate', 'heavy', and 'very heavy'. According to Ng et al. (2009), the specific values of METs per hour given above were matched to how the majority of individuals reported their physical activity level in the workplace.

Housework

Individual MET hours per week from housework were summed from preparing food, buying food, doing laundry, and cleaning house. Average hours per week spent on each activity in the past year were multiplied by specific values of METs per hour based on the Compendium of Physical Activities (Ainsworth and Haskell, 2000) with 2.3 for buying food, 2.25 for preparing food or cooking, 2.15 for doing laundry, and 3.3 for house cleaning. Hours spent per week on cleaning house was asked from 1997 onwards. Time spent on childcare was also asked in the questionnaire, but it was not included in this section. Because the energy spent on childcare per hour may vary a lot between individuals, thus it is difficult to give an accurate value of METs per hour. Also, excessive caring responsibly has been linked to increased CVD, so spending time on caring cannot be considered as a physical active lifestyle, thus it is not appropriate to include this as a potential mediator.

Leisure activity

From 1997 onwards, participants were asked their leisure physical activities in the past year, and the average time spent per week on each leisure activity. According to Compendium of Physical Activities (Ainsworth et al., 2000), the values of METs per hour used for leisure activities were: 4.5 for marital arts, 7.5 for jogging or swimming, five for dancing or aerobics, six for playing basketball, volleyball or soccer, and five for playing tennis, badminton or ping-pong.

Transportation mode

Since 1997, participants were asked about their transportation mode (motorised vehicle, bicycle, or walking) and time spent travelling to and from work. Again, according to the Compendium of Physical Activities (Ainsworth et al., 2000), METs per hour was 1.5 for taking a motorised vehicle, four for bicycling, and three for walking.

A total physical activity was computed as summing all MET hours per week spent on occupation, housework, leisure activity and transportation. Because transportation mode and leisure activity were only from 1997 onwards, so the total physical activity was only computed at each wave from 1997 to 2011. The distribution of total physical activity was skewed, and thus was log-transformed.

7.3 Analytic methods

This chapter tested the potential mediating roles of per capita household income, daily fat intake, daily energy intake, alcohol consumption, and total physical activity level. Before adding them to the mediating model, this chapter first tested whether these mediator variables are in fact associated with retirement. To assess their associations, piecewise regressions were again utilised, and trajectory graphs of each potential mediator before and after retirement are shown in the next section.

This chapter used the same exposure variables, outcome variables and covariates as those used in Chapter 5, and it tested the potential mediating roles by adding each mediator as a time-varying variable into the piecewise models of Chapter 5. This chapter showed the effects of retirement on CVD risk factors first without and then with a potential mediator. The magnitude of the mediating effect was assessed by the percentage change in the effect of retirement. For continuous health outcomes, including SBP, DBP, and WC, the effect of retirement is presented by slope change after retirement (i.e. coefficients), so the magnitude of the mediating effect was assessed by the percentage change in the coefficient, computed as [(Coefficient of model with a mediator - Coefficient of base model without a mediator) /(Coefficient of base model without a mediator)] × 100. For the categorical behaviour outcome (alcohol consumption), the effect of retirement is presented by the change of RRR of being a heavy drinker versus a non-drinker after retirement, so the mediating effect was qualified by the percentage change in the RRR. A RRR equals to one suggests no difference in risk, and a RRR less than one suggests a reduced risk, while a RRR larger than one means an increased risk. The effect of RRR was dependent on the ‘distance’ from one, so the mediating effect in this chapter was qualified by [(RRR of model with a mediator - RRR of base model without a mediator) /(RRR of base model without a mediator-1)] × 100.

The analytic sample here identical with that of Chapter 5, with a sample size of 1,084 for SBP and DBP, and a smaller sample size of 970 for WC and alcohol consumption as they were collected from 1993 onwards. I only tested the mediating role of household income in the association between retirement and alcohol consumption, but did not test the meditation roles of dietary nutrient intake or total physical activity level, as they are not on the hypothesised causal pathway between retirement and alcohol consumption.

Besides being an outcome, alcohol consumption was also tested as a mediator in the association between retirement and blood pressure and WC. When testing its mediating role, only individuals who retired after 1993 were used (n=970). Several subsets of the total physical activity level were not collected before 1997, so only individuals who retired after 1997 were used when testing the mediating role of total physical activity level.

Missing data in the outcomes, covariates and potential mediators were already multiply imputed in section 4.4.4 in Chapter 4.

7.4 Changes of potential mediators before and after retirement

The trajectories of total household income per capita, total fat intake, total calories intake, alcohol consumption and total physical activity level before and after retirement are shown in Figures 7.1 to 7.5. All these potential mediators changed after retirement. The speed of the growth of household income slowed after retirement, but carried on growing (Figure 7.1). The trajectories of fat and total energy intake went down after retirement (Figures 7.2 and 7.3), and the probability of being a heavy drinker also decreased after retirement (Figure 7.4). Retirees experienced a large drop in total physical activity level after retirement (Figure 7.5), which is because their main occupational activity were coded as zero after retirement. Physical inactivity is linked with increased obesity and other metabolic risk factors. Decreased total physical activity level after retirement is unlikely to explain the beneficial associations found in the CHNS, thus was not tested as a mediator. The remaining variables were included in the following analyses, and tested their mediating roles.

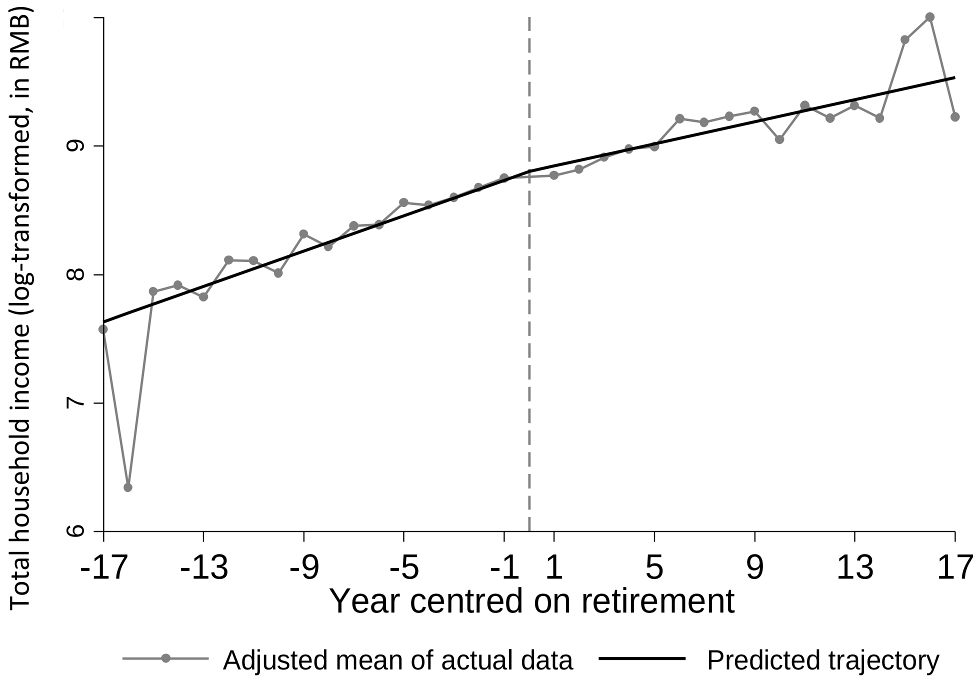

Figure 7. 1 Trajectories of total household income per capita before and after retirement.

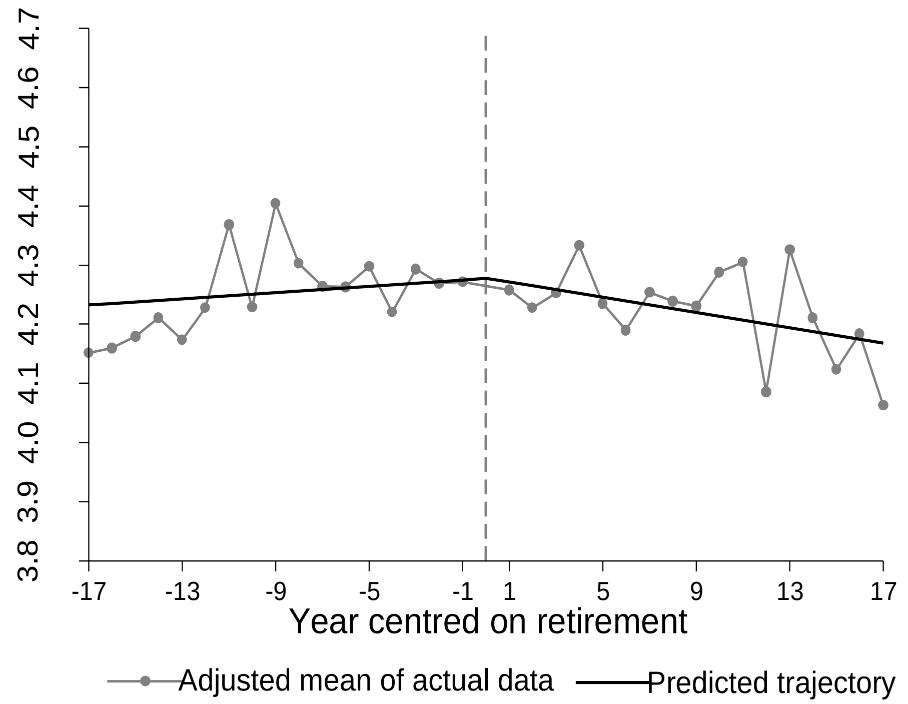

Figure 7. 2 Trajectories of total fat intake before and after retirement.

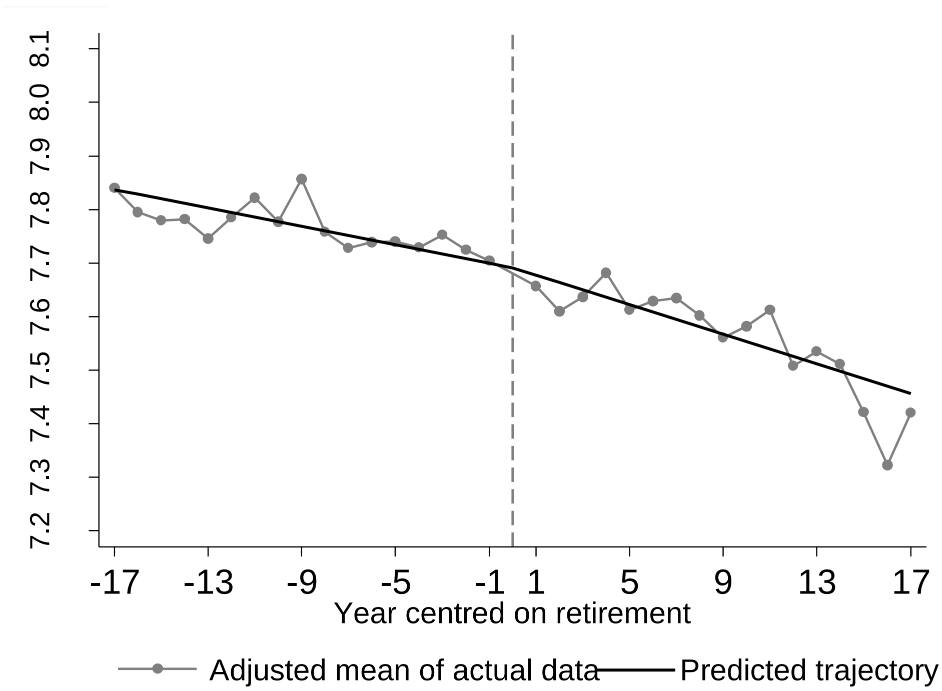

Figure 7. 3 Trajectories of total energy intake before and after retirement.

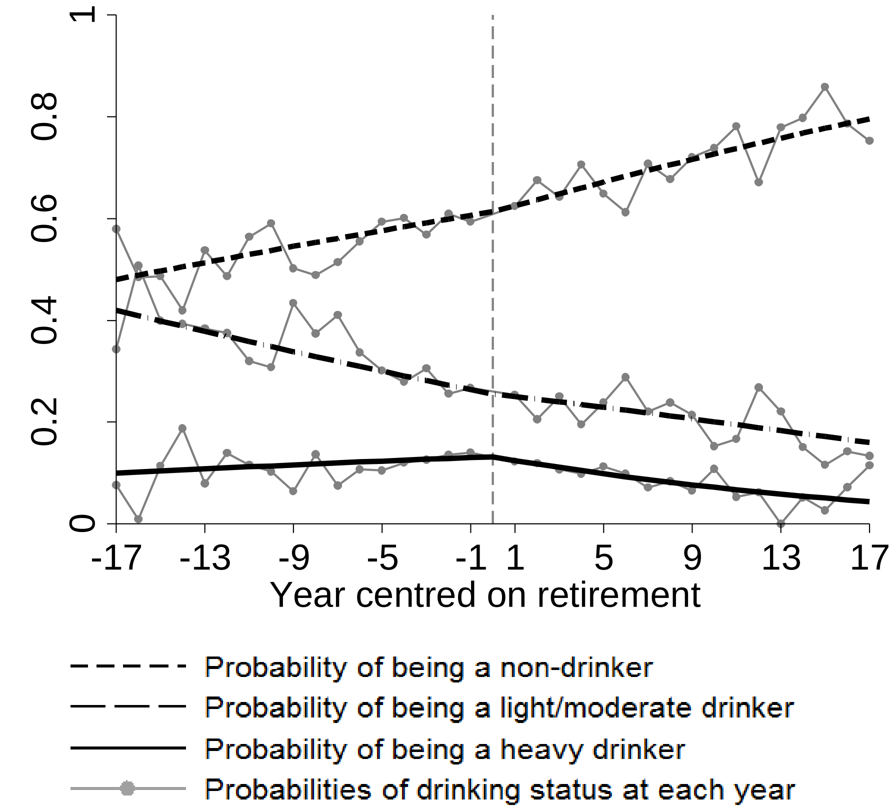

Figure 7. 4 Trajectories of alcohol consumption before and after retirement.

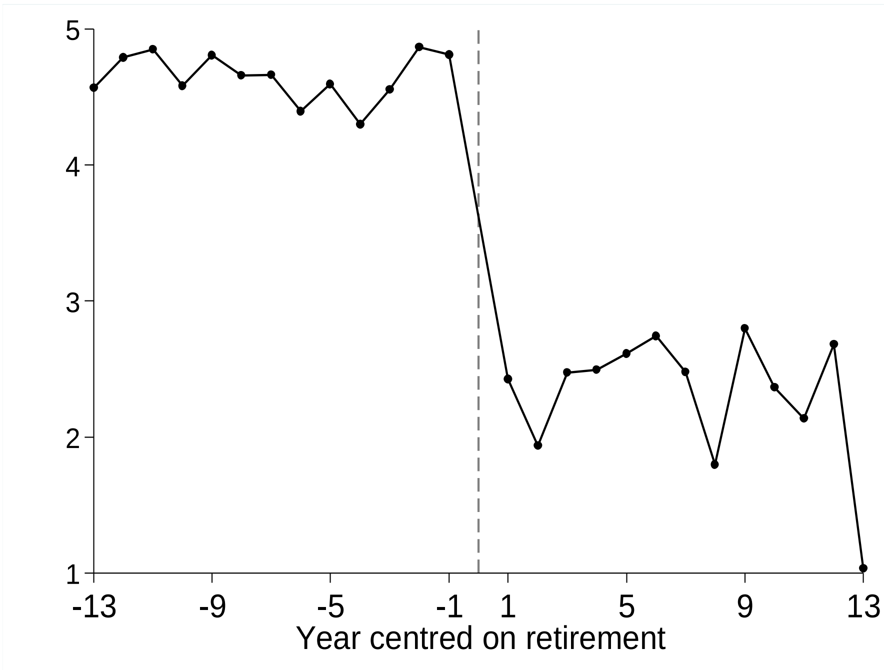

Figure 7. 5 Trajectories of total physical activity before and after retirement.

7.5 Results of the mediating effect

7.5.1 Mediating effect in the association between retirement and blood pressure

Table 7.1 shows the slope change (β) of blood pressure after retirement first without and then with a potential mediator. The 'without' estimation repeated the results of Chapter 5. To assess the magnitude of the mediating effect, percentage change in the slope change (β) with and without a mediator was shown. For SBP, the slope change after retirement without mediators was -0.463. This negative coefficient means that the slope of SBP decreased after retirement. After adding household income as a mediator, the effect of retirement on SBP was not attenuated (β=-0.464). After adding dietary total fat intake as a mediator, the effect of retirement on SBP was slightly attenuated (β=-0.461). The percentage change in β after adding dietary fat intake was -0.6%, computed as [(-0.461) - (-0.463)/(-0.463)]. In other worlds, dietary total fat intake only explained 0.6% of the effect of retirement on SBP. After adding dietary total calories intake as a mediator, the effect of retirement on SBP was not attenuated either (β=-0.464). For DBP, the slope change after retirement without mediators was -0.557. After adding household income as a mediator, the effect of retirement was not attenuated, but increased slightly (β=-0.560). Adding dietary total fat intake or dietary total calories intake only explained 0.1% of the effect of retirement on DBP.

Table 7.2 shows the mediating effect of alcohol consumption. As alcohol consumption were collected from 1993 onward, so the results here were based on a restricted sample who retired in 1997 or later (*n*=970). The slope change (β) of SBP after retirement without a mediator was -0.440, and adding alcohol consumption as a mediator reduced this slope change to -0.435, which explained 1.1% of the effect of retirement on SBP. The slope change of DBP after retirement without a mediator was -0.529, and adding alcohol consumption as a mediator reduced this slope change to -0.515, which explained 2.6% of the effect of retirement on DBP.

Table 7. 1 Slope change of blood pressure after retirement without and with a potential mediator.

	SBP (*n*=1,084)				DBP (*n*=1,084)			
	β	**95% CI**	***P***	**% change in β**	**β**	**95% CI**	***P***	**% change in β**
Base model without mediators	-0.463	-0.663, -0.264	<0.001	Reference	-0.557	-0.682,-0.433	<0.001	Reference
Base model+ household income	-0.464	-0.663, -0.265	<0.001	0.2	-0.560	-0.685,-0.436	<0.001	0.5
Base model+ total fat intake	-0.461	-0.660, -0.261	<0.001	-0.6	-0.556	-0.680,-0.432	<0.001	-0.1
Base model+ total calories intake	-0.464	-0.664, -0.265	<0.001	0.2	-0.556	-0.680,-0.432	<0.001	-0.1

Table 7. 2 Slope change of blood pressure after retirement without and with alcohol consumption.

	SBP (*n*=970)				DBP (*n*=970)			
	β	**95% CI**	***P***	**% change in β**	**β**	**95% CI**	***P***	**% change in β**
Base model without mediators	-0.440	-0.654, -0.227	<0.001	Reference	-0.529	-0.651, -0.407	<0.001	Reference
Base model+ alcohol consumption	-0.435	-0.630, -0.240	<0.001	-1.1	-0.515	-0.649, -0.381	<0.001	-2.6

7.5.2 Mediating effect in the association between retirement and adiposity measures

Table 7.3 shows the slope change (β) of WC after retirement first without and then with a potential mediator. The slope change without a mediator was -0.142, and adding household income or dietary total fat intake as a mediator only reduced this slope change to -0.141, which explained 0.7% of the effect of retirement on WC. Adding dietary total calories intake as a mediator reduced the base slope change to -0.139, which explained 2.1% of the effect of retirement on WC. Adding alcohol consumption as a mediator reduced the base slope change to -0.140, which explained 1.4% of the effect of retirement on WC.

Table 7. 3 Slope change of WC after retirement without and with a potential mediator.

	WC (*n*=970)			
	β	**95% CI**	***P***	**% change in β**
Base model without mediators	-0.142	-0.249, -0.035	<0.01	Reference
Base model+ household income	-0.141	-0.248, -0.034	0.01	-0.7
Base model+ total fat intake	-0.141	-0.248, -0.034	0.01	-0.7
Base model+ total calories intake	-0.139	-0.247, -0.032	0.01	-2.1
Base model+ alcohol consumption	-0.140	-0.248, -0.033	0.01	-1.4

7.5.3 Mediating effect in the association between retirement and alcohol consumption.

Table 7.4 shows the change of RRR on alcohol consumption after retirement first without and then with a potential mediator. In the base model without mediators, the change of RRR after retirement was 0.919, suggesting the ratio of the probability of being a heavy drinker over the probability of being a non-drinker decreased by 8.1% (1-0.919) every year after retirement. After adding household income as a mediator, the RRR changed to 0.927, so now the ratio of the probability of being a heavy drinker over the probability of being a non-drinker decreased by 7.3% (1-0.927) every year after retirement. Household income explained 9.9% of the effect of retirement on alcohol consumption, computed as (0.927-0.919)/(0.919-1).

Table 7. 4 Change of RRR after retirement without and with a potential mediator.

	Alcohol consumption (*n*=970)			
	RRR [a]	**95% CI**	***P***	**% change in β**
Base model without mediators	0.919	0.862,0.982	0.01	Reference
Base model+ household income	0.927	0.871,0.986	0.02	-9.9

[a] Being a heavy drinker vs. a non-drinker.

7.6 Discussion of the chapter

This chapter tested the potential mediating role of household income, total fat intake, total energy intake, and alcohol consumption. Most of these potential mediators only played a minimal role in the associations between retirement and CVD risk factors, with a possible exception of household income, which explained 9.9% of the relationship between retirement and heavy drinking. The following paragraphs will discuss each mediator in turn.

First, the trajectories show that post-retirement household income continues to grow but at a slower speed compared to pre-retirement. This reflects the generous pension scheme in China with an 81% replacement rate (pre-retirement income that is paid out by a pension program upon retirement), which is much higher than the OECD average level and many Western countries. Therefore, generous pension income makes retirement a less difficult financial transition in China, and household income may then have a minimal influence on blood pressure and WC. For heavy drinkers, who usually have to spend a big portion of income on alcohol, retirement may reduce their budget for buying alcohol somewhat. Household income is still not the main reason for reduced alcohol consumption after retirement, and the probability of being a heavy drinker over the probability of being a non-drinker still decreased by 7.3% every year after retirement, after adding household income as a mediator. As mentioned previously, it is likely due to drinking culture in the workplace in China, and retirement offers an opportunity to stop using alcohol. In addition, reduced probability of being a heavy drinker may be related to decreased levels of stress after retirement. For example, an USA study found that there was a consistent positive relationship between number of stressors experienced in the past-year and all measures of heavy drinking, and this relationship was particularly strong for job-related stress (Dawson, Grant, and Ruan, 2005). For Chinese workers, daily work stress was related to both daily alcohol use and desire to drink (Liu et al., 2009). There is no information about participants' stress level or psychological health condition in the CHNS, thus their mediating roles cannot be tested.

Second, this study used detailed measures of dietary nutrient intake, which were collected using 24-hour recalls in three consecutive days. Neither dietary fat intake nor dietary total energy intake explained much of the associations between retirement and blood pressure or WC. This result is contrary to a study in the Netherlands, which estimated that dietary factors explained 15% of the increased risk for CHD in the retired group (Méjean et al., 2013). It is possible that diet plays a less important role in retirement in the Chinese context, as the trajectory of total energy intake was only slightly changed after retirement. For blood pressure, dietary salt intake is particularly important (Kaplan and Opie, 2006), but the CHNS did not collect the information about salt intake. This information may have been helpful in understanding the retirement related blood pressure changes.

Third, alcohol consumption explained no more than 3% of the associations between retirement and CVD risk factors. The less obvious effect of alcohol consumption is probably because only the proportion of heavy drinkers was reduced after retirement, while the proportion of light and moderate drinkers, who are the majority, was not changed after retirement.

Total physical activity level was not tested as a mediator, as its trajectory was largely reduced after retirement, which unlikely to cause beneficial effects. Total physical activity was calculated as the value of MET per hour multiplied by average hours spent in occupation, housework, leisure activities, and transportation per week. However, it is consistently difficult to use questionnaires to collect accurate information of total physical activity level, because there are so many different types of physical activities per day. For example, walking is probably the main leisure physical activity for elders, and studies have shown that retirement was associated with increase time spent walking (Sjösten et al., 2012). However, time spent walking was not asked in this questionnaire, thus this may be a limitation in measuring leisure activity in this chapter, and may lead to an underestimate of activity level after retirement.

Analysis in this chapter has several other limitations. China has generally two different retirement systems in urban and rural areas. Thus, retirement is likely to influence urban and rural dwellers' health in different ways. For example, for urban dwellers, reduced household income after retirement may lead to less consumption in eating out and drinking alcohol. In contrast, for rural retirees, it could mean poor quality food and the inability to see a doctor when necessary. Thus, reduced income after retirement may have contrary impacts on health for urban and rural retirees, but this chapter did not test the mediators for urban and rural participants separately, due to the small number of rural retirees.

In addition, this chapter added potential mediators as time-varying variables into regression models to see if there is any change in the association between retirement and risk factors. This method can give a general idea about which variable may mediate associations, but cannot estimate the causal effects of mediators, nor can identify the causal mechanisms. Mediation analysis could be a useful extension to the analysis presented within this thesis to understand how retirement influences CVD risk factors, in particular how much of retirement's effect is mediated by an intermediate variable and how much retirement directly affects the outcome independently.

Chapter 8: Conclusions and Discussion

8.1 Overview of findings

The work presented within this thesis aimed to answer two key research questions. The first asked whether there are differences in retirement behaviour between China and England, as well as whether there are differences between the two countries in the associations between retirement, and CVD and CVD risk factors. The second question asked whether there are effects of retirement on CVD risk factors in China, independent of any reciprocal effects of CVD risk factors on retirement, and whether these effects are moderated by gender, area of residence, and spouse's employment status or mediated by household income, total fat intake, total calories intake, alcohol consumption, and total physical activity. To answer these questions, a cross-national comparison between China and England was conducted, and a longitudinal analysis on the effects of retirement on CVD risk factors was also conducted. This thesis also systematically reviewed previous research on retirement and CVD/CVD risk factors.

Comparisons between China and England

The cross-national study found both similarities and differences between China and England in terms of retirement behaviour. People who were older, female, had relatively low family income, and had more depressive symptoms were more likely to be retired in both countries. In China, urban dwellers and those who were advantaged in educational attainment and occupation skill level were more likely to be retired, but this was less the case in the England. The median retirement age in China was 5 years earlier than in England, and the gender and urban-rural differences in retirement age were much bigger in China. Many of the differences in retirement behaviour can be explained by the compulsory retirement policy of formal sectors in China. Chinese people who live in urban areas, and have higher education and occupation skill level are often working in formal sectors, thus have to retire much earlier, and women in formal sectors have to retire 5 to 10 years earlier than men.

Overall, retired people in China had worse health than those in paid work, but retirees in England had better health conditions than working counterparts. In China, retired people had higher levels of BMI, WC, and CRP compared to those in paid work. While in England, retired people had lower levels of blood pressure and HbA1c than their working counterparts. Retirement was associated with reduced risk of being a smoker in England, and was associated with reduced risk of being a drinker in China. In both China and England, retired people had higher risks of ever having heart disease and stroke than their working counterparts, and effects of these associations seemed to be always stronger in China. While retired people in China generally had worse health than those in paid work in this cross-sectional analysis, longitudinal analysis in Chapter 5 has ruled out the possibility that retirement triggers worse cardiovascular health in China. Therefore, the cross-sectional results in China are likely due to reverse causation that worse health leads to retirement. Then the stronger detrimental associations in China than in England may suggest that Chinese elder workers are less likely to continue to work after having chronic CVD related illness compared to English workers.

This cross-sectional result also shows that gender and spouse’s employment could influence the association between retirement and health outcomes in both China and England. In China, women had a stronger detrimental association between retirement and blood total cholesterol, but a stronger beneficial association with drinking frequency. In England, men had stronger beneficial associations between retirement and both DBP and smoking. In China, retirees with a working spouse or without a spouse had significantly lower probability of being a drinker than their working counterparts, but this was not observed among retirees who lived with a non-working spouse. In England, the associations between retirement and lower level of HbA1c and less likely to be a light/moderate smoker were stronger for people with a non-working spouse. China and England may have very different gender norms and values towards a spouse, so it is possible that these differences will contribute to various health behaviours and different health conditions by gender and by spouse’s employment status after retirement in these two countries. Urbanisation can moderate the associations only in the Chinese retirement context, but not in England, which is likely because the pension system is the same between urban and rural areas in England.

Longitudinal associations between retirement and CVD risk factors in China

Longitudinal analyses were carried out in a 20-year prospective population study in China. Outcome risk factors included objectively measured SBP, DBP, BMI, and WC as well as self-reports of current smoking status and alcohol consumption. Using two-segment piecewise regressions, this thesis tested whether the trajectories of risk factors differ before and after retirement to understand the potential long-term associations between retirement and risk factors. This longitudinal analysis found that retirement was accompanied by a reduction in DBP, a slowdown in the increase of SBP, and a reduction in the probability of being a heavy drinker in China. Results for heavy smoking mirrored those for heavy drinking, but were weaker and only reached borderline statistical significance. Retirement was also found to slowdown the increase of WC with years, but no significant effect of retirement on BMI was found. The beneficial association between retirement and blood pressure was stronger for men than women, for urban dwellers than rural dwellers and for retirees with an already non-working spouse compared to retirees with a working spouse, but those retired jointly with their spouse tend to have a temporary increase in BMI after retirement.

In addition, two sensitivity analyses tested the robustness of the results. The first sensitivity analysis excluded any observations after retirees went back to work. Estimations were very similar to the original analysis, and did not change the conclusion that retirement is beneficial for elders in the Chinese context. The second sensitivity analysis, which combined both the original sample and people who moved from working to doing housework, showed a similar pattern on associations between retirement and CVD risk factors, although results were less pronounced compared to the original analysis. There are more women, especially more rural women in this sensitivity analysis sample, as they are less able to conduce formal retirement, and often considered them as housewives. The gender differences in blood pressure become bigger and the non-significant gender interactions with WC and BMI in the original analysis became statistically significant in the sensitivity analysis. This may support the findings that retirement was more beneficial for men in the Chinese context, and the gender differences maybe exist in both blood pressure and adiposity measures.

Potential mediators, including household income, daily fat intake, daily total calories intake, and alcohol consumption were tested. Household income explained 9.9% of the relationship between retirement and heavy drinking, but other variables only played a minimal role in the associations between retirement and CVD risk factors.

Compare findings in the literature

A total of 102 studies was included overall, on the basis that they test the effects of retirement on CVD or CVD risk factors. The studies varied in many aspects, including different concepts of retirement, different health measures, different methods of analysis, and the characteristics of the study populations also differ. In an attempt to find some common effects, studies were broken down by type of health outcome: CVD, CVD metabolic risk factors, and CVD behavioural risk factors. Among studies of CVD, empirical studies in the USA often found no significant effect of retirement on CVD, while studies in Europe, except France, showed consistent detrimental effect of retirement on CVD. For CVD metabolic risk factors, the majority of cross-sectional studies suggested retirement were associated with increased metabolic risk factors, but their results are likely to be overestimated because of healthy worker effects. For longitudinal studies, retirement was linked to increased adiposity measures in the US context, especially among those retired from physically demanding jobs, but results from other countries were less consistent. In terms of diagnosed diabetes and hypertension, five out of seven longitudinal studies suggest no effects of retirement. For CVD behavioural risk factors, retirement was associated with an increase in both leisure-time physical activities and sedentary behaviours, and there was no clear pattern emerged with regard to total physical activity level. Seven out of ten studies on smoking suggested retirement did not increase smoking. Results on alcohol consumption and diet are mixed, and no clear pattern can be found. Although the overall findings of the systematic review were inconclusive, country level characteristics are likely to be one of the most important factors influence the cardiovascular health of individuals after retirement, which supports the cross-national comparison results found in this thesis. It is also interesting to note that, regardless of heterogeneity, none of the included studies have found any beneficial effects of retirement on CVD, and only a few of them suggested that retirement reduced metabolic risk factors of CVD, which is contrary to the results found in the longitudinal analysis in this thesis. One possible reason for the inconsistent findings between this thesis and Western studies is that the generous pension system in the formal sector in China plus the supports from adult children could provide enough financial resources for older Chinese people after retirement. Besides, generally less favourable working environment in China than developed countries may make retirement a 'desirable' life course transition, thus leads to better cardiovascular health outcomes after retirement. In addition, retirement in China is more of a midlife transition, rather than a transition to old age, thus is easier for retirees in China to acquire new roles and to develop new self-identities, which may be beneficial for health.

8.2 Applying the study findings to theories of retirement and health

Theoretical mechanisms linking retirement and mental health discussed earlier in the thesis were role theory, continuity theory, stage theory, and the life course perspective. A theoretical framework based on the life course perspective and is specific to CVD/CVD risk factors was also proposed (Chapter 2). The following paragraphs will compare the study findings with each of these specific theories.

Role theorists argue that, on the one hand, the loss of the critically important work role accompanying retirement can lead to low levels of well-being. On the other hand, retirement from the demands of one's primary occupation may be a major role exit that serves to reduce role strain, and, therefore, enhance the well-being of retirees. Therefore, retirement may lead to either better or worse mental health depending on the quality of working role (Vandewater et al., 1997). The results of the longitudinal analysis in this thesis suggest that protective effects on cardiovascular health may be achieved by retirement in the Chinese context, but this was not found in the studies based on Western countries. China and Western older people can experience retirement differently by various means. One of the possible explanations for the inconsistent results between this thesis and Western studies is the different qualities of the working role. For example, employees in China often work in relatively poorer conditions than their counterparts in Western countries, characterised by longer working hours (OECD, 2015), fewer days of paid level, and higher level of work-life conflict (Xiao and Cooke, 2012). In addition, Chinese workers may have to bear with the workplace drinking culture. Therefore, retirement may offer many Chinese people an opportunity to exit the burdensome working role, thus improves cardiovascular health. Although the role theory is mainly applied the study of metal health, this thesis suggests that the quality of working role may be also important in the development of CVD after retirement.

Continuity theorists contend that occupational identity is not the only central role for many workers, and view retirement as an opportunity for individuals to maintain earlier lifestyle patterns, previous levels of self-esteem, and longstanding values (Atchley, 1989). The beneficial effects of retirement on cardiovascular health found in the longitudinal results in this thesis support this continuity theory. This thesis also found that rural retirees benefit less from retirement than urban retirees in China do. Urban-rural differences exist in many aspects in China, but the biggest disparity for older people is that rural retirees in China often have no pension income and less wealth after retirement (Giles et al., 2011; Gong et al., 2012), thus they may experience more difficulties in maintaining previous lifestyle without sufficient financial resources. Therefore, the findings in this thesis also point to the importance of maintaining adequate resources after retirement.

Stage theory suggests that retirement may constitute a long and complex process of adjustment, and retirees' health may vary during each specific adjustment stage. An idea central to the stage theory is the 'honeymoon' period, whereby the initial relief of stressful working roles leads to a temporary period of improved mental health (Atchely, 1982), although the effect often attenuates thereafter (Ekerdt et al., 1985). The idea of the 'honeymoon' period is reflected in previous literature, with one study showing significant beneficial associations between retirement and depression attenuating one year after retirement (Oksanen et al., 2011), and another showing a beneficial effect of retirement of less than one year on depression only among men with a non-working spouse (Szinovacz and Davey, 2004). However, other studies have suggested that associations between retirement and depression and self-rated health persisted regardless of retirement length (Calvo et al., 2013; Coe and Lindeboom, 2008; Westerlund et al., 2009). Whether the results can be applied to other health outcomes is not evaluated in the literature. In this thesis, a 'honeymoon' effect of retirement could potentially be identified through the adjusted mean values of health outcomes at each year (i.e. the dots in trajectory figures), but this thesis did not find any obvious difference between the trajectory in the first few years and those in later years. Therefore, findings in this thesis do not support the stage theory. This is probably because the impact of retirement on CVD is likely to be more complex than many other health outcomes.

According to the proposed theoretic framework on retirement and CVD (Figure 2.1), retirement is viewed as a life course transition, whereby the individual, contextual, and institutional characteristics before, during, and after retirement interact to influence the ways in which retirement impacts aspects of health and health behaviours. Diverse associations on the basis of gender were observed in this thesis, in that the beneficial effects of retirement was less strong for women than for men. There are various means by which men and women experience the role of employment differently over their adult lifespans (e.g. employment history, work demands, work support), thus men and women are likely to have different health effects of retirement. For example, women's compulsory retirement age is five to 10 years earlier than men in China and traditional gender role expectations emphasize women's role as housewives, therefore it is likely that women are tied to family-related labour burden to a greater extent than men after retirement (Szinovacz and Harpster, 1994). High levels of family obligation, such as care giving, has been suggested to be associated with increased CVD (Lee and Colditz, 2003; Lee et al., 2003), which might reduce the beneficial effects of retirement for women. In addition, this theoretic framework places retirement in the larger context of both current individual exigencies and other life pathways. For example, marital life may play an important role in retirement adjustment because it provides retirees with alternative salient identities after retirement and offers opportunities for retirees to engage in meaningful and desirable activities other than paid work (Wang et al., 2011). This thesis found that the protective effects on cardiovascular health was stronger for people with an already non-working spouse than retirees with a working spouse. Joining with the spouse in a non-working life can reduce marital conflict (Moen, Kim, and Hofmeister, 2012), and thus improve the health and well-being of elders, while a working spouse may be less able to engage in desirable activities, and thus reduce the beneficial effects of retirement. Besides, according to the theoretic framework, age of retirement may influence the effect of retirement on CVD/CVD risk factors. Retirement in China is more of a midlife transition, rather than a transition to old age. Therefore, people who retire at an early age in China are more easily to acquire new roles (e.g. taking care of grandchildren), continue in other roles (e.g. friend or spouse), and develop new self-identities (Kim and Moen, 2001) which may lead to better cardiovascular health.

In summary, findings from this thesis have shown the complex nature of underlying mechanism through which retirement has effects on CVD and CVD risk factors. Understanding these factors, which may interact with individuals' adaptation to retirement, is particularly important for retiree's health and well-being.

8.3 Strengths and limitations

Few studies in China have assessed the effects of retirement on CVD or CVD risk factors, and these studies in the literature are all cross-sectional designs, making this the first longitudinal investigation of retirement and health in the Chinese context. An advantage of this longitudinal analysis on the same individual both before and after retirement is that it reduces the likelihood of reverse causality. Another strength of this longitudinal analysis is long follow-up before and after retirement at yearly intervals. A multilevel framework was used to account for between and within-cluster effects. Missing values in the covariates have been multiply imputed, which allows for the use of information from all cases. This thesis also benefits from the objective measures of CVD risk factors, particularly in the context of rural China where CVD is likely to be under-diagnosed. In addition to longitudinal analysis, the cross-national comparison between China and England highlights the unique aspects of retirement behaviour in China, and provides possible explanations for the different longitudinal results found in this thesis and to those in Western studies. This cross-sectional study is also the first study examining the association between retirement and CVD biomarker risk factors in China.

Detailed descriptions of specific study limitations are provided in the discussion sections of each of the relevant chapters. However, there are some key limitations to the research presented within this thesis that relate to overall findings and so will hereby be pointed out.

First, the piecewise method in the longitudinal analysis answered the research questions set out for the thesis, and reduced sources of covariate bias. However, neither the piecewise longitudinal analysis nor the cross-sectional analysis were able to account for unobserved sources of bias, such as characteristics that change over time, as each individual acts as their own control. As a result, the conclusions presented within this thesis must be treated with caution, as confounding from unknown characteristics is still possible.

Second, retirement does not always mean permanent withdrawal from the labour force. People may transfer between working and out of labour force for several times. Therefore, sensitivity analysis by excluding observations after back to work was carried out in order to establish reliable results. However, it is possible that the retirement observed in the survey was not the first occurrence of retirement. Previous unobserved experiences of retirement may influence the health effects of retirement captured in this thesis, and it is likely that non-first-time retirement may have less impact on retirees' health and well-being. Not only retirement, but also the history of unemployment or other reasons for being out of the labour force, as well as the total length of working life, can interact with the health effects of retirement.

Third, this thesis tested the effects of retirement in China, rather than the effect of extending retirement age in China. Answering whether extending working lives in China is good or not for cardiovascular health will be more politically relevant, but because this policy has not been implemented in China, there is no 'treatment effect' that can be tested for in this thesis. Comparing the health status of people who retired at compulsory retirement ages with those who keep working beyond retirement age is inappropriate in this case, because of heterogeneous nature of these two groups of people in China. Other methods, for example propensity score matching, can successfully account for many group differences that may be related to retirement decisions, such as education, income, and health condition. However, this method cannot match for differences in jobs, as those retired at compulsory retirement age belonged to the formal sector by definition, while those working longer will be in the informal sector.

8.4 Policy implications

In light of the ageing population, some countries have initiated changes in pension ages in order to ease the burden of public spending. The SPA in the UK is currently rising from 60 to 65 for women, and will continue to rise to 68 for women and men simultaneously thereafter. China also plans to raise the official compulsory retirement age. The results in this thesis show that the median retirement age in China is 5 years earlier than in England, and the gap in women's retirement age is 8 years. The early retirement age in China is largely because of the young compulsory retirement age, which was established in early 1950s, when the Chinese life expectance was 30 years shorter than now. Therefore, extending working lives is considered to be an essential aspect of reducing the strains on public finances and social-security system as well as ensuring the future success of the economy in China. However, the potential health effects of extending retirement age has received less consideration. Empirical studies in Western countries have often found retirement to be related to increased CVD/CVD metabolic risk factors, thus extending working life is likely to be beneficial for the older population's cardiovascular health. In contrast, findings in the longitudinal analysis in this thesis demonstrate the health benefits of retirement in the Chinese context; therefore, extending working lives may worsen the health and well-being of older Chinese people in turn. This thesis suggests that when China looks to Western countries to inform policy making on population ageing and retirement, it is important to take into account specific aspects of the Chinese context in order to minimize detrimental effects on the health and wellbeing of the older population in China.

One possible reason for the inconsistent findings between this study from China and Western studies is the generally less favourable working environment in China than developed countries. For example, Chinese workers are working longer hours than their peers from more developed countries. The average worker residing in OECD countries works some 1,770 hours every year, and this figure in the UK is 1,674, but the Chinese worker works on average between 2,000-2,200 hours (OECD, 2015). China is also one of the countries have lowest holiday allowance for workers in the world (ILO, 2013). If extending the retirement age in China is necessary for social welfare and the labour supply, then cutting working hours for older people and a more generous annual leave system could be a way of making delayed retirement less detrimental for older workers' health in China. These measures may also can contribute to greater job satisfaction and thus encourage Chinese workers to stay in the labour force for a longer period.

Besides, this thesis suggests that policy concerning extending the retirement age in China needs to focus on the diverse nature of transitions into retirement from work and on ensuring they are suited to the individual. For example, the findings suggest that retirement is less beneficial for women than for men. This is likely to be because women often experience greater discontinuity in the labour force, together with more household responsibilities, and are also less likely to be covered by a pension. Therefore, a diverse range of retirement and pension policies are needed to suit workers' needs, and to make sure that both men and women are covered by financial supports after retirement.

This thesis also found that retirees benefit more on cardiovascular health when they have an already non-working spouse before their retirement. One of the reasons behind this may be that joining non-working life with a spouse may reduce family conflict and thus improve health. These findings suggest that it is important to keep a work-life balance for older workers. On one hand, a more family-friendly workplace environment, such as flexible working hours and allowing remote work, is needed to encourage Chinese older people to stay in the labour force. On the other hand, older workers should be allowed to exit from employment if there is a high level of family obligation.

The longitudinal study in this thesis showed that the beneficial effect of retirement on CVD risk factors is less strong for rural residents than urban residents, but this urban-rural difference was not found in any Western studies. This is probably because the retirement policy and welfare supports in Western countries are the same in urban and rural areas, but there is a big gap in the pension system between urban and rural China. Many rural residents have to rely on adult children's financial support after retirement. Therefore, this thesis suggests that it is necessary to reduce the gap in welfare provisions between urban and rural areas, and to ensure the older rural population has access to sufficient financial resources after retirement.

Findings also suggest that, in China, retirement reduced heavy drinking. If this is related to the drinking culture in the workplace in China, and retirement offers an opportunity to stop using alcohol, then changing the role of alcohol as a 'social lubricant' within Chinese work culture could be beneficial for workers' health and working ability. This could be achieved by increasing the public awareness of the hazard of heavy drinking (Anderson et al., 2009).

In summary, if policies to maintaining longer periods of workforce participation are to be successful, the government and employers need to ensure that the working environment is suitable for maintaining employment while minimizing detrimental effects on health and wellbeing.

8.5 Further research

The research presented in this PhD thesis could be extended to a life course framework, with a focus on the impacts of the quality of work, family roles, and area factors on the relationship between retirement and CVD risk factors. Life course hypotheses fall into two general categories: accumulation and critical/sensitive period. Further research can evaluate whether the health effects of retirement depend on the cumulative quality of the working role or whether there is a critical or sensitive period, such as the quality of the working role right before retirement. Job quality might be measured by occupational skill level, employment grade, job demands, and social supports in the workplace. Family roles are a typical determinant of retirement, and can influence both the working history over the adulthood as well as the on-going activities after retirement. Sequence analysis could be applied to identify the work-family life courses, combining information on work, partnership, parenthood, and caring responsibilities. Area unemployment rate may influence how individuals perceive retirement, thus influences the retirement adjustment. Understanding the moderating effects of work characteristics, family roles, and area environment could provide useful information in healthy ageing and could guide the policy on extending working lives in China.

Additionally, this thesis only proposed a theoretical framework on retirement and CVD, further research is required to investigate the pathways through which retirement influences elders' health and well-being. This thesis added potential mediators as time-varying variables into regression models to see if there was any change in the association between retirement and risk factors, but this method cannot identify the causal mechanisms between retirement and health. Mediation analysis would be a useful extension to understand how retirement influences health, in particular how much of the effect of retirement is mediated by each intermediate variable. Identifying the important mediators would help with understanding the practical differences between being retired in China and in Western countries.

8.6 Final reflections

The work presented in this PhD thesis contributes towards in understanding of the extent to which factors, at country, area, family, and individual level can impact retirement behaviour and, more importantly, the health of older people after retirement. In general, this thesis indicates that retirement is a complex process, and may have completely contrary effects on different health outcomes and for different people. When government seeks to set retirement policies, it is advised to provide elders with more flexibility and to allow enough time to implement policies gradually.

Reference

Adam, S. et al. (2007). *Retirement and cognitive reserve: a stochastic frontier approach applied to survey data*. HEC-ULg, CREPP working papers, 4.

Adams, G. et al. (2002). Applying work-role attachment theory to retirement decision-making. *The International Journal of Aging and Human Development*, 54(2), 125-137.

Ainsworth, B. & Haskell, W. (2000). Compendium of physical activities: an update of activity codes and MET intensities. *Medicine and Science in Sports and Exercise*, 54(2), 125-137.

Al-Daghri, N. (2014). Gender-dependent associations between socioeconomic status and metabolic syndrome: a cross-sectional study in the adult Saudi population. *BMC cardiovascular disorders*, 14(1), 51.

Allison, P. D. (2001). *Missing Data* (Vol. 136). London: SAGE Publications.

Ambrose, J. A. & Barua, R. S. (2004). The pathophysiology of cigarette smoking and cardiovascular disease: an update. *Journal of the American College of Cardiology*, 43(10), 1731-1737.

Anderson, C. A. M. et al. (2010). Dietary sources of sodium in China, Japan, the United Kingdom, and the United States, women and men aged 40 to 59 years: the INTERMAP study. *Journal of the American Dietetic Association*, 110(5), 736-745.

Anderson, P. et al. (2009). Effectiveness and cost-effectiveness of policies and programmes to reduce the harm caused by alcohol. *The Lancet*, 373(9682), 2234-2246.

APHO (2012). *APHO Diabetes Prevalence Model for England*. Available at: http://www.yhpho.org.uk/default.aspx?RID=81090.

Ardern, C. I. et al. (2003). Discrimination of health risk by combined body mass index and waist circumference. *Obesity research*, 11(1), 135-142.

Ariyo, A. et al. (2000). Depressive symptoms and risks of coronary heart disease and mortality in elderly Americans. *Circulation*, 102(15), 1773-1779.

Asher, M. & Zen, F. (2016). *Age Related Pension Expenditure and Fiscal Space: Modelling Techniques and Case Studies from East Asia*. New York, NY: Routledge.

Ashforth, B. (2000). *Role transitions in organizational life: An identity-based perspective*. Mahwah, NJ: Routledge.

Atchley, R. (1989). A continuity theory of normal aging. *The gerontologist*, 29(2), 183-190.

Atchley, R. (1999). Continuity theory, self, and social structure. *The self and society in aging processes*. 94, 121.

Atchley, R. (1972). *The social forces in later life: an introduction to social gerontology*. 2nd edition. Michigan: Wadsworth Pub. Co.

Atchley, R. (1976). *The sociology of retirement*. New York, NY: John Wiley and Sons.

Attard, S. M. et al. (2015). Differential associations of urbanicity and income with physical activity in adults in urbanizing China: findings from the population-based China Health and Nutrition Survey 1991-2009. *International Journal of Behavioral Nutrition and Physical Activity*, 12(1), 152.

Ayyagari, P. (2014). The Impact of Retirement on Smoking Behavior. *Eastern Economic Journal*, 42(2), 270-287.

Azimi-Nezhad, M. (2008). Prevalence of type 2 diabetes mellitus in Iran and its relationship with gender, urbanisation, education, marital status and occupation. *Singapore Medical Journal*, 49(7), 571-576.

Azur, M. J. et al. (2011). Multiple imputation by chained equations: what is it and how does it work? *International journal of methods in psychiatric research*, 20(1), 40-49.

Bacharach, S. B. et al. (2008). Perceived Agency in Retirement and Retiree Drinking Behavior: Job Satisfaction as a Moderator. *Journal of vocational behavior*, 73(3), 376-386.

Bacharach, S. B. et al. (2004). Retirement, risky alcohol consumption and drinking problems among blue-collar workers. *Journal of Studies on Alcohol*, 65(4), 537-545.

Bakker, A. B., & Demerouti, E. (2007). The job demands-resources model: State of the art. *Journal of managerial psychology*, 22(3), 309-328.

Bamia, C. et al. (2008). Age at retirement and mortality in a general population sample: the Greek EPIC study. *Am. J. Epidemiol*, 167(5), 561-569.

Bandura, A. (1982). Self-efficacy mechanism in human agency. *American Psychologist*, 37(2), 122-147.

Banks, J. et al. (2006). *Retirement, health and relationships of the older population in England: The 2004 English Longitudinal Study of Ageing (Wave 2)*. Kent: The Institute for Fiscal Studies.

Banks, J. (2006). Retirement in the UK. *Oxford Review of Economic Policy*, 22(1), 40-56.

Banks, J. et al. (2010). *The dynamics of retirement behavior in couples: Evidence from the UK and the US*. MIMEO, UCLA.

Banks, J. & Casanova, M. (2002). 'Work and retirement', in M Marmot & J Banks (eds.) *Health, wealth and lifestyles of the older population in England*. London: The Institute for Fiscal Studies. pp. 127-166.

Barnes-Farrell, J. (2003). 'Beyond health and wealth: Attitudinal and other influences on retirement decision-making.', in GA Adams & TA Beehr (eds.) *Retirement: Reasons, processes, and results.* New York, NY: Springer Publishing Company. pp. 159-187.

Barnett, I.. et al. (2013). Changes in household, transport and recreational physical activity and television viewing time across the transition to retirement: longitudinal evidence from. *Journal of Epidemiology & Community Health*, 68(8), 747-753.

Barua, R. S. et al. (2002). Heavy and light cigarette smokers have similar dysfunction of endothelial vasoregulatory activity. *Journal of the American College of Cardiology*, 39(11), 1758-1763.

Bazzano, L. A. et al. (2007). Alcohol consumption and risk for stroke among Chinese men. *Annals of neurology*, 62 (6), 569-578.

Bazzano, L. A. et al. (2009). Alcohol consumption and risk of coronary heart disease among Chinese men. *International journal of cardiology*, 135(1), 78-85.

Beehr, T. A. & Bowling, N. A. (2012). 'Variations on a Retirement Theme: Conceptual and Operational Definitions of Retirement', in M. Wang (eds.) *The Oxford Handbook of Retirement.* New York, NY:Oxfrod University Press. pp.47-48.

Behncke, S. (2012). Does retirement trigger ill health? *Health economics*, 21(3), 282-300.

Benjamin, D. et al. (2003). *Ceaseless Toil? Health and Labor Supply of the Elderly in Rural China.* William Davidson Institute Working Paper No. 579. Available at SSRN: http://ssrn.com/abstract=417820

Berger, U. et al. (2005). The impact of retirement on physical activity. *Ageing and Society*, 25(02), 181-195.

Bhatnagar, P. et al. (2015). The epidemiology of cardiovascular disease in the UK 2014. *Heart*, 101(15), 1182-1189.

Bigaard, J. et al. (2005). Waist circumference and body composition in relation to all-cause mortality in middle-aged men and women. *International journal of obesity*, 29(7), 778-784.

Blau, D. (1994). Labor force dynamics of older men. *Econometrica: journal of the Econometric Society*, 62(1), 117-156.

Bobo, J. K. et al. (2013). Predicting 10-year alcohol use trajectories among men age 50 years and older. *The American journal of geriatric psychiatry : official journal of the American Association for Geriatric Psychiatry*, 21(2), 204-213.

Bobo, J. K. & Greek, A. A. (2011). Increasing and decreasing alcohol use trajectories among older women in the U.S. across a 10-year interval. *International journal of environmental research and public health*, 8(8), 3263-3276.

Boden, J. M., & Fergusson, D. M. (2011). Alcohol and depression. *Addiction*, 106(5), 906-914.

Boey, K. W. (1999). Cross-validation of a short form of the CES-D in Chinese elderly. *International journal of geriatric psychiatry*, 14(8), 608-617.

Bonnet, F., et al. (2005). Anxiety and depression are associated with unhealthy lifestyle in patients at risk of cardiovascular disease. *Atherosclerosis*, 178(2), 339-344.

Bonsang, E. et al. (2012). Does retirement affect cognitive functioning? *Journal of* *health economics*, 31(3), 490-501.

Bound, J. & Waidmann, T. (2007). *Estimating the health effects of retirement.* Michigan Retirement Research Center Research Paper No. UMWP168. Available at: http://ssrn.com/abstract=1082047

Bowlby, G. (2007). Defining retirement. *Perspectives on labour and income*, 19(1), 55-59.

Bozio, A., Crawford, R., & Tetlow, G. (2010). *The history of state pensions in the UK: 1948 to 2010*. IFS briefing note No. BN105. Available at: https://www.ifs.org.uk/bns/bn105.pdf

Brennan, P. L. et al. (2010). Retired Status and Older Adults' 10-Year Drinking Trajectories. *Journal of Studies on Alcohol and Drugs*, 71(2), 165-168.

Bridges, S., Hussey D, Blake M. (2015). *The dynamics of ageing: The 2012 English Longitudinal Study of Ageing (Wave 6) Technical Report*. Available at NatCen: http://doc.ukdataservice.ac.uk/doc/5050/mrdoc/pdf/5050_elsa_w6_technical_report_v1.pdf.

Britton, A. (2000). The relation between alcohol and cardiovascular disease in Eastern Europe: explaining the paradox. *Journal of Epidemiology & Community Health*, 54(5), 328-332.

Broersen, J. P. et al. (1996). Health complaints and working conditions experienced in relation to work and age. *Occupational and Environmental Medicine*, 53(1), 51-57.

Brown, W. J. et al. (2009). Life events and changing physical activity patterns in women at different life stages. *Annals of behavioral medicine : a publication of the Society of Behavioral Medicine*, 37(3), 294-305.

Brunello, G. & D'Hombres, B. (2007). Does body weight affect wages? Evidence from Europe. *Economics and human biology*, 5(1), 1-19.

Buckley, D. I., Fu, R., Freeman, M., Rogers, K., & Helfand, M. (2009). C-reactive protein as a risk factor for coronary heart disease: a systematic review and meta-analyses for the US Preventive Services Task Force. *Annals of internal medicine*, 151(7), 483-495.

Burkhauser, R. V. & Cawley, J. (2006). The Importance of Objective Health Measures in Predicting Early Receipt of Social Security Benefits: The Case of Fatness. Michigan Retirement Research Center Research Paper No. WP 2006-148. Available at SSRN: http://ssrn.com/abstract=1095344

Butterworth, P. et al. (2006). Retirement and mental health: analysis of the Australian national survey of mental health and well-being. *Social science & medicine (1982)*, 62(5), 1179-1191.

Buxton, J. W. et al. (2005). The mental health of early retirees- national interview survey in Britain. *Social psychiatry and psychiatric epidemiology*, 40(2), 99-105.

Cahill, K. E., Giandrea, M. D., & Quinn, J. F. (2011). Reentering the labor force after retirement. *Monthly Labor Review*, 134(6), 34-42.

Cai, Y. (2006). *State and Laid-Off Workers in Reform China: The Silence and Collective Action of the Retrenched (Routledge Studies on China in Transition)*. New York, NY: Routledge.

Calasanti, T. M. (1996). Gender and Life Satisfaction in Retirement: An Assessment of the Male Model. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 51B(1), S18-S29.

Calvo, E. et al. (2013). Causal effects of retirement timing on subjective physical and emotional health. *The journals of gerontology. Series B, Psychological sciences and social sciences*, 68(1), 73-84.

Capewell, S. & Ford, E. S. (2011). Why have total cholesterol levels declined in most developed countries? *BMC public health*, 11(1), 641.

Carpenter, J.R. & Kenward, M. G. (eds.) (2013). *Multiple Imputation and its Application*, First Edition. Chichester, UK: John Wiley & Sons, Ltd.

Carlsson, A. C. et al. (2014). Financial stress in late adulthood and diverse risks of incident cardiovascular disease and all-cause mortality in women and men. *BMC public health*, 14(1), 17.

Carolina Population Center (2011). *China Health and Nutrition Survey*. Available at: http://www.cpc.unc.edu/projects/china (Accessed 1 May 2016).

Casscells, W. et al. (1980). Retirement and coronary mortality. *The Lancet*, 315(8181), 1288-1289.

Chadwick, D. J. & Goode, J. A. (eds.) (2007). *Novartis Foundation Symposium 216 - Alcohol and Cardiovascular Diseases*. Novartis Foundation Symposia. Chichester, UK: John Wiley & Sons, Ltd.

Chandola, T. et al. (2007). Social inequalities in self reported health in early old age: follow-up of prospective cohort study. *Bmj,* 334(7601), 990.

Chandola, T. et al. (2008). Work stress and coronary heart disease: what are the mechanisms? *European heart journal,* 29(5), 640-648.

Chen, F. et al. (2011). Intergenerational Ties in Context: Grandparents Caring for Grandchildren in China. *Social forces; a scientific medium of social study and interpretation,* 90(2), 571-594.

Chung, R. Y. et al. (2015). Socioeconomic Determinants of Multimorbidity: A Population-Based Household Survey of Hong Kong Chinese. *PloS one*. 10 (10), e0140040.

Chung, S. et al. (2007). Effect of retirement on eating out and weight change: an analysis of gender differences. *Obesity,* 15(4), 1053-1060.

Chung, S. et al. (2009). Retirement and physical activity: analyses by occupation and wealth. *American journal of preventive medicine*, 36(5), 422-428.

Chung, S., Domino, M. E. & Stearns, S. C. (2009). The effect of retirement on weight. *The journals of gerontology. Series B, Psychological sciences and social sciences*, 64(5), 656-665.

Clark, C., et al. (2017). Impact of childhood and adulthood psychological health on labour force participation and exit in later life. *Psychological Medicine*, 1-12.

Cochrane, J. et al. (2003) Alcohol use in China. *Alcohol and Alcoholism,* 38, 537–542.

Coe, N. B. & Lindeboom, M. (2008). *Does Retirement Kill You? Evidence from Early Retirement Windows.* CentER Discussion Paper Series No. 2008-93. Available at SSRN: http://ssrn.com/abstract=1295315

Coe, N. B. & Zamarro, G. (2011). Retirement effects on health in Europe. *Journal of health economics,* 30(1), 77-86.

Coile, C. (2004). *Health Shocks and Couples' Labor Supply Decisions*. NBER Working Paper No. 10810. Available at: http://www.nber.org/papers/w10810

Coile, C. (2004). Retirement Incentives and Couples' Retirement Decisions. *Topics in Economic Analysis & Policy*, 4(1), 1538-0653.

Coile, C. & Gruber, J. (2001). Social security incentives for retirement. In *Themes in the Economics of Aging* (pp. 311-354). Chicago: University of Chicago Press.

Collins, L. et al. (2001). A comparison of inclusive and restrictive strategies in modern missing data procedures. *Psychological methods*, 6(4), 330.

Cooke, F. L. (2001). Equal opportunity? The role of legislation and public policies in women's employment in China. *Women in Management Review*, 16(7), 334-348.

Coursolle, K. M. et al. (2010). The association between retirement and emotional well-being: does prior work-family conflict matter? *The journals of gerontology. Series B, Psychological sciences and social sciences*, 65(5), 609-620.

Covey, H. (1981). A reconceptualization of continuity theory: Some preliminary thoughts. *The Gerontologist*, 21(6), 628-633.

Cox, B. (1987). *The Health and lifestyle survey : preliminary report of a nationwide survey of the physical and mental health, attitudes and lifestyle of a random sample of 9,003 British adults*. London: Health Promotion Research Trust.

Coyle, J. (2003). Use it or lose it-Do effortful mental activities protect against dementia? *New England Journal of Medicine*, 348 (25), 2489-2490.

Cui, J. S., Hopper, J. L., & Harrap, S. B. (2003). Antihypertensive treatments obscure familial contributions to blood pressure variation. *Hypertension*, 41(2), 207-210.

Dave, D. et al. (2006). *The Effects of Retirement on Physical and Mental Health Outcomes*. No. w12123. National Bureau of Economic Research.

Davies, A. R. et al. (2007). Contribution of changes in incidence and mortality to trends in the prevalence of coronary heart disease in the UK: 1996 2005. *European heart journal*, 28(17), 2142-2147.

Davies, L. et al. (1986). Dietary fibre intakes in the United Kingdom before and after retirement from work. *Human nutrition. Applied nutrition*, 40(6), 431-439.

Dawson, D. A., Grant, B. F., & Ruan, W. J. (2005). The association between stress and drinking: modifying effects of gender and vulnerability. *Alcohol and alcoholism*, 40(5), 453-460.

Denier, N. et al. (2017). Retirement and cognition: A life course view. *Adv Life Course Res.* 31(2017), 11-21.

Dentinger, E. & Clarkberg, M. (2002). Informal Caregiving and Retirement Timing among Men and Women: Gender and Caregiving Relationships in Late Midlife. *Journal of Family Issues*, 23(7), 857-879.

Denton, F. T., & Spencer, B. G. (2009). What is retirement? A review and assessment of alternative concepts and measures. *Canadian Journal on Aging*, 28(1), 63-76.

Department of Health (1995). *Sensible Drinking: The Report of an Inter-Departmental Working Group.* UK: Department of Health; December, 1995:28-34.

Disney, R. et al. (2006). Ill health and retirement in Britain: a panel data-based analysis. *Journal of health economics*, 25(4), 621-649.

Dixit, A. R., & Crum, R. M. (2000). Prospective study of depression and the risk of heavy alcohol use in women. *American Journal of Psychiatry*, 157(5), 751-758.

Dogra, S. & Stathokostas, L. (2014). Correlates of extended sitting time in older adults: an exploratory cross-sectional analysis of the Canadian Community Health Survey Healthy Aging Cycle. *International journal of public health*, 59(6), 983-991.

Dong, Y. & Peng, C. Y. J. (2013). Principled missing data methods for researchers. *SpringerPlus*, 2(1), 222.

Drentea, P. (2002). Retirement and Mental Health. *Journal of Aging and Health*, 14(2), 167-194.

Dupre, M. E. et al. (2012). The cumulative effect of unemployment on risks for acute myocardial infarction. *Archives of internal medicine*, 172(22), 1731-1737.

Eastern Stroke and Coronary Heart Disease Collaborative Research Group (1998). Blood pressure, cholesterol, and stroke in eastern Asia. *The Lancet*, 352(9143), 1801-1807.

Eibich, P. (2015). Understanding the effect of retirement on health: Mechanisms and heterogeneity. *Journal of health economics*, 43, 1-12.

Ekerdt, D. et al. (1984). Change in blood pressure and total cholesterol with retirement. *Am. J. Epidemiol*, 120 (1), 64-71.

Ekerdt, D. J. et al. (1983). The effect of retirement on physical health. *American Journal* *of Public Health*, 73(7), 779-783.

Elder, G. H. J. (1995). ‘The life course paradigm: Social change and individual development.’, in P. Moen et al. (eds.) *Examining lives in context: Perspectives on the ecology of human development*. Washington, DC: American Psychological Association. pp. 101-140.

Elderon, L., & Whooley, M. A. (2013). Depression and cardiovascular disease. *Progress in cardiovascular diseases*, 55(6), 511-523.

Enders, C.K. (2010). *Applied missing data analysis*. New York, London: Guilford Press.

Enders, C.K. (2013). Dealing with missing data in developmental research. *Child Development Perspectives*, 7(1), 27-31.

Evandrou, M & Glaser, K. (2004). Family, work and quality of life: changing economic and social roles through the lifecourse. *Ageing and Society*, 24(5), 771-791.

Evenson, K. R. et al. (2002). Influence of Retirement on Leisure-time Physical Activity: The Atherosclerosis Risk in Communities Study. *Am. J. Epidemiol*, 155(8), 692-699.

Ezzati, M. & Lopez, A. D. (2003). Estimates of global mortality attributable to smoking in 2000. *The Lancet*, 362 (9387), 847-852.

Falk, D. et al. (2006). An epidemiologic analysis of co-occurring alcohol and tobacco use and disorders. *Alcohol Res Health*, 29(3), 162-171.

Fan, C. (2008). ‘China Urbanizes: Consequences, Strategies, and Policies’, in *China urbanizes: consequences, strategies and policies.* Yusuf S, S Washington, DC: World Bank Publications. pp. 213.

Feldman, D. C. (1994). The decision to retire early: a review and conceptualization. *Academy of Management Review*, 19(2), 285-311.

Fernandez, M. E. et al. (1998). Ethnicity, Gender, and Depressive Symptoms in Older Workers. *The Gerontologist*, 38(1), 71-79.

Finegold, J. A. et al. (2013). Mortality from ischaemic heart disease by country, region, and age: Statistics from World Health Organisation and United Nations. *International Journal of Cardiology*, 168(2), 934-945.

Fisberg, R. et al. (2006). Dietary quality and associated factors among adults living in the state of São Paulo, Brazil. *J Am Diet Assoc*, 106(12), 2067-2072.

Fitzgibbons Shafer, E. (2010). The Effect of Marriage on Weight Gain and Propensity to Become Obese in the African American Community. *Journal of Family Issues*, 31(9), 1166-1182.

Fonseca, A. & Paúl, C. (2003). Health and aging: does retirement transition make any difference? *Reviews in clinical gerontology* , 13(03), 257-260.

Forman-Hoffman, V. L. et al. (2008). Retirement and Weight Changes Among Men and Women in the Health and Retirement Study. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 63(3), S146-S153.

Gall, T. L., Evans, D. R., & Howard, J. (1997). The Retirement Adjustment Process: Changes in the Well-being of Male Retirees Across Time. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 52B(3), P110-P117.

Gall, B., & Parkhouse, W. (2004). Changes in physical capacity as a function of age in heavy manual work. *Ergonomics*, 47(6), 671-687.

Gallo, W. T., et al. (2000). Health effects of involuntary job loss among older workers findings from the health and retirement survey. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences,* 55(3), S131-S140.

García-Gómez, P. et al. (2010). Health effects on labour market exits and entries. *Labour Economics*, 17(1), 62-76.

Gee, G. C. et al. (2007). Trajectories of Alcohol Consumption among Older Japanese Followed from 1987 1999. *Research on Aging*, 29(4), 323-347.

George, L. K. (1993). Sociological Perspectives on Life Transitions. *Annual Review of Sociology*, 19(1), 353-373.

Georgiades, A. et al. (2009). Financial strain predicts recurrent events among women with coronary artery disease. *International journal of cardiology*, 135(2), 175-183.

Giles, J. et al. (2012). *Institutional determinants of the retirement patterns of China's urban and rural residents.* Working paper. Availale at: https://www.gwu.edu/~iiep/assets/docs/gtwoatgw/2012/zhao_ppt_chineseretirementpatterns.pdf

Gilbert, B. (1966). *The Evolution of National Insurance in Great Britain.* London: Michael Joseph.

Giles, J. et al. (2015). *One Country, Two Systems: Evidence on Retirement Patterns in China*. World Bank, Washington, DC, and Peking University, Beijing. Availale at: http://abfer.org/docs/2015/program-4/one-country-two-systems-evidences-on-retirement-patterns-in-china.pdf

Giles, J. et al. (2011). *The Labor Supply and Retirement Behavior of China's Older Workers and Elderly in Comparative Perspective*. World Bank Policy Research Working Paper Series, Vol (2011). Available at SSRN: http://ssrn.com/abstract=1948991

Glynn, R. J. et al. (1988). Alcohol consumption, type A behavior, and demographic variables: results from the Normative Aging Study. *Am. J. Epidemiol*, 127(2), 310-320.

Godard, M. (2016). Gaining weight through retirement? Results from the SHARE survey. *Journal of health economics*, 45, 27-46.

Godet-Mardirossian, H. et al. (2012). Patterns of hypertension management in France (ENNS 2006-2007). *European Journal of Preventive Cardiology*, 19(2), 213-220.

Godfrey, A. et al. (2013). The association between retirement and age on physical activity in older adults. *Age and Ageing*, 43(3), 386-393.

Gong, P. et al. (2012). Urbanisation and health in China. *The Lancet*, 379(9818), 843-852.

González, E. & Johansson, S. (2009). Trends in the prevalence and incidence of diabetes in the UK: 1996-2005. *Journal of Epidemiology and Community Health*, 63(4), 332-336.

Goux, D. et al. (2011). Worktime Regulations and Spousal Labor Supply. *The American Economic Review*, 104(1), 252-276.

Graham, J. (2009). Missing data analysis: Making it work in the real world. *Annual review of psychology*, 60, 549-576.

Greenland, S. (2000). An introduction to instrumental variables for epidemiologists. *International journal of epidemiology*, 29(4), 722-729.

Gu, D. et al. (2005). Prevalence of the metabolic syndrome and overweight among adults in China. *The Lancet*, 365 (9468), 1398-1405.

Gueorguieva, R. et al. (2011). Differential changes in body mass index after retirement by occupation: hierarchical models. *International journal of public health*, 56(1), 111-116.

Hao, W. & Young, D. (2000) Drinking pattern and problems in China. J*ournal of Substance Use*, 5, 71–78.

Harel, O. & Zhou, X. (2007). Multiple imputation: review of theory, implementation and software. *Statistics in medicine*, 26(16), 3057-3077.

Hayward, M. D., & Gorman, B. K. (2004). The long arm of childhood: The influence of early-life social conditions on men's mortality. *Demography*, 41(1), 87-107.

Helldán, A. & Lallukka, T. (2012). Changes in healthy food habits after transition to old age retirement. *European Journal of Public Health*, 22(4), 582-586.

Henkens, K. et al. (2008). Effects of retirement voluntariness on changes in smoking, drinking and physical activity among Dutch older workers. *European journal of public health*, 18(6), 644-649.

Herzog, A., & House, J. S. (1991). Productive activities and aging well. *Generations: Journal of the American Society on Aging*, 19(1), 49-54.

Hesketh, T. et al. (2005). The effect of China's one-child family policy after 25 years. *New England Journal of Medicine*, 353(11), 1171-1176.

Hippel, P. Von (2007). Regression with missing Ys: An improved strategy for analyzing multiply imputed data. *Sociological Methodology*, 37(1), 83-117.

HM Treasury (2013). *Autumn Statement 2013*. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/263942/35062_Autumn_Statement_2013.pdf

Ho, J. H. & Raymo, J. M. (2008). Expectations and Realization of Joint Retirement Among Dual-Worker Couples. *Research on Aging*, 31(2), 153-179.

Hoffman, L. & Rovine, M. J. (2007). Multilevel Models for the Experimental Psychologist: Foundations and Illustrative Examples. *Behavior Research Methods*, 39(1), 101-117.

Hooper, L. (2001). Dietary fat intake and prevention of cardiovascular disease: systematic review. *BMJ*, 322(7289), 757-763.

Horner, E. M. & Cullen, M. R. (2016). The impact of retirement on health: quasiexperimental methods using administrative data. *BMC health services research*, 16(1), 68.

Horton, N. J. & Kleinman, K. P. (2007). Much ado about nothing: A comparison of missing data methods and software to fit incomplete data regression models. *The American statistician*, 61(1), 79-90.

Horton, N. J. & Lipsitz, S. R. (2001). Multiple Imputation in Practice. *The American Statistician*, 55(3), 244-254.

Hox, J., & Stoel, R. D. (2005). 'Multilevel and SEM Approaches to Growth Curve Modeling', in Everitt & Howell (eds.) *Encyclopedia of Statistics in Behavioral Science*. Chichester: John Wiley& Sons, Ltd. pp. 1296-1305.

Hu, S. (eds.) (2013). *Report on Cardiovascular Disease in China, 2013*. Beijing: Encyclopedia of China Publishing House.

Hu, S. et al. (eds.) (2015). *Report on cardiovascular disease in China 2015*. Beijing: Encyclopedia of China Publishing House.

Hu, X. (2004). On Gradually increasing the management level of old-age insurance. *Chinese Social Security*, pp. 121.

Hu, Y. W. (2006). *Pension reform in China - a case study*. Dept of Economics and Finance Research Papers. Available at: http://bura.brunel.ac.uk/handle/2438/1020

Hultsch, D. F. et al. (1999). Use it or lose it: Engaged lifestyle as a buffer of cognitive decline in aging? *Psychology and Aging* , 14(2), 245-263.

Humphrey, A. et al. (2003). *Factors affecting the labour market participation of older workers*. Department for Work and Pensions, Research Report No 200. Available at: http://praha.vupsv.cz/fulltext/ul_363.pdf

Huot, I. et al. (2004). Factors associated with overweight and obesity in Quebec adults. *International journal of obesity and related metabolic disorders : journal of the International Association for the Study of Obesity*, 28(6), 766-774.

Huxley, R. R. & Woodward, M. (2011). Cigarette smoking as a risk factor for coronary heart disease in women compared with men: a systematic review and meta-analysis of prospective cohort studies. *The Lancet*, 378(9799), 1297-1305.

Idler, E. et al. (2004). In Sickness but Not in Health: Self-ratings, Identity, and

Mortality. *Journal of Health and Social Behavior*, 45(3), 336-356.

ILO (2013). *Working conditions laws report 2012: A global review*. International Labour Organization, Geneva. Availabe at: http://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---travail/documents/publication/wcms_235155.pdf

ILO (2012). *International Standard Classifi cation of Occupations : ISCO-08. Structure, group definitions and correspondence tables.* International Labour Organization, Geneva. Availabe at: http://www.ilo.org/public/english/bureau/stat/isco/isco08/

Insler, M. (2014). The Health Consequences of Retirement. *Journal of Human Resources*, 49(1), 195-233.

Iparraguirre, J. (2015). Socioeconomic determinants of risk of harmful alcohol drinking among people aged 50 or over in England. *BMJ open*, 5(7), e007684.

Irz, X. et al. (2014). Sociodemographic determinants of diet quality of the EU elderly: a comparative analysis in four countries. *Public health nutrition*, 17(5), 1177-1189.

Isengard, B. & Szydlik, M. (2012). Living Apart (or) Together? Coresidence of Elderly Parents and Their Adult Children in Europe. *Research on Aging*, 34(4), 449-474.

Jacobs, J. C. et al. (2014). Caregiving intensity and retirement status in Canada. *Social science & medicine*, 102(2014), 74-82.

Jani, B. & Rajkumar, C. (2006). Ageing and vascular ageing. *Postgraduate medical journal*, 82(968), 357-362.

Janssen, I. et al. (2004). Waist circumference and not body mass index explains obesity-related health risk. *Am J Clin Nutr*, 79(3), 379-384.

Jiang, Y. et al. (2010). Quitting smoking in China: findings from the ITC China Survey. *Tobacco control*, 19(Suppl_2), i12-i17.

Joffres, M. et al. (2013). Hypertension prevalence, awareness, treatment and control in national surveys from England, the USA and Canada, and correlation with stroke and ischaemic heart disease mortality: a cross-sectional study, *BMJ open*, 3(8), e003423.

Jokela, M. et al. (2010). From midlife to early old age: health trajectories associated with retirement. *Epidemiology (Cambridge, Mass.)*, 21(3), 284-290.

Jones, A. M. et al. (2010). Sick of work or too sick to work? Evidence on self-reported health shocks and early retirement from the BHPS. *Economic Modelling*, 27(4), 866-880.

Jurj, A. L. et al. (2007). Patterns and correlates of physical activity: a cross-sectional study in urban Chinese women. *BMC public health*, 7(1), 213.

Kämpfen, F. & Maurer, J. (2016). Time to burn (calories)? The impact of retirement on physical activity among mature Americans. *Journal of health economics*, 45, 91-102.

Kang, M. & Kim, H. (2014). Association between Voluntary/Involuntary Job Loss and the Development of Stroke or Cardiovascular Disease: A Prospective Study of Middle-Aged to Older. *PloS one*, 9(11), e113495.

Kantarci, T. & Van Soest, A. (2008). Gradual retirement: Preferences and limitations. *De Economist*, 156(2), 113-144.

Kaplan, G. & Baron-Epel, O. (2003). What lies behind the subjective evaluation of health status? *Social science & medicine*, 56(8), 1669-1676.

Kaplan, N. M., & Opie, L. H. (2006). Controversies in hypertension. *The Lancet*, 367(9505), 168-176.

Karpansalo, M. et al. (2004). Perceived health as a predictor of early retirement. *Scandinavian journal of work, environment & health*, 30(4), 287-292.

Karpansalo, M. et al. (2005). Depression and early retirement: prospective population based study in middle aged men. *Journal of Epidemiology and Community Health*, 59(1), 70-74.

Ke, L. et al. (2015). Prevalence, awareness, treatment and control of hypertension in Macau: results from a cross-sectional epidemiological study in Macau, China. *American journal of hypertension*, 28(2), 159-165.

Kiecolt-Glaser, J. K. & Newton, T. L. (2001). Marriage and health: his and hers. *Psychological bulletin*, 127(4), 472-503.

Kim, J. & Moen, P. (2001). Is Retirement Good or Bad for Subjective Well-Being? *Current Directions in Psychological Science*, 10(3), 83-86.

Kim, J. & Moen, P. (2002). Retirement transitions, gender, and psychological well-being a life-course, ecological model. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 57(3), 212-222.

Kincannon, C. L. et al. (2006). Demography of Aging in China and the United States and the Economic Well-Being of their Older Populations. *Journal of Cross-Cultural Gerontology*, 20(3), 243-255.

Kinsella, K. & He, W. (2009). *An aging world: 2008: International population reports.* U.S. Census Bureau. Washington, DC: US Government Printing Office.

Kivimäki, M. et al. (2006). Work stress in the etiology heart disease - A meta-analysis. *Scandinavian Journal of Work, Environment & Health*, 32(6), 431-442.

Koeneman, M. A. et al. (2012). Do major life events influence physical activity among older adults: the Longitudinal Aging Study Amsterdam. *The international journal of behavioral nutrition and physical activity*, 9(1), 147.

Kohl, H. (2001). Physical activity and cardiovascular disease: evidence for a dose response. *Medicine and Science in Sports and Exercise*, 33 (Supplement), S472-S483.

Koskenvuo, K. et al. (2011). Smoking strongly predicts disability retirement due to COPD: the Finnish Twin Cohort Study. *The European respiratory journal*, 37(1), 26-31.

Kowalkowska, J. & Poínhos, R. (2016). General and abdominal adiposity in a representative sample of Portuguese adults: dependency of measures and socio-demographic factors' influence. *British Journal of Nutrition*, 115(1), 185-192.

Kuhn, A. et al. (2010). *Fatal Attraction? Access to Early Retirement and Mortality*. CEPR Discussion Paper No. DP8024. Available at SSRN: http://ssrn.com/abstract=1711017

Kuvaja-Köllner, V. et al. (2013). The impact of time cost of physical exercise on health outcomes by older adults: the DR's EXTRA Study - Springer. *The European Journal of Health Economics*, 14(3), 471-479.

Lacey, R. et al. (2015). Work-family life courses and markers of stress and inflammation in mid-life: evidence from the National Child Development Study. International Journal of Epidemiology

Lahmann, P. H. et al. (2000). Sociodemographic factors associated with long-term weight gain, current body fatness and central adiposity in Swedish women. *International Journal of Obesity*, 24(6), 685-694.

Lahti, J. & Laaksonen, M. (2011). Changes in leisure-time physical activity after transition to retirement: a follow-up study. *The international journal of behavioral nutrition and physical activity*, 8(1), 36.

Lakier, J. B. (1992). Smoking and cardiovascular disease. *The American Journal of Medicine*, 93 (1), S8-S12.

Lang, I. A. et al. (2007). Smoking cessation and transition into retirement: analyses from the English Longitudinal Study of Ageing. *Age and ageing*, 36 (6), 638-643.

Latif, E. (2012). The Impact of Retirement on Health in Canada. *Canadian Public Policy*, 38(1), 15-29.

Lauque, S. et al. (1998). A prospective study of changes on nutritional patterns 6 months before and 18 months after retirement. *The journal of nutrition, health & aging*, 2(2), 88-91.

Lee, K. J. & Simpson, J. A. (2014). Introduction to multiple imputation for dealing with missing data. *Respirology*, 19(2), 162-167.

Lee, S. et al. (2003). Caregiving and risk of coronary heart disease in US women: a prospective study. *American Journal of Preventive Medicine*, 24(2), 113-119.

Lee, S. et al. (2011). UK stroke incidence, mortality and cardiovascular risk management 1999-2008: time-trend analysis from the General Practice Research Database. *BMJ open*, 1(2), e000269.

Lee, S. & Colditz, G. (2003). Caregiving to children and grandchildren and risk of coronary heart disease in women. *American Journal of Public Health*, 93(11), 1939-1944.

Levy, R. et al. (2013). ‘Trajectories between the family and paid work’, in R. Levy & E. Widmer (eds.) *Gendered Life Courses.* Zurich, Switzerland: Liturgical Press.

Lewington, S. et al. (2002). Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. *The Lancet*, 360(9349), 1903-1913.

Li, H. & Ge, J. (2015). Cardiovascular diseases in China: Current status and future perspectives. *IJC Heart & Vasculature,* 6, 25-31.

Lin, J. P. & Yi, C. C. (2011). Filial norms and intergenerational support to aging parents in China and Taiwan. *International Journal of Social Welfare*, 20, S109-S120.

Lindquist, T. et al. (1997). Influence of lifestyle, coping, and job stress on blood pressure in men and women. *Hypertension*, 29(1), 1-7.

Little, R. J. A. & Rubin, D. B. (2002). *Statistical Analysis with Missing Data*. New York, NY: John Wiley & Sons.

Liu, S. et al. (2009). Daily work stress and alcohol use: testing the cross‐level moderation effects of neuroticism and job involvement. *Personnel Psychology*, 62(3): 575-597.

Löckenhoff, C. et al. (2015). 'Cross-Cultural Differences in Attitudes About Aging: Moving Beyond the East-West Dichotomy.', in S.T. Cehng et al. (eds.) *Successful Aging*, pp. 321-337. Netherlands, Springer.

Luger, T. M., Suls, J., & Vander Weg, M. W. (2014). How robust is the association between smoking and depression in adults? A meta-analysis using linear mixed-effects models. *Addictive behaviors,* 39(10), 1418-1429.

Lund, T. et al. (2001). Work environment factors, health, lifestyle and marital status as predictors of job change and early retirement in physically heavy occupations. *American journal of industrial medicine*, 40(2), 161-169.

Luoh, M. & Herzog, A. (2002). Individual consequences of volunteer and paid work in old age: Health and mortality. *Journal of Health and Social Behavior*, 43(4), 490-509.

Lupton, M. K. et al. (2010). Education, occupation and retirement age effects on the age of onset of Alzheimer's disease. *International journal of geriatric psychiatry*, 25(1), 30-36.

Ma, J. et al. (eds.) (2012). *China Statistical Yearbook 2012*. Beijing: China Statistics Press.

MacMahon, S. et al. (1990). Blood pressure, stroke, and coronary heart disease *1Part 1, prolonged differences in blood pressure: prospective observational studies corrected for the regression dilution bias. *The Lancet*, 335(8692), 765-774.

Madani Larijani, K. (2012). *Metabolic syndrome in Canadian adults*. Doctoral thesis. Available at: http://hdl.handle.net/10388/etd-03302012-225240

Mandal, B. & Roe, B. E. (2007). Job loss, retirement and the mental health of older

Americans. Available at SSRN: http://ssrn.com/abstract=991134

Mao, Q. et al. (2010). Socioeconomic status predicting cardiovascular disease incidence in Chinese adults. Circulation, 122(2), E90-E90.

Marmot, M. et al. (1997). Contribution of job control and other risk factors to social variations in coronary heart disease incidence. *The Lancet*, 350(9073), 235-239.

Marmot, M. et al. (1994). Alcohol and blood pressure: the INTERSALT study, *BMJ*. 308(6939), 1263-1267.

Martens, E. P. et al. (2006). Instrumental variables: application and limitations. *Epidemiology*, 17(3), 260-267.

Martín, A. R. et al. (2008). Overweight and obesity: the role of education, employment and income in Spanish adults. *Appetite*, 51(2), 266-272.

Masoudkabir, F. et al. (2012). Socioeconomic status and incident cardiovascular disease in a developing country: findings from the Isfahan cohort study (ICS). *International journal of public health*, 57(3), 561-568.

McFadden, E. et al. (2008). Occupational social class, risk factors and cardiovascular disease incidence in men and women: a prospective study in the European Prospective Investigation of Cancer and Nutrition in Norfolk (EPIC-Norfolk) cohort. *European journal of epidemiology*, 23(7), 449-458.

McMunn, A. et al. (2009). Participation in socially-productive activities, reciprocity and wellbeing in later life: baseline results in England. *Ageing and Society*, 29(5), 765.

Mein, G. K. (2003). Is retirement good or bad for mental and physical health functioning? Whitehall II longitudinal study of civil servants. *Journal of Epidemiology & Community Health*, 57(1), 46-49.

Mein, G. K. et al. (2005). Work, retirement and physical activity: cross-sectional analyses from the Whitehall II study. *European journal of public health*, 15(3), 317-322.

Méjean, C. et al. (2013). The contribution of diet and lifestyle to socioeconomic inequalities in cardiovascular morbidity and mortality. *International journal of cardiology*, 168(6), 5190-5195.

Menai, M. et al. (2014). Changes in sedentary behaviours and associations with physical activity through retirement: a 6-year longitudinal study. *PloS one*, 9(9), e106850.

Menec, V. H. (2003). The Relation Between Everyday Activities and Successful Aging: A 6-Year Longitudinal Study. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 58(2), S74-S82.

Meng, A. (2012). Informal home care and labor-force participation of household members. *Empirical Economics*, 44(2), 959-979.

Mensah, G. et al. (2005). State of disparities in cardiovascular health in the United States. *Circulation*, 111(10), 1233-1241.

Meyer, J. W. (1986). 'The institutionalization of the life course and its effects on the self', in A. B. Sörenson et al. (eds.) *Human development and the life course: Multidisciplinary perspectives*. Hillsdale, NJ: Erlbaum Press.

Midanik, L. T. et al. (1995). The Effect of Retirement on Mental Health and Health Behaviors: The Kaiser Permanente Retirement Study. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 50B(1), S59-S61.

Ministry of Human Resources and Social Security in China (2015). Report on the work of the government.

Moen, P. (1996). A life course perspective on retirement, gender, and well-being. *Journal of occupational health psychology*, 1(2), 131-144.

Moen, P. et al. (2012). Couples' work/retirement transitions, gender, and marital quality. *Social Psychology Quarterly*, 64(1), 55-71

Moen, P. et al. (2005). Embedded Career Clocks: The Case of Retirement Planning. *Advances in Life Course Research*. 9, 237-265.

Moen, P. & Fields, V. (2002). Midcourse in the United States: Does unpaid community participation replace paid work? *Ageing International*, 27(3), 21-48.

Mojon-Azzi, S. et al. (2007). The effect of retirement on health: a panel analysis using data from the Swiss Household Panel. *Swiss Medical Weekly*, 137(41-42), 581-585.

Molarius, A. et al. (1997). Smoking and relative body weight: an international perspective from the WHO MONICA Project. *Journal of Epidemiology & Community Health*, 51(3), 252-260.

Molenberghs, G. & Fitzmaurice, G. (2009). 'Incomplete data: introduction and overview', in G. Molenberghs et al. (eds.) *Longitudinal Data Analysis*. Florida: CRC

Press.

Monsivais, P. et al. (2015). Job-loss and weight gain in British adults: Evidence from two longitudinal studies. *Social science & medicine*, 143(2015), 223-231.

Moon, J. R. et al. (2012). Transition to retirement and risk of cardiovascular disease: prospective analysis of the US health and retirement study. *Social science & medicine,* 75(3), 526-530.

Mooney, A. et al. (2002). *The Pivot Generation. Informal care and work after fifty*. Londond: Policy Press.

Morris, J. K. et al. (1994). Loss of employment and mortality. *BMJ,* 308(6937), 1135-1139.

Morris, J. K. et al. (1992). Non-employment and changes in smoking, drinking, and body weight. *BMJ,* 304(6826), 536-541.

Müller, G. et al. (2013). Gender differences in the association of individual social class and neighbourhood unemployment rate with prevalent type 2 diabetes mellitus: a cross-sectional study from the DIAB-CORE consortium. *BMJ open,* 3 (6), e002601.

Murtagh, E. et al. (2015). Prevalence and correlates of physical inactivity in community-dwelling older adults in Ireland. *PloS one*, 10(2), e0118293.

Musil, C. M. et al. (2002). A Comparison of Imputation Techniques for Handling Missing Data. *Western Journal of Nursing Research*, 24(7), 815-829.

Mutran, E. J. et al. (1997). Factors that Influence Attitudes Toward Retirement. *Research on Aging*, 19(3), 251-273.

Najdi, A. et al. (2011). Correlates of physical activity in Morocco. *Preventive medicine*, 52(5), 355-357.

National Bureau of Statistics of China (2014a). *China Statistical Yearbook*. Beijing: China Statistics Press.

National Bureau of Statistics of China (2014b). *National data: Consumer Price Index 1991-2011*. Available at: http://data.stats.gov.cn/easyquery.htm?cn=C01&zb=A0902&sj=2014.

National Health and Family Planning Commission (2003). *China Health Statistics Yearbook 2003*. Beijing: Pecking Union Medical College Press.

NCCD (2013). *Report on Cardiovascular Diseases in China*. China National Center for Cardiovascular Diseases, Beijing.

Nekuda, J. (2009). The Effect of Retirement on Vigorous Physical Activity Controlling for the Socio-Demographic Variables of Age, Gender, Education, Income, Race and Perceived Health Status Affect. Doctoral thesis. Available at: http://digitalcommons.unl.edu/cehsdiss/37/

Neuhaus, J. & Kalbfleisch, J. (1998). Between-and within-cluster covariate effects in the analysis of clustered data. *Biometrics*, 54(1998), 638-645.

Neve, R. J. M. et al. (2000). Changes in Alcohol Use and Drinking Problems in Relation to Role Transitions in Different Stages of the Life Course. *Substance abuse*, 21(3), 163-178.

Ng, S. W. et al. (2009). Why have physical activity levels declined among Chinese adults? Findings from the 1991-2006 China Health and Nutrition Surveys. *Social science & medicine*, 68(7), 1305-1314.

Nimrod, G. (2007). Expanding, Reducing, Concentrating and Diffusing: Post Retirement Leisure Behavior and Life Satisfaction. *Leisure Sciences*, 29(1), 91-111.

Nooyens, A. et al. (2005). Effects of retirement on lifestyle in relation to changes in weight and waist circumference in Dutch men: a prospective study. *Public health nutrition*, 8(8), 1266-1274.

O'Keefe, J. H. et al. (2007). Alcohol and cardiovascular health: the razor-sharp double-edged sword. *Journal of the American College of Cardiology*, 50(11), 1009-1014.

OECD (2015). *Average annual hours actually worked per woker*- OECD Stat. Organisation for Economic Co-operation and Development, Paris. Available at: https://stats.oecd.org/Index.aspx?DataSetCode=ANHRS

OECD (2014). *Pensions - Net pension replacement rates - OECD Data*. Organisation for Economic Co-operation and Development, Paris. Available at: https://data.oecd.org/pension/net-pension-replacement-rates.htm

Oksanen, T. et al. (2011). Is retirement beneficial for mental health?: antidepressant use before and after retirement. *Epidemiology*, 22(4), 553-559.

Olesen, K. et al. (2014). Does retirement reduce the risk of myocardial infarction? A prospective registry linkage study of 617 511 Danish workers. *International journal of epidemiology*, 43(1), 160-167.

ONS (2016). *Overview of the UK population: February 2016.* Office for National Statistics, London. Available at: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/articles/overviewoftheukpopulation/february2016#how-are-the-characteristics-of-the-uk-population-changing

ONS (2015). *Opinions and Lifestyle Survey: 2013.* Office for National Statistics, London. Available at: https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/healthandlifeexpectancies/compendium/opinionsandlifestylesurvey/2015-03-19

Palmore, E. B. et al. (1984). Consequences of Retirement. *Journal of Gerontology*, 39(1), 109-116.

Pan, K. et al. (2014). Increased energy intake and a shift towards high-fat, non-staple high-carbohydrate foods amongst China's older adults, 1991-2009. *The journal of aging research & clinical practice*, 3(2), 107-115.

Pang, L. et al. (2004). Working until you drop: The elderly of rural China. *The China Journal*, (52), 73-94.

Patrick, J. et al. (1982). Changes in body fat and muscle in manual workers at and after retirement. *Eur J Appl Physiol Occup Physiol*, 8(8), 1266-1274.

Patrick, J. M. et al. (1986). Objective measures of customary physical activity in elderly men and women before and after retirement. *Quarterly Journal of Experimental Physiology*, 71(1), 47-58.

Penninx, B. W., Deeg, D. J., van Eijk, J. T. M., Beekman, A. T., & Guralnik, J. M. (2000). Changes in depression and physical decline in older adults: a longitudinal perspective. *Journal of affective disorders*, 61(1), 1-12.

Perreira, K. M. & Sloan, F. A. (2001). Life events and alcohol consumption among mature adults: a longitudinal analysis. *Journal of Studies on Alcohol*, 62 (4), 501-508.

Peters, D. H. et al. (2008). Poverty and access to health care in developing countries. *Annals of the New York Academy of Sciences*, 1136(1), 161-171.

Petrelli, A. et al. (2006). Socioeconomic inequalities in coronary heart disease in Italy: a multilevel population-based study. *Social science & medicine*, 63(2), 446-456.

Phillipson, C. & Smith, A. (2005). *Extending working life: A review of the research literature*. Vol. 299. Leeds: Corporate Document Services.

Pinquart, M. & Schindler, I. (2007). Changes of life satisfaction in the transition to retirement: a latent-class approach. *Psychology and aging*, 22(3), 442.

Platt, A. et al. (2010). Alcohol-Consumption Trajectories and Associated Characteristics Among Adults Older Than Age 50. *Journal of Studies on Alcohol and Drugs*, 71(2), 169-179.

Popkin, B. M. et al. (2010). Cohort profile: The China Health and Nutrition Survey-monitoring and understanding socio-economic and health change in China, 1989-2011. *International Journal of Epidemiology*, 39(6), 1435-1440.

Popkin, B. M. et al. (1995). Dietary and environmental correlates of obesity in a population study in China. *Obesity research*. 3 Suppl 2135s-143s.

POST (2011). *An Ageing Workforce.* The Parliamentary Office of Science and Technology, London. Available at: file:///C:/Users/baowe/Desktop/POST-PN-391.pdf.

Price, J. (1999). Relationship between smoking and cardiovascular risk factors in the development of peripheral arterial disease and coronary artery disease; Edinburgh Artery Study Edinburgh Artery Study. *European Heart Journal*, 20(5), 344-353.

Rabe-Hesketh, S. & Anders, S. (2008). *Multilevel and Longitudinal Modeling Using Stata, Second Edition*. Texas: STATA press.

Reddy, K. S. & Katan, M. B. (2007). Diet, nutrition and the prevention of hypertension and cardiovascular diseases. *Public Health Nutrition*, 7(1a), 167-186.

Regitz-Zagrosek, V. et al. (2007). Gender Aspects of the Role of the Metabolic Syndrome as a Risk Factor for Cardiovascular Disease. *Gender Medicine*. 4, S162-S177.

Rehm, J. et al. (2004). 'Alcohol use', in M. Ezzati et al. (eds.) *Comparative quantification of health risks* (pp. 968.). Geneva: World Health Organization.

Reitzes, D. C. et al. (1996). Does retirement hurt weil-being? Factors influencing self-esteem and depression among retires and workers. *The Gerontologist*, 36(5), 649-656.

Rendall, M. S. et al. (2011). The protective effect of marriage for survival: a review and update. *Demography*, 48(2), 481-506.

Riley, M. & Riley, J. (1994). 'Structural lag: Past and future.', in M. W. Riley et al. (eds.). *Age and structural lag:The mismatch between people's lives and opportunities in work, family, and leisure* (pp. 15-36). New York, NY: Wiley.

Rimm, E. B. et al. (1999). Moderate alcohol intake and lower risk of coronary heart disease: meta-analysis of effects on lipids and haemostatic factors. *BMJ*, 319(7224), 1523-1528.

Roberts, B. A. et al. (2011). Does retirement influence cognitive performance? The Whitehall II Study. *Journal of epidemiology and community health*, 65(11), 958-963.

Roberts, E. T. et al. (2012). Abstract 18949: Socioeconomic Patterning of Hypertension in Grenada. *Circulation*. 126 (21_MeetingAbstracts), A18949.

Rodriguez, E. & Chandra, P. (2006). Alcohol, employment status, and social benefits: one more piece of the puzzle. *The American journal of drug and alcohol abuse*, 32(2), 237-259.

Roebuck, K. (2012). *Predictive Analysis: High-impact Emerging Technology - What You Need to Know: Definitions, Adoptions, Impact, Benefits, Maturity, Vendors*. Emereo Publishing.

Roerecke, M., Kaczorowski, J., Tobe, S. W., Gmel, G., Hasan, O. S., & Rehm, J. (2017). The effect of a reduction in alcohol consumption on blood pressure: a systematic review and meta-analysis. *The Lancet Public Health*, 2(2), e108-e120.

Rohwedder, S. & Willis, R. J. (2010). Mental Retirement. *The journal of economic perspectives : a journal of the American Economic Association*, 24(1), 119-138.

Ronksley, P. et al. (2011). Association of alcohol consumption with selected cardiovascular disease outcomes: a systematic review and meta-analysis. *Bmj*, 342(2011): d671.

Rothenbacher, D. et al. (1998). Early retirement due to permanent disability in relation to smoking in workers of the construction industry. *Journal of occupational and environmental medicine /American College of Occupational and Environmental Medicine*, 40(1), 63-68.

Rubin, D. B. (2012). Multiple Imputation after 18+ Years. *Journal of the American Statistical Association*, 91(434), 473-489.

Rubin, D. B. (eds.) (1987). *Multiple Imputation for Nonresponse in Surveys*. Wiley Series in Probability and Statistics. Hoboken, NJ: John Wiley & Sons, Inc.

Salokangas, R. K. R. & Joukamaa, M. (1991). Physical and Mental Health Changes in Retirement Age. *Psychotherapy and Psychosomatics*, 55(2-4), 100-107.

Saquib, N. et al. (2013). Self-perceived physical health predicts cardiovascular disease incidence and death among postmenopausal women. *BMC Public Health*, 13(1), 468.

Scarborough, P. et al. (2011). *Trends in coronary heart disease, 1961-2011*. London: British Heart Foundation.

Scarmeas, N. & Stern, Y. (2010). Cognitive Reserve and Lifestyle. *Journal of Clinical and Experimental Neuropsychology*, 25(5), 625-633.

Schafer, J. (1997). *Analysis of incomplete multivariate data*. London: Chapman & Hall.

Schafer, J. & Graham, J. (2002). Missing data: our view of the state of the art. *Psychological methods* , 7(2), 147.

Schafer, J. L. (1999). Multiple imputation: a primer. *Statistical methods in medical research*, 8(1), 3-15.

Schafer, J. & Schenker, N. (2000). Inference with imputed conditional means. *Journal of the American Statistical Association*, 95(14009), 144-154.

Schenker, N. & Taylor, J. M. G. (1996). Partially parametric techniques for multiple imputation. *Computational Statistics & Data Analysis*, 22(4), 425-446.

Schirle, T. (2008). Why have the labor force participation rates of older men increased since the mid-1990s? *Journal of Labor Economics*, 26(4), 549-594.

Schulz, R. & Beach, S. R. (1999). Caregiving as a Risk Factor for Mortality. *JAMA*, 282(23), 2215.

Scuteri, A. et al. (2005). The metabolic syndrome in older individuals: Prevalence and prediction of cardiovascular events the cardiovascular health study. *Diabetes care*, 28(4), 882-887.

Seitsamo, J. et al. (2007). Activity, functional capacity and well-being in ageing Finnish workers. *Occupational medicine*, 57(2), 85-91.

Seow, L. & Subramaniam, M. (2015). Hypertension and its associated risks among

Singapore elderly residential population. *Journal of Clinical Gerontology and Geriatrics*, 6(4), 125-132.

Settersten, R. A. (1998). Time, Age, and the Transition to Retirement: New Evidence on Life-Course Flexibility? *The International Journal of Aging and Human Development*, 47(3), 177-203.

Shah, N. M. et al. (2010). Prevalence and correlates of major chronic illnesses among older Kuwaiti nationals in two governorates. *Medical principles and practice : international journal of the Kuwait University, Health Science Centre*, 19(2), 105-112.

Shamshirgaran, S. (2013). Independent roles of country of birth and socioeconomic status in the occurrence of type 2 diabetes. *BMC public health*, 13(1), 1223.

Shannon, M., & Grierson, D. (2004). Mandatory retirement and older worker employment. *The Canadian Journal of Economics*, 37(3), 528-551.

Shimizutani, S., & Oshio, T. (2010). New evidence on initial transition from career job to retirement in Japan. *Industrial Relations: A Journal of Economy and Society*, 49(2), 248-274.

Shuaib, F. et al. (2011). Smoking, sociodemographic determinants, and stress in the Alabama Black Belt. *The Journal of rural health : official journal of the American Rural Health Association and the National Rural Health Care Association*, 27(1), 50-59.

Shultz, K. S. et al. (1998). The Influence of Push and Pull Factors on Voluntary and Involuntary Early Retirees' Retirement Decision and Adjustment. *Journal of Vocational Behavior*, 53(1), 45-57.

Silverstein, M. et al. (2006). Intergenerational Transfers and Living Arrangements of Older People in Rural China: Consequences for Psychological Well-Being. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 61(5), S256-S266.

Silverstein, M. & Parker, M. G. (2002). Leisure Activities and Quality of Life among the Oldest Old in Sweden. *Research on Aging*, 24(5), 528-547.

Singh-Manoux, A. et al. (2006). What does self rated health measure? Results from the British Whitehall II and French Gazel cohort studies. *Journal of epidemiology and community health*, 60(4), 364-372.

Siscovick, D. (1990). Retirement and primary cardiac arrest in males. *American journal of public health*, 80(2), 207-208.

Sivén, S. & Niiranen, T. (2015). Social, lifestyle and demographic inequalities in hypertension care. *Scandinavian journal of public health*, 43(3), 246-253.

Sjösten, N. et al. (2012). Change in physical activity and weight in relation to retirement: the French GAZEL Cohort Study. *BMJ open*, 2(1), e000522.

Slingerland, A. S. et al. (2007). Aging, retirement, and changes in physical activity: prospective cohort findings from the GLOBE study. *Am. J. Epidemiol*, 165(12), 1356-1363.

Snijders, T. & Bosker, R. J. (2012). *Multilevel analysis : An introduction to basic and advanced multilevel modeling (2nd ed.).* Lodon: SAGE.

Stamler, J. et al. (2000). Relationship of baseline serum cholesterol levels in 3 large cohorts of younger men to long-term coronary, cardiovascular, and all-cause mortality and to longevity. *JAMA*, 284(3), 311-318.

Steen, B. et al. (1988). Age retirement in women. II. Dietary habits and body composition. *Comprehensive gerontology. Section A, Clinical and laboratory sciences*, 2(2), 78-82.

Steindorf, K. (2010). Determinants of sports, cycling, walking and overall leisure-time physical activity among postmenopausal women in Germany. *Public health nutrition*, 13(11), 1905-1914.

Stenholm, S. et al. (2014). Age-related trajectories of physical functioning in work and retirement: the role of sociodemographic factors, lifestyle and disease. *Journal of epidemiology and community health*, 68(6), 503-509.

Steptoe, A. et al. (2013). Cohort profile: the English longitudinal study of ageing. *International journal of epidemiology*, 42(6), 1640-1648.

Stern, Y. (2002). What is cognitive reserve? Theory and research application of the reserve concept. *Journal of the International Neuropsychological Society*, 8(3), 448-460.

Sterne, J. A. C. et al. (2009). Multiple imputation for missing data in epidemiological and clinical research: potential and pitfalls. *BMJ*, 338, b2393.

Stevens, J. (2002). Fitness and Fatness as Predictors of Mortality from All Causes and from Cardiovascular Disease in Men and Women in the Lipid Research Clinics Study. *Am. J. Epidemiol*, 156(9), 832-841.

Stevens, K. N. et al. (2008). Epidemiology of balance and dizziness in a national population: findings from the English Longitudinal Study of Ageing. *Age and ageing*, 37(3), 300-305.

Stock, J. & Wise, D. (1990). The pension inducement to retire: An option value analysis, in D. A. Wise (eds.) *Issues in the Economics of Aging* (pp. 205-230). Chiargo and London: University of Chicago Press.

Strawbridge, W. J., et al. (2002). Physical activity reduces the risk of subsequent depression for older adults. *American journal of epidemiology*, 156(4), 328-334.

Sullivan, T. R. et al. (2015). Bias and Precision of the 'Multiple Imputation, Then Deletion' Method for Dealing With Missing Outcome Data. *Am. J. Epidemiol*, 182(6), 528-534.

Swinburn, B. et al. (2009). Increased food energy supply is more than sufficient to explain the US epidemic of obesity. *The American journal of clinical nutrition*, 90(6), 1453-1456.

Szinovacz, M. E. & Davey, A. (2004). Honeymoons and Joint Lunches: Effects of Retirement and Spouse's Employment on Depressive Symptoms. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 59(5), 233-245.

Szinovacz, M. E. & Davey, A. (2005). Predictors of Perceptions of Involuntary Retirement. *The Gerontologist*, 45(1), 36-47.

Szinovacz, M. & Harpster, P. (1994). Couples' employment/retirement status and the division of household tasks. Journal of Gerontology, 49(3), S125-S136.

Talaga, J. A. & Beehr, T. A. (1995). Are there gender differences in predicting retirement decisions? *Journal of Applied Psychology*, 80(1), 16.

Tamers, S. et al. (2014). The impact of stressful life events on excessive alcohol consumption in the French population: findings from the GAZEL cohort study. *PloS one*, 9(1), e87653.

Teufel-Shone, N. I. et al. (2015). Demographic characteristics and food choices of participants in the Special Diabetes Program for American Indians Diabetes Prevention

Demonstration Project. *Ethnicity & health*, 20(4), 327-340.

Thomson, L. et al. (2000). Employee absence, age and tenure: a study of nonlinear effects and trivariate models. *Work & Stress*, 14(1), 16-34.

Tobin, M. D. et al. (2005). Adjusting for treatment effects in studies of quantitative traits: antihypertensive therapy and systolic blood pressure. *Statistics in medicine,* 24(19), 2911-2935.

Touvier, M. et al. (2010). Changes in leisure-time physical activity and sedentary behaviour at retirement: a prospective study in middle-aged French subjects. *International Journal of Behavioral Nutrition and Physical Activity*, 7(1), 14.

Townsend, N. et al. (2015). Cardiovascular sisease statistics 2015. London: British Heart Foundation.

Townsend, N. & Wickramasinghe, K. (2012). Coronary heart disease statistics 2012 edition. *London: British Heart Foundation.*

Tsiara, S. et al. (2003). Influence of Smoking on Predictors of Vascular Disease. *Angiology*. 54(5), 507-530.

Tuan, N. T. et al. (2010). Prediction of hypertension by different anthropometric indices in adults: the change in estimate approach. *Public health nutrition*, 13(5), 639-646.

Turrell, G. et al. (2014). Change in walking for transport: a longitudinal study of the influence of neighbourhood disadvantage and individual-level socioeconomic position in mid-aged adults. *International Journal of Behavioral Nutrition and Physical Activity*, 11(1), 1.

Twisk, J. W. R. (2006). *Applied Multilevel Analysis：A Practical Guide for Medical Researchers*. Cambridge: Cambridge University Press.

UN (2015). *United Nations World Population Prospects: 2015 revision*. United Nations, Washington DC.

UN (2016). *World Statistics Pocketbook*. United Nations, Washington DC.

Vallery-Masson, J. et al. (1981). Retirement and morbidity: a three-year longitudinal study of a French managerial population. *Age and Ageing*, 10(4), 271-276.

Van Aerde, M. A. et al. (2013). Dairy intake in relation to cardiovascular disease mortality and all-cause mortality: the Hoorn Study. *European journal of nutrition*, 52(2), 609-616.

Van Solinge, H. (2007). Health change in retirement a longitudinal study among older workers in the Netherlands. *Research on Aging*, 29(3), 225-256.

Van Solinge, H. & Henkens, K. (2007). Involuntary Retirement: The Role of Restrictive Circumstances, Timing, and Social Embeddedness. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 62(5), S295-S303.

Van Houtven, C. H. et al. (2013). The effect of informal care on work and wages. *Journal of health economics*, 32(1), 240-252.

Van Lennep, J. E. R. et al. (2002). Risk factors for coronary heart disease: implications of gender. *Cardiovascular Research*, 53(3), 538-549.

Vandewater, E. (1997). Predicting women's well-being in midlife: the importance of personality development and social role involvements. *Journal of personality and social psychology*, 72(5), 1147-1160.

Vijan, S. et al. (2004). The impact of diabetes on workforce participation: results from a national household sample. *Health services research*, 39(6 Pt 1), 1653-1669.

Vilela, A. (2013). *Pension coverage in China and the expansion of the New Rural Social Pension*. HelpAge International Briefing No.11. Available at: http://www.refworld.org/pdfid/5301df5d4.pdf

Vrijkotte, T. G. M. et al. (2000). Effects of Work Stress on Ambulatory Blood Pressure, Heart Rate, and Heart Rate Variability. *Hypertension*, 35(4), 880-886.

Waite, L. J. (1995). Does Marriage Matter? *Demography*, 32(4), 483.

Walford, R. L. et al. (1992). The calorically restricted low-fat nutrient-dense diet in Biosphere 2 significantly lowers blood glucose, total leukocyte count, cholesterol, and blood pressure in humans. *Proceedings of the National Academy of Sciences*, 89(23), 11533-11537.

Wang, J. et al. (2014). Prevalence, awareness, treatment, and control of hypertension in China: results from a national survey. *American journal of hypertension*. 27 (11), 1355-1361.

Wang, M. (2007). Profiling retirees in the retirement transition and adjustment process: Examining the longitudinal change patterns of retirees' psychological well-being.

Journal of Applied Psychology, 92(2), 455-474.

Wang, M. et al. (2011). Retirement adjustment: A review of theoretical and empirical advancements. *American Psychologist*, 66(3), 204-213.

Wang, M. & Adams, G. (2009). 'Bridge Employment and Retirement', in S. G. Baugh & S. E. Sullivan (eds.) *Maintaining Focus, Energy, and Options Over the Career* (pp. 135-162). Charlotte, North Carolina: Information age publishing..

Wang, Z. et al. (2014). Fatty and lean red meat consumption in China: differential association with Chinese abdominal obesity. *Nutrition, metabolism, and cardiovascular diseases*, 24(8), 869-876.

Warr, P. et al. (2004). Older people's well-being as a function of employment, retirement, environmental characteristics and role preference. *British journal of psychology*, 95(Pt 3), 297-324.

Weisberg, S. (2005). *Applied Linear Regression*. Wiley Series in Probability and Statistics. Hoboken, NJ: John Wiley & Sons, Inc.

Welborn, T. A. & Dhaliwal, S. S. (2007). Preferred clinical measures of central obesity for predicting mortality. *European journal of clinical nutrition*, 61(12), 1373-1379.

Wells, Y. & Kendig, H. (1999). Psychological resources and successful retirement. *Australian Psychologist*, 34(2), 111-115.

Westerlund, H. et al. (2010). Effect of retirement on major chronic conditions and fatigue: French GAZEL occupational cohort study. *BMJ*, 341 (nov23_1), c6149.

Westerlund, H. et al. (2009). Self-rated health before and after retirement in France (GAZEL): a cohort study. *The Lancet*, 374 (9705), 1889-1896.

White, I. R. I. et al. (2011). Multiple imputation using chained equations: Issues and guidance for practice. *Statistics in medicine*, 30(4), 377-399.

Whiting, E. (2005). The labour market participation of older people. *Labour Market Trends*, 113(7), 285-295.

WHO (2015). *Fact sheets Cardiovascular disease*. World Health Organization, Geneva. Available at: http://www.wpro.who.int/china/mediacentre/factsheets/cvd/en/.

WHO (2010a). *Global Adult Tobacco Survey (GATS) — China section*. World Health Organization, Geneva. Available at:

http://www.who.int/tobacco/surveillance/gats_china/en/.

WHO (2011). *Global Atlas on cardiovascular disease prevention and control*. S. Mendis et al. (eds.). World Health Organization, Geneva.

WHO (2010b). *Global Health Observatory data: Prevalence of insufficient physical activity*. World Health Organization, Geneva. Available at: http://www.who.int/gho/ncd/risk_factors/physical_activity/en/.

WHO (2014a). *Global status report on alcohol and health 2014*. World Health Organization, Geneva.

WHO (2014b). *Noncommunicable diseases country profiles 2014 - China*. World Health Organization, Geneva. Available at: http://www.who.int/nmh/countries/chn_en.pdf?ua=1.

Wickrama, K. K. & O'Neal, C.W. (2013). The influence of working later in life on memory functioning. *Adv Life Course Res.* 18(2013), 288-295.

Wildman, R. P. et al. (2005). Are waist circumference and body mass index independently associated with cardiovascular disease risk in Chinese adults? *Am J Clin Nutr*. 82 (6), 1195-1202.

Will, J. C., Galuska, D. A., Ford, E. S., Mokdad, A., & Calle, E. E. (2001). Cigarette smoking and diabetes mellitus: evidence of a positive association from a large prospective cohort study. *International journal of epidemiology*, 30(3), 540-546.

Williams, K. (2004). The Transition to Widowhood and the Social Regulation of Health: Consequences for Health and Health Risk Behavior. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 59(6), S343-S349.

Williams, E. D. et al. (2012). Risk of cardiovascular and all-cause mortality: impact of impaired health-related functioning and diabetes. *Diabetes Care*, 35(5), 1067-1073.

Wilson, P. W. F. et al. (2002). Overweight and Obesity as Determinants of Cardiovascular Risk. *Archives of Internal Medicine*, 162(16), 1867-1872.

Wilson, S. E. (2012). Marriage, gender and obesity in later life. *Economics and human biology*, 10(4), 431-453.

Winkleby, M. & Jatulis, D. (1992). Socioeconomic status and health: how education, income, and occupation contribute to risk factors for cardiovascular disease. *American* *journal of public health*, 82(6), 816-820.

Wister, A. V. (1996). The Effects of Socioeconomic Status on Exercise and Smoking: Age-Related Differences. *Journal of Aging and Health*, 8(4), 467-488.

Wong, C. (2015). *China Sets Timeline for First Change to Retirement Age Since 1950s* . Available at: http://blogs.wsj.com/chinarealtime/2015/03/10/china-sets-timeline-for-first-change-to-retirement-age-since-1950s/.

Wong, L. (eds.) (2005). *The 2002 China National Nutrition and Health Survey (1): General Report*. Beijing: People Health Publishing House.

World Bank (2015). *Data: Population ages 65 and above.* Available at: http://data.worldbank.org/indicator/SP.POP.65UP.TO.ZS?locations=CN

World Heart Federation (2016). *Cardiovasular disease risk factors*. Available at: http://www.world-heart-federation.org/cardiovascular-health/cardiovascular-disease-risk-factors/diet/

Wu, F. et al. (2015). Common risk factors for chronic non-communicable diseases among older adults in China, Ghana, Mexico, India, Russia and South Africa: the study on global AGEing and adult health (SAGE) wave 1. *BMC public health*, 15 (2015): 88.

Wu, Y. et al. (2008). Prevalence, awareness, treatment, and control of hypertension in China: data from the China National Nutrition and Health Survey 2002. *Circulation*, 118(25), 2679-2686.

Xi, B. et al. (2013). Prevalence of metabolic syndrome and its influencing factors among the Chinese adults: the China Health and Nutrition Survey in 2009. *Preventive medicine*, 57(6), 867-871.

Xi, B. et al. (2012). Secular trends in the prevalence of general and abdominal obesity among Chinese adults, 1993-2009. *Obesity reviews : an official journal of the International Association for the Study of Obesity*, 13(3), 287-296.

Xiao, Y. & Cooke, F. L. (2012). Work-life balance in China? Social policy, employer strategy and individual coping mechanisms. *Asia Pacific Journal of Human Resources*, 50(1), 6-22.

Xin, X. et al. (2001). Effects of Alcohol Reduction on Blood Pressure: A Meta-Analysis of Randomized Controlled Trials. *Hypertension*, 38(5), 1112-1117.

Xu, X. et al. (2015). Assessing dietary quality of older Chinese people using the Chinese Diet Balance Index (DBI). *PloS one*, 10(3), e0121618.

Xu, Y. et al. (2013). Prevalence and control of diabetes in Chinese adults. *JAMA*, 310(9), 948-959.

Yan, S. et al. (2012). The expanding burden of cardiometabolic risk in China: The China Health and Nutrition Survey. *Obesity Reviews*, 13(9), 810-821.

Yang, F. et al. (2016). Prevalence of cardiovascular disease risk factor clustering in Chinese adults. *Clinical Trials and Regulatory Science in Cardiology*, 15(2016), 1-6.

Yang, L. et al. (2012). Alcohol drinking and overall and cause-specific mortality in China: nationally representative prospective study of 220,000 men with 15 years of follow-up. *International journal of epidemiology*, 41(4), 1101-1113.

Yang, W. et al. (2010). Prevalence of diabetes among men and women in China. *The New England journal of medicine*, 362(12), 1090-1101.

Yang, W. et al. (2012). Serum lipids and lipoproteins in Chinese men and women. *Circulation*, 125(18), 2212-2221.

Young, R. & Johnson, D. (2010). 'Imputing the Missing Y's: Implications for Survey Producers and Survey Users. In *Proceedings of the AAPOR Conference Abstracts* (pp. 6242-6248).

Yusuf, S. et al. (2001). Global Burden of Cardiovascular Diseases: Part II: Variations in Cardiovascular Disease by Specific Ethnic Groups and Geographic Regions and Prevention Strategies. *Circulation*, 104(23), 2855-2864.

Yusuf, S. et al. (2005). Obesity and the risk of myocardial infarction in 27 000 participants from 52 countries: a case-control study. *The Lancet*, 366(9497), 1640-1649.

Zhang, B. et al. (2014). The China Health and Nutrition Survey, 1989-2011. *Obesity Reviews*. 15(S1), 152-157.

Zhang, H. et al. (2013). Relation of socio-economic status to impaired fasting glucose and Type 2 diabetes: findings based on a large population-based cross-sectional study in Tianjin, China. *Diabetic medicine : a journal of the British Diabetic Association*, 30(5), e157-e162.

Zhao, Y. et al. (2014). Cohort profile: the China Health and Retirement Longitudinal

Study (CHARLS). *International journal of epidemiology*, 43(1), 61-68.

Zheng, Y. (2008). *Economic Determinants of Obesity Among Older Americans*. RAND Disseration. Available at: http://www.rand.org/pubs/rgs_dissertations/RGSD237.html

Zhou, B. et al. (2002). Overweight is an independent risk factor for cardiovascular disease in Chinese populations. *Obesity Reviews*, 3(3), 147-156.

Zhou, M. et al. (2008). Body mass index, blood pressure, and mortality from stroke: a nationally representative prospective study of 212,000 Chinese men. *Stroke*, 39(3), 753-759.

Zhu, S. et al. (2004). Combination of BMI and Waist Circumference for Identifying Cardiovascular Risk Factors in Whites. *Obesity research*, 12(4), 633-645.

Zimmer, Z. & Kwong, J. (2004). Socioeconomic status and health among older adults in rural and urban China. *Journal of aging and health*, 16(1), 44-70.

Zins, M. et al. (2011). Effect of retirement on alcohol consumption: longitudinal evidence from the French Gazel cohort study. *PloS one*, 6(10), e26531.

Appendices

Appendix 2.1.a Systematic review searching commands in Medline, Embase, PsycINFO, and Social Policy and Practice. [7]

1. exp Retirement/
2. retirement.tw.
3. retired.tw.
4. 1 or 2 or 3
5. (cardiovascular adj disease$).tw.
6. exp Cardiovascular Diseases/
7. (heart adj disease$).tw.
8. (heart adj attack).tw.
9. (coronary adj3 disease$).tw.

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[7] '/' after an index term indicates that all subheadings were selected.
'exp' before an index term indicates that the term was exploded.
'.tw.' indicates a search for a term in title/abstract.
'.mp.' indicates a free text search for a term.
'$' at the end of a term indicates that this term has been truncated.
'? 'in the middle of a term indicates the use of a wildcard.
'adj' indicates a search for two terms where they appear adjacent to one another.

10. angina.tw.
11. (myocardial adj infarction).tw.
12. (isch?mi$ adj3 heart).tw.
13. (heart adj failure).tw.
14. (heart adj3 infarc$).tw.
15. (cardiac$ adj3 disease$).tw.
16. or/5-15
17. (cerebrovascular$ or (cerebral adj vascular)).tw.
18. (infarct$ or insch?emi$ or thrombo$ or emboli$ or apoplexy).tw.
19. 17 and 18
20. (stroke$ or poststroke$ or cva$).tw.
21. (hemipleg$ or hemipar$ or post-stroke).tw.
22. (brain adj attack).tw.
23. (cardiovascular adj3 (outcome$ or morbidity or event$)).mp.
24. exp Hypertension/
25. (blood adj pressure).tw. Insert Search Statement
26. exp Metabolic Diseases/ Insert Search Statement
27. ((metabolic adj syndrome) or (metabolic adj factor$)).tw.
28. hyperlipid$.tw.
29. hypercholesterol$.tw.
30. cholesterol$.tw.
31. dyslipidaemia.tw.
32. exp lipid blood level/
33. triglycerides.tw.
34. (blood adj fat$).tw.
35. (HDL or LDL).tw.
36. exp Hemoglobin A, Glycosylated/
37. HbA1c.tw.
38. inflammation.tw.
39. (inflammatory adj markers).tw.
40. exp Diabetes Mellitus/
41. diabetes.tw.
42. exp Body mass index/
43. BMI.tw.
44. exp overweight/ or exp obesity/
45. ((physical adj3 inactiv$) or (physical adj activity) or (sport$ adj3 participat$)).tw.
46. exp Sedentary Lifestyle/ or Exercise/
47. exp Smoking/
48. exp Tobacco/
49. tobacco$.tw.
50. cigarette$.tw.
51. exp Alcohol Drinking/
52. drinking.tw.
53. alcohol$.tw.
54. exp Diet/
55. exp Food Habits/
56. eating.tw.

57. or/19-56
58. 16 or 57
59. 4 and 58
60. remove duplicates from 59

Appendix 2.1.b Systematic review searching commands in Social Science Citation Index[8].

1. TS=retirement
2. TS=(retired or retire*)
3. #2 OR #1
4. TS=(cardiovascular NEAR/1 disease$)
5. TS=cardiovascular disease$
6. TS= (heart NEAR/1 disease$)
7. TS=(coronary NEAR/3 disease$)
8. TS=angina
9. TS= (heart NEAR/3 attack)
10. TS= (myocardial NEAR/1 infarction)
11. TS=(isch*mi$ NEAR/3 heart)
12. TS= (heart NEAR/1 failure)
13. TS= (heart NEAR/3 infarc*)
14. TS=(cardiac NEAR/3 disease$)
15. #14 OR #13 OR #12 OR #11 OR #10 OR #9 OR #8 OR #7 OR #6 OR #5 OR #4
16. TS= (cerebrovascular or (cerebral NEAR/1 vascular))
17. TS=(infarct* or insch*emi* or thrombo* or emboli* or apoplexy)
18. #17 AND #16
19. TS= (stroke$ or poststroke$ or cva$)
20. TS=(hemipleg* or hemipar* or post-stroke)
21. TS= (brain NEAR/3 attack）
22. TS= (cardiovascular NEAR/3 (outcome$ or morbidity or event$))
23. TS=Hypertension
24. TS= blood pressure
25. TS= Metabolic Disease$
26. TS= ((metabolic NEAR/1 syndrome) or (metabolic NEAR/1 factor$))
27. TS= hypercholesterol$
28. TS=hypercholesterol$
29. TS=cholesterol$
30. TS=dyslipidaemia
31. TS=lipid blood level
32. TS= triglycerides
33. TS= (blood NEAR/1 fat$)
34. TS= (HDL or LDL)
35. TS= glycosylated haemoglobin
36. TS= HbA1c
37. TS=inflammation

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[8] '*' in the middle of a term indicates the use of a wildcard, and at the end of a term indicates that this term has been truncated.

38. TS = (inflammatory NEAR/1 markers)
39. TS= diabetes
40. TS= body mass index
41. TS=BMI
42. TS= (overweight or obesity)
43. TS= ((physical NEAR/3 inactiv*) or (physical NEAR/1 activity) or (sport* NEAR/3 participat*))
44. TS= (Sedentary Lifestyle or Exercise)
45. TS= (smoking or tobacco$ or cigarette$)
46. TS= (alcohol$ or drinking)
47. TS= (diet or eating or food habits)
48. #47 OR #46 OR #45 OR #44 OR #43 OR #42 OR #41 OR #40 OR #39 OR #38 OR #37 OR #36 OR #35 OR #34 OR #33 OR #32 OR #31 OR #30 OR #29 OR #28 OR #27 OR #26 OR #25 OR #24 OR #23 OR #22 OR #21 OR #20 OR #19 OR #18 OR #15
49. #48 AND #3

Appendix 2.2.a Studies on retirement and CVD

Author (year), and study type	**Data used**	**Sample size, age (mean), and % women**	**Type of analysis & covariates**	**Effects on outcome measure(s)**	**Effect type**	**Overview of findings**
Kang and Kim (2014) Longitudinal	Korean Longitudinal Study of Aging (2006, 2008, 2010, and 2012)	10,254 ≥45 y 35.3%	Multivariate: adjusted for age, gender, history of diabetes and hypertension, diabetes, and smoking, heavy drinking, regular exercise, BMI, and income.	**Diagnosed stroke or CVD** Men and women Voluntary: 2.595 (1.595,4.074)* Involuntary: 2.955 (1.908,4.577)* Men Voluntary: 2.879 (1.533, 5.409)* Involuntary: 3.560 (2.055, 6.168)* Women Voluntary: 2.410 (1.177, 4.934)* Involuntary: 1.864 (0.839,4.140)	HR (95%CI) from Cox proportional hazard regression analysis (retired vs. working)	Both voluntary and involuntary retirement were associated with increase CVD or stroke, and the relationship was stronger among male subjects.
Olesen et al.	A registry-based	617,511	Multivariate: adjusted	**Diagnosed MI**	HR (95%CI) from	Retirement was

(2014) Longitudinal	cohort study including all Danish citizens born between 1932 and 1948.	60-67 y 44%	for baseline year, sex, occupational position, education, income, residential area, cohabitation and being immigrant.	Men Newly retired (≤26 weeks): 1.14 (1.05, 1.24)* Retired workers: 1.10 (1.05, 1.16)* Women Newly retired: 0.84 (0.68, 1.02) Retired workers: 1.14 (1.03,1.27)*	Cox proportional hazard regression analysis (retired vs. working)	associated with a modestly increased risk of MI.
Méjean et al. (2013) Longitudinal	Dutch segment of the European Investigation into Cancer and Nutrition study (1993-1997)	33,106 20-70 y 94.9% of retirees and 66.5% of working people are women	Adjusted for gender and age	**Diagnosed CHD** HR:1.20 (1.05, 1.37)* **Diagnosed stroke** HR: 1.05 (0.85,1.31) **+ dietary factors:** 15.15% (9.56,24.04) **+ all lifestyle factors:** 30.30% (22.07,38.05)	HR (95%CI) from Cox proportional hazard regression analysis (retired vs. working) %: percentage reduction in HR of CHD	Retired subjects more often suffered from CHD than working people, but not from stroke. Dietary factors and lifestyle factors explained 15% and 30% of the increased HRs for CHD in the retired group, respectively.
Behncke (2012)	English Longitudinal	1,439 >=50 y	1. State retirement age (65 years) as an IV	**Diagnosed CVD (angina, MI or**	Coefficients from non-parametric	Retirement people had significantly higher CVD

Longitudinal	Study of Ageing (2002-2006)	50.5%	for retirement: adjusted for age, gender, job characteristics, anticipation to stay in work, and pre-retirement health 2. Propensity score matching	**stroke)** Matching: 0.039* IV: 0.074	IV and non-parametric matching methods.	incidence than working people.
Dupre et al. (2012) Longitudinal	US Health and Retirement Study (1992-2010)	13,451 51-75 y (55.2 y) 48.8%	Multivariate: adjusted for age, gender, race/ethnicity, marital status, geographic region, educational household income, health insurance, current smoking status, alcohol use, vigorous physical exercise, regular cholesterol screenings, BMI, hypertension, diabetes, ADLs, and number of depressive	**Diagnosed AMI** 1.20 (0.971.48)	HR (95%CI) from Cox proportional hazard regression analysis (retired vs. working)	Retirement was not associated with AMI incidence.

			symptoms.			
Masoudkabir, (2012) Longitudinal	Isfahan cohort study (three counties in central Iran)	6,504 35-75 y (50.7 y) 48.1%	Multivariate: adjusted for gender, age, baseline smoking status, body mass index, and hypertension.	**Diagnosed CVD (ischemic heart disease and stroke)** Manual worker: 0.84 (0.29,2.39) Non-manual worker: 0.86 (0.30,2.44) Retired people: 0.65 (0.22,1.86)	HR (95%CI) from Cox proportional hazard regression analysis (housewife as reference)	There was no significant occupational difference on CVD incidence.
Moon (2012) Longitudinal	US Health and Retirement Study (1998-2008)	5,422 >=50 y 54%	Multivariate: adjusted for age, sex, childhood and adult SES, behaviour, and co-morbidities.	**Diagnosed CVD (stroke or MI)** First year after retirement: 1.55 (1.03, 2.33)* ≥2 years after retirement 1.35 (0.96, 1.91)	HR (95%CI) from discrete-time survival analyses based on pooled logistic regression (fully retired people vs. full time working people)	CVD risk was increased after retirement, especially in the first year.
Mao et al. (2010) Longitudinal (Conference	China National Hypertension Survey Epidemiology	158,666 ≥40 y	Baseline age, systolic BP, cigarette smoking, alcohol consumption, BMI physical activity,	**Diagnosed CVD incidence/ death from CVD** Not stated in the	Not stated in the abstract	Among men, unemployed individuals and farmers had the highest risk of having MI, stroke or dying

abstract, no full text)	Follow Up Study (1991-1999/2000)		education, geographic region and urbanization.	abstract, no full text.		of CVD, followed by workers and retirees. Men who were working in other occupations had the lowest risks. No occupational difference was found in Chinese women.
Shah (2010) Cross-sectional	Kuwait, randomly selected households	2,487 >=50 y 25.3%	Multivariate: adjusted for age, gender, exercise, BMI, ethnicity, social activities, education, income	**Heart disease** 2.94 (1.233,7.027)*	OR (95%CI) from logistic regression (retired people vs. working people)	Retired people have higher risk of having CVD than working people.
Westerlund, (2010) Longitudinal	France, GAZEL study (1989-2007)	14,104 20.3%	Multivariate: adjusted for sex, year of birth, and marital status.	**Cumulative prevalence of diagnosed CVD (angina, MI or stroke)**	Not stated	Cumulative prevalence of CVD increased with age, with no break in the trend around retirement.
Bamia (2008) Longitudinal	Greek segment of the European Investigation into Cancer and Nutrition study	16,827 20-86 y 47%	Multivariate: adjusted for age at baseline, education, smoking, physical activity, BMI, total energy intake	**Death from circulatory diseases** 1.73 (1.10, 2.73)*	HR (95%CI) from Cox proportional hazard regression analysis (retired vs. working)	Retired people have higher risk of death from circulatory disease than working people.

	(1994-2006)		and alcohol intake.			
Coe and Lindeboom (2008) Longitudinal	US Health and Retirement Study (1992-2005)	3,657 50-70 y (59.19 y) 0%	Offered a retirement window as an IV for retirement: adjusted for white/blue-collar worker, age, age^2, education, marital status, net worth deciles, race, Hispanic, US-born, the number of children, and wave.	**Diagnosed MI** 2 years: -0.0421 4 years: 0.0779	Coefficients from dynamic IV analysis.	Retirement had no effect on MI in the short run (within 2 years) or long run (within 4 years).
Bound & Waidmann (2007) Cross-sectional	English Longitudinal Study of Ageing (2004/05)	Approximately 12,000 53-89 y	Not stated	**Diagnosed heart diseases/diabetes** Men: 5.858 Women: 25.513***	Coefficients from the post-retirement ages deviate from the pre-retirement trend.	Women had significantly higher likelihood of diagnosis of heart disease/diabetes after SPA, but this pattern was not observed in men.
Dave et al. (2006) Longitudinal	US Health and Retirement Study (1992-	4,951 to 5,289 50-75 y	Gender, ethnicity, education, marriage, religious, income,	**Diagnosed heart disease and stroke** Heart: 0.0268***	Marginal effect of complete retirement on	Retirement was associated with increased incidence of heart disease

	2005)		health insurance, parents' age and education, native-born, risk averse, planning horizon, fixed effects of age, year, census division, and individual.	Stroke: 0.0173*** Restricted to samples who are healthy pre-retirement Heart: 0.0148* Stroke: 0.0075* Restricted to samples who are healthy pre-retirement &consistently insured Heart: 0.0084 Stroke: 0.0052	health	and stroke, but not once samples were restricted to those consistently insured in all waves.
Petrelli et al. (2006) Longitudinal	Turin Longitudinal Study in Italy (1997-2002)	523,755 35-74 y 52.1%	Multivariate: adjusted for age, education, income and area of birth.	**Diagnosed CHD** Men: 1.14 (1.06-1.23)* Women: 1.20 (1.03-1.41)* **Death from CHD** Men: 1.54 (1.26-1.89)* Women:	Coefficients from hierarchical Poisson models (retired vs. working)	Retired people have higher incidence of CHD and higher risk of death from CHD than working people.

				2.06 (1.43-2.97)*		
Morris et al. (1994) Longitudinal	British Regional Heart Study (1978/80-1983/85)	6,191 40-59 y (49.9 y) 0%	Multivariate: adjusted for age, town, social class, smoking, alcohol intake, and pre-existing disease at initial screening.	**Death from circulatory disease** 1.81 (1.12, 2.93)*	HR (95%CI) from Cox proportional hazard regression analysis (retired vs. working)	Retired people have higher risk of death from circulatory disease than working people.
Siscovick (1990) Case-control	Male cases and controls in the US, without prior heart disease or comorbidity.	126 cases 126 controls 25-75 y 0%	Matched for age, gender, marital status, and region. Adjusted for age, history of hypertension treatment, current cigarette smoking, habitual physical activity, and alcohol consumption.	**Diagnosed primary cardiac arrest (case)** 1.1 (0.5, 2.8)	OR (95%CI) from logistic regression (retired people vs. working people)	There was no significant association between retirement and primary cardiac arrest.
Vallery-Masson (1981) Longitudinal	Parisian male managers (1976-1979), France.	156 63-64 y 0%	Adjusted for age and baseline income	**Diagnosed CVD incidence** Retired: 27% Working 16%	Percentage of people have diagnosed CVD in the follow-up	Retired men did not show significantly higher CVD incidence.
Casscells et	Male cases and	568 cases	Matched for same	**Die of CHD**	OR (95%CI) from	Retired people were more

al. (1980) Case-control	controls in the US	568 controls 0%	neighbourhood and age range. Adjusted for age and history of hospitalisation for MI.	1.8 (1.0-3.3)*	logistic regression (retired people vs. working people)	likely to die of CHD.

HR: hazard ratio. OR: odds ratio. *p<0.05; **p<0.01; ***p<0.001

Appendix 2.2.b Studies on retirement and adiposity measures

Author (year), and study type	**Data used**	**Sample size, age (mean), and % women**	**Type of analysis & covariates**	**Effects on outcome measure(s)**	**Effect type**	**Overview of findings**
Kowalkowska et al. (2016) Cross-sectional	Portuguese Population's Food Habits and Lifestyle (2009)	3,529 ≥18 y (45.2 y) 52.1%	Multivariate: adjusted for age, gender, education, occupation, marriage, region, energy intake, physical activity and smoking status.	**General adiposity:** 1.37 (0.95,1.98) **Abdominal adiposity:** 1.09 (0.76,1.56)	OR for retired people vs. working people (95%CI)	Retirement is not associated with general or abdominal adiposity.
Godard (2016)	Survey of	2,599	Early retirement age as	**BMI:**	Fixed effects IV	Retirement induced by

Longitudinal	Health, Ageing and Retirement in Europe (2004, 2006 and 2010-2011)	50-69 y (59.8 y) 54.7%	an IV for retirement: adjusted for age, age^2, wave, and live with spouse.	Men: 0.419 Women: 0.733 **Probability of being overweight/obese (25≤BMI):** Men: 0.050 Women: 0.085 **Probability of being obese (BMI ≥30):** Men: 0.115* Women: 0.026 Men (strenuous job): 0.104* Women (strenuous job): -0.037	coefficients	early retirement rules causes a 11.5% increase in the probability of being obese among men within 2-4 years, which is driven by men retiring from strenuous jobs and by those who were already at risk of obesity. No significant results are found among women.
Eibich (2015) Longitudinal	German Socio-Economic Panel Study (1984-2004)	More than 20,000 individuals 55-70 y (61.7 y) 51.8%	Regression Discontinuity Design using eligibility ages (60 and 65) as exogenous variation in retirement: adjusted for age, gender, lived in East Germany in 1989,	**BMI:** -0.424	Coefficients of Regression Discontinuity Design	No significant impact of retirement on BMI was found.

			education, occupation physical and mental strain, and partner is retired.			
Monsivais et al. (2015) Longitudinal	European Prospective Investigation of Cancer Norfolk study in the UK (1993-97)	7,201 39-76 y 52.5%	Multivariate: adjusted for age, sex, education, smoking, and measured body weight at baseline.	**Body weight change over follow-up years:** 0.49 (0.42, 0.57)	Annualised mean change (95% CI), kg/year	Weight changes associated with retirement were similar to those staying in work, so retirement was not associated with body weight change.
Gueorguieva, (2011) Longitudinal	US Health and Retirement Survey (1992-2002)	2,096 (56.7 y) 42.8%	Multivariate: adjusted for year before retirement, gender, race, education, marriage, health behaviours, economic status, job characters, non-housing wealth, health insurance, and attrition/dropout.	**BMI trajectories**	Post-retirement slope Service: 0.08* Other blue-collar: 0.09**	Those in service and other blue-collar occupations had significant increases in the slopes of their BMI trajectories after retirement, whereas individuals in white-collar occupations exhibit no change.
Kong (2011) Cross-sectional	Cycle 3.1 of the Canadian Community Health Survey	3,854 60-70 y 53.5%	OLS regression & Regression discontinuity design using eligibility age 65	OLS estimations: **Obese:** -0.067** **Physical activity index [e]:** -0.344**	Coefficients from OLS regression and RD method.	OLS estimates suggest retirement is associated with a more physically active, and less

	(2005)		as exogenous variation in retirement: adjusted for age, age^2, gender, education, and family income.	RD estimations: **Obese:** -0.247 **Physical activity index:** 0.103		obese, but RD results show no such causal relationships.
Touvier (2010) Longitudinal	SU.VI.MAX study in France (1998-2001)	1,389 45-64 y (Women: 52.3 y, Men: 57.1 y) 49.7%	Age, education level and baseline value of the corresponding variable.	**Change of BMI in the follow-up** Retired men: 0.4 Working men: 0.4 Retired women: 0.6 Working women:0.6 **Change of WC in the follow-up** Retired men: 1.1 Working men: 1.6 Retired women: 1.9 Working women:3.3	Mean	No difference between retirees and employees in the change of BMI and waist circumference with time.
Chung et al. (2009) Longitudinal	US Health and Retirement Study (1992-2002)	10,565 50-71 y (60.6 y) 49.4%	1-year lagged eligibility for the early Social Security benefit, which is 63y, as an IV for retirement: adjusted for age, age2, income, smoking, physical activity, and spousal	**BMI** Total: 0.242* Physically demanding job: 0.478* Sedentary job: 0.043 Initially BMI≥25: 0.294* Initially BMI<25:	Marginal effects of retirement from fixed effects IV	Weight gain with retirement was found among people who were already overweight and those retiring from physically demanding occupations.

			factors	0.073		
Zheng (2008) Longitudinal	US Health and Retirement Study (1992-2004)	6,935 50-73 y 43.2%	Ages of Social Security (62y) and Medicare (65y) eligibility as IVs for retirement: adjusted for age, age^2, education, ethnicity, income, wealth, number of IADL/ADL limitations, self-rated health, ever being diagnosed cancer, diabetes, heart disease, hypertension, lung disease, and stroke.	**BMI** Men: -0.180 Women: 0.446 Men from strenuous occupation:0.621*** Women from strenuous occupation: 0.091	Fixed effects IV coefficients	Retirement was associated with higher BMI among men retiring from strenuous jobs. No significant results were found among women.
Martin (2008) Cross-sectional	Spain, residents of the city of Cadiz	2,640 15-82 y (43.3 y) 52.7%	Age, gender, physical exercise, education level, income, and marital status.	**Overweight or obesity** 1.08 (0.72-1.61) Men: 0.966 (0.565, 1.651) Women: 1.618 (0.839, 3.120)	OR for retired people vs. working people (95%CI)	No association between retirement and the presence of overweight and obesity.
Forman-	US Health and	3,725	Baseline functional	**>=5% increase in**	OR for retired	Retirement was associated

Hoffman et al. (2008) Longitudinal	Retirement Study (1994-2002)	53-63 y 47.2%	limitations, medical condition, depression, weight, marriage, physical activity, age, smoking, ethnicity, education, occupation, alcohol consumption, time period	**BMI:** Blue collar women: 1.58 (1.13,2.21)* White collar women: 1.13 (0.92,1.39) Blue collar men: 1.05 (0.83,1.34) White collar men: 0.85 (0.65,1.10)	people vs. working people (95%CI)	with a significant weight gain only among women in blue-collar jobs, but no effect was found among men.
Nooyens et al. (2005) Longitudinal	Doetinchem Cohort Study in the Netherlands, (1994/1997-1999/2002)	288 55-65 y 0%	Adjusted for age	**Weight** Sedentary job: 0.08 Active job: 0.42* **Waist circumference:** Sedentary job: 0.23 Active job: 0.77*	Mean change in the outcomes of retirees in the follow-up	Retired men gained more weight than continued employed men and that the weight gain was greater among retirees from physically active jobs than retirees from sedentary jobs.
Lahmann et al. (2000) Cross-sectional	Subsample of Malmö Diet and Cancer prospective cohort Study in Sweden (1994/1996)	5,464 45-73 y 100%	Multivariate: adjusted for age, initial BMI, menopausal status, hormonal therapy, parity, age at menarche, smoking status, physical activity, alcohol consumption,	**Weight gain:** 1.363* **% body fat:** 0.713** **Waist:** 2.547*** **WHR:** 0.014***	Coefficients from linear regression	Compared to working women, retired women were more likely to have long-term weight gain, higher current body fatness and higher waist and WHR.

			past change in diet, ethnicity, living along, education, own occupation, parental occupation.			
Morris et al. (1992) Longitudinal	British Regional Heart Study (baseline: 1978-1980, follow up until 1983-1985)	6,057 40-59 y 0%	Age, social class, and town of residence.	**Loss BMI>10%** Continuously employed: 2.1 Non-continuously employed: 2.9 **Gain BMI>10%** Continuously employed: 5.0 Non-continuously employed: 7.5	% of people who loss or gain BMI	Non-continuously employed men were more likely to either gain or lose weight, whereas weight was stable among the continuously employed men.
Patrick et al. (1982) Longitudinal	73 men retiring from manual work in the UK	73 64.5 y 0%	Did not adjust any covariates.	**Fat mass:** 3.1%* **% fat:** 2.7%*	Change of means for fat measures in the follow-up	Body fat increased by about 3% between measurements made just before retirement and again 1 year later.

OR: odds ratio. *p<0.05; **p<0.01; ***p<0.001

Appendix 2.2.c Studies on retirement and metabolic chronic conditions (except for obesity).

Author (year), and study type	Data used	Sample size, age (mean), and % women	Type of analysis & covariates	Effects on outcome measure(s)	Effect type	Overview of findings
Horner and Cullen (2016) Longitudinal	Secondary data on a cohort of male manufacturing workers in a US setting (1997-2009)	1,008 55-70 y 0%	Reach age 62 (earliest age received a private pension) as an IV for retirement: adjusted for plant and age polynomial.	**Probability of having hypertension:** −0.00174 **Probability of having diabetes:** 0.0613	IV coefficients	Retirement induced by private pension age at 62 has no effects on hypertension or diabetes.
Chung et al. (2015) Cross-sectional	Thematic Household Survey in Hong Kong, China (October 2011-January 2012)	25,780 ≥15 y 52.2%	Multivariate: adjusted for education, housing type, family income smoking, age, and gender.	**OR for having multimorbidity:** 1.764 (1.646-1.891)** **RR for number of chronic conditions:** 1.594 (1.536-1.654)**	OR for retired people vs. working people (95%CI) RR for retired people vs. working people (95%CI)	Retirement is associated with presence of multimorbidity and increased number of chronic diseases.
Ke et al. (2015) Cross-sectional	A random sample in Macau, China (August to	1,410 18-93 y (47 y) 54.8%	Multivariate: adjusted for age, gender, marriage, education, BMI, physical activity.	**Risk of having hypertension:** 2.0 (1.8-2.3)*	OR for retired people vs. not retired people (95%CI)	Being retired was associated with increased risk of having hypertension.

	September 2012)		smoking, and salt knowledge.			
Seow et al. (2015) Cross-sectional	Well-being of the Singapore Elderly study (October 2012 to December 2013)	2,488 ≥60 y 55.9%	Multivariate: adjusted for age, gender, ethnicity, marriage education, BMI, exercise, and smoking.	**Risk of having hypertension:** 1.37 (0.95, 1.96)	OR for retired people vs. working people (95%CI)	Retired people were more likely to have hypertension, although it only reaches a 1% significant level.
Insler (2014) Longitudinal	US Health and Retirement Study (1992-2010)	6,276 ≥50 y (workers: 59.4; retirees: 66.4) Workers:43% Retirees:46%	Workers' self-reported probabilities of working past ages 62 and 65 as an IV for retirement, adjusted for age, age^2, gender, black, Hispanic, married, assets, debt, and education.	**Hypertension** -0.0906*** **Diabetes** -0.0966***	Coefficients of IV analysis	Retirement exerts a beneficial influence on prevention of diabetes and hypertension
Sivén et al. (2015) Cross-sectional	A nationwide representative sample of the Finnish adult population (2011)	4,230 ≥18 y (55.2 y) 55.5%	Multivariate: adjusted for age, gender, education, marriage, BMI, smoking, drinking, heavy alcohol, and physical activity levels.	**Risk of having hypertension:** 1.29 (1.06-1.58)*	OR for retired people vs. working people (95%CI)	Retired people were more likely to have hypertension.
Al-Daghri et al.	Biomarkers	9,164	Adjusted for age	**Risk of having**	OR, working	Retired people have higher

(2014) Cross-sectional	Screening Program Database in Saudi (March-August, 2009)	18-70y (Men: 41.4 y, Women:37.4 y) 51.8%		**metabolic syndrome** Men: Retired: 1.4 (1.0, 1.9)* Working in private sector: 1.4 (0.97, 2.1) Women: Retired: 0.77 (0.22, 2.6) Working in private sector: 1.0 (0.28, 3.6)	people in the government sector as reference (95%CI)	risk of having metabolic syndrome compared to working people.
Müller et al. (2013) Cross-sectional	Diabetes Collaborative Research of Epidemiologic Studies in Germany (pooled data collected between 1997 and 2006)	8,871 45-74 y 48.8%	Multivariate: adjusted for age, social class, employment status, neighbourhood unemployment rate, marital status, body mass index, physical exercise, smoking status (only for men).	**Risk of having diagnosed type 2 diabetes/treatment** Women: 1.66 (1.02, 2.69) Men: 1.01 (0.72, 1.42)	OR for retired people vs. working people (95%CI)	Retired women are more likely to have diabetes than working women, but this association is not found in men.
Roberts et al. (2013) Cross-	Grenada Heart Project (2008 and 2010)	2,827 (44.8 y) 57.5%	Adjusted for age and sex	**Risk of having hypertension:** Retired:	OR, government employees as	Retired people were more likely to have hypertension.

sectional				2.40 (1.69, 3.42)* Non-government employees: 1.09 (0.79, 1.50)	reference (95%CI)	
Shamshirgaran et al. (2013) Cross-sectional	Participants selected at random from the Medicare Australia	266,848 ≥45 y 53.6%	Multivariate: adjusted for age, sex, country of birth, work status, household income, educational qualification, BMI, smoking, sessions of physical activity.	**Ever been diagnosed with diabetes** 1.25 (1.18-1.32)*	OR (retired vs. people in paid work)	Diabetes is more prevalent among retired people than working people.
Zhang et al. (2013) Cross-sectional	Tianjin Diabetes Mellitus Project in China (July 2005)	7,315 20-79 y	Multivariate: adjusted for age, sex, income, education, cigarette smoking, alcohol drinking, physical inactivity, BMI, hypertension and family history of diabetes.	**Impaired fasting glucose** Retired: 1.91 (1.40-2.45)* Non-manual worker: 0.90 (0.65-1.20) **Undiagnosed Type 2 diabetes** Retired: 2.01 (1.40-2.89)* Non-manual worker: 1.05 (0.70-1.55**)**	OR (manual workers as reference) World Health Organization criteria	Retired people were more likely to have impaired fasting glucose, diagnosed and undiagnosed Type 2 diabetes.

				Diagnosed Type 2 diabetes Retired: 3.02 (2.12-4.22)* Non-manual worker: 1.23 (0.82-1.80)		
Behncke (2012) Longitudinal	English Longitudinal Study of Ageing (2002-2006)	1,439 >=50 y 50.5%	1. State retirement age (65 years) as an IV for retirement: adjusted for age, gender, job characteristics, anticipation to stay in work, pre-retirement health 2. Propensity score matching	**Diagnosed metabolic syndrome** matching: 0.072⍰ IV: 0.069⍰	Coefficients from non-parametric IV and non-parametric matching methods.	Retirement people had higher metabolic syndrome incidence than working people, but only at the 10% significance level.
Madani Larijani et al. (2012) Cross-sectional	Canadian Heart Health Survey (1986-1992)	9,436 18-74 y 49.9%	Multivariate: adjusted for age, education, income adequacy, alcohol drinking status, smoking status, and marital status	**Risk of having metabolic syndrome (objective)** Men ATP III: 2.1(1.1-3.8) IDF: 1.8(0.9-3.9) Women: Results not stated	Full time working people as reference	Retirement is associated with increased risk of having metabolic syndrome regardless of definition for men, but not a risk factor for women.

Oksanen et al. (2011) Longitudinal	Finnish Public Sector Study cohort (1995-2004)	11,019 23-67 y 75%	Adjusted retirement age and calendar year	**Diabetes medication purchases** Not state	Not state	The trend of purchases of diabetes medication was not altered by retirement; no matter it was statutory retirement or early retirement.
Shah et al. (2010) Cross-sectional	Kuwait, randomly selected households	2,487 >=50 y 25.3%	Multivariate: adjusted for age, gender, exercise, BMI, ethnicity, social activities, education, income	**Risk of having hypertension:** 1.65 (1.072,2.552)* **Risk of having diabetes:** 2.43 (1.556,3.799)***	OR (95%CI) from logistic regression (retired people vs. working people)	Retired people have higher risk of having hypertension than working people.
Westerlund et al. (2010) Longitudinal	France, GAZEL study (1989-2007)	14,104 20.3%	Multivariate: adjusted for sex, year of birth, and marital status.	**Cumulative prevalence of diagnosed diabetes** Not stated	Not stated	Cumulative prevalence of CVD increased with age, with no break in the trend around retirement.
Azimi-Nezhad et al. (2008) Cross-sectional	Cluster-stratified sampling from Khorasan residences in	3,778 15-64 y (43.3 y) 50.9%	Did not include any covariates	**Prevalence of diabetes** (objective: fasting blood sugar> 126 mg/dL) Retirees:14.4%	Chi-square test	The prevalence of diabetes is highest in retirees.

	Iran.			Officer: 3.2% Manual worker: 4.1%		
Coe and Lindeboom (2008) Longitudinal	US Health and Retirement Study (1992-2005)	3,657 50-70 y (59.19 y) 0%	Offered a retirement window as an IV for retirement: adjusted for white/blue-collar worker, age, age^2, education, marital status, net worth deciles, race, Hispanic, US-born, the number of children, and wave.	**Diagnosed diabetes** 2 years: 0.0873 4 years: 0.0753 **Diagnosed hypertension** 2 years: -0.0061 4 years: -0.0173	Coefficients from dynamic IV analysis.	Retirement had no effect on the incidence of diabetes or hypertension in the short run (within 2 years) or long run (within 4 years).
Zheng (2008) Longitudinal	US Health and Retirement Study (1992-2004)	6,935 50-73 y 43.2%	Ages of Social Security (62y) and Medicare (65y) eligibility as IVs for retirement: adjusted for age, age^2, education, ethnicity, income, wealth, number of IADL/ADL limitations, self-rated health, ever being diagnosed cancer, diabetes, heart	**Ever diagnosed with diabetes** Retired: -0.008 Retired*strenuous occupation:0.028	Fixed effects IV coefficients	Retirement has no casual effect on diabetes

			disease, hypertension, lung disease, and stroke.			
Bound & Waidmann (2007) Cross-sectional	English Longitudinal Study of Ageing (2004/05)	Approximately 12,000 53-89 y	Not stated	**Risk of having metabolic syndrome** (objective) Men: -3.301*** Women: 1.202	Coefficients from the post-retirement ages deviate from the pre-retirement trend.	Men had significantly lower likelihood of diagnosis of metabolic syndrome after SPA than that would be predicted by preretirement ages, but this pattern was not observed in women.
Dave et al. (2006) Longitudinal	US Health and Retirement Study (1992-2005)	4,951 to 5,289 50-75 y	Gender, ethnicity, education, marriage, religious, income, health insurance, parents' age and education, native-born, risk averse, planning horizon, fixed effects of age, year, census division, and individual.	**Diagnosed diabetes** 0.0126*** Restricted to samples who are healthy pre-retirement 0.0126* Restricted to samples who are healthy pre-retirement &consistently insured 0.0142**	Marginal effect of complete retirement on health	Retirement was associated with increased incidence of heart disease and stroke, but not once samples were restricted to those consistently insured in all waves.

Ekerdt et al. (1984) Longitudinal	US Normative Aging Study (1972-1981)	262 55-70y (63.6 y) 0%	Adjusted for baseline level of the dependent variable, time between examinations, age, baseline BMI and change in BMI	**Change of SBP** 3.44 mmHg* **Change of DBP** 1.62 mmHg* **Change of total blood cholesterol** 5.560 mg/dl	Retired vs. working people	Retirement was associated with increased SBP and DBP but not total cholesterol.

OR: odds ratio. † p<0.1; *p<0.05; **p<0.01; ***p<0.001

Appendix 2.2.d Studies on retirement and physical activity**.**

Author (year), and study type	**Data used**	**Sample size, age (mean), and % women**	**Type of analysis & covariates**	**Effects on outcome measure(s)**	**Effect type**	**Overview of findings**
Kämpfen and Maurer (2016) Longitudinal	U.S. Health and Retirement Study (waves 7 to 10: 2004-2010)	13,491 50-80 y (65.3 y) 57%	Early and normal retirement ages as IVs for retirement: adjusted for age, age^2, gender, race, ethnicity, marriage, education, household	**Probability of meeting the US governments' 2008 Physical Activity Guidelines:** Men: 0.333* Women: 0.392**	IV coefficients IV Fixed effects coefficients	Retirement increases the probability of meeting physical activity guidelines.

			wealth, number of children, smoking, drinking, physical demands of the current/longest held job, wave and interview date.	Men (Fixed): 0.328* Women (Fixed): 0.227?		
Murtagh et al. (2015) Cross-sectional	Irish Longitudinal Study on Ageing (baseline: October 2009 and February 2011)	4,892 ≥60 y 53.4%	Multivariate: adjusted for age, gender, SES level, education, living along, having children, car ownership, self-related overall and emotional health, look after grandchildren, attend a course and urban/rural location.	**Risk of physical inactivity (through total life activity)** Men: 0.82 (0.79, 0.86) Women: 1.48 (1.42, 1.54)*	OR for retired people vs. working people (95%CI)	Retirement was significantly associated with physical inactivity for women, but not for men.
Eibich et al. (2015) Longitudinal	German Socio-Economic Panel Study (1984-2004)	More than 20,000 individuals 55-70 y (61.7) 51.8%	Regression Discontinuity Design using eligibility ages (60 and 65) as exogenous variation in retirement: adjusted for age, gender, lived in East Germany in	**Probability of doing regular physical activity:** 0.107**	Coefficients of Regression Discontinuity Design	Retirement decreases the probability of regular physical activity.

			1989, education, occupation physical and mental strain, and partner is retired.			
Barnett et al. (2014) Longitudinal	European Prospective Investigation into Cancer and Nutrition - Norfolk study in the UK	3,334 45-79 y 52.0%	Multivariate: adjusted for age, BMI, change in marital status, physical activity or TV viewing time at baseline, incidence of chronic disease, alcohol consumption, smoking.	**Overall physical activity (MET h/wk)** Non-manual social class Men: −40.9 (−49.5, −32.5) *** Women: −26.9 (−33.9, −19.9) *** Manual social class Men: −49.6 (−63.2, −35.9) *** Women: −31.6 (−43.4, −19.7) ***	Coefficients of linear regressions	Compared with continued employment, retirement was associated with a decline in overall activity. The decline is bigger among those retired from manual social class.
Dogra and Stathokostas (2014) Cross-sectional	Canadian Community Health Survey (Healthy Aging Cycle, 2008-2009)	14,560 ≥65 y 59.6%	Adjusted for age	**Risk of extended self-reported sitting time** Men: 1.54* (1.16,2.04) Women: 1.22 (0.89,1.69)	OR for completely retired people vs. not completely retired people (95%CI)	Complete retired people are more likely to sit for 4 or more hours per day than not completely retired people.

Insler (2014) Longitudinal	US Health and Retirement Study (1992-2010)	6,276 ≥50 y (workers:59.4y; retirees: 66.4 y) Workers:43% Retirees:46%	Workers' self-reported probabilities of working past ages 62 and 65 as an IV for retirement, adjusted for age, age^2, gender, black, Hispanic, married, assets, debt, and education.	**Participant in vigorous physical activity 3 or more times per week** Long-term: 0.227 Short-term: 0.048	Coefficients of IV analysis	Retirement has no effect on vigorous activity.
Menai et al. (2014) Longitudinal	SU.VI.MAX (Supplementation with Antioxidants and Minerals) study in France (2001-2007)	2,841 ≥45 y (57.3 y) 48.9%	Multivariate: adjusted for age, sex, educational level, smoking status, and occupational physical activity at baseline.	**Sedentary behaviour** Retired: 8.4 (0.42) * Not retired: 4.7 (0.35) **Leisure physical activity** Retired: 2.5 (0.18)* Not retired: 0.7 (0.11)	Mean (SE) changes in hours spend per week	In subjects transitioning to retirement, both sedentary behaviour and physical activity during leisure-time increased substantially over the 6-year follow-up period. The mean increase in total sedentary behaviour was about three times higher than the mean increase in leisure-time physical activity.
Turrell et al. (2014) Longitudinal	How Areas in Brisbane Influence Health	9,577 40-65 y	Multilevel modelling: neighbourhoods (level 3), between-	**Minutes walking for transport** White collar:	Coefficients of multilevel mixed-effects	Among the employed, there was no association between occupation and minutes

	and Activity study in Australia (2007,2009, and 2011)		individuals (level 2), and within-individuals (level 1). Multivariate: adjusted for age, sex, year, neighbourhood disadvantage, education and household income.	0.6 (−5.8, 7.0) Blue collar: 3.0 (−5.2, 11.1) Retired: −16.0 (−24.0, −7.9)** White collar × time: −3.4 (−9.5, 2.7) Blue Collar × time: −0.9 (−8.6, 6.9) Retired × time: −11.1 (−18.3, −4.0)**	linear regression, professionals as reference	walking for transport. Compared with managers and professionals, retired people walked on average 16 minutes less. Average minutes of walking for transport declined for all socioeconomic groups; however, the declines were steeper for the retired.
Godfrey et al. (2013) Cross-sectional	Incidence of Cognitive Impairment in Cohorts with Longitudinal Evaluation—Parkinson's Disease study in the UK	98 (69.1 y) 49.0%	Univariate: Healthy aged-matched participants.	**% of time sedentary:** Working: 78.00 (6.17) Retired: 74.73 (5.77)** **Long bouts of sitting (>55 min):** Working: 15.16 (4.75) Retired: 12.98(5.28)* **% of time walking** Working: 6.24 (2.18) Retired: 7.34 (2.27)*	Mean (SD), significance test is from ANOVA. % of people who are meeting physical activity guidelines, significance test is from chi-square test	Being retired was associated with a reduced percentage of sedentary behaviour; reduced long bouts of sitting and increased the percentage of walking. With respect to recommended amounts of PA, there was no difference between retired and employed adults

				% meeting guidelines Working: 16% Retired: 24%		
Koeneman, (2012) Longitudinal	Longitudinal Aging Study Amsterdam in the Netherlands (1992/1993 - 1995/1996)	186 >=55 y 36%	Gender, baseline activity, age, gender and educational.	**Moderate to vigorous physical activity** 32.5***	Linear regression coefficient after ranking	Retirement was associated with increased moderate to vigorous physical activity.
Kuvaja-Kollner et al. (2012) Longitudinal	Eastern Finnish men and women	1,410 57-78 y (Men: 66.3 y; Women: 66.6 y) 50.6%	Multivariate: adjusted for age, gender, income, education, and intervention dummies groups.	**Time spent on moderate-heavy physical exercise (hours/week)** 1.03***	Coefficients of linear random effect	Retirement was associated with increased time spent on moderate-heavy physical exercise.
Sjösten et al. (2012) Longitudinal	GAZEL cohort (employees of French national gas and electricity company, 2002-2009)	2,711 35-50 y 37%	Sex, age at retirement, marital status and occupational position.	**% walking at least 5 km/week** Men: 36% Women: 61%	Mean percentage	In both men and women, statutory retirement was associated with higher likelihood of walking at least 5 km/week.
Lahti et al.	City of Helsinki	6,706	Baseline BMI,	**Change on time**	Adjusted mean	Retirement was associated

(2011) Longitudinal	study in Finland (baseline in 2000-2002, follow up until 2007)	40-60 y 81.3%	smoking, physical strenuousness of work, social economic position, and limiting longstanding illness.	**spent (min/week) in leisure physical activity** Men: 42 (18-67)* Women: 31 (18-44)* **Physical inactivity:** Men: 0.66 (0.43-1.04) Women: 0.77 (0.60-0.99)*	(95% CI) OR of physical inactivity for retired people vs. working people (95% CI)	with an increase in moderate-intensity leisure-time physical activity and a decrease in the proportion of inactive.
Najdi et al. (2011) Cross-sectional	Survey of Moroccan adults (May 2008)	2,613 26-57 y (41.4 y) 48.1%	Age, income, overweight and obesity, living in an urban area.	**Low total physical activity** Men: 1.87 (1.07,3.27)*	OR for retired people vs. working people (95% CI)	Retirees are more likely to have low total physical activity level.
Steindorf, (2010) Cross-sectional	MARIE study in Germany (2002-2005)	6,569 >=50 y 100%	Age, BMI at 25-50years old, education, occupation, working hours, housework, marital status, number of children, age at first pregnancy, ever breastfed, nationality, smoking, and coexisting	**Leisure-time sports** 0.80 (0.65, 0.98)* **Leisure-time walking** 0.56 (0.45, 0.69)**	OR of ever doing physical activity for working people vs. (95% CI) retired people	Retirement was associated with higher odds of doing sports and walking.

			diseases.			
Touvier (2010) Longitudinal	SU.VI.MAX study in France (1998-2001)	1,389 45-64 y (Women: 52.3 y Men: 57.1 y) 49.7%	Age, education level and baseline value of the corresponding variable.	**Change in leisure physical activity (MET-h/week)** Men Working: -0.5 Retired: 8.1 *** Women Working: -1.9 Retired: 6.8*** **Change in time spent watching TV (min/day**) Men: Working: 15.0 Retired: 40.5*** Women: Working:19.9 Retired: 33.5*	Mean	Retirement was associated with an increase in leisure-time physical activity and time spent on watching TV.
Brown et al. (2009) Longitudinal	Australian Longitudinal Study on Women's Health (2001-2004)	8,762 51-56 y 100%	Multivariate: adjusted for area of residence and education, country of birth, household income,	**Increasing leisure physical activity** 1.54 (1.24,1.91)***	OR for retired people vs. non-retired people (95%CI)	Retirees were more likely to report an increase in leisure physical activity (compared to 3 years ago) than participants who were still

			and weight change.			employed
Chung et al. (2009) Longitudinal	US Health and Retirement Study (1996-2002)	11,469 50-71 y (60.3 y) 52.9%	Multivariate: adjusted for age, race/ethnicity education, marital status, household income, and current health problems.	**Total physical activity** Physically demanding job: −0.075** Sedentary job: 0.044**	Coefficients from fixed-effects regression	Physical activity decreased with retirement from a physically demanding job but increased with retirement from a sedentary job.
Nekuda (2009) Longitudinal	US Health and Retirement Study (1998-2000)	5,351 (59 y) 48.3%	Multivariate: adjusted for age, gender, education, income, race and perceived health status.	**Participant in vigorous physical activity 3 or more times per week** 1.06 (0.89,1.246)	OR for retired people vs. working people (95%CI)	Retirement is not associated with vigorous physical activity.
Henkens et al. (2008) Longitudinal	Panel study of retirement in the Netherlands (2001-2007)	1,604 50-64 y (54.8 y) 25%	Multivariate: adjusted for gender, age, wealth, education and work environment in baseline.	**Increased leisure physical activity** Voluntarily: 2.90(2.19-3.84) Involuntarily: 2.14 (1.47-3.13) **Decreased physical activity** Voluntarily: 0.35 (0.22-0.56)	RR from logistic regression	People report more exercise after retirement, no matter retirement was perceived as voluntary or not.

				Involuntarily: 0.46 (0.23-0.92)		
Zheng (2008) Longitudinal	US Health and Retirement Study (1992-2004)	6,935 50-73 y 43.2%	Ages of Social Security (62y) and Medicare (65y) eligibility as IVs for retirement: adjusted for age, age^2, education, ethnicity, income, wealth, number of IADL/ADL limitations, self-rated health, ever being diagnosed cancer, diabetes, heart disease, hypertension, lung disease, and stroke.	**Participant in vigorous physical activity 3 or more times per week** Men: 0.146	Fixed effects IV coefficients	Retirement was not associated with vigorous physical activity.
Jurj et al. (2007) Cross-sectional	Baseline of Shanghai Women's Health Study in China (1997-2000)	74,942 40-70 y (52.1 y) 100%	Multivariate: adjusted for age, BMI, menopausal status, marital status, education, occupation, income, family size, chronic diseases.	**Sports/exercise** 1.87 (1.79, 1.95)* **Biking (not for transportation to work)** 3.21 (3.09, 3.34)*	OR for non-working women vs. working women (95%CI)	Being non-employed were associated with increased participation in exercise/sports and biking, and higher levels of housework.

				Housework: 2.97 (2.86, 3.09)*		
Slingerland et al. (2007) Longitudinal	GLOBE Study in the Netherlands (1991-2004)	971 40-65 y 30%	Multivariate: adjusted for sex, age, marital status, chronic diseases, and education	**Decline in work-related transport physical activity:** 3.03 (1.97, 4.65)*** **Decline in sports participation:** 0.66 (0.39, 1.10) **Decline in non-sports leisure-time physical activity:** 0.36 (0.19, 0.68)***	OR for retired people vs. working people (95%CI)	Retirement was associated with a significantly higher odds for a decline in physical activity from work-related transportation.
Berger et al. (2005) Longitudinal	West of Scotland Twenty-07 Study in the UK (1991-1995/1996)	699 60 y 54.5%	Multivariate: adjusted for gender, social class, car ownership, education, smoking, deprivation score, diet, and self-rated health.	**Meeting physical activity recommendations** (**through total life activity)** 2.72 (1.88, 3.97)*	OR for working people vs. retired people (95%CI)	Employed had higher odds of meeting physical activity recommendations with total physical activity compared to retired people.
Mein et al. (2005)	Whitehall II longitudinal	6,224 45-69 y	Multivariate: adjusted for age, marital status,	**Meeting physical activity**	OR for retired people vs.	Fully or partly retired people are more likely to

Longitudinal	study in the UK (phase 5)	27.7%	month of questionnaire completion, and employment grade.	**recommendations (through total life activity)** Partly retried (work < 30h/week) Men: 2.65 (1.89-3.71) * Women: 1.89 (1.07-3.34) Fully retired Men: 3.46 (2.78-4.30) * Women: 2.53 (1.85-3.46)*	working people (95%CI)	take the recommended amount of physical activity than working people, and this benefit is evident amongst those who retired from higher employment grades
				Men: 0.36 (0.19-0.69)* Women: 0.53 (0.29-0.97)*	OR according to employment grade, lowest vs. highest (95%CI)	
Fonseca et al. (2003) Cross-sectional	Individuals residing in their homes in the north of Portugal	100 (50 retired + 50 non-retired), 50-70 y (59.4 y) 50%	Not state	**Total physical activity** Coefficients are not state	Not state	No difference in total physical activity between retirees and employees.

Evenson et al. (2002) Longitudinal	US Atherosclerosis Risk in Communities Study cohort (baseline: 1986-1989, follow up until 1993-1995)	7,782 45-65 y 30%	Age, centre, education, and baseline perceived health status	**Sport plus leisure scores** African-American women Retired: 0.29 (0.17, 0.42)* Working: 0.15 (0.05, 0.25)* African-American men Retired: 0.43 (0.26, 0.60)* Working: 0.03 (−0.09, 0.15) White women Retired: 0.15 (0.07, 0.23)* Working: −0.05 (−0.11, 0.01) White men Retired: 0.20 (0.14, 0.26) Working: 0.00 (−0.05, 0.05)	Adjusted mean (95%CI)	Participants who retired during follow-up were more likely to increase their sport participation and television watching than those who continued to work.
Wells, 1999	Health Status of	363	Gender, age, physical	**Decrease Total**	OR for retired	Recently retired men were

Cross-sectional	Older People in Australia	≥65 y (69.9 y) 100%	activity at 5 years ago	**physical activity** Recently retired: 3.89* Long-term retired:1.65 Partly retired: 2.38	people vs. working people	more likely to report a decreased physical activity than employed men. This was not found in long-term retired people and partly retired people.
Wister (1996) Cross-sectional	Canadian Health Promotion Survey in 1990	5,333 >=45 y 55.5%	Education, income, gender, marriage, stress, activity restriction, occupational health promotion, and other smoker in house	**Taking vigorous leisure exercise** 45-64y: 1.73 *** ≥64y: 1.64 *	OR for retired people vs. working people	Retirees were more likely to participate in exercise.
Midanik et al. (1995) Longitudinal	Kaiser Permanente Retirement Study in the USA (1985-1987)	595 60-66 y 42.5%	Multivariate: adjusted for baseline mental health or health behaviour, age, gender, marital status, and education.	**Leisure regular exercise** 3.5 (2.0, 6.2)*** 2.2 (1.2, 4.0)**	RR for retired people vs. not retired people (95%CI)	Retired members were more likely to engage in regular exercise more often as compared to those who did not retire.
Patrick et al. (1986) Longitudinal	Volunteers from the steel industry and a light manufacturing	72 ≥60 y 52.7%	No adjustment	**Time spend on total physical activity** Pre-retirement: Men: 91 Women: 89	Mean (minutes/day), p-value from t-test	Retirement was associated with an increase in total physical activity in men and a decrease in women.

	industry in the UK			Post-retirement: Men:109* Women: 62*		

OR: odds ratio. *p<0.05; **p<0.01; ***p<0.001

Appendix 2.2.e Studies on retirement and smoking.

Author (year), and study type	**Data used**	**Sample size, age (mean), and % women**	**Type of analysis & covariates**	**Effects on outcome measure(s)**	**Effect type**	**Overview of findings**
Eibich (2015) Longitudinal	German Socio-Economic Panel Study (1984-2004)	More than 20,000 individuals 55-70 y (61.7 y) 51.8%	Regression Discontinuity Design using eligibility ages (60y and 65y) as exogenous variation in retirement: adjusted for age, gender, lived in East Germany in 1989, education, occupation physical and mental strain, and partner is retired.	**Probability of smoking:** -0.057*	Coefficients of Regression Discontinuity Design	Retirement decreases the probability of smoking.
Ayyagari (2014)	US Health and Retirement	11,576 60-80 y	Eligibility age of Social Security	**Probability of smoking:**	Marginal probability of	Retirement at age 62 significantly increases the

Longitudinal	Study (1992-2008)	(68.6 y) 46.4%	benefits (62y) as an IV for retirement: adjusted age, age^2, gender, race, education, wave, and census division.	0.225**	smoking from IV analysis	marginal probability of retirement by 4.6 percentage points.
Insler (2014) Longitudinal	US Health and Retirement Study (1992-2010)	6,276 ≥50 y (Workers: 59.4 y; Retirees: 66.4 y) Workers:43% Retirees:46%	Workers' self-reported probabilities of working past ages 62 and 65 as an IV for retirement, adjusted for age, age^2, gender, black, Hispanic, married, assets, debt, and education.	**Smoking** Long-term: -0.393* Short-term: -0.273	Coefficients of IV analysis	Retirement exerts a beneficial influence on quit smoking.
Shuaib et al. (2011) Cross-sectional	Alabama Black Belt in the US	1,387 >=19 y (50.8 y) 67.5%	Multivariate: adjusted for age, gender, race, marital status, and education.	**Risk of smoking** 1.49 (1.15-2.20)*	OR for retired or unable to work people vs. working people (95%CI)	Retirement was associated with increased risk of smoking.
Henkens (2008) Longitudinal	A panel study on retirement behavior in the	1,604 50-64 y (54.8 y)	Multivariate: adjusted for gender, age, wealth, education and	**Risk of decreased smoking** Involuntarily	RR for retired people vs. working people	Voluntary retirement was not associated with smoking status.

	Netherlands, carried out by the Netherlands Interdisciplinary Demographic Institute (2001-2007)	25%	work environment in baseline	0.50 (0.25, 0.99)* Voluntarily 0.95 (0.66,1.38) **Risk of increased smoking** Involuntarily 3.68 (1.45, 9.30)** Voluntarily 2.06 (0.74,5.79)	(95%CI)	The involuntarily retired had both higher risk of increased smoking and lower risk of decreased smoking.
Lang et al. (2007) Longitudinal	Health Survey for England 1998 - English Longitudinal Study of Ageing 2004	1,712 55-70y 55.4%	Multivariate: adjusted for age, gender, BMI, alcohol consumption, household wealth, longstanding limiting disabilities, and education.	**Risk of quitting smoking** 2.50 (1.35-4.62)* 2.33 (1.24-4.38)	OR for retired people vs. working people (95%CI) OR for retired people (retired for reasons of ill-health were excluded) vs. working people (95%CI)	Retired people were more likely to quit smoking as those who continued to work. Results were robust when those who retired for reasons of ill-health were excluded.
Wister (1996) Cross-sectional	Canadian Health Promotion	5,333 >=45 y 55.5%	Education, income, gender, marriage, stress, activity	**Risk of smoking** 45-64 y: 0.76 *	OR for retired people vs. working people	Retirees were less likely to be smokers.

	Survey in 1990		restriction, occupational health promotion, and other smoker in house			
Midanik et al. (1995) Longitudinal	Kaiser Permanente Retirement Study in the USA (1985-1987)	595 60-66 y 42.5%	Multivariate: adjusted for baseline mental health or health behaviour, age, gender, marital status, and education.	**Risk of smoking** Men: 0.6 (0.2,2.1) Women: 1.2 (0.3,4.9)	RR for retired people vs. not retired people (95%CI)	Retirement was not associated on smoking status.
Morris et al. (1992) Longitudinal	British Regional Heart Study (baseline: 1978-1980, follow up until 1983-1985)	6,057 40-59 y 0%	Adjusted for age, social class, and town of residence.	**Quit smoking** Retired (not due to illness): 31.4 Working: 26.2 **Drinkers reduce drinking:** Retired (not due to illness): 37.9 Working:34.9	% of people	No significant association between retirement and smoking.
Cox et al. (1987) Cross-sectional	A representative sample of the UK population	8,775 56.5%	Not stated	**Risk of smoking** Men: 0.80 (0.62-1.03) Women: 0.74 (0.58-0.96)*	OR for retired people vs. working people (95%CI)	Retirement was associated with decreased risk of smoking among women, but the effect on men did not reach a statistically

						significant level.

Appendix 2.2.f Studies on retirement and drinking.

Author (year), and study type	Data used	Sample size, age (mean), and % women	Type of analysis & covariates	Effects on outcome measure(s)	Effect type	Overview of findings
Eibich (2015) Longitudinal	German Socio-Economic Panel Study (1984-2004)	More than 20,000 individuals 55-70y (61.7) 51.8%	Regression Discontinuity Design using eligibility ages (60 and 65) as exogenous variation in retirement: adjusted for age, gender, lived in East Germany in 1989, education, occupation physical and mental strain, and partner is retired.	**Probability of drinking regularly:** 0.048 **Probability of no drinking:** -0.116* **Probability of having health conscious diet:** 0.056	Coefficients of Regression Discontinuity Design	Retirement decreases the probability of abstaining from alcohol. No significant impact of retirement on the probability of regular alcohol consumption or following health conscious diet was found.
Iparraguirre (2015) Longitudinal	English Longitudinal Study of Ageing (wave	9,251 50-89 y (66.6 y) 55.5%	Multivariate: adjusted for age, marriage, caring responsibilities, number of children	**From not at higher risk to higher risk drinker:** Men: OR=1.298	Coefficients of logistic regression (retired people vs. working	Being retired at baseline (wave 4) is not associated with the transition between not being at a

	4-5)		inside the household, economic activity, social detachment, and healthy diet.	(0.891, 1.890) Women: OR=1.131 (0.793, 1.614) **From higher risk drinker to not at higher risk:** Men: OR=1.017 (0.707, 1.465) Women: OR=1.28 (0.936, 1.750)	people) Transition among retired people, OR from Markov chain models (95%CI)	higher risk to becoming a higher risk drinker, and vice versa.
Tamers et al. (2014) Longitudinal	GAZEL cohort (employees of French national gas and electricity company, 1992 to 2008)	20,625 35-50 y 23.6%	Multivariate: adjusted for age, self-rated health, education and employment grade.	**Risk of heavy alcohol consumption** Men *Year -1 vs. -5:* 1.15 (1.08, 1.23)*** *Year +1 vs. -1:* 1.38 (1.32, 1.47)*** *Year 0:* 1.21 (1.15, 1.27)*** *Year +5 vs. +1:* 0.869 (0.83, 0.92)*** Women *Year -1 vs. -5:* 1.23 (0.99, 1.54)�	OR for before, during, after, and at the time of retirement	For men, heavy alcohol consumption increased in the years up to, surrounding retirement, and at the time of retirement, and then decreased after retirement. Women follow the similar pattern, but the increase of heavy alcohol consumption before retirement and the decrease after retirement did not reach a 0.5%

				Year +1 vs. -1: 1.34 (1.11, 1.62)** *Year 0:* 1.19 (1.01,1.40)* *Year +5 vs. +1:* 0.877 (0.72,1.07)		significance level.
Wang et al. (2014) Longitudinal	US Health and Retirement Study (seven waves 1995-2008)	4,674 >50 y 45.2%	Multivariate: adjusted for race/ethnicity, education, age, marital status, non-housing wealth, depressive symptoms score, number of medical conditions and alcohol consumption at baseline.	**Average weekly alcohol consumption** Among participants who reported alcohol use at follow-up Men: 1.14 (−0.10, 2.38) Women: −0.33 (−1.50, 0.85) Among participants who reported alcohol use at both baseline and follow-up Men: 1.90 (0.43, 3.36)* Women: −0.33 (−1.90, 1.25)	Coefficients of linear regressions	Retirement is associated with higher weekly alcohol consumption for men who reported drinking at both follow-up and the baseline (i.e. consistent drinkers). No association was observed among women.
Bobo et al.	US Health and	3,105	Multivariate: adjusted	**Infrequent/ non-**	OR for working	Retirement is not

(2013) Longitudinal	Retirement Study (1998-2008	50-65 y 0%	for baseline age, race, ethnicity, education, marital status, smoking, binge drinking, vigorous exercise, body mass index, depression, pain, self-reported health, and chronic disease.	**drinkers to follow an increasing consumption trajectory** 0.86 (0.53,1.40) **Regular drinkers at baseline to follow a decreasing trajectory** 1.18 (0.73,1.91) **Highest alcohol intake at baseline to follow a decreasing trajectory** 1.48 (0.83,2.64)	people vs. fully retired people (95%CI)	associated with of the trajectories of alcohol consumption among men.
Bobo et al. (2011) Longitudinal	US Health and Retirement Study (1998-2008)	4,439 50-65 y 100%	Multivariate: adjusted for baseline age, race, ethnicity, education, marital status, smoking, binge drinking, vigorous exercise, body mass index, depression, pain, self-reported	**Increasing drinkers vs. non/infrequent drinkers** 1.53 (0.97,2.40) **Decreasing drinkers vs. stable drinkers** 0.63 (0.41,0.98)*	OR for working people vs. fully retired people (95%CI)	Retired women were more likely to become decreasing drinkers.

			health, and chronic disease.			
Zins et al. (2011) Longitudinal	GAZEL cohort in France (1992 - 2007)	12,384 50-63 y 19%	Multivariate: adjusted for time window, birth cohort, SES category and the interaction 'year × SES category'.	**Prevalence of heavy drinking 1 year before to 1 year after retirement** Men: Increase by 1.3% to 3.1% according to occupations. Women: Increase by 3.3% to 6.6% **Prevalence of heavy drinking 1 to 5 years after retirement** Men: Decrease by 0.4% to 2.8% Women: Decrease by 0% to 2.4%	% of change	Retirement increase the risk of excessive alcohol consumption, temporarily (1 year before and after retirement) in most people and permanently in the small group of women managers
Brennan et al. (2010) Longitudinal	A 10-year longitudinal study of late-life drinking behaviour in	595 (62 y) 44%	Multivariate: adjusted for baseline age, gender, income, health, and problem drinker status	**Quantity of alcohol consumed** 0.29 **Frequency of alcohol consumption**	Slopes of trajectories	Retirement status cannot predict frequency or quantity of alcohol consumption.

	the USA			0.14		
Platt et al. (2010) Longitudinal	US Health and Retirement Study (1992-2006)	6,787 51-61 y 54.7%	baseline characteristics and changes in demographic characteristics, health, and social support that occurred during the observation period.	**Increasing drinker** 0.974 (0.636, 1.492) **Decreasing drinker** 0.990 (0.811, 1.208)	OR for retired people vs. not retried (95%CI)	Retirement was not associated with drinking behaviour.
Henkens (2008) Longitudinal	Netherlands (2001-2007)	1,604 50-64 y 25%	Multivariate: adjusted for gender, age, wealth, education and work environment in baseline	**Risk of decreased alcohol use** Involuntarily 0.47 (0.29,0.73)** Voluntarily 0.72 (0.51,1.01) **Risk of increased alcohol use** Involuntarily 0.48 (0.19, 1.20) Voluntarily 1.36 (0.80, 2.34)	RR from logistic analyses	Voluntary retirement was not associated with alcohol consumption status. The involuntarily retired had lower risk of decreased alcohol use.
Perreira and	US Health and	7,731	Multivariate: adjusted	**Increased drinking**	OR for retired	people who experienced

Sloan (2001) Longitudinal	Retirement Study	51-61 y 49.5%	for social support/coping skills, baseline socioeconomic characteristics: annual household income; years of education; race/ethnicity, religious affiliation, age, gender, and marital status	Retired: 1.6 (1.3, 2.1)** **Decreased drinking** Retired*problem drinking: 0.7 (0.5-1.0)*	people vs. working people (95%CI)	retirement in recent years were more likely to increase drinking, and people who had a history of problem drinking were less likely to decrease drinking if they had experienced retirement.
Bacharach et al. (2004) Longitudinal	A cohort of blue collar males in the USA (2000-2002)	307 43-70 y (57 y) 0%	Multivariate: adjusted for baseline age, marital status, and health status	**Drinking frequency** 0.003 **Drinking quantity** 0.03 **Problem drinking** 0.005 **Currently drinking** -0.24 **Periodic heavy drinking** 0.70*	Coefficients from logistic regression	Retirement generally heralds no great shift in alcohol consumption or drinking behaviours, but individuals opting to retire fully were twice as likely to engage in periodic heavy drinking as those continuing to work.
Gee et al. (2007)	National longitudinal	2,566 60- 96 y (68 y)	Multivariate: adjusted for age, gender,	**Declined trajectory** (drank the most at	RRR for not working people	Alcohol consumption dropped significantly with

Longitudinal	study of health and aging in Japan (1987-1999)	54.4%	education, cognitive impairment, social support, depression and demographics.	age 60, but exhibited the sharpest decline over age) 1.65** **Stable trajectory** 1.14 **Curvilinear trajectory** 1.20	vs. working people (95%CI)	not working people
Rodriguez & Chandra (2006) Longitudinal	National Survey of Families and Households in the USA (1987/88 - 1991/92)	7,599 ≥16 y 60%	Multivariate: adjusted for age, race/ ethnicity, marital status and partnership stability, years of education, total household income, total assets value, number of children in the household, satisfaction with relationships with friends and family, having a mental or physical condition, weeks	**≥ 5 drinks at one time vs. no drinking** Men: 0.57 (0.33, 0.96)* Women: 1.74 (0.88, 3.29) **< 5 drinks at one time vs. no drinking** Men: 1.30 (0.91, 1.85) Women: 1.15 (0.85, 1.55) **≥5 at one time vs. drinking less** Men:	OR for retired people vs. full time working people (95%CI)	Retired men were more likely to drink less, but not retired women.

			unemployed and looking for work in 1991, having alcohol problems in 1987, unemployment rates in 1992, and type of residence area	0.40 (0.23, 0.71)* Women: 1.37 (0.69, 2.69) **≥30 drinks in past 30 days vs. drinking < 30 drinks** Men: 0.58 (0.35, 0.93)* Women: 1.55 (0.98, 2.45)		
Neve et al. (2000) Longitudinal	Participants of the Dutch province of Limburg	1,980 16-64 y	Age, gender, education	**Average Alcohol Consumption** Men:-2.9 Women:+0.05 **Drinking Problems** Men: -0.3 Women: -0.1	Change of % people	Retirement was associated with a decrease in alcohol consumption and alcohol-related problems.
Midanik et al. (1995) Longitudinal	Kaiser Permanente Retirement Study in the USA (1985-1987)	595 60-66 y 42.5%	Multivariate: adjusted for baseline mental health or health behaviour, age, gender, marital status, and education.	**Heavy drinking** 1.0 (0.5, 2.2) 0.8 (0.3, 2.3) **No alcohol problems** 1.0 (0.5, 2.0)	RR for retired people vs. not retired people (95%CI)	Retired women were more likely to report no alcohol problems as compared to non-retired women. There were no differences between the groups on

				2.8 (1.0, 8.0)* **Frequency of drunkenness** 0.6 (0.3,1.2) 0.7 (0.2,2.2)		alcohol consumption, and frequency of drunkenness.
Morris et al. (1992) Longitudinal	British Regional Heart Study (baseline: 1978-1980, follow up until 1983-1985)	6,057 40-59 y 0%	Multivariate: adjusted for age, social class, and town of residence.	**Drinkers reduce drinking:** Retired (not due to illness): 37.9 Working: 34.9	% of people	No significant association between retirement and decreased drinking.
Ekerdt et al. (1989) Longitudinal	Veterans Administration Normative Aging Study (1981-1983)	416 0%	Multivariate: adjusted for baseline age, marital status, occupational prestige and follow-up reports of decreased drinking due to health,	**Onset of periodic heavier drinking** Working: 3.2 Retired: 8.5* **Onset of problems with drinking** Working: 2.8 Retired: 9.0*	% change from T1 to T2.	Retirement generally heralds no great shift in alcohol consumption or drinking behaviors. However, retirees were more likely to report the onset of periodic heavier drinking and problems with drinking.
Glynn et al. (1988)	Normative Aging Study in	1,556 39-92 y (60.1y)	Multivariate: adjusted for age, type A score,	**Non-drinking** 0.0107	Coefficient from logistic regression	Retirement was not related alcohol

Longitudinal	the USA (1982-1984)	0%	social status, marital status	**Drinking 3 or more drinks per day** 0.324 **Problems with drinking** 0.186 **Periodic heavier drinking** 0.078	consumption or drinking behaviour.

Appendix 2.2.g Studies on retirement and diet.

Author (year), and study type	Data used	Sample size, age (mean), and % women	Type of analysis & covariates	Effects on outcome measure(s)	Effect type	Overview of findings
Teufel-Shone et al. (2014) Cross-sectional	Participants in the Special Diabetes Program for American Indians Diabetes Prevention Demonstration Project (2004)	3,135 ≥18y 74.3%	Multivariate: adjusted for age, gender, education, marriage, household income, and urban/rural area.	**Healthy food score** Retired: 0.171** Working: −0.079 **Unhealthy food score** Retired: −0.212*** Working: 0.032	Coefficients of linear regressions	Retired people were more likely to consume healthy foods and less likely to consume unhealthy foods.
Irz et al. (2014) Cross-sectional	Expenditure and Food Survey in the UK (2006 and 2007), Household Budget Survey in Finland (1998 and 2006), and Multi-purpose Survey on Daily	UK: 4,749 Finland: 2,994 Italy: 7,564 ≥50y	Multivariate: adjusted for total expenditure, food share of expenditure, gender, education, age, interview year, and quarter.	**Diet quality index** *UK* Self-employed: 0.252 Manager: 2.641** Employee: -0.890 *Italy* Self-employed: -0.000 Manager: -0.029*	Coefficients of linear regressions	In the UK, active managers adopt relatively healthier diets than pensioners, but there is no statistically significant difference in diet quality between pensioners and the other socio-professional categories. In Italy, managers are found to choose diets of relatively poorer quality than

	Life in Italy (2009).			Employee: -0.013* *Finland* Entrepreneur: 0.773 White collar: 1.164 Blue collar: -1.110 Other: -0.380		pensioners. For Finland, no association between employment status and diet quality was found.
Helldan et al. (2012) Longitudinal	Helsinki Health Study cohort in Finland (baseline: 2000-02, follow-up until 2007.	2,428 55-60 y 77%	Baseline food habits, marital status, occupational class, household income, limiting long-standing illness, BMI, physical activity, smoking	**Healthy food habits** Men: 1.11 (0.73,1.70) Women: 1.32 (1.08,1.62)	OR for retired people vs. working people (95%CI)	Transition to old age retirement led to healthier food habits among women. For men, similar trends could not be confirmed.
Fisberg et al. (2006) Cross-sectional	Adults living in regions of the State of São Paulo in Brazil.	3,454 ≥20 y	Not stated	**Healthy Eating Index** Not stated	Not stated	Retired people ate more healthily than other population groups
Lauque et al. (1998) Longitudinal	A two-year prospective study on diet in France	In French	In French	In French	In French	The amount of dietary nutrients consumed remained the same before and after retirement.
Steen et al. (1988)	Employed women in	116 62-64 y	No full text	**Dietary habits**	No full text	People were more likely to have unhealthy dietary

Longitudinal	Malmö in Sweden	100%				habit after retirement, such as increased consumption of pastry, potato chips and similar food items.
Davies et al. (1986) Longitudinal	A 4-year longitudinal nutritional survey in the UK	89	No full text	**Dietary fibre intakes** Pre-retirement: 17.6 Post-retirement: 18.4	Mean of intake (g/day)	There was little change in these percentages of reaching the NACNE recommendation after retirement from work.

Appendix 3.1 Missing data

Sources and patterns of missing data

Unit non-response occurs when the entire data of one subject was not collected, due to subjects refusing to take part in the survey, or not being at home during the home visit, etc. If subjects do not respond to certain questions in the questionnaire, then item non-response occurs. It usually happens when the study collects a large number of characteristics for each individual. In longitudinal studies, subjects may be present for some waves of data collection and missing for others. This situation is often referred in the literature as wave non-response. Attrition is the most common type of wave non-response, and occurs when subjects leave the study and do not return. The terms 'attrition', 'drop-out', 'loss to follow-up' and 'withdrawal' are used interchangeably in the literature to refer to this form of missingness. Sometimes participants may be absent from one wave and reappear subsequently. Data sets can be arranged in matrix form, thus forming three main patterns of missing data: univariate, monotone, and arbitrary (Schafer and Graham, 2002; Dong and Peng, 2013).

A data set is said to have a univariate pattern if for some items we have full observations, and for some other items we have missing values (completely or partly missing). Monotone missing pattern occurs when variables are ordered such that if variable j is missing, then items $j+1, \dots, k$ are also missing. Monotone missing may arise in longitudinal studies with attrition, so if an item is missing in some wave, it continuous to be missing in the next waves. In arbitrary pattern, any set of variables may be missing for any participant.

Maximum likelihood method vs. multiple imputation (MI)

In a complete-data analysis, maximum likelihood estimation repeats different combinations of population parameter values until it identifies the set of values that maximizes the log-likelihood value (i.e., the best fit of the data). Conceptually, the maximum likelihood estimation process in missing data is the same as that used in complete data (Enders, 2010). Maximum likelihood method integrates the missing data into the estimation, and it temporarily imputes missing values during the estimation process and discards the imputations once the estimation is finished (Enders, 2013). So this method is also referred to as full information maximum likelihood. The parameter values that produce the highest sample log-likelihood will be found in the estimation. MI and maximum likelihood estimation are more popular in the literature. These methods are superior, because they yield accurate estimates under an MCAR or an MAR mechanism and can use information from incomplete cases (Enders, 2013). MI requires many more decisions than maximum likelihood methods, such as the number of data sets to produce, how many iterations between data sets, what prior distribution to use (Enders, 2010). Maximum likelihood method is ideal for analyses with incomplete outcome variables, but it is less flexible when the independent variables are incomplete (Enders, 2013). However, there is literature points out that, although these two methods require different procedural steps, they tend to yield similar results (Collins et al., 2001).

Steps in multiple imputation by chained equations (MICE)

There are three steps in MICE: 1) replace missing data by plausible values from random draws of posterior predictive distribution of missing data conditional on observed data. This procedure repeats *m* times to generate *m* imputed data sets; 2) analyze each of the *m* imputed data sets separately by standard complete-data methods; and 3) combine the separate *m* estimates of the parameter of interest into an overall estimate together with variances and confidence intervals (Sterne et al., 2009; White et al., 2011). The procedure of MICE was summarised in Figure A3.1.

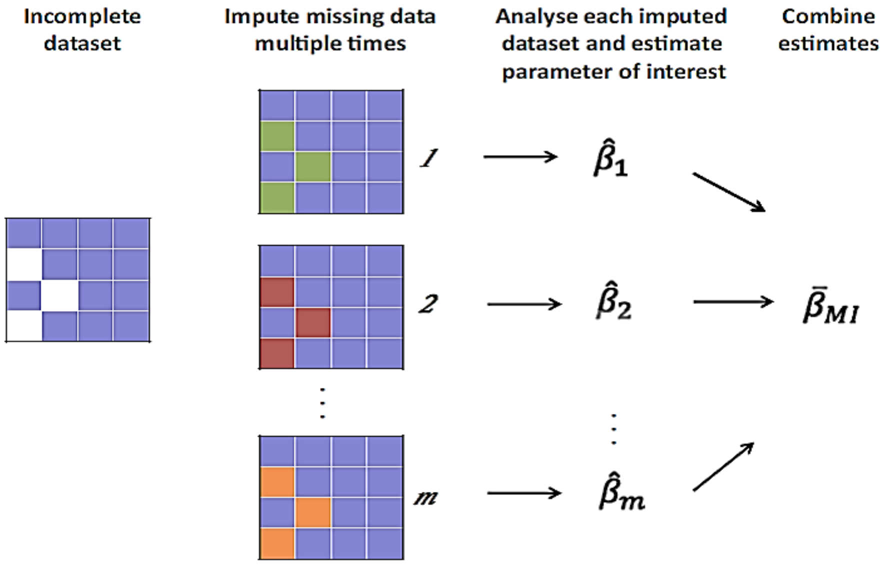

Figure A3. 1 Procedures of MI in handling missing data (adopted from Lee and Simpson, 2014).

In the first step, variables with missing values were ordered from those with the least missing values to those with the most (x_1, x_2,....x_k). The first variable with at least one missing value (x_1) is regressed on all other variables (x_2,....x_k), restricted to individuals with the observed x_1. Missing values in x_1 are replaced by simulated draws from the corresponding posterior predictive distribution of x_1. Then, the next variable with missing values (x_2) is regressed on all other variables (x_1, x_3,....x_k). The estimation is restricted to individuals with the observed x_2, and uses the imputed values of x_1. Again, missing values in x_2 are replaced by draws from the posterior predictive distribution of x_2. This process carries on until all the variables with missing values are imputed, and it is called a cycle (or an iteration).

In order to stabilise the results, the imputation procedure is usually repeated for several cycles to produce one imputed data set. A low number of cycles, say 10 to 20, is often sufficient (White et al., 2011). The whole procedure is then repeated m times to produce m imputed data. The number of imputations (m) should be large enough so as not to impact the conclusions or inhibit analysis reproducibility. Once the *m* imputations have been generated, each imputed data set is analysed separately. This is the second step of MI. Complete-data methods were performed in this step. Regression coefficients were estimated from each imputed data set, together with their variance-covariance matrices.

The results of these *m* analyses differ because the missing values have been replaced by different imputations (White et al., 2011).

In the final MI step, the *m* estimates are combined into an overall estimate and variance-covariance matrix using Rubin's rules. Rubin's rules are based on asymptotic theory in a Bayesian framework. The combined variance-covariance matrix incorporates both within-imputation variability (uncertainty about the results from one imputed data set) and between-imputation variability (reflecting the uncertainty due to the missing information). Equations of Rubin's rules are shown below. Where, $\hat{\theta}$ denotes the combined estimate of the parameters; $\hat{\theta}_j$ denotes the estimate in j^{th} imputed data set; W_j denotes the variance of $\hat{\theta}_j$; **W** denotes within-imputation variance; **B** denotes between-imputation variance (Rubin, 1987).

$$\hat{\theta} = \frac{1}{m}\sum_{j=1}^{m}\hat{\theta}_j$$

$$\mathrm{var}(\hat{\theta}) = \mathbf{W} + (1 + \frac{1}{m})\mathbf{B}$$

$$\mathbf{W} = \frac{1}{m}\sum_{j=1}^{m}W_j$$

$$\mathbf{B} = \frac{1}{m-1}\sum_{j=1}^{m}(\hat{\theta}_j + \hat{\theta})^2$$

Appendix 3.2.a Mutually adjusted model for factors related to heart disease and stroke.

Characteristics	CHARLS (*n*=12,706)				ELSA (*n*=8,243)			
	OR of heart disease (95% CI)	***P***	**OR of stroke (95% CI)**	***P***	**OR of heart disease (95% CI)**	***P***	**OR of stroke (95% CI)**	***P***
Age	1.317(1.171,1.481)	<0.001	3.221(2.312,4.487)	<0.001	1.184(1.078,1.301)	<0.001	1.341(1.062,1.693)	0.014
Age^2	0.998(0.997,0.999)	<0.001	1.256(1.041,1.516)	0.017	0.999(0.999,1.000)	0.025	0.999(0.997,1.000)	0.069
Income (log)	1.001(0.980,1.022)	0.953	1.014(0.970,1.060)	0.531	0.977(0.915,1.042)	0.477	0.957(0.883,1.036)	0.276
Wealth (log)	1.006(0.985,1.027)	0.576	1.043(1.000,1.088)	0.051	0.981(0.965,0.997)	0.023	0.972(0.947,0.997)	0.026
CESD score	1.072(1.060,1.086)	<0.001	1.090(1.066,1.115)	<0.001	1.108(1.072,1.146)	<0.001	1.157(1.090,1.228)	<0.001
Women (vs. men)	1.513(1.216,1.884)	<0.001	0.631(0.443,0.898)	0.011	0.898(0.788,1.023)	0.106	0.737(0.575,0.943)	0.015
Rural (vs. urban)	0.784(0.664,0.925)	0.004	0.765(0.541,1.082)	0.131	1.081(0.882,1.325)	0.452	0.972(0.678,1.393)	0.877
Spouse status:								
Working	Reference		Reference		Reference		Reference	
Not working	1.341(1.092, 1.648)	0.005	1.319(0.97, 1.86)	0.113	1.047(0.866,1.265)	0.636	1.224(0.798,1.878)	0.354
No spouse	1.180(0.922, 1.509)	0.188	1.175(0.83, 1.94)	0.472	0.959(0.769,1.198)	0.715	0.905(0.528,1.552)	0.717
Education level:								
Low	Reference		Reference		Reference		Reference	
Middle	1.555 (1.263, 1.914)	<0.001	1.090(0.727,1.635)	0.676	1.086(0.928,1.271)	0.301	0.829(0.621,1.108)	0.205
High	1.659 (1.318, 2.087)	<0.001	1.158(0.790,1.696)	0.451	1.253(1.061,1.480)	0.008	0.829(0.603,1.139)	0.247
ISCO skill level:								

1 (lowest)	Reference		Reference		Reference		Reference	
2	1.290(1.024,1.624)	0.030	1.335(0.892,1.998)	0.160	0.977(0.804,1.187)	0.814	0.942(0.675,1.313)	0.723
3	1.250 (0.743,2.103)	0.401	1.470(0.892,1.998)	0.470	1.122(0.864,1.459)	0.388	0.990(0.606,1.619)	0.969
4 (highest)	1.707(1.183, 2.462)	0.004	0.594(0.316,1.118)	0.106	0.996(0.796,1.245)	0.969	1.110(0.744,1.656)	0.609
Smoking status:								
Never smoker	Reference		Reference		Reference		Reference	
Ex-smoker	1.722(1.312, 2.260)	<0.001	1.692(1.112,2.575)	0.014	1.171(1.023,1.339)	0.022	1.255(0.955,1.651)	0.103
Light/moderate smoker	1.484(1.079, 2.040)	0.015	0.940(0.548,1.611)	0.821	0.890(0.666,1.189)	0.430	1.878(1.164,3.028)	0.010
Heavy smoker	1.020(0.722, 1.442)	0.910	0.642(0.365,1.131)	0.125	0.921(0.569,1.491)	0.737	1.798(0.888,3.641)	0.103
Drinking frequency:								
Non-drinkers	Reference		Reference		Reference		Reference	
< Everyday	0.842(0.653,1.087)	0.187	0.691(0.428,1.116)	0.130	0.974(0.838,1.133)	0.732	0.831(0.605,1.141)	0.252
≥ Every day	0.495(0.374, 0.654)	<0.001	0.685(0.408,1.149)	0.151	1.058(0.839,1.333)	0.635	0.847(0.534,1.344)	0.481

Appendix 3.2.b Mutually adjusted model for factors related to adiposity measures.

Characteristics	CHARLS (*n*=12,706)				ELSA (*n*=8,243)			
	β of BMI (95% CI)	***P***	**β of WC (95% CI)**	***P***	**β of BMI (95% CI)**	**P**	**β of WC (95% CI)**	**P**
Age	0.110 (-0.048,0.268)	0.171	0.361 (-0.072,0.794)	0.102	0.403 (0.213,0.594)	<0.001	1.126 (0.641, 1.610)	<0.001
Age^2	-0.001 (-0.0026,-0.0002)	0.025	-0.003 (-0.0062,0.0005)	0.090	-0.003 (-0.005,-0.002)	<0.001	-0.008 (-0.012,-0.005)	<0.001
Income (log)	0.005 (-0.021,0.031)	0.707	0.001 (-0.080,0.082)	0.979	0.052 (-0.084,0.189)	0.450	0.157 (-0.179,0.494)	0.358
Wealth (log)	-0.012 (-0.054, 0.031)	0.589	0.014 (-0.097,0.125)	0.807	-0.090 (-0.136,-0.043)	<0.001	-0.211 (-0.321,-0.102)	<0.001
CESD score	-0.046 (-0.063,-0.030)	<0.001	-0.116 (-0.163,-0.069)	<0.001	0.188 (0.097,0.278)	<0.001	0.604 (0.384,0.825)	<0.001
Women (vs. men)	0.926 (0.644,1.209)	<0.001	1.510 (0.728, 2.293)	<0.001	-0.235(-0.536,0.067)	0.127	-10.751 (-11.502,-9.992)	<0.001
Rural (vs. urban)	-1.035 (-1.334,-0.737)	<0.001	-3.069 (-3.818,-2.320)	<0.001	-0.135 (-0.573,0.304)	0.545	0.015 (-1.103,1.133)	0.979
Spouse status:								
Working	Reference		Reference		Reference		Reference	
Not working	0.488 (0.199,0.779)	0.001	1.490 (0.692,2.289)	<0.001	0.345 (-0.059,0.749)	0.094	0.811 (-0.171,1.793)	0.105
No spouse	-0.368 (-0.672,-0.063)	0.018	-0.589 (-1.449,0.270)	0.179	-0.350 (-0.824,0.125)	0.149	-0.847 (-2.043,0.349)	0.165

Education level:								
Low	Reference		Reference		Reference		Reference	
Middle	0.399 (0.112,0.686)	0.006	0.864 (0.149,1.580)	0.018	-0.468 (-0.845,-0.090)	0.015	-0.954 (-1.892,-0.017)	0.046
High	0.347 (0.030,0.663)	0.032	0.869 (0.008,1.731)	0.048	-1.063 (-1.440,-0.686)	<0.001	-2.774 (-3.712,-1.836)	<0.001
ISCO skill level:								
1 (lowest)	Reference		Reference		Reference		Reference	
2	0.369 (0.045, 0.692)	0.026	1.352 (0.447,2.258)	0.004	-0.156 (-0.674,0.362)	0.555	-0.400 (-1.615,0.815)	0.519
3	0.521 (-0.372,1.413)	0.252	0.774 (-1.565,3.114)	0.515	-0.214 (-0.878,0.451)	0.528	-0.596 (-2.225,1.034)	0.473
4 (highest)	0.843 (0.324, 1.362)	0.002	1.914 (0.317,3.501)	0.018	-0.219 (-0.784,0.347)	0.448	-0.405 (-1.782,0.971)	0.564
Smoking status:								
Never smoker	Reference		Reference		Reference		Reference	
Ex-smoker	0.520 (0.11, 0.86)	0.009	1.699 (0.736, 2.663)	0.001	0.464 (0.135,0.792)	0.006	1.820 (1.026,2.614)	<0.001
Light/moderate	-0.660 (-1.021, -0.300)	<0.001	-1.546 (-2.660, -0.432)	0.007	-1.998 (-2.640,-1.356)	<0.001	-3.081 (-4.692,-1.470)	<0.001
Heavy smoker	-0.831 (-1.177, -0.484)	<0.001	-1.228 (-2.152, -0.304)	0.009	-1.330 (-2.345,-0.315)	0.010	-0.121 (-2.739,2.497)	0.928
Drinking frequency:								
Non-drinkers	Reference		Reference		Reference		Reference	
< Everyday	0.166	0.309	0.269	0.529	-0.883	<0.001	-2.101	<0.001

	(-0.153, 0.485)		(-0.570, 1.107)		(-1.234,-0.532)		(-2.973,-1.228)	
≥ Every day	-0.175 (-0.490, 0.139)	0.273	0.087 (-0.852, 1.027)	0.855	-1.595 (-2.137,-1.052)	<0.001	-2.851 (-4.267,-1.436)	<0.001

Appendix 3.2.c Adjusted model for factors related to blood pressure measures.

Characteristics	CHARLS (n=12,706)				ELSA (*n*=8,243)			
	β of SBP (95% CI)	***P***	**β of DBP (95% CI)**	***P***	**β of SBP (95% CI)**	***P***	**β of DBP (95% CI)**	***P***
Age	0.049 (-0.876,0.975)	0.917	-0.120 (-0.634,0.394)	0.646	1.146 (0.533,1.758)	<0.001	0.447 (0.064, 0.830)	0.022
Age^2	0.003 (-0.004,0.010)	0.406	-0.0004 (-0.004,0.003)	0.823	-0.007 (-0.011,-0.002)	0.003	-0.006 (-0.009,-0.003)	<0.001
Household income (log)	-0.106 (-0.281,0.070)	0.236	-0.003 (-0.102,0.095)	0.947	0.150 (-0.244,0.544)	0.455	0.305 (0.037,0.572)	0.026
Household wealth (log)	-0.135 (-0.408,0.136)	0.325	-0.135 (-0.321,0.051)	0.154	-0.004 (-0.124,0.116)	0.948	0.049 (-0.028,0.126)	0.215
CESD score	-0.188 (-0.303,-0.074)	0.001	-0.086 (-0.153,-0.020)	0.011	-0.068 (-0.351,0.216)	0.639	-0.038 (-0.205,0.130)	0.66
Women (vs. men)	2.147 (0.295, 3.998)	0.023	-0.384 (-1.453,0.686)	0.481	-2.292 (-3.291,-1.292)	<0.001	-1.442 (-2.052,-0.831)	<0.001
Rural (vs. urban)	-2.861	0.001	-2.020	<0.001	0.209	0.770	0.347	0.440

	(-4.514,-1.208)		(-3.097,-0.942)		(-1.196,1.615)		(-0.536,1.229)	
Spouse status:								
Working	Reference		Reference		Reference		Reference	
Not working	1.463	0.123	0.327	0.552	-0.975	0.136	-0.591	0.168
	(-0.400,3.325)		(-0.751,1.404)		(-2.258,0.308)		(-1.432,0.250)	
No spouse	4.190	<0.001	2.058	<0.001	-0.648	0.408	0.552	0.261
	(2.204,6.175)		(0.963,3.152)		(-2.185,0.888)		(-0.411,1.514)	
Education level:								
Low	Reference		Reference		Reference		Reference	
Middle	0.978	0.250	1.341	0.013	-1.102	0.066	-0.450	0.215
	(-0.688,2.645)		(0.280, 2.402)		(-2.277,0.072)		(-1.164,0.262)	
High	-0.162	0.851	1.041	0.047	-1.452	0.025	-0.354	0.357
	(-1.862,1.536)		(0.015,2.067)		(-2.721,-0.183)		(-1.109,0.400)	
ISCO skill level:								
1 (lowest)	Reference		Reference		Reference		Reference	
2	-1.593	0.079	-1.457	0.008	0.318	0.701	1.262	0.013
	(-3.373,0.188)		(-2.531,-0.383)		(-1.308,1.944)		(0.269,2.255)	
3	-1.508	0.586	-0.145	0.929	0.294	0.784	0.964	0.138
	(-6.956,3.940)		(-3.324,3.035)		(-1.813,2.402)		(-0.311,2.238)	
4 (highest)	-0.773	0.674	-0.552	0.571	-0.093	0.920	0.915	0.096
	(-4.384,2.838)		(-2.435,1.362)		(-1.910,1.724)		(-0.163,1.992)	
Smoking status:								
Never smoker	Reference		Reference		Reference		Reference	
Ex-smoker	1.165	0.354	0.902	0.286	0.985	0.051	0.410	0.175
	(-1.300,3.630)		(-0.757,2.561)		(-0.006,1.976)		(-0.183,1.003)	

Light/moderate smoker	0.946 (-1.358, 3.250)	0.420	0.603 (-0.768,1.974)	0.388	-0.215 (-2.307,1.876)	0.840	-0.138 (-1.324,1.047)	0.819
Heavy smoker	0.048 (-2.163, 2.259)	0.966	-0.744 (-2.078, 0.590)	0.273	2.684 (-1.198,6.566)	0.175	0.418 (-1.992,2.828)	0.734
Drinking frequency:								
Non-drinkers	Reference		Reference		Reference		Reference	
Less than everyday	0.387 (-1.500,2.275)	0.687	0.461 (-0.853,1.775)	0.491	-0.136 (-1.265,0.993)	0.813	0.281 (-0.434,0.997)	0.440
Every day or more	2.049 (0.223 3.874)	0.028	1.623 (0.440, 2.805)	0.007	1.828 (0.121,3.534)	0.036	1.179 (0.102,2.255)	0.032

Appendix 3.2.d Adjusted model for factors related to blood biomarkers.

Characteristics	**CHARLS (*n*=8,714)**				**ELSA (*n*=5,628)**			
	β of CRP (95% CI)	***P***	**β of HbA1c (95% CI)**	***P***	**β of CRP (95% CI)**	***P***	**β of HbA1c (95% CI)**	***P***
Age	0.001 (-0.049,0.051)	0.969	0.012(0.002,0.022)	0.014	0.022 (-0.024,0.069)	0.343	0.012 (0.007,0.017)	<0.001
Age^2	0.0001 (-0.0003,0.0004)	0.765	-0.0001 (-0.00017,-0.00002)	0.016	-0.0001 (-0.0004,0.0003)	0.638	-0.0001 (-0.0001,-0.00003)	<0.001
Household income (log)	-0.001 (-0.009, 0.007)	0.777	-0.0005 (-0.0002,0.0009)	0.456	-0.022 (-0.048,0.003)	0.080	0.001 (-0.003, 0.005)	0.718
Household wealth (log)	0.003 (-0.005, 0.010)	0.477	0.0010 (-0.0004,0.0024)	0.171	-0.007 (-0.017,0.002)	0.128	0.0001 (-0.001, 0.002)	0.609

CESD score	0.000 (-0.005, 0.005)	0.992	0.0005 (-0.0004,0.0015)	0.253	0.034 (0.014, 0.054)	0.001	0.003 (0.000, 0.005)	0.045
Women (vs. men)	-0.018 (-0.109, 0.073)	0.693	0.0021 (-0.0132,0.0174)	0.790	0.034 (-0.037,0.106)	0.349	0.003 (-0.005, 0.012)	0.440
Rural (vs. urban)	-0.169 (-0.234, -0.103)	<0.001	-0.0089 (-0.0212,0.0033)	0.153	-0.071 (-0.169,0.027)	0.155	0.001 (-0.010, 0.013)	0.823
Spouse status:								
Working	Reference		Reference		Reference		Reference	
Not working	0.082 (0.002, 0.162)	0.044	0.0079 (-0.0059,0.2173)	0.262	0.0002 (-0.090,0.090)	0.996	-0.001 (-0.012, 0.010)	0.923
No spouse	0.060 (-0.030, 0.150)	0.191	-0.0114 (-0.0279,0.0051)	0.175	-0.018 (-0.128, 0.092)	0.746	-0.013 (-0.025 , 0.000)	0.046
Education:								
Low	Reference		Reference		Reference		Reference	
Middle	-0.008 (-0.089, 0.073)	0.848	-0.0022 (-0.0165,0.0120)	0.759	-0.099 (-0.183,-0.014)	0.022	-0.004 (-0.014, 0.006)	0.422
High	-0.012 (-0.092, 0.068)	0.771	-0.0041 (-0.019,0.0109)	0.595	-0.163 (-0.250,-0.076)	<0.001	-0.003 (-0.014 , 0.007)	0.522
ISCO skill level:								
1 (lowest)	Reference		Reference		Reference		Reference	
2	-0.086 (-0.172,0.0002)	0.051	-0.0001 (-0.0152,0.0151)	0.994	0.001 (-0.110,0.113)	0.982	0.004 (-0.010, 0.018)	0.601
3	0.017 (-0.202, 0.237)	0.877	-0.0042 (-0.0673, 0.0590)	0.896	-0.098 (-0.241, 0.045)	0.180	-0.007 (-0.024, 0.010)	0.433

4 (highest)	-0.110 (-0.256, 0.037)	0.141	0.0084 (-0.0150,0.0317)	0.483	-0.088 (-0.214, 0.037)	0.169	-0.006 (-0.021, 0.009)	0.410
Smoking status:								
Never smoker	Reference		Reference		Reference		Reference	
Ex-smoker	0.160 (0.037, 0.282)	0.011	-0.0003 (-0.0210,0.0204)	0.977	0.078 (0.008, 0.148)	0.029	0.005 (-0.004, 0.013)	0.251
Light/moderate smoker	0.060 (-0.065, 0.185)	0.349	-0.0053 (-0.0266, 0.0149)	0.606	0.226 (0.049, 0.403)	0.012	0.015 (-0.006, 0.036)	0.172
Heavy smoker	0.204 (0.093, 0.316)	<0.001	-0.0001 (-0.0184,0.0183)	0.944	0.236 (-0.003, 0.475)	0.053	0.042 (0.011, 0.074)	0.008
Drinking frequency:								
Non-drinkers	Reference		Reference		Reference		Reference	
< Everyday	-0.042 (-0.136, 0.052)	0.379	-0.0231 (-0.0388, -0.0074)	0.004	-0.143 (-0.225,-0.061)	0.001	-0.024 (-0.034, -0.014)	<0.001
≥ Every day	-0.129 (-0.251, -0.008)	0.037	-0.0541 (-0.0711,-0.0371)	<0.001	-0.168 (-0.298,-0.038)	0.011	-0.038 (-0.053, -0.023)	<0.001

Appendix 3.2.e Adjusted model for factors related to blood total cholesterol.

Characteristics	CHARLS (n=8,714)		ELSA (5628)	
	β of total cholesterol (95% CI)	***P***	**β of total cholesterol (95% CI)**	***P***
Age	-0.186 (-0.344, -0.029)	0.021	1.039 (-0.784,2.861)	0.264
Age^2	-0.006 (-0.020, 0.006)	0.295	-0.014 (-0.027,-0.001)	0.033
Household income (log)	0.081 (-0.212, 0.374)	0.588	0.007 (-0.023, 0.037)	0.666
Household wealth (log)	-0.066 (-0.391, 0.260)	0.691	0.009 (0.000, 0.018)	0.055
CESD score	-0.071 (-0.261, 0.118)	0.461	0.009 (-0.014, 0.032)	0.445
Women (vs. men)	16.828 (13.749,19.907)	<0.001	0.511 (0.439, 0.583)	<0.001
Rural (vs. urban)	1.303 (-1.047, 3.654)	0.277	0.085 (-0.024, 0.194)	0.126
Spouse status:				
Working	Reference		Reference	
Not working	0.400 (-2.626, 3.426)	0.796	0.010 (-0.082, 0.102)	0.831
No spouse	-0.996 (-4.334, 2.343)	0.559	0.006 (-0.101, 0.113)	0.909
Education level:				
Low	Reference		Reference	
Middle	2.488 (-0.417, 5.394)	0.093	-0.026 (-0.109, 0.058)	0.546
High	1.402 (-1.647, 4.451)	0.367	0.052 (-0.037, 0.142)	0.252
ISCO skill level:				
1 (lowest)	Reference		Reference	
2	-3.497 (-6.935, -0.059)	0.046	0.060 (-0.051, 0.170)	0.291
3	-1.155 (-13.587, 11.277)	0.855	0.067 (-0.080, 0.214)	0.371
4 (highest)	0.235 (-5.073, 5.544)	0.931	0.088 (-0.037, 0.213)	0.169
Smoking status:				
Never smoker	Reference		Reference	
Ex-smoker	4.254 (0.469, 8.040)	0.028	0.019 (-0.052, 0.090)	0.605
Light/moderate smoker	1.031 (-2.698, 4.759)	0.588	0.053 (-0.110, 0.217)	0.522
Heavy smoker	1.351	0.474	0.241	0.064

	(-2.353, 5.055)		(-0.014, 0.496)	
Drinking frequency:				
Non-drinkers	Reference		Reference	
< Everyday	0.849	0.581	0.093	0.029
	(-2.162, 3.859)		(0.009, 0.176)	
≥ Every day	7.885	<0.001	0.176	0.010
	(4.608, 11.162)		(0.041, 0.311)	

Appendix 3.3 Sensitivity analyses

<u>Sensitivity analysis without adjusting medication/ treatment</u>

In the main analysis, whether currently taking medication/treatment was adjusted when modelling blood pressure, blood total cholesterol and HbA1c. This sensitivity analysis provides the results of the association between retirement and health outcomes without adjusting medication/treatment.

Appendix 3.3.a shows the results for SBP and DBP in both datasets. For ease of comparison, results from the main analysis were repeated in this table as well. Sensitivity analysis did not change the original conclusion in the main analysis. Nevertheless, some coefficients were changed. The coefficient of HbA1c in CHARLS changed from 0.0001 in the main analysis to 0.012 in the sensitivity analysis, and the *P* value reduced from 0.989 to 0.082. In ELSA, the coefficient of HbA1c changed from -0.995 in the main analysis to -0.013 in the sensitivity analysis, and the *P* value increased from 0.001 to borderline significance at 0.053.

Appendix 3.3.a The association between retirement and CVD risk factors without adjusting medication/treatment.

	CHARLS			ELSA		
	β	**95% CI**	***P***	**β**	**95% CI**	***P***
Sensitivity analyses [a]						
SBP	0.411	-1.296, 2.119	0.637	-0.960	-2.225, 0.305	0.137
DBP	0.798	-0.152, 1.748	0.100	-0.805	-1.568, -0.041	0.039
HbA1c (log)	0.012	-0.002, 0.025	0.082	-0.013	-0.027, 0.0002	0.053
Total cholesterol	1.764	-1.017, 4.545	0.214	-1.801	-5.424, 1.821	0.330
Main analyses [b]						
SBP	-1.177	-2.842, 0.489	0.166	-1.149	-2.406, 0.109	0.073
DBP	0.084	-0.863, 1.032	0.861	-0.838	-1.600, -0.075	0.031
HbA1c (log)	0.0001	-0.014, 0.014	0.989	-0.017	-0.030, -0.007	0.001
Total cholesterol	1.610	-1.137, 4.356	0.251	-0.995	-4.452, 2.461	0.572

[a] Adjusted for age, age^2, gender, spouse status, highest education, occupation skill level, household total income, household total wealth, urban/rural, smoking status, drinking frequency, and depressive symptoms.

[b] Further adjusted for medication/treatment.

Sensitivity analysis using completed retirement procedure as the definition of retirement

In CHARLS, retirement was defined as 'currently not working and mentions having completed retirement procedures' or 'currently not working and stopping the most recent job at or after age 45, and were not searching for a new job or on sick/other leave'. In this sensitivity analysis, only these 1608 people who were currently not working and had completed retirement procedure were considered as retired. These were compared to the working people. The total sample size in the sensitivity analysis was 9,922. When modelling blood biomarkers, only the 6,874 participants who provided blood samples were used. Results are shown in Appendices 3.3.b to 3.3.d.

In this sensitivity analysis (Appendix 3.3.b), the association between retirement and raised risk of heart disease became stronger, as the OR was 1.959 (fully adjusted) in the main analysis, and it became 2.505 (fully adjusted) in this sensitivity analysis. In contrast, the association between retirement and raised risk of stroke was attenuated somewhat. The fully adjusted OR was 3.221 in main analysis, and it became 3.160 in the sensitivity analysis. Nevertheless, this sensitivity analysis did not change the findings that retirement was associated with increased risk of heart disease and stroke in CHARLS.

Appendix 3.3.b Sensitivity analyses on the associations between retirement and CVD amongst formal retirees in CHARLS.

	Sensitivity analyses			**Main analyses**		
	OR	**95% CI**	***P***	**OR**	**95% CI**	***P***
Heart disease	2.505	1.861, 3.370	<0.001	1.959	1.649, 2.327	<0.001
Stroke	3.160	1.822, 5.480	<0.001	3.221	2.312, 4.487	<0.001

[a] Adjusted for age, age^2, gender, spouse status, highest education, occupation skill level, household total income, household total wealth, urban/rural, smoking status, drinking frequency, and depressive symptoms.

The sensitivity analysis for BMI and WC only slightly changed the coefficients of main analysis (Appendix 3.3.c), and retirement was still associated with increased BMI (β=0.632) and WC (β=2.039). However, the sensitivity analysis for blood pressure showed a different result. The main analysis did not find any statistically significant associations between retirement and blood pressure, but the sensitivity analysis found that, compared to working people, formal retirees had on average 3.549 mm Hg lower SBP (P=0.024) and 1.740 mm Hg DBP (P=0.059) compared with working people. In the main analysis, retirement was associated with increased CRP, but this association no longer existed in the sensitivity analysis. In both main and sensitivity analysis, retirement was not associated with HbA1c or blood total cholesterol.

Appendix 3.3.c Sensitivity analyses on the associations between retirement and CVD risk factors amongst formal retirees in CHARLS.

	Sensitivity analyses			**Main analyses**		
	β	**95% CI**	***P***	**β**	**95% CI**	***P***
BMI	0.632	0.130,1.134	0.014	0.540	0.252, 0.829	<0.001
WC	2.039	0.651,3.427	0.004	1.860	1.081, 2.640	<0.001
SBP [b]	-3.549	-6.640,-0.458	0.024	-1.177	-2.842, 0.489	0.166
DBP [b]	-1.740	-3.547,0.067	0.059	0.084	-0.863, 1.032	0.861
Total cholesterol[b]	-1.994	-7.810,3.822	0.502	1.610	-1.137, 4.356	0.251
CRP	0.037	-0.142,0.215	0.688	0.210	0.114,0.305	<0.001
HbA1c[b]	0.004	-0.013,0.022	0.620	0.0001	-0.014,0.014	0.989

[a] Adjusted for age, age^2, gender, spouse status, highest education, occupation skill level, household total income, household total wealth, urban/rural, smoking status, drinking frequency, and depressive symptoms.

[b] Further adjusted for medication/treatment.

Appendix 3.3.d shows sensitivity results for smoking and drinking frequency. This sensitivity analysis did not change the conclusion that retirement was not associated with smoking, but the significant association with drinking frequency no longer existed. The RRR of less than every day drinking versus non-drinking changed from 0.619 in the main analysis to 0.792 in the sensitivity analysis, and the RRR of drinking every day versus non-drinking changed from 0.600 to 0.686.

Appendix 3.3.d Sensitivity analyses on the associations between retirement and behavioural risk factors amongst formal retirees in CHARLS.

	Sensitivity analyses			**Main analyses**		
	RRR	**95% CI**	**P**	**RRR**	**95% CI**	**P**
Smoking status [a]						
Never smoker	Reference			Reference		
Ex-smoker	1.158	0.796,1.686	0.443	1.156	0.912, 1.466	0.230
Light/moderate	0.846	0.565,1.265	0.415	1.029	0.801, 1.321	0.825
Heavy smoker	1.040	0.669,1.617	0.863	0.913	0.693, 1.203	0.517
Drinking frequency [b]						
Non-drinkers	Reference			Reference		
< everyday	0.792	0.563,1.113	0.180	0.619	0.498, 0.770	<0.001
≥ every day	0.686	0.452,1.042	0.077	0.600	0.465, 0.775	<0.001

[a] Adjusted for age, age^2, gender, spouse status, highest education, occupation skill level, household total income, household total wealth, urban/rural, drinking frequency, and depressive symptoms.

[b] Adjusted for age, age^2, gender, spouse status, highest education, occupation skill level, household total income, household total wealth, urban/rural, smoking status and depressive symptoms.

Appendix 4.1 Number of observations at each year centred on retirement in the CHNS.

Years centred on retirement	*n*	%
-19	46	0.8
-18	6	0.1
-17	99	1.7
-16	20	0.3
-15	51	0.9
-14	81	1.4
-13	61	1.0
-12	107	1.8
-11	114	1.9
-10	154	2.6
-9	64	1.1
-8	256	4.3
-7	56	1.0
-6	234	4.0
-5	257	4.3
-4	329	5.6
-3	175	3.0
-2	423	7.1
-1	451	7.6
1	689	11.6
2	276	4.7
3	225	3.8
4	256	4.3
5	248	4.2
6	171	2.9
7	161	2.7
8	176	3.0
9	132	2.2
10	135	2.3
11	71	1.2
12	122	2.1
13	50	0.8
14	90	1.5
15	42	0.7
16	31	0.5
17	41	0.7
19	21	0.4
Total	5921	100.0

Appendix 5. 1 Results of piecewise regressions on blood pressure after excluding those went back to work in the CHNS.

	SBP (*n*=1,084)			DBP (*n*=1,084)		
	β	95% CI	*P*	β	95% CI	*P*
Pre-retirement						
Linear slope	0.790	0.654,0.927	<0.001	0.407	0.322,0.491	<0.001
Post-retirement change						
Linear slope change	-0.480	-0.693,-0.267	<0.001	-0.560	-0.689,-0.431	<0.001

Appendix 5. 2 Results of piecewise regressions on adiposity measures after excluding observations since back to work in the CHNS.

	BMI (*n*=1,084)				WC (*n*=970)		
	β	95% CI	*P*	Joint *P*	β	95% CI	*P*
Pre-retirement							
Linear slope	0.191	0.120,0.261	<0.001		0.374	0.301,0.447	<0.001
Quadratic slope	-0.004	-0.006,-0.001	<0.01				
Post-retirement change							
Linear slope change	-0.001	-0.070,0.068	0.97	0.77	-0.174	-0.287,-0.060	<0.01
Quadratic slope change	0.001	-0.002,0.005	0.47				

Appendix 5. 3 Results of piecewise multinomial logistic regressions on categorical behavioural risk factors after excluding observations since back to work in the CHNS.

	Smoking Status (*n*=1,084)			Alcohol Consumption (*n*=970)		
	RRR	**95% CI**	***P***	**RRR**	**95% CI**	***P***
Light/moderate versus Non						
Pre-retirement	0.948	0.925,0.972	<0.001	0.909	0.880,0.941	<0.001
Post-retirement change	1.004	0.963,1.044	0.69	1.011	0.959,1.066	0.69
Heavy versus Non						
Pre-retirement	0.957	0.933,0.984	<0.01	0.951	0.912,0.992	0.02
Post-retirement change	0.966	0.921,1.006	0.09	0.915	0.851,0.983	0.02