Three essays on retirement insurance in China

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Publication Date:
2021

DOI:
https://doi.org/10.26190/unsworks/2017

Three essays on retirement insurance in China

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A thesis in fulfilment of the requirements for the degree of

Doctor of Philosophy

School of Risk and Actuarial Studies

UNSW Business School

The University of New South Wales

December 2021

1. THESIS TITLE & ABSTRACT

Thesis Title

Three essays on retirement insurance in China

Thesis Abstract

This thesis studies several important issues for ageing populations in developing countries facing basic public provisions of health services and pensions and high levels of air pollution. In particular I investigate the demand for longevity, critical illness insurance (CII), and long-term care insurance (LTCI) in developing countries from both theoretical and empirical perspectives. I also study how PM2.5 (particles less than 2.5 micrometres in diameter) affects multimorbidity, cognition, and disability in activities of daily living (ADL) that are important health indicators for the old. The results provide insights for the design and risk management of retirement insurance products and government policies.

First, we conduct an online experimental survey to elicit and analyse preferences for retirement portfolio including longevity, CII, and LTCI products after the COVID-19 pandemic outbreak in urban China. We observe a high variation of insurance demand by individual factors and COVID-19 experience, and their effects can be opposite by health-contingent insurance and life annuity. On average, the most preferred retirement portfolio contains health-contingent insurance that covers half of the expected out-of-pocket (OOP) costs for critical illness and long-term care expenditures, a monthly annuity of 20% of the disposable income. The portfolio that covers half of the OOP cost for long-term care, critical illness, or both, is most effective in increasing annuitisation.

Next, we derive the optimal portfolio for retirees in China facing uncertain lifespan, catastrophic medical expenditures, and long-term care costs. An optimal portfolio highly depends on a retiree's economic background. For a retiree with an average pension, we find that at least 30% of retirement wealth is allocated to CII, while at least 40% is allocated to a life annuity for those with a low pension. The demand for LTCI is less than 15% of retirement savings. State-dependent utility and bundled insurance products can both increase annuity demand for some retirees.

Finally, we investigate the long-term impact of exposure to PM2.5 on multimorbidity, cognition, and ADL disability for the middle- and old-aged adults in China. We find different non-linear associations between PM2.5 exposure and the three health outcomes, and we also observe different impacts of past and current exposure to PM2.5 on them. We interpret the risk of PM2.5 exposure by comparing it to the effects of ageing.

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Abstract

This thesis studies several important issues for ageing populations in developing countries facing basic public provisions of health services and pensions and high levels of air pollution. In particular I investigate the demand for longevity, critical illness insurance (CII), and long-term care insurance (LTCI) in developing countries from both theoretical and empirical perspectives. I also study how fine particulate matter ($PM_{2.5}$, particles less than 2.5 micrometres in diameter) affects multimorbidity, cognition, and disability in activities of daily living (ADL) that are important indicators for critical illness and long-term disability. The results provide insights for the design and risk management of retirement insurance products and government programs.

First, we conduct an online experimental survey to elicit and analyse preferences for retirement portfolio including longevity, CII, and LTCI products in the wake of the coronavirus disease 2019 (COVID-19) outbreak in China. On average, the most preferred retirement portfolio comprised health-contingent insurance that covers 50% of the expected out-of-pocket (OOP) costs for critical illnesses and LTC, a monthly annuity of about 19.6% of the average disposable income in urban China, with the remaining retirement wealth placed in a savings account. However, we found considerable variation in portfolio composition by personal characteristics and experiences with COVID-19. The portfolio that covers 50% of the OOP costs for LTC is most effective to release precautionary savings to increase annuitisation.

Next, we derive the optimal portfolio for retirees in China facing uncertain lifespan, catas-

trophic medical expenditures, and long-term care costs. An optimal portfolio highly depends on a retiree's economic background. For a retiree with an average pension, we find that at least 30% of retirement wealth is allocated to CII, while at least 40% is allocated to a life annuity for those with a low pension. The demand for LTCI is usually between 5% to 15% of retirement savings. Health state-dependent utility for consumption and bundled longevity, critical illness insurance, or long-term care insurance products can both increase annuity demand for some retirees.

Finally, we investigate the long-term impact of exposure to $PM_{2.5}$ on cognition, multimorbidity, and ADL disability for the middle- and old-aged adult population in China. We identified different non-linear links between $PM_{2.5}$ exposure and the three health measures. First, annual exposure to $PM_{2.5}$ of 25 $\mu g/m^3$ or higher was linked to more severe multimorbidity. Second, annual reductions of $PM_{2.5}$ exposure were linked to less severe multimorbidity, better cognition, and lower rates of disability. Third, past exposure to severe $PM_{2.5}$ pollution modified the effect of current $PM_{2.5}$ exposure on multimorbidity and cognition, and finally, urban residents, middle-aged adults, and males were more sensitive to air pollution, with different effects for multimorbidity, cognition, and disability. Overall, we found that the health risk of $PM_{2.5}$ exposure was high compared with that of ageing.

Acknowledgement

First and foremost, I would like to express my deepest appreciation to my supervisors Professor Hazel Bateman and Dr Katja Hanewald, for their sincere guidance and constant support during my time in Sydney and 19 months in China due to the COVID-19 pandemic. They have spent extensive time on the development of my three projects, and this thesis would not have been possible without their invaluable support. They have also shared valuable experience in research and have provided generous support in all kinds to expand my network and help me build a research career. I would also like to place my sincere gratitude to my supervisor Professor Hanming Fang. I am deeply impressed by his innovative insights and constructive comments on my projects.

Second, I would like to thank many people for their support of my research. I am indebted to Professor Olivia S. Mitchell for her very detailed feedback and warm encouragements on my optimal insurance project in Chapter 4, and I am grateful to Professor Fedor Iskhakov, Associate Professor Jeppe Druedahl and Associate Professor Thomas H. Jørgensen, Dr Mengyi Xu for kindly sharing their expertise in life-cycle modelling. I would also like to thank Associate Professor Ruth Peters and Dr Michal Kicinski for sharing their advice and suggestions on the air pollution project in Chapter 5. I am thankful to Professor Jennifer Alonso-García, Dr Inka Eberhardt, Dr Junhao Liu and research teams in Willis Towers Watson Research and Innovation Centre (Wuhan and Reigate Offices) for their helpful comments and suggestions on the survey design and translation in Chapter 3.

Third, I am also very grateful to my PhD Panel members: Professor Michael Sherris, Associate Professor Ramaprasad Bhar, Dr Jae Kyung Woo and Dr Yang Shen for the time they spent on my progress review throughout my PhD. I acknowledge the financial supports from the Phoenix Healthcare Finance Research Center at Tsinghua University, the University of Pennsylvania QUARTET competition and the Australian Research Council Centre of Excellence in Population Ageing Research (CEPAR). CEPAR provides a wonderful cross-disciplinary work environment and I benefit a lot from CEPAR's research activities and comments received from CEPAR research fellows in actuarial science, economics and neuroscience. I would also like to thank my fellow PhD students, in particular, Shu Chen and Dr Zhiwei Tong, without whom my study would have been much less fun.

Fourth, I would like to thank my friends from UNSW Cycling Club. They have led me into a balanced and healthy life during a very intensive PhD training program. Their experiences with cycling and work have greatly expanded my understanding of healthy ageing and stamina in research.

Finally, I would like to give my sincere appreciation to my parents for their unconditional love. They are always supportive of my decisions and have taken good care of my life, especially during the COVID-19 pandemic. Also, they have provided invaluable feedback on the design of the experimental survey in Chapter 3 because they are the targeted group of the proposed retirement insurance in my research. This thesis is a joint achievement with them.

Publications and Presentations

List of Presentations

- A version of Chapter 3 'The demand for longevity, critical illness insurance and long-term care insurance in the wake of the COVID-19 pandemic' has been presented to the public at the following conferences:
  - **American Risk and Insurance Association Annual Meeting**, 'The demand for longevity, health and long-term care insurance in the COVID-19 pandemic', 3 Aug 2021
  - **Asian-Pacific Risk and Insurance Association Annual Meeting**, 'The demand for longevity, health and long-term care insurance in the COVID-19 pandemic', 28 July 2021
  - **4th International Health Economics Association World Congress**, 'The demand for longevity, health and long-term care insurance in the COVID-19 pandemic', 12 July 2021
  - **24th International Congress on Insurance: Mathematics and Economics**, 'The demand for longevity, health and long-term care insurance in the COVID-19 pandemic', 8 July 2021
- Two versions of Chapter 4 'Optimal portfolio choice with longevity, critical illness

insurance and long-term care insurance' have been presented to the public at the following conferences:

  - **University of Melbourne, Actuarial Seminar**, 'Optimal portfolio choice with longevity and health insurance products: A developing country context', 30 July 2021
  - **4th International Health Economics Association World Congress**, 'Optimal portfolio choice with longevity and health insurance products: A developing country context', 8 July 2021
  - **Netspar International Pension Workshop**, 'Optimal portfolio choice with longevity and health insurance products: A developing country context', 20 January 2021
  - **28th Colloquium on Pensions and Retirement Research**, 'Optimal portfolio choice with longevity and health insurance products: A developing country context', 9 December 2020
  - **World Risk and Insurance Economics Congress**, 'Optimal portfolio choice with longevity and health insurance products in a developing country context', 7 August 2020

- A version of Chapter 5 'The effects of past and current air pollution exposure on multimorbidity, cognition and disability in China' has been presented to the public at the following conferences:

  - **University of Melbourne, Actuarial Seminar**, 'The effects of past and current air pollution exposure on multimorbidity, cognition and disability in China', 10 September 2021
  - **International Longevity Risk and Capital Markets Solutions Conference**, 'The effects of past and current air pollution exposure on multimorbidity, cognition and disability in China', 14 August 2021

– **24th International Congress on Insurance: Mathematics and Economics**, 'The effects of past and current air pollution exposure on multimorbidity, cognition and disability in China', 10 July 2021

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Chapter 1

Introduction

Rapid population ageing has put pressure on China's social insurance systems. In addition, outdoor air pollution has grown to become the largest environmental health risk in developing countries. In the wake of the COVID-19 pandemic, older people became the most vulnerable group, and concerns about health-related risks have surged. Individuals are increasingly required to take on greater responsibility for managing risks like critical illness, long-term care and longevity as they face retirement. This thesis investigates the demand for life annuities, critical illness insurance (CII) and long-term care insurance (LTCI) from both theoretical and empirical perspectives, and it studies the associations between air pollution (i.e., $PM_{2.5}$ - particles less than 2.5 micrometres in diameter) and the three key health measures in old age: multimorbidity, cognition and disability.

The core research questions of this thesis are as follows:

- What are the stated preferences for retirement portfolios of longevity and health-contingent insurance products, and how are they influenced by personal characteristics? Does access to health-contingent insurance products release precautionary savings for the purchase of longevity insurance? How does experience with and attitudes towards COVID-19 influence the choices of retirement portfolios? These questions are addressed in Chapter 3 using stated preference data from an online survey with embedded choice tasks.

- What are the optimal retirement portfolios with longevity and health-contingent insurance products for retirees facing an uncertain lifespan, catastrophic medical expenditures and long-term care costs? How would the health state-dependent utility of consumption affect choices for an optimal portfolio? What are the welfare gains of the optimal portfolios? These questions are answered in Chapter 4 using a life-cycle model.

- What are the non-linear associations between air pollution and multimorbidity, cognition and disability? How does experience with severe air pollution in the past affect the impact of present exposure to air pollution on health? Are there population segments more sensitive to air pollution? These questions are addressed in Chapter 5 using generalised additive mixed models with combined satellite data on $PM_{2.5}$ and individual-level data from a nationally representative longitudinal survey.

The discoveries of this thesis provide valuable insights for policymakers and insurers in China on social insurance expansion, suggest how to design bundled insurance products and inform clean air policies in developing countries that have similar institutional and policy settings as China.

The remainder of the chapter is structured as follows. Section 1.1 discusses the background and motivation of the thesis. Section 1.2 provides an overview of the results and highlights the contributions of the thesis to the literature. Section 1.3 outlines the remainder of this thesis.

1.1 Background and motivation

The percentage of the Chinese population aged 60 years or older is expected to increase from 18% in 2019 to about 35% in 2050 (United Nations, 2019). China's current social security system is unlikely to be able to provide adequate resources to support the rapid growth of retirees (Yin et al., 2019; Zhao and Mi, 2019), and the decline in economic activity in the wake of the Coronavirus (COVID-19) pandemic further adversely affects the sustainability of the social insurance system (Mitchell, 2020). Retirees face an increased risk of outliving their retirement resources as the replacement rate of the mandatory pension scheme has fallen steadily from over 80% in 1995 to about 40% in recent years (Zhao and Mi, 2019; Zhu and Walker, 2018). Catastrophic medical costs pose a considerable risk because public health insurance provides limited cover for advanced medical treatments and drugs for critical illness (Hou et al., 2014; Meng et al., 2012; Zhang et al., 2017a; Zhu et al., 2016). Furthermore, the elderly care traditionally provided by families has been weakened by the one-child policy and rural-urban migration (Zhen et al., 2015), while China's public long-term care programs remain in an infantile stage with availability limited to 49 cities by August 2021. Moreover, the financing of these long-term care insurance schemes continues to be an issue (Yin et al., 2019).

Because of the meagre coverage of public insurance, individuals are increasingly expected to take more responsibility in managing retirement risks. In the wake of the COVID-19 pandemic, concern about health-related risks skyrocketed as the older population developed into the most vulnerable sector (Pifarré i Arolas et al., 2021). This could further affect the demand for both longevity and health-related insurance. However, enterprise annuities cover less than 6% of urban employees in China, and most private annuities are investment products that do not intend to provide lifetime income (Fang and Feng, 2020). Most private health-contingent insurance products are short-term in nature with a maximum age for purchase. Since 2020, China's State Council has emphasised the need to develop high-quality personal insurance products to meet people's demands for health, old-age support and safety protection. They have in particular highlighted the role of commercial insurance in social services (CBIRC, 2020; Xinhua, 2020). However, few suitable products exist for the elderly, and the acceptance of private longevity or health insurance is low due to an underdeveloped private market for such products. It is therefore important to design suitable retirement insurance products that meet the demand of retirees.

In developing countries like China, airborne particulate matter serves as the largest environmental detriment to health (Ebenstein et al., 2017). The level of air pollution in these countries can be five to ten times higher than in developed countries and considerably higher than what World Health Organization (WHO) considers safe (Ebenstein et al., 2017; World Health Organization, 2016). Among all air pollutants, $PM_{2.5}$ poses the greatest health risks as it can penetrate the lung barrier and invade the bloodstream due to its small size. A high concentration of air pollutants adversely can affect human health (e.g., Brunekreef and Holgate, 2002). Multimorbidity status, cognitive function and performance of activities of daily living (ADL disability) are three key health indicators of illness intensity and independent living in old age. A better understanding of the associations between $PM_{2.5}$ exposure and each of the aforementioned factors provides insights into pricing and risk management of relevant longevity and health-contingent insurance products.

This thesis examines retirement insurance products with the potential to aid Chinese retirees to better finance their retirement consumption and health care costs. It will also study the health effect of a particularly relevant risk factor in a developing country: $PM_{2.5}$ exposure for middle- and old-aged Chinese people. The thesis will provide new insights regarding a) the theoretical optimal retirement portfolio with longevity and health-contingent insurance products for individuals close to retirement with typical wealth and income levels, b) stated preferences for retirement portfolio with longevity and health-contingent insurance products for individuals with heterogeneous economic backgrounds and c) associations between $PM_{2.5}$ exposure and multimorbidity, cognition and ADL disability. This project will further extend the literature to include developing countries. More details of the contributions are discussed in Section 1.2.

1.2 Contribution to literature and overview of results

This section provides an overview of research findings and highlights the key contributions.

Chapter 3 conducts an online survey with a sample of 1,000 urban Chinese individuals of retirement age to analyse preferences for retirement insurance products consisting of longevity, critical illness and long-term care products in the wake of the COVID-19 outbreak. It designs a sequence of choice tasks to elicit the preferred allocation of retirement financial assets across a savings account, a life annuity, critical illness insurance and long-term care insurance and the extent to which access to retirement insurance products would lead them to release precautionary savings for longevity insurance. It also collects comprehensive data on personal preferences, financial competence, demographics and socioeconomic indicators as well as variables measuring the effects of COVID-19 on personal finance, mental stress and risk-taking behaviours.

On average, the most preferred retirement portfolio comprised health-contingent insurance that covers 50% of the expected out-of-pocket (OOP) costs for critical illness and long-term care, a monthly annuity of about 19.6% of the average disposable income in urban China and the remaining retirement wealth placed in a savings account. A portfolio that covers 50% of the OOP costs for long-term care proved to be the most effective in convincing the participants to release precautionary savings to purchase longevity insurance (annuities). These findings confirm the significance of health risks and their related uncertain costs in retirement planning as emphasised in the literature (e.g., Ameriks et al., 2020; De Nardi et al., 2010; Pang and Warshawsky, 2010; Reichling and Smetters, 2015). They also link this study to the 'annuity puzzle' (e.g., Benartzi et al., 2011; Brown, 2009; Inkmann et al., 2011; Pashchenko, 2013; Peijnenburg et al., 2017) as we find substantial stated demand for annuities in contrast to extremely low voluntary annuitisation in China.

This chapter also highlights the importance of individual heterogeneity in retirement planning with insurance products. We determined that personal background plays a part in retirement insurance demand. In particular, risk tolerance in financial matters is positively correlated with annuity demand, which cannot be explained by classical economic theory. A better understanding of retirement insurance products is negatively associated with annuity demand but positively with health-contingent insurance. Health state-dependent consumption preferences hinge on health-contingent insurance demand but not for annuities. In the context of COVID-19, individuals whose mental health was below the sample median due to COVID-19 had lower stated demand for annuities and preference for health-contingent insurance. There was no association between insurance demand and the purchase of any health-related insurance other than that for COVID-19. Undertaking riskier behaviours following a relaxation of the lockdowns was associated with a lower preference for health-contingent insurance but showed no significant association with annuity demand.

Chapter 4 derives the optimal portfolio for a retiree in a developing country context facing the risk of critical illness, long-term care dependence, uncertain longevity as well as stochastic medical and care-related expenditures. It also considers a health-state dependent utility function under which the utility of non-medical consumption depends on the retiree's current health state. The retiree chooses consumption and allocates his retirement wealth among a portfolio of life annuities, critical illness insurance, long-term care insurance and a savings account to maximise their expected lifetime utility. This chapter expounds upon the existing literature mainly by including the state of being critically ill, random catastrophic medical costs and critical illness insurance.

This chapter finds that, in emerging economies like China, there exists a demand for all four products, and that critical illness insurance is an important component of an optimal portfolio. For retirees with an average public pension, at least 30% of retirement wealth is allocated to critical illness insurance, while at least 40% is allocated to a life annuity for those with a low public pension. Long-term care insurance comprises between 5% and 15% of retirement wealth depending on a retiree's background. Taking account of health state-dependent utility increases the demand for annuities. The results are robust and require only slight adjustments depending on assumptions about health transitions, individual preferences and government subsidy. These optimal portfolios predicted for retirees with different economic backgrounds provide substantial welfare gains compared with no private insurance, which is the status quo for retirees in China. Findings in this chapter also suggest that bundling longevity and health-related insurance products helps achieve a lower price, and can increase annuity demand for some retirees.

Chapter 5 adds to the emerging literature on air pollution and health by studying the effects of $PM_{2.5}$ exposure on multimorbidity, cognition and ADL disability, using a nationally representative cohort study from 2011 to 2018 in China combined with high-resolution satellite data on $PM_{2.5}$. This chapter investigates the effects of both past and current exposure to $PM_{2.5}$, and both the annual exposure and the Year-Over-Year growth of $PM_{2.5}$ exposure on each of the three health measures in old age. It uses generalised additive mixed models to relate multimorbidity, cognition and ADL disability to $PM_{2.5}$ variables, age, gender and socioeconomic factors, controlling for economic development at the city level and correlations for repeated measures on individuals and locations.

Findings in this chapter show different non-linear links between $PM_{2.5}$ exposure and multimorbidity, cognition, and ADL disability: i) annual exposure to $PM_{2.5}$ of 25 $\mu g/m^3$ or higher is linked to more severe multimorbidity; ii) annual reductions in $PM_{2.5}$ exposure are linked to less severe multimorbidity, better cognition and lower rates of disability; iii) past exposure to severe $PM_{2.5}$ pollution modifies the effect of current $PM_{2.5}$ exposure on multimorbidity and cognition; and iv) urban residents, middle-aged adults and males are more sensitive to air pollution with different effects on multimorbidity, cognition and disability.

1.3 Thesis outline

The remainder of this proposal is structured as follows. Chapter 2 presents institutional background on public and private insurance in China and a review of the literature on retirement insurance demand and health effects of air pollution. Chapter 3 studies the demand for life annuities, critical illness insurance and long-term care insurance and factors affecting the demand based on stated preference data from an online experimental survey. Chapter 4 provides a theoretical analysis of the demand for life annuities, critical illness insurance and long-term care insurance, taking into account random health transitions, random health costs and a health state-dependent utility function. Chapter 5 examines the health effects of past and current exposure to air pollution on multimorbidity, cognition and disability, using a satellite-based $PM_{2.5}$ dataset and a nationally representative cohort study. Chapter 6 provides concluding remarks.

Chapter 2

Institutional background and literature review

This thesis studies the demand for longevity insurance and health-contingent insurance, which includes critical illness insurance (CII) and long-term care insurance (LTCI), in China from both theoretical and empirical perspectives. It also examines the associations between air pollution and multimorbidity, cognition and disability.

Section 2.1 provides context by summarising current public and private retirement insurance arrangements in China. Section 2.2 outlines studies related to the demand for annuities and health-contingent insurance, which are relevant to Chapters 3 and 4 regarding the demand for retirement insurance products. Section 2.3 summarises the literature on the associations between air pollution and health and focuses on its impact on diseases, cognition and disability. Section 2.4 concludes this chapter by summarising the identified literature gaps.

2.1 China's public and private insurance in retirement

This section provides context for the research conducted in this thesis by briefly describing public and private retirement income arrangements (including annuity demand and supply) and the health-related insurance market in China.[1]

2.1.1 Public pensions and private retirement income products

In 2020, China's public pensions comprised two main types: the Basic Old Age Insurance (BOAI) for employees in firms and the government and the Resident Pension for urban and rural residents without formal employment. However, there are at least eight other types of social pension because of transitions caused by a series of reforms (Zhu and Walker, 2018). Before merging into the BOAI system in 2015, the pension for employees in the government sector provided most of the generous retirement income with a replacement rate of up to 90%. However, the average monthly pension of the Resident Pension was only CNY 127 in 2017 (i.e., about 4.2% of the average disposable income in urban China)[2] (Fang and Feng, 2020). The average pension payment of BOAI was CNY 2,870 per month (i.e., about 94.6% of the average disposable income) in 2017 (Fang and Feng, 2020). However, there are large regional differences in BOAI payments. In 2020, in more developed cities like Beijing or Shanghai, the average BOAI was around CNY 4,000 per month (about 69.1% of the average disposable income in Beijing), while the pension amount in less developed provinces is half of the pension in Beijing despite a lower cost of living. The replacement rate of the BOAI has fallen from over 80% in 1995 to around 40% in 2016 (Zhu and Walker, 2018). Under the pressure of a rapidly ageing population and a slowdown of economic growth, the sustainability of the current public pension system has been questioned, and adjustments of the retirement age and benefits are likely in the future (e.g., Deng et al.,

[1] For detailed information about the history and reform of China's social insurance, please refer to Fang and Feng (2020) and Chen and Turner (2021) for the pension system and Sun et al. (2017) for the healthcare system.

[2] The disposable income here (in 2017) and later (from respective years) can be accessed from `www.stat.com.cn` and websites of local municipal bureau of statistics. 1 USD equalled about 6.8 CNY on September 1 2020.

2021; Zhao and Mi, 2019).

The coverage of private pensions is low and the market for Enterprise Annuities is still underdeveloped. A small proportion (0.35%) of firms, typically large state-owned enterprises, provide Enterprise Annuities and cover about 5.8% of the total BOAI participants (Fang and Feng, 2020). A number of private annuity products are offered, but according to the CHARLS survey conducted in 2015, the annuity ownership rate was less than 5%. This could be because most of the annuity products are sold as wealth management products and are not intended to provide lifetime income (Fang and Feng, 2020). Another explanation could be that annuities are expensive as China's regulation requires a discount rate of no more than 3.5% for the pricing of long-term insurance products. Among the private annuity holders, 76% were farmers and self-employed, and 17% were employees in firms (Zhu and Walker, 2018).

2.1.2 Public and private health insurance

After a series of reforms, China achieved nearly universal health insurance by 2011 (Yip et al., 2012). Currently, the main components of China's public health insurance are the Employee Medical Insurance and the Resident Medical Insurance.[3] Both programs provide basic coverage for major diseases, but the latter scheme is less generous. Their capacities to reduce financial strains on retiree households due to critical illnesses are limited. Public health insurance often excludes expensive advanced drugs and medical treatments,[4] and individuals must pay out of pocket (OOP) if they desire to access advanced medical services. Past studies have suggested using private health insurance to finance the medical services not covered by the public health insurance (e.g., Li et al., 2013a). For example, China's government recently started to develop supplemental insurance for large medical expenditures with insurance companies (Liu et al., 2017b). Since October 2020, the Beijing

[3]Since 2016, China started to integrate the Urban Resident Basic Medical Insurance and the New Rural Cooperative Medical Scheme into the Resident Medical Insurance (Pan et al., 2016).

[4]The more expensive drugs or treatments are often not included in the National Essential Medicine Scheme or the local Reimbursement Drug list, which is a catalogue of drugs and treatments that are priced at the manufacturer's cost and has higher reimbursement rates available (Li et al., 2013c; Liu et al., 2017b).

government has worked with the insurance industry to subsidise a long-term supplementary medical insurance scheme to reduce catastrophic medical expenditures. However, this mode of insurance remains rare in China. Overall, the reimbursement rate of the national health insurance programs for large critical illness medical expenditure is approximately 50% (Zhu et al., 2016).

China's private health insurance has developed rapidly in recent years. The annual growth rate was about 28% from 2015 to 2020, and the total premium income of private health insurance was CNY 817 billion in 2020 (CBIRC, 2021). CII stands out as the most popular health insurance product, accounting for about 60% of the total premium of private health insurance in 2021 (Ernst and Young, 2017; The Actuary, 2021). However, products specifically designed for retirees are rare. Access to CII is often subjected to an age limit. A supplementary private medical insurance has received public attention since 2016 for its large coverage and low price. However, it is primarily a one-year product and often sets an age limit to purchase as well. Aside from the traditional insurance channels, a crowd-funded mutual aid program named 'Xiang Hu Bao' emerged in 2018, aiming to provide coverage for critical illness. It has attracted more than 100 million users by 2019. However, it also excludes adults older than 60 years old. The CHARLS survey suggests that the overall ownership of private health insurance was less than 5% in 2015.

2.1.3 Long-term care services and insurance

In China, long-term care services are based on its tradition of filial piety. The large demographic changes and fast urbanisation have weakened such a tradition, but more than 8% of the care in 2015 was still provided by family members (Zhen et al., 2015). China initiated the first public LTCI pilot program in 2012 (Lu et al., 2017). Given the regional disparities in economic development, before implementing a national-level scheme, an umbrella of policy experimentation has been conducted through trial and error, and by August 2021, there existed 49 pilot programs. The criteria for participation in and benefits of these LTCI programs vary (e.g., by coverage of age, level of co-payment, and type of benefits (Zhu and Österle, 2019)). The schemes are primarily funded by local governments (Yang et al., 2016). The government guidance emphasises the use of the funds from the Employee Medical Insurance; however, this is unlikely to be sustainable (Yin et al., 2019).

The first private LTCI schemes entered the Chinese market in 2005, but most products pay lump sums and are designed mainly as a vehicle for investment. Overall, few satisfactory private long-term care products are offered in China (Huang et al., 2019c).

2.1.4 Summary

China's public pensions and health insurance arrangements provide universal but basic coverage. There are a number of public LTCI pilot programs in different cities but no universal coverage. China's private insurance market offers annuities, medical insurance, CII and LTCI.[5] However, annuities are designed mainly as investment products rather than lifetime income products, and most health-contingent insurance products are short-term in nature with a maximum age for purchase. The State Council's executive meeting in December 2020 (Xinhua, 2020) emphasised the need to develop high-quality personal insurance products to meet people's needs for health, old-age support and safety protection. It also highlighted the importance to develop commercial health insurance that suited the needs and paying capacity of the old. However, few such products for the elderly exist, the coverage of private longevity or health insurance is low and the private market for them remains undeveloped.

2.2 Demand for retirement insurance products

Chapters 3 and 4 of the thesis study the demand for retirement insurance products, and this section summarises studies related to the demand for annuities, CII and LTCI. Section

[5] Currently, insurance claims are in practice mostly tax-free in China. However, there are tax-deferred annuity products designed for the younger working population to better finance themselves in retirement.

2.2.1 presents a review of literature on annuity demand with a focus on health risks and associated financial costs.[6] Section 2.2.2 reviews studies on the demand for health-contingent insurance. Section 2.2.3 discusses the experimental studies on retirement insurance products, which are relevant to the hypothetical survey developed in Chapter 3.

2.2.1 Demand for annuities

Among retirement insurance products, a life annuity, which provides annuitants with an income stream until death, stands out as an important component of an optimal retirement portfolio. Standard life-cycle analysis as per Yaari (1965) and Davidoff et al. (2005) demonstrates that, without bequest motives, a risk-averse individual should fully annuitise in a complete market. However, empirical results reveal that voluntary annuitisation is still rare (Johnson et al., 2004; Mitchell et al., 2011). For example, in a survey of 450 large 401(k) plans in the US, Schaus (2005) discovers that merely 6% of the members chose an annuity when it was available. Boardman (2006) and Inkmann et al. (2011) provide similar results for the UK. Since pension freedoms were introduced in April 2015, market data in the UK shows that the voluntary annuitisation rate sits at approximately 12% compared to over 50% that have been fully withdrawn and about 30% that have entered into drawdown products (Financial Conduct Authority, 2018). In Australia, Bateman and Piggott (2011) point out that few life annuities are sold each year and that the annuity market is almost non-existent (recently, insurance companies have begun to sell annuities, e.g., the number of new annuity policies sold increased from 53 in 2010 to over 9000 in 2016 (Challenger, 2017), but the annuitisation rate nonetheless remains low). Some countries such as Switzerland and Sweden have a substantial voluntary annuitisation rate, but annuities there were often the default option of retirement benefits (Bütler and Teppa, 2007; Hagen, 2015).[7]

[6]These costs, depending on the study, can include out-of-pocket medical costs such as inpatient/outpatient expenditures not covered by insurance, premiums for health insurance, and long-term care expenditures. In the thesis, I use the term 'health-related costs' to refer to such costs if the cost type is not explicitly mentioned.

[7]See Mitchell et al. (2011) for results in other countries.

The mismatch between the theoretical predictions and empirical observations is the source of the so-called 'annuity puzzle'.[8] There have been many attempts to solve this puzzle. In the following, I first provide an overview of these explanations through behavioural and rational factors. Then I discuss literature on the role of health risks and associated costs in explaining the annuity puzzle as well as experimental studies on retirement insurance products.

Behavioural factors

Prior studies have attempted to explain the annuity puzzle from a behavioural perspective. The identified behavioural factors include (i) framing: whether an annuity product is presented in a way that makes it unattractive to potential purchasers (e.g., in an investment rather than a consumption frame or a loss rather than a gain frame) (Agnew et al., 2008; Beshears et al., 2014; Bockweg et al., 2017; Brown et al., 2016b, 2008); (ii) presentation formats of annuity income: whether an increment is represented in a fixed term or percentage points because individuals are likely to undervalue payment growths with percentage increase and therefore find annuities presented in such format less attractive (Bateman et al., 2014; Huber et al., 2014; Shu et al., 2015); (iii) excessive extrapolation of past stock market performance: individuals are likelier to participate in the stock market rather than purchasing annuities when recent stock returns are high (Agnew et al., 2015; Previtero, 2014); (iv) default choices: individuals are likely to accept the default option of retirement benefits provided to them (Beshears et al., 2009; Bütler and Teppa, 2007; Dobrescu et al., 2018); (v) peer effects: individuals tend to follow choices from their peers because they may believe that their peers have better knowledge to make decisions (Alonso-García et al., 2021; Benartzi and Thaler, 2007; Duflo and Saez, 2002, 2003; Park and Banerjee, 2020), but such effects can also have an opposite impact due to discouragement from upward social comparisons (Beshears et al., 2015); (vi) a lack of trust in insurance companies (Beshears et al., 2014; Gardner and Wadsworth, 2004); and other factors such as buyer's remorse, regret aversion, stickiness to control, loss aversion, reference points and mental

[8] Brown (2009), Benartzi et al. (2011), MacDonald et al. (2013), and Ramsay and Oguledo (2018) provide reviews of literature on the explanations of annuity puzzle.

accounting (e.g., Brown, 2009; Brown et al., 2008; MacDonald et al., 2013).

Rational factors

Many rational factors have been identified that affect the annuity puzzle as well. Before they consider any voluntary annuitisation, retirees might already possess a noticeable amount of annuity in other forms, e.g., a government pension, means-tested support, or a corporate DB pension (Ameriks et al., 2003; Bütler et al., 2017; Bütler and Teppa, 2007; Dushi and Webb, 2004; Hulley et al., 2013; Iskhakov et al., 2015; Milevsky and Young, 2007; Pashchenko, 2013). They may alternatively have substitutes such as family risk sharing (Brown and Poterba, 2000; Inkmann et al., 2011) or 'insurance' provided by illiquid wealth such as housing (Andréasson and Shevchenko, 2018; Davidoff, 2009; Hanewald et al., 2016; Poterba et al., 2011; Venti and Wise, 2004). Retirees may wish to leave an endowment to their families after their death (Ameriks et al., 2011; De Nardi and Fella, 2017; Inkmann and Michaelides, 2012; Kopczuk and Lupton, 2007; Lockwood, 2012; Pashchenko, 2013). Some retirees may perceive annuities as expensive for reasons including fairness or asymmetric information (Brunner and Pech, 2005; Cappelletti et al., 2013; Chiappori and Salanie, 2000; Mitchell et al., 1999), speculation on alternative investments (Blake et al., 2003; Chalmers and Reuter, 2012; Friedman and Warshawsky, 1990; Milevsky, 1998; Previtero, 2014), and low financial literacy or cognitive ability (Bateman et al., 2017, 2018; Brown, 2008; Brown et al., 2017b; Lusardi and Mitchell, 2014). In addition, financial advisers may be reluctant to sell single-premium immediate annuities because they would forfeit advisory opportunities in the future (Greenwald and Krieger, 2006; Iannicola and Parker, 2010).

Each of the reasons above can depress the demand for annuities. Although the impact of a single rational reason may not be sufficient to explain the observed low voluntary annuitisation rate, a combination of them can generate predictions consistent with empirical results even without resorting to behavioural factors (e.g., Inkmann et al., 2011). However, particular rational reasons may be more informative; for example, Lockwood (2012) showed that moderate bequest motives can prevent individuals from annuitising any wealth. A high proportion of pre-annuitised wealth eliminates the need for a private annuity (Dushi and Webb, 2004; Hubener et al., 2014). In addition, means-tested pension incomes are especially important for the lower-income population as they can crowd out their need for annuitisation (Andréasson and Shevchenko, 2018; Iskhakov et al., 2015; Pashchenko, 2013).

Health risks and precautionary savings due to uncertain health expenditure

One key reason for the existence of the annuity puzzle relevant to this thesis is concern towards health risks and associated health costs (e.g., Ameriks et al., 2011; Sinclair and Smetters, 2004; Turra and Mitchell, 2008). Pang and Warshawsky (2010) showed that uncertain health spending will induce a portfolio shift to safer assets such as annuities because they are more efficient than bonds due to their mortality credits. Peijnenburg et al. (2017) found that the low voluntary annuitisation observed empirically can be largely explained by concern for medical expenditure, and the timing of medical expenditure is crucial. A medical cost shock early in retirement decreases annuity demand, while if the shock occurs later in life, demand instead increases. Reichling and Smetters (2015) suggested that a low or even negative amount of annuity (e.g., through life insurance) is optimal if considering stochastic mortality and correlated medical costs. Yogo (2016) found that, after considering housing wealth, health risks and associated medical expenditures in a life-cycle model, the asset allocation and health expenditure patterns in the US can be well explained. However, Zhao (2015) showed that, due to the offset of uncertainties in longevity and health expenses, even without bequest motives, individuals should neither fully insure their health expenses nor longevity risk.

The above-cited studies mostly focus on the role of uncertain health expenditures in retirement portfolios with annuities, equity and bonds but fail to consider access to health-contingent insurance products. Another strand of studies has investigated the possibility of bundled health and longevity insurance products (e.g., hybrid LTCI and life annuities) to increase the demand for both insurance products simultaneously (e.g., Brown and Warshawsky, 2013; Murtaugh et al., 2001; Webb, 2009; Wu et al., 2016). These focus on the advantages of combining health and longevity insurance products; although, with the exception of Wu et al. (2016), they do not study the most optimal situation where bundled insurance products are part of a retirement portfolio. Both strands of studies have identified the significance of health risks and health insurance during retirement planning. However, few have considered both health-contingent insurance and longevity insurance products explicitly in a life-cycle framework to examine choices of an optimal portfolio in retirement (Koijen et al., 2016; Wu et al., 2016). Specifically, individuals can choose to purchase life insurance, annuities and LTCI in Koijen et al. (2016), while in Wu et al. (2016) individuals can choose life care annuities (i.e., a bundled product comprising a life annuity and a disability-contingent annuity). None of these theoretical studies considers the impact of catastrophic medical expenditures and related health insurance products, such as CII, which are important considerations in countries with less-developed healthcare systems.

2.2.2 Demand for health-contingent insurance

Many have studied the impact of health status or health-related costs on portfolio choices and suggested that health crucially influences an agent's financial decision (e.g., Berkowitz and Qiu, 2006; Hambel, 2020; Hugonnier et al., 2013; Love and Smith, 2010; Pang and Warshawsky, 2010; Peijnenburg et al., 2017; Yogo, 2016). However, most of these studies exclusively consider the portfolio allocation problems in regard to bonds, equities and sometimes life insurance or housing. A limited number consider the role of LTCI in a portfolio choice (e.g., Ameriks et al., 2020; Davidoff, 2009; Koijen et al., 2016). Significantly less investigate the explicit demand for CII in a life-cycle model (Hambel, 2020; Schendel, 2014).

Critical illness insurance

CII was introduced in 1983 in South Africa. Since then, the product has successfully spread to many insurance markets, especially in Asia (Gatzert and Maegebier, 2015). The product typically provides a health-contingent lump sum benefit that can be used for any purpose including paying for medical expenditures. This makes CII popular in countries with potentially high OOP health costs.

Schendel (2014) studied the demand for CII in a life-cycle model with exogenous out-of-pocket health expenses. An individual can invest in bonds, equities, real estate and can purchase CII. Hambel (2020) considered a similar model but includes housing assets in the portfolio as well. Both concluded that CII is an excellent instrument for hedging health risk and consumption smoothing across different health states. Access to CII reduces the need for precautionary savings and leads to significant welfare gains.

Also, Schendel (2014) and Hambel (2020) found that optimal demand for CII is negatively related to financial wealth because wealthier individuals have better resources to cope with the impact of a health shock. Yet, the demand rises with income as higher-income individuals have greater consumption patterns and therefore require more CII coverage to maintain smoothed consumption streams. As well, they show that the optical demand decreases with age. With an insurance loading of 20%, more than half of retirees should contract CII (Schendel, 2014). For the preferences parameters, both studies found that optimal CII demand increases with risk aversion, but bequest motives offer little impact. However, Hambel (2020) stated the demand increases with time preference because a higher time preference puts more weight on the younger ages where a health shock has the largest impact. Conversely, Schendel (2014) found the demand decreases with time preference. The intuition is that the present cash flows have a higher value compared to future cash flows due to a higher time preference, which increases the value for the premium of CII but decreases the value of future insurance payments.

Empirically studies on demand for CII (either public or private) are limited in China. Ying et al. (2007) investigated the demand for CII explicitly by conducting a survey using contingent valuation methods. They find that males, income, higher education levels, working in private firms or self-employed (compared with unemployed), are positively associated with the demand for CII. In contrast, older adults (age 60 and above) and a higher premium are negatively associated with demand for CII. No significant associations are identified for health conditions and marital status. Swiss Re (2016) conducted a discrete choice experiment to study the demand for CII attributes among Chinese adults aged 30 to 80 years old. They find that disease coverage, premium levels, and insurance brands are the most important features. However, there are wide differences in preferences and these differences are only partially explained by demographic factors.

Long-term care insurance

There is a large strand of literature on LTCI demand. I first list several factors related to LTCI demand identified in developed countries. Next, I discuss several LTCI studies in China.

The largest supply-side factors related to private LTCI demand are costs and adverse selection. For example, Brown and Finkelstein (2007) found that prices of private LTCI were substantially higher than actuarially fair levels. Finkelstein and McGarry (2006) identified multiple dimensions of private information in the LTCI market. A recent study by Braun et al. (2019) consistently found that administrative costs and adverse selection are the reasons for low take-up rates for the rich. Further, Murtaugh et al. (2001) and Brown and Warshawsky (2013) showed that combining annuities and LTCI could reduce adverse selection in their separate insurance markets and minimise the underwriting process to achieve a lower insurance cost and a potential larger insurance market.

However, Brown and Finkelstein (2007) demonstrated that the small market for private LTCI in the US is unlikely to be sufficiently explained by the market failure from the supply side. Several demand-side factors also contribute to the low coverage of private LTCI. In particular, public LTCI could crowd out the demand for private LTCI while other approaches such as self-insurance and home equity could offer alternative ways to finance long-term care services. For example, Brown and Finkelstein (2008) demonstrated that public insurance (Medicaid) has a large impact on crowding out private LTCI such that even with an actuarially fair price for private LTCI, the bottom two-thirds of the wealth distribution would be better off without private LTCI, due to a means-tested LTC benefit program from Medicaid. Also, Braun et al. (2019) discovered that Medicaid accounts for the low LTCI take-up rate of poorer individuals. Ameriks et al. (2020) showed that self-insurance against long-term-care risk explains a substantial fraction of the wealth holding of many older Americans. Davidoff (2009) demonstrated that annuities and LTCI become less attractive and may become substitutes rather than complements if consumers only liquidate home equity in the event of illness or very old age.

As well, recent studies have identified potential behavioural factors related to LTCI demand. For example, Gottlieb and Mitchell (2020) found that participants subject to narrow framing are less likely to buy LTCI, and the effect is much larger than that of risk aversion or adverse selection based on the Health and Retirement Study. Eling et al. (2021) found a positive association between willingness to take financial risk and LTCI and life insurance based on the Survey of Health, Ageing and Retirement in Europe. This finding could not be explained in the classic expected utility framework, and behavioural models with prospect theory are likely needed.

In China, public LTCI programs are still in a pilot phase while private LTCI products are nigh-non-existent. Limited studies have examined the demand for LTCI. For example, Wang et al. (2017) used contingent valuation to study the willingness to pay for LTCI and to explore the determinants of LTCI demand. Their study design is very similar to Ying et al. (2007) who studied the demand for CII in China. Wang et al. (2017) found that premium, age, are negatively associated with LTCI demand, while education and income are positively associated with it. Gender, marital status, and having chronic conditions do not show significant effects.

Also, several studies examine the revealed and stated preferences for private health insurance in China. However, they do not distinguish between CII and LTCI because the overall take-up rates of private health insurance are low. For example, Wan et al. (2020) used nationally representative data from the China Household Finance Survey in 2017 for individuals aged 18 years and above. They found that socioeconomic factors are significantly associated with the demand for private health insurance. Wo et al. (2020) surveyed the demand for tax-subsidised private health insurance. Both studies show that educational level is positively associated with the demand for private health insurance, while there is no significant effect of being married. For the other factors, Wan et al. (2020) found that income, working in firms (compared to government-related institutes), good health, having purchased private insurance before, having middle-sized medical expenditures, are positively associated with the demand for private health insurance, while age, household size, living in rural areas show negative influences. Gender, Hukou and being retired show no significant effects. Wo et al. (2020) found that number of elderly supported with no disease history and better knowledge of private health insurance are positively associated with the demand for private health insurance. Gender, age, number of children, disease at present and family disease history show no significant effects.

2.2.3 Experimental studies for retirement insurance products

There is a strand of literature that uses hypothetical surveys to understand the demand for retirement insurance products including life annuities or health-related insurance (Bateman et al., 2018; Brown et al., 2019, 2017b; Wang et al., 2017; Wu et al., 2018b; Ying et al., 2007). Most of these studies focus on the design or specific behavioural issues for one type of insurance. For annuities, the studies include individual capability and effort (Bateman et al., 2018), the complexity of annuity products (Brown et al., 2019), cognitive constraints (Brown et al., 2017a), framing (Beshears et al., 2014; Bockweg et al., 2017; Brown et al., 2008), and insurance attributes such as periods for guaranteed annuity payments (Chou et al., 2016; Shu et al., 2015), and payment paths (e.g., Beshears et al., 2014; Shu et al., 2015). For health-related insurance, the studies include attributes of CII (Swiss Re, 2016; Ying et al., 2007) and attributes of LTCI (Wang et al., 2017). These attributes of retirement insurance are important considerations for individuals with heterogeneous health risks. More importantly, as Koijen et al. (2016) have emphasised, retirement planning should consider a portfolio of retirement insurance products simultaneously, rather than product by product. To the best of my knowledge, Wu et al. (2018b) is the only experimental study that investigates individuals' demand for both longevity insurance and health-related insurance (LTCI). More research to study consumers' demand for health and longevity products from an overall portfolio allocation perspective is therefore necessary.

It is also important to note that health systems can have a large impact on out-of-pocket medical expenditures, for example, the out-of-pocket health costs in Europe are negligible Peijnenburg et al. (2016). The above-cited studies mostly focus on developed countries, where the health care systems are much more advanced than in developing countries. In the COVID-19 pandemic, under a less well-developed health care system, the risks of out-of-pocket medical expenditures for critical illnesses and care-related costs can be substantial. It is therefore important to study how individuals living in developing countries plan for retirement in the pandemic.

2.3 Ambient air pollution on health

Ambient air pollution, in contrast to household air pollution, is a general term that refers to air pollution in outdoor environments. Its major pollutants include ozone, nitrogen dioxide, sulphur dioxide, and particulate matter in the air, such as dust and smoke from wildfires and agricultural burns. Among these pollutants, particulate matter is often used as a proxy for air pollution because it affects more people than any other pollutant. Particulate matter less than 10 micrometres in diameter (PM_{10}) can be inhaled into and accumulate in the respiratory system, while particulate matter less than 2.5 micrometres in diameter ($PM_{2.5}$) poses the greatest health risks as it can penetrate the lung barrier and enter the blood system due to its small sizes. A high level of concentrations of air pollutants can adversely affect human health (Brunekreef and Holgate, 2002), and Ebenstein et al. (2017) suggest that particulate matter is the largest environmental risk to health. World Health Organisation estimates that about 90% of the world's population lives in places where the quality of air pollution exceeds WHO's limit (World Health Organization, 2016). Among these places, developing countries experience the highest burden.

Many studies have investigated the association between mortality and air pollution. For example, the Global Burden of Disease Study (GBD 2015 Risk Factors Collaborators, 2016) estimates that $PM_{2.5}$ accounts for worldwide 4.2 million premature deaths per year due to cardiovascular and respiratory diseases and lung cancers, and about 88% of these deaths occur in developing countries.[9] In China, Ebenstein et al. (2017) and Chen et al. (2013) estimate that a 10-µg/m^3 increase of PM_{10} reduces life expectancy by 0.64 years, based on a quasi-experiment with China's regional policy of indoor heating. Other studies find positive associations between disease-specific mortality and air pollution (e.g., Liu et al., 2018; Mokoena et al., 2019; Yin et al., 2017; Zhou et al., 2015).

Other than mortality, disease incidence, cognitive impairment, and disability status are key overall health indicators of self-care and independent living for the old, and they are important for pricing and risk management of relevant insurance products, especially CII, and LTCI. However, compared with the literature on mortality and air pollution, the health effects on diseases, cognitive impairment, and disability status are less investigated. In the remaining part of this section, I summarise the studies on the associations between the three health indicators and air pollution.

Disease

Adverse associations between air pollution and diseases have been documented by studies from developed countries (e.g., Bai et al., 2019; Cesaroni et al., 2014; Je et al., 2015; Miller et al., 2007; Peters et al., 2019; Stafoggia et al., 2014). In China, for cardiovascular diseases, based on a large-scale population-based prospective cohort study and satellite-based $PM_{2.5}$ estimates, Li et al. (2020) find that an increase of 10 µg/m^3 in long-term exposure to $PM_{2.5}$ is linked to a 40% higher hazard ratio for coronary heart disease (CHD). The elderly and the hypertensive individuals were more sensitive to $PM_{2.5}$-induced CHD. Huang et al. (2019a) and Liang et al. (2020) find that the health effect of $PM_{2.5}$ on CHD is larger than that on stroke. Other studies suggest that long-term exposure to $PM_{2.5}$ is linked to a higher risk of CVD factors such as hypertension and diabetes (Huang et al., 2019b; Liang et al., 2019; Lin et al., 2017a; Liu et al., 2017a, 2016a). For respiratory diseases, Wang et al. (2018) find that exposure to annual average $PM_{2.5}$ of 50 µg/m^3 or higher is positively associated with the risk of chronic obstructive pulmonary disease (COPD), and the odds ratio is comparable to that of smoking exposure of 20 years or

[9]Please refer to a recent meta-analysis for the association between air pollution and mortality (Orellano et al., 2020).

more, based on a cross-sectional design with more than 50,000 adults older than 20 years. Other studies find a positive link between air pollution and Parkinson's disease (Liu et al., 2016c) as well as mental health and depression (Ren et al., 2019; Zhang et al., 2017b).

However, few studies investigate the association between air pollution and co-morbidity or multimorbidity. Zeng et al. (2010) and Hu et al. (2020) identify an adverse effect of air pollution on the incidence of frailty, which is a multi-dimensional health measure including the total number of diseases, cognition, mental health, disability, heart rhythm, self-rated and interviewer-reported health status. Both studies find no significant results that individual socio-economics factors modify the effect of air pollution. However, Hu et al. (2020) state that the impact of air pollution on frailty depends on past exposure to air pollution, i.e., the elderly living in areas where air pollution increased were associated with noticeable increases in frailty compared with those living areas where air pollution remained relatively unchanged.

Cognition

Many studies have found an adverse impact of air pollution on cognition in developed countries (e.g., Gatto et al., 2014; Power et al., 2016; Tzivian et al., 2015; Weuve et al., 2012).[10] In China, several studies on air pollution and cognitive impairment have used the sample from the Chinese Longitudinal Healthy Longevity Survey (CLHLS). For example, both Sun and Gu (2008) and (Zeng et al., 2010) use an air pollution index as the proxy for air pollution from the 2002 wave of CLHLS, and they find an adverse association between air pollution and cognition. However, contrary to the finding in the developed countries that the health effect of air pollution is stronger in less wealthy areas, results in Sun and Gu (2008) show that old residents living in more developed urban areas are more susceptible to the effect of air pollution, compared with those living in less developed urban areas, while results in Zeng et al. (2010) do not support whether living in urban or rural areas modifies the health effect of air pollution on cognition.

[10] Please refer to Delgado-Saborit et al. (2021) and Clifford et al. (2016) for recent systematic reviews on the associations between air pollution and cognitive function.

Wang et al. (2020) used a satellite-based $PM_{2.5}$ dataset and the CLHLS data from 2002 to 2014. They find that 10-µg/m^3 increase in $PM_{2.5}$ was associated with a 5% increased hazard ratio of poorer cognitive function. This association is stronger for males than females and is weakest for the adults aged 100 years or older but similar for the younger age groups. Similar to Zeng et al. (2010), they do not find evidence whether residing in urban or rural areas modifies the effect of air pollution on cognition. Zhang et al. (2018) use a younger sample (aged ten and older) from the 2010 and 2013 waves of the China Family Panel Studies. They consider both the transitory (daily exposure) and cumulative (annual exposure) effects of air pollution on cognition and find that only annual exposure to air pollution lowers cognitive performance in verbal and math tests. This effect is more pronounced for males, older people and the less educated.

Disability

Physical limitations are common consequences of diseases associated with air pollution exposure, such as heart diseases, stroke, lung cancers and hypertension. It is possible that air pollution also affects physical functioning. Globally, a cross-sectional analysis in six low- and middle-income countries (i.e., China, Ghana, India, Mexico, Russia, and South Africa) supports the view that exposure to $PM_{2.5}$ is positively associated with disability (Lin et al., 2017b). In developed countries, a prospective cohort study in the US finds that long-term exposure to traffic-related air pollution (NO_x) is positively associated with disability progression for individuals over 65 years old (Weuve et al., 2016). However, a prospective cohort study among old Dutch adults (De Zwart et al., 2018) finds that most air pollutants (e.g., NO_2, NO_x, PM_{10} and $PM_{2.5}$) are associated with reduced performance-based physical disabilities (e.g., walking speed, ability to rise from a chair, balance test), but the results are generally not significant with self-reported disabilities (e.g., getting up and down in a chair, bathing, dressing).

In China, Zeng et al. (2010) showed that a higher air pollution index is associated with a 25% higher risk of ADL disability using the 2002 wave of the CLHLS data. Lv et al. (2020) use the CLHLS data from 2002 to 2014 for the oldest old population (more than 85 years old) and satellite-based $PM_{2.5}$ dataset. They find a J-shaped association between

$PM_{2.5}$ exposure and ADL disability with a threshold at 33 µg/m^3. Above the threshold, an increase of 10 µg/m^3 corresponds to a 7.7% increase of the risk of ADL disability. However, their estimation approach uses a fixed degree of freedom and does not allow for a more flexible non-linear relationship. They find that men, smokers and participants with cognitive impairment are more sensitive to $PM_{2.5}$ exposure.

2.4 Conclusion

Prior studies on the demand for retirement insurance indicate the importance of considering health risks and related expenditures in retirement planning (e.g., Ameriks et al., 2020; De Nardi et al., 2010; Pang and Warshawsky, 2010; Peijnenburg et al., 2017; Reichling and Smetters, 2015; Yogo, 2016), and the importance of considering a portfolio of retirement insurance products simultaneously, rather than product by product (e.g., Koijen et al., 2016). However, there are several gaps in the literature.

First, theoretical studies on the optimal consumption and portfolio allocation with longevity and health-contingent insurance are still rare, and most of them consider annuities and LTCI or life care annuity (e.g., Davidoff, 2009; Koijen et al., 2016; Wu et al., 2016), while insurance that pays a lump sum benefit which could potentially cover catastrophic medical expenditures, such as CII, is missing in the retirement portfolio. A limited group of studies have investigated the role of CII in a portfolio such as Schendel (2014) and Hambel (2020), although both fail to consider access to annuities or LTCI. No study covers access to life annuities, CII and LTCI in a retirement portfolio simultaneously, and access to these such products can be crucial in developing countries where public insurance only provides basic coverage. Second, health state-dependent utility of consumption can have a substantial effect on retirement planning (e.g., Blundell et al., 2020; Brown et al., 2016a; Finkelstein et al., 2013), and it is especially relevant in a life-cycle model with health risks and costs. Yet, studies on optimal retirement portfolio mostly do not consider it, and some find it has little impact on optimal annuity demand (e.g., Peijnenburg et al., 2017; Wu et al., 2016). The role of this parameter in optimal insurance is under-investigated, especially in cases of illness and disability, because empirical studies found evidence that the marginal utility of consumption is higher in one state but lower in the other (e.g., Finkelstein et al. 2013, Ameriks et al. 2020 in the US and Wang and Wang, 2020 in China). Third, empirical studies to understand consumers' preference for retirement portfolios including both longevity and health-contingent insurance products are limited. Most of these studies focus on specific issues for one type of insurance, i.e., annuities (e.g., Bateman et al., 2018; Beshears et al., 2014; Brown et al., 2019, 2017b; Lee et al., 2019), CII (Ying et al., 2007) or LTCI (Wang et al., 2021, 2017). Few of the studies consider retirement insurance choice in a portfolio allocation framework (Bateman et al., 2016; Wu et al., 2018b) and generally include longevity or health-contingent insurance products (Wu et al., 2018b is the exception). There is no exploration of stated choices of portfolios of retirement insurance including a life annuity, LTCI, and CII. As well, the effect of the COVID-19 pandemic on preferences for retirement insurance is largely unknown. Lastly, existing studies mostly focus on developed economies, and more research is needed for developing countries.

Prior studies on the association between air pollution and health have shifted from a cross-sectional design (e.g., Zeng et al., 2010) to a cohort design (e.g., Hu et al., 2020; Lv et al., 2020; Zhang et al., 2018), and more recent studies (e.g., Lv et al., 2020; Wang et al., 2020) start to use satellite-based $PM_{2.5}$ rather than air pollution indices which are less accurate and limited in location and time. Importantly, most of the prior studies only consider the effect of current exposure to air pollution. However, diseases, cognition or disability have a correlation with progressive and chronic effects wrought by $PM_{2.5}$ exposure. Potential risk factors such as past exposure to air pollution and year-over-year growth of air pollution exposure that measure long-term accumulative exposure and growth rates of local air pollution are mostly not considered in the previous studies. In particular, how past air pollution exposure can modify the effect of current exposure to air pollution is largely unknown. In addition, the assumption of linear health effects of air pollution exposure can be less appropriate in developing countries because the level of $PM_{2.5}$ concentrations can be more than five times that in developed countries. However, only limited studies consider studying non-linear associations between air pollution and health, but with limited degrees of freedom set prior to estimation (e.g., Lv et al., 2020).

As well, most studies on the health effect of air pollution on diseases focus on a single type of illness (e.g., Li et al., 2020; Liang et al., 2020; Liu et al., 2016c; Ren et al., 2019; Wang et al., 2018; Zhang et al., 2017b), while few studies have focused on aggregate measures that are helpful for a broader perspective such as clinical planning and retirement planning (Zeng et al. (2010) and Hu et al. (2020) are two exceptions but their measure is too general). Lastly, population segments that are more sensitive to air pollution do not have conclusive results even in studies with similar samples and study designs (e.g., Hu et al., 2020; Lv et al., 2020; Zeng et al., 2010). More research using consistent modelling strategies and comparable samples is necessary to understand which groups are more sensitive to air pollution according to different health measures.

These issues are addressed in the subsequent chapters of this thesis.

Chapter 3

The demand for longevity, critical illness insurance and long-term care insurance in the wake of the COVID-19 pandemic

3.1 Introduction

Rapid population ageing has put pressure on the ability of social insurance systems to spread demographic and economic shocks across different generations. The decline of economic activities following the COVID-19 pandemic further adversely affects retirement systems in both developed and developing countries (Mitchell, 2020). Individuals are increasingly required to take on greater responsibility for managing risks they face in retirement. Life annuities have been identified as the appropriate product to address longevity risk (Davidoff et al., 2005; Yaari, 1965), yet the demand has been inhibited by precautionary savings due to uncertain health expenditures (Ameriks et al., 2020; De Nardi et al., 2010; Peijnenburg et al., 2017; Reichling and Smetters, 2015). In the wake of the

COVID-19 pandemic, the elderly group is most vulnerable. Concerns about health-related risks have surged, which could further affect the demand for both longevity and health-related insurance. Therefore, it is essential to understand how people close to retirement plan for longevity and healthcare risks in the aftermath of the pandemic, especially for those living in developing countries, where healthcare systems are often less capable of providing adequate cover for catastrophic medical expenditures and long-term care (LTC) costs.

To address these issues, we designed an online survey with embedded choice tasks to study the preferences for retirement insurance products to address emerging longevity and health-related risks.[1] We aim to answer three questions: First, what are the stated preferences for alternative portfolios of longevity and health-contingent insurance products, and how are the stated preferences for portfolios of retirement insurance products influenced by personal characteristics? Second, what factors are associated with the demand for longevity insurance, and in particular, does access to health-contingent insurance products release precautionary savings for purchasing life annuities? Third, how do experience with and attitudes towards COVID-19 influence annuity demand and preferences for retirement portfolios that include health-contingent insurance?

We conducted the survey in China, which is particularly suitable for this research. China is the country where COVID-19 was first detected, and severe lockdown measures were imposed for several months in cities with virus outbreaks. Additionally, China represents a country with a less well-developed public insurance system and immature private insurance markets.[2] The sustainability of the public pension system is of great concern, and it is unlikely to provide adequate resources to fund retirement in the future (Fang and Feng, 2020). In addition, individuals may be subject to catastrophic medical expenditures due to a limited public healthcare system, which has insufficient cover for critical illnesses (CIs) (Hou et al., 2014; Meng et al., 2012; Zhang et al., 2017a) and only partial insurance cover for LTC (Zhu and Österle, 2019).

[1] Health-related risks include uncertain catastrophic medical expenditures and long-term care costs.

[2] Chapter 2.1 provides a brief background of China's public and private insurance in retirement.

In the online survey, near-retirement individuals from major cities in China were invited to allocate retirement wealth between a savings account and three retirement insurance products: a life annuity that provides income for life, LTC insurance (LTCI) that provides disability-contingent income, and CI insurance (CII) that provides a health-contingent lump-sum payment. The payments from LTCI and CII can be used for any purpose, including paying for LTC services or medical expenditures associated with a CI. To simplify the complex task of allocating between four options (three retirement insurance products and a savings account) - the main survey task was simplified into nine sequential allocations between a savings account and life annuity with different fixed cover for out-of-pocket (OOP) CI and LTC costs, followed by a best/worst choice task to elicit the most preferred allocation of retirement insurance products. The survey concluded with collection of information on exposure to health risks, retirement planning, personality traits and preferences, financial competence, demographics, and COVID-19 related experiences and attitudes.

Following the related literature, the results confirm the significance of health risks and the associated uncertain costs in retirement planning. Although such health risks and related costs could make annuities more appealing (Pang and Warshawsky, 2010), most studies have found that they can explain low voluntary annuitisation rates (e.g., Peijnenburg et al., 2017; Sinclair and Smetters, 2004; Turra and Mitchell, 2008) and even make a negative amount of annuity optimal (Reichling and Smetters, 2015). Importantly, with multiple types of risks, Koijen et al. (2016) suggested that insurance cover should be considered comprehensively rather than product by product. On average, the most preferred retirement portfolio comprises health-contingent insurance that covers 50% of the expected OOP costs for CI and LTC and a monthly annuity income of about 19.6% of average disposable income in urban China, with the remaining wealth allocated to a savings account. Purchasing insurance cover for 50% of the expected OOP costs of CI or LTC is likely to release precautionary savings for an annuity purchase of about 1.2% to 1.5% of the average disposable income.

These results also link the present study to the ‘annuity puzzle’ literature (Benartzi et al., 2011; Brown, 2009; Inkmann et al., 2011; Pashchenko, 2013; Peijnenburg et al., 2017). We also found substantial stated demand for annuities in contrast to extremely low voluntary annuitisation in China.

This study is also related to the literature using hypothetical choice tasks to understand the demand for retirement insurance products, including life annuities and health-related insurance. Most studies have focused on specific issues for one type of insurance, such as annuities (e.g., Bateman et al., 2018; Beshears et al., 2014; Brown et al., 2019, 2017b), CII (e.g., Ying et al., 2007), and LTCI (e.g., Wang et al., 2017). Few studies have considered the retirement insurance choice in a portfolio allocation framework (Bateman et al., 2016; Wu et al., 2018b) and generally have included the consideration of longevity or health-contingent insurance products (except Wu et al., 2018b). We contribute to this literature by demonstrating that a complex four-product allocation can be simplified to a two-stage design consisting of conditional choice tasks in the first stage and best/worst elicitation of conditional choices in the second stage. This promising design has the potential to be applied to other portfolio selection problems involving multiple products. To the best of our knowledge, we provide the first exploration of stated choices of retirement insurance product portfolios, including a savings account, a life annuity, LTCI, and CII, following the outbreak of COVID-19.

This study highlights the importance of individual heterogeneity in the most preferred retirement portfolio and, therefore, in the extent of the cover of LTCI and CII (i.e., health-contingent insurance). We found that factors such as wealth and income, understanding retirement insurance products, financial capabilities, personality traits, preferences, and intended spending in retirement are associated with preferences for health-contingent insurance. In particular, a higher preference to spend more in a poor health state is linked to a lower preference for retirement portfolios with more cover of health-contingent insurance. Moreover, individuals tend to use health-contingent insurance to cover uncertain health costs to leave a bequest. Several findings regarding insignificant associations are worth mentioning. We also discovered that most of the variables included in measuring one's own and family health experiences are not associated with the preference for health-contingent insurance, but several are linked with annuity demand.

There is also substantial variation in annuity demand. Demographics and socioeconomic factors, personality traits, preferences, and intended spending in retirement are all associated with annuity demand. Interestingly, A higher appetite for taking risks in financial matters is linked with a higher stated demand for annuities. A better understanding of retirement insurance products and better financial capabilities are linked to a lower stated annuity demand. The results also suggest the potential for selection in the annuity market, which is not due to subjective information, such as subjective survival expectations or comparison with peers, but to objective information, such as observed illness within a family and such health measures as body mass index (BMI).

The survey was administered in 2020; thus, we had the opportunity to explore the influence of COVID-19 on preferences for retirement insurance products. Mental health problems due to COVID-19 were negatively associated with both annuity demand and preferences for health-contingent insurance. Purchasers of COVID-19 insurance exhibit a unique risk appetite, revealing a strong positive preference for the full cover of health-contingent insurance but a strong negative preference for longevity insurance. Undertaking more risky behaviour following the relaxation of lockdowns was associated with a lower preference for health-contingent insurance but exhibited no significant association with annuity demand.

Overall, this study contributes to the growing literature on financial planning with retirement insurance products. This study confirms that access to health-contingent insurance can release precautionary savings for the purchase of life annuities, which links the study to theoretical studies with life-cycle models highlighting the significance of health risks and associated uncertain costs in retirement planning (e.g., Pang and Warshawsky, 2010; Peijnenburg et al., 2017; Reichling and Smetters, 2015).

This study is the first to examine the demand for annuities, CII, and LTCI in a portfolio allocation framework using an online experimental survey. Most literature employing survey methods to study insurance demand focus on specific issues for one type of these insurance products (e.g., Bateman et al., 2018; Beshears et al., 2014; Brown et al., 2019, 2017b; Wang et al., 2021, 2017; Ying et al., 2007). Findings highlight the importance of heterogeneity in retirement insurance demand. We confirmed a wide range of factors associated with the demand for retirement insurance, such as financial literacy and numeracy (e.g., Banks and Oldfield, 2007; Lusardi and Mitchell, 2011; Van Rooij et al., 2011), and health state-dependent utility (e.g., Blundell et al., 2020; Brown et al., 2016a; Finkelstein et al., 2013).

This study also examines how experiences and attitudes towards COVID-19 influence insurance demand (e.g., Qian, 2021). Another strength of this study is that we observed the demand for longevity and health-contingent insurance for the same sample; thus, the identified associations provide valuable insight into the design of bundled longevity and health-contingent insurance products (Brown and Warshawsky, 2013; Murtaugh et al., 2001; Webb, 2009). We demonstrate that the two-stage embedded choice task is a promising design for simplifying the portfolio allocation task with multiple financial products, and this design can be applied to studies facing similar problems. Lastly, most studies on retirement insurance demand focus on developed countries; therefore, by conducting a study in China, we provide an important contribution to the development of both public and private insurance in developing countries facing population ageing and incomplete insurance markets.

This study can inform policy development in the context of the 14th Five-Year Plan (2021 to 2025), which promotes the development of commercial retirement insurance and the integration of commercial insurance in social services. For policymakers, these results suggest that a demand exists to insure around 50% of the uncertain OOP health costs due to CI and LTC and that a substantial demand exists for regular income of around 19.6% of the average disposable income in urban China. These results provide empirical evidence to inform policymakers about the expansion of social insurance and cooperation with private insurers.

For insurers, these findings provide insight into the design of bundled longevity and health insurance products, and we identified a wide range of individual factors that can assist advisers in providing better risk management services. First, we discovered evidence of selection in longevity insurance but not in health-contingent insurance, and we reveal how bundled insurance products can increase annuity demand. Second, this study indicates that individual characteristics and preferences alone could separate the market for annuities and health insurance regardless of one's health status. Finally, the results suggest that individuals treat life annuities as investment products and consider them risky and less attractive. Insurers may need to consider a consumption framing for annuities to make them more appealing.

This chapter is organised as follows. In Section 3.2, we describe the online survey and embedded choice tasks. Section 3.3 presents summary statistics, preferences for alternative retirement insurance portfolios, annuity choices, and the experience of COVID-19. In Section 3.4, we discuss the regression results, and finally, Section 3.5 concludes the study.

3.2 Eliciting choices for retirement insurance products

Individuals from major cities in China[3] were invited to participate in an online survey about decisions to allocate household wealth at retirement among a selection of retirement insurance products. The embedded choice tasks focus on answering two research questions. First, what are the stated preferences for alternative retirement portfolios comprising a life annuity, CII, LTCI, and a savings account? Second, does access to health-contingent insurance release precautionary savings for the purchase of life annuities? To reduce the complexity of the allocation of retirement wealth across the four financial products, we simplified the decision to a two-stage choice task. In the first stage, participants completed nine sequential allocation tasks between a savings account[4] (i.e., risk-free growth) and a life annuity, each with a different level of cover for OOP costs of CI and LTC (0%, 50%,

[3]We included 52 cities, covering all Tier 1 and New Tier 1 cities (quota: 20% of the total participants) and most Tier 2 and 3 cities (quota: 60% and 20% of the total participants, respectively). The classification is based on the '2018 Most Commercial Charming Cities in China' published by *Yicai*, a financial magazine in China. Wuhan, the city where the virus was first detected, is included. The participants were randomly sampled to meet the requirements for the included cities and the quotas set for the tiers.

[4]A savings account that grows at a risk-free rate is the typical option for saving in China, as the financial markets are relatively unsophisticated.

or 100% cover). In the second stage, participants completed a sequence of best/worst choice tasks to elicit their most preferred of the nine possible allocations. After the choice task, we collected information on personal characteristics, preferences, and experiences with COVID-19 to investigate the factors influencing preferences for retirement insurance portfolios. The survey was drafted in English and then tested and administered in Chinese.

The survey structure is illustrated in Figure 3.1. The survey starts with preliminary questions to select eligible participants and allocate them to the wealth and pension groups closest to their financial circumstances. Module 1 introduces the retirement insurance products included in the choice task and concludes with a quiz to test and enhance their understanding of the product characteristics. Module 2 collects their stated choices. Participants completed a sequence of choice tasks to select their preferred allocation of their retirement wealth across a savings account and three retirement insurance products: a life annuity, CII and LTCI. The remaining modules ask questions about additional product attributes (Module 3) and personal characteristics, such as risk and time preferences, health state-dependent consumption, financial competence, and personality traits (Module 4), the effects of COVID-19 (Module 5) and other background information, such as demographics and socioeconomic indicators that may help explain the preferences for the retirement portfolios (Module 6).

3.2.1 Sample

We targeted near-retirement urban Chinese rather than the entire population because the socioeconomic differences between rural and urban Chinese are significant, and for this group, the consideration of retirement planning and risks in retirement is current.[5] The survey was conducted in August and September of 2020. It can be accessed online, and the

[5]The public health system in China has different insurance schemes for the rural and urban populations (Zhang et al., 2017a). The rural population is less likely to purchase private insurance because of the crowding-out effect of urban medical insurance (Jin et al., 2016). Compared to the urban population, residents of rural areas have significantly higher incidence rates and mortality rates for critical illnesses, such as cancers (Chen et al., 2016). Further, rural and urban populations exhibit considerable differences in family size, pension, income, savings rates and education (Chamon et al., 2013; Liu et al., 2016b).

Preliminary screening
Age 45 to 69, not retired, no history of CI, no help needed to perform three or more ADLs
Allocated to groups matching gender (2), wealth (4) and expected pension (5)

Background information and retirement insurance products
Module 1: Introduce each type of risk in retirement, the product (annuity, CII, or LTCI) to cover it, and a savings account
Quiz to test and enhance the knowledge of the four financial products

Choice task
Module 2: Preference for retirement portfolios

- Stage 1: Choice of annuitisation in nine tasks with different cover levels of CII and LTCI

	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Task 9
CII cover	0%	50%	100%	0%	0%	50%	100%	50%	100%
LTCI cover	0%	0%	0%	50%	100%	50%	50%	100%	100%

- Stage 2: Rank the nine portfolios from Stage 1 (select most and least preferred portfolios from each of 12 choice sets of three portfolios, following a balanced incomplete design)

Survey questions
Module 3: Separately Rank four additional attributes for each of the annuity, CII and LTCI
Module 4: Questions on retirement planning, health, preferences, personality traits and financial competence
Module 5: Questions on experiences with and attitudes towards COVID-19
Module 6: Questions on demographics and socioeconomics

Figure 3.1: Survey overview

Notes: ADLs: activities of daily living including bathing, dressing, toileting, getting in or out of bed, continence, and feeding; CII: critical illness insurance; LTCI: long-term care insurance.

survey screenshots are available in English (translated, Supplementary Materials A.1.1) and in Chinese (Supplementary Materials A.1.2).[6] Our sample includes 1,000 people ages 45 to 69 years old (45 to 59 for females and 55 to 69 for males) not yet retired from a large commercial web panel maintained by dataSpring.[7] We included people beyond

[6]The online surveys can be accessed using the following links: `https://pro.wenjuan.com/s2/ed9e935f47c050001a75bb5/?test_mode=1` (English version), and `https://pro.wenjuan.com/s2/5ef01abfcabdf500010c25a8/?test_mode=1` (Chinese version).

[7]DataSpring is a market research company based in Japan, providing high-quality online and mobile samples in Asia, survey software tools, and data collection operations. DataSpring recruited participants

the statutory retirement ages (50 and 55 for females with ordinary or management roles, respectively, and 60 for males) because it is common for people to continue to work after reaching the official retirement age (Zhao et al., 2013). We set a quota to ensure an equal number of males and females and did not include individuals who reported that they were ‘retired’, ‘previously diagnosed with a CI’, or ‘unable to perform at least three of the six activities of daily living (ADLs), including bathing, dressing, toileting, getting in or out of bed, continence, and feeding’, because we wanted to avoid the effect of actual experiences with any of the retirement insurance products.

The eligible participants were assigned to different groups to match their gender (2), wealth (4), and (expected) pension income (5). We did this to ensure that the hypothetical scenarios presented to participants were not too far from their actual circumstances. The four hypothetical wealth levels (CNY 150,000, CNY 300,000, CNY 500,000, and CNY 1,000,000) were chosen based on the distribution of total wealth of a matched China Health and Retirement Longitudinal Study (CHARLS) sample comprising non-retired urban individuals. The five monthly pension levels (CNY 500, CNY 1,000, CNY 2,000, CNY 3,000, and CNY 3,500) were based on the average pension income published by sub-national Chinese governments in 2020 and by Fang and Feng (2020) and Zhu and Walker (2018). Participants were allocated to the wealth and pension groups closest to the financial information they provided at the start of the survey. They were recruited by email invitation and received a flat payment about CNY 50 after completing the survey and a bonus payment of up to about CNY 20 based on their performance on a quiz designed to test their understanding of the retirement financial products introduced in the survey.[8]

by email invitation. Participants who were interested in participating in the project registered for the online survey with the research company.

[8]We did not provide an incentive-compatible reward mechanism because of the complexity of information needed for retirement planning and the limitation of the online platform (e.g., no moderators to ensure the understanding of the remuneration process). Aside from that, the amount of monetary reward is too low to be comparable in real life (Noussair et al., 2014). However, Miller et al. (2011) found that hypothetical surveys without a compatible incentive can still generate correct demand curves and pricing decisions.

3.2.2 Retirement insurance products

Following the preliminary screening, before completing the choice task, participants proceeded to Module 1, where they read information about the health-related and longevity risks they may face in retirement and the expected costs:

- For longevity risk, participants were told that a life annuity provides a regular inflation-adjusted monthly income as long as the insured is alive.
- For health-related CI risks, participants were told that CII provides an inflation-adjusted one-off payment if the insured is diagnosed with one of 25 critical conditions (e.g., cancer, stroke, or heart attack) and qualification for CII payments if infected by COVID-19.[9]
- For health-related LTC risks, participants were told that LTCI provides an inflation-adjusted monthly income during periods that the insured needs LTC, defined as needing help to complete three or more of the six ADLs: bathing, dressing, toileting, getting in or out of bed, continence, and feeding.[10]

We follow standard insurance pricing practice in China, and the details are provided in Appendix 3.6.3. For all three products, participants were told that if the insured dies, the payments stop, and no refund is provided. They were also shown a description of the savings account, which is an option if participants do not want to spend all or any of their wealth on retirement insurance products.[11] We include a savings account rather than stocks in our retirement portfolio for three reasons. First, retirees in China tend to save in low return savings accounts rather than invest in the stock market which is more

[9] The 25 conditions were standard according to the China Bank and Insurance Regulatory Commission (CBIRC) before an update of the standard in 2020. The official update had not been released by the time the survey was distributed.

[10] The definition of the long-term care state is not consistent in China. For example, hospitals and long-term care facilities can use a comprehensive array (e.g., ADLs and instrumental ADLs) to measure the need for care. The commercial insurance market usually uses three or more of the six ADLs or dementia for long-term care qualification, but the definition is not consistent across different providers.

[11] The 4^{th}, a savings account, is included in the introduction to reduce the potential bias due to the emphasis on retirement insurance products, as it is also an important component of a retirement portfolio.

typical in developed countries. The average stock market participation rate in China is about 8%, compared to 50% in the US (Chen and Ji, 2017) and is even lower among the elderly. Data collected in the latest CHARLS in 2018 shows that less than 5% of people aged 50-69, still working and living in an urban area (our sub-population of interest) participate in the stock market. Second, we wanted to be able to compare the results from the stated choice study in this chapter with the life-cycle model presented in Chapter 4. Given that we already include three retirement insurance products, we decided against adding further complexity to that model with the inclusion of risky assets. Finally, we wanted to minimise complexity for survey participants in the choice tasks, which already asked participants to allocate wealth across three retirement insurance products.

Each insurance product was introduced directly after presenting the risk and cost the product was designed to cover to minimise the cognitive burden of processing new information. For example, the CII was explained immediately after the information about the costs associated with CI. There are also complementary public arrangements in China; therefore, we also presented information on the average pension and health-related benefits that a typical urban retiree could expect to receive from China's public insurance scheme. We presented participants with the relevant health risk information by gender, including life expectancies associated with official retirement ages and the cumulative probabilities of obtaining CI or needing LTC.

To encourage participants to read the product information carefully, we informed them that their knowledge of the three retirement insurance products and the savings account would be tested in a quiz and that they would receive a bonus payment determined by the number of questions correctly answered. After completing the quiz, we showed participants the correct answers to further enhance their understanding of the products.

Focus groups were conducted in Beijing in January 2019 to inform the naming of the products used in the survey, the design of the choice tasks, and the most relevant product attributes. We found that the descriptions 'lifetime income product', 'critical illness cash product', and 'long-term care income product' were well received by urban Chinese.

3.2.3 Choice task

Allocating retirement wealth to one to four options from a life annuity, CII, LTCI, and savings account is a complex task that is challenging to operationalise in an online environment. To make the allocation task less cognitively demanding, we simplified it into a two-stage choice task, as summarised in Module 2 in Figure 3.1. In Stage 1, participants completed nine sequential allocation tasks between a savings account and life annuity, each with a different cover level for the OOP costs of CI and LTC (0%, 50%, or 100% cover). In Stage 2, participants completed a series of best/worst choice tasks to rank the nine allocations chosen in Stage 1.

3.2.3.1 Stage 1: Choice of annuitisation with fixed critical illness and long-term care insurance

The nine hypothetical scenarios for allocating retirement wealth between a savings account and life annuity are illustrated in the ‘choice task’ box in Figure 3.1. Zero indicates that no commercial insurance (either CII or LTCI) is purchased to cover any remaining costs after reimbursement from public health insurance, whereas 100% and 50% denote that purchased insurance can be expected to cover all or half of the OOP costs. To ease the cognitive load, we presented the nine choice sets sequentially from 0% to 100% cover (for OOP health-related risks) rather than assigning the choice sets randomly. We began with three levels of CII (0%, 50% and 100%) because this product is more familiar to participants in China. These choice tasks with different covers of health-related risks form the treatment variables when analysing the extent to which access to health-contingent insurance can release precautionary savings for purchasing longevity insurance (i.e., annuities).

In each hypothetical scenario, we asked the participants to suppose they were at their official retirement age (55 for females and 60 for males). An illustrative screenshot of Task 1 is presented in Figure 3.2. In this scenario, the participant was female and had just retired at age 55 with a retirement wealth of CNY 500,000, a monthly pension of

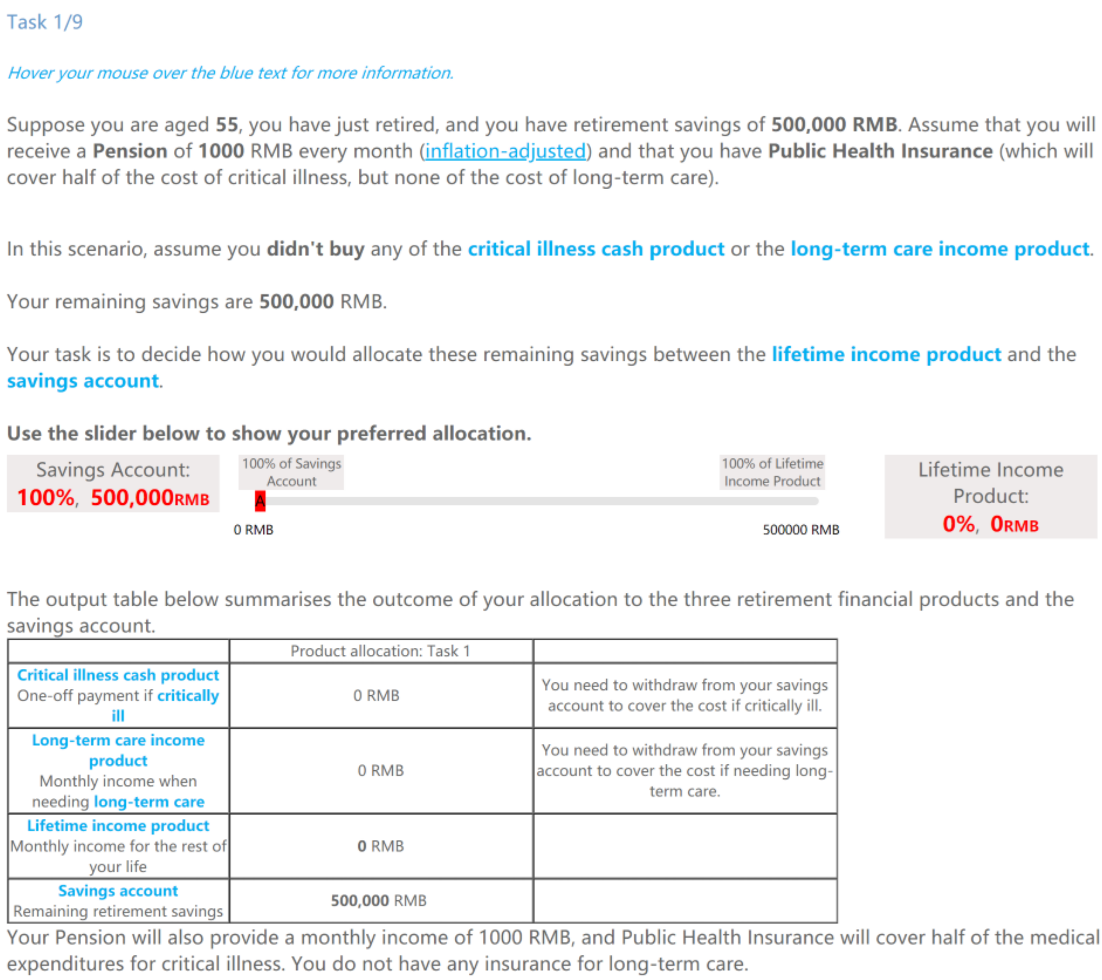
CNY 1,000, and access to typical public health insurance. In the example scenario, the participant was told that she had not purchased any CII or LTCI and was asked to use a slider (Figure 3.2, middle) to indicate her preferred allocation of retirement wealth between a savings account and a 'lifetime income product' (life annuity). A summary table (Figure 3.2, bottom) simultaneously showed that the current outcome of the slider choice was 100% or CNY 500,000 for the savings account and zero for the annuity. Her purchased CII and LTCI were both zero, and she needed to withdraw from her savings account to cover the OOP costs for CI or LTC.[12] The monthly income provided by the annuity was zero, and the remaining savings account was CNY 500,000. The information about her public pension (CNY 1,000) and health insurance (50% cover for the CI cost and zero cover for the LTC cost) was also provided below the summary table as a just-in-time reminder.

Before completing the nine allocation tasks, participants were presented with an example to familiarise themselves with the provided information and the choice they were asked to make. When allocating between a savings account and life annuity, participants were required to move the slider at least once (and could move it back to zero if their choice was to choose no annuity). After choosing an allocation, participants were asked to confirm whether the choice was final, and if not, they were prompted to reallocate.

3.2.3.2 Stage 2: Rank the nine portfolios made in Stage 1

After completing the nine choice tasks, participants proceeded to Stage 2, where they were asked to indicate their preferred allocation from the nine portfolios chosen in Stage 1. Given the difficulty of ranking nine portfolios directly, we used best-worst (B-W) scaling (Louviere et al., 2015). We adopted a balanced incomplete design such that each participant only needed to choose the most and least preferred among three portfolio options in each choice set. A total of 12 choices sets, each including three of the previously chosen allocations, were randomly assigned to each participant to compare the nine chosen

[12] We included the additional description in the third column to remind participants that public health insurance would not pay all health-related costs, and in the absence of insurance purchase, the participant would need to pay the health-related OOP costs. We highlighted the savings account to facilitate task simplicity.


Task 1/9

Hover your mouse over the blue text for more information.

Suppose you are aged **55**, you have just retired, and you have retirement savings of **500,000 RMB**. Assume that you will receive a **Pension** of **1000** RMB every month (inflation-adjusted) and that you have **Public Health Insurance** (which will cover half of the cost of critical illness, but none of the cost of long-term care).

In this scenario, assume you **didn't buy** any of the **critical illness cash product** or the **long-term care income product**.

Your remaining savings are **500,000** RMB.

Your task is to decide how you would allocate these remaining savings between the **lifetime income product** and the **savings account**.

Use the slider below to show your preferred allocation.

Savings Account: **100%, 500,000RMB**

100% of Savings Account

100% of Lifetime Income Product

0 RMB

500000 RMB

Lifetime Income Product: **0%, 0RMB**

The output table below summarises the outcome of your allocation to the three retirement financial products and the savings account.

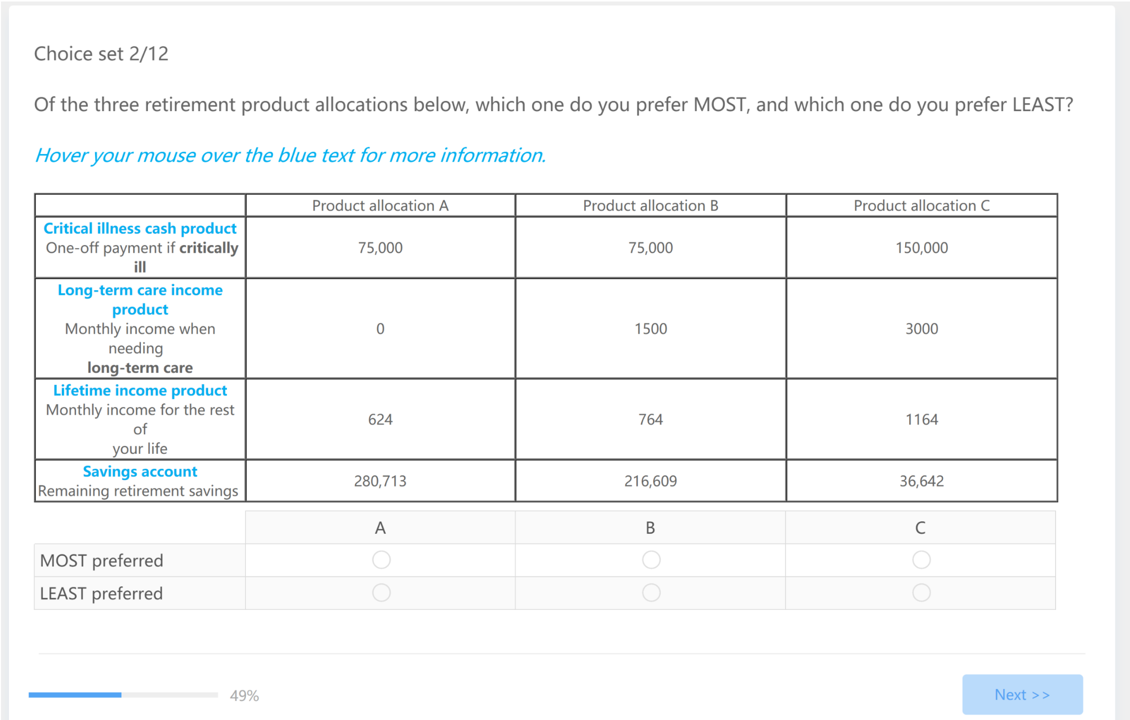
	Product allocation: Task 1	
Critical illness cash product One-off payment if **critically ill**	0 RMB	You need to withdraw from your savings account to cover the cost if critically ill.
Long-term care income product Monthly income when needing **long-term care**	0 RMB	You need to withdraw from your savings account to cover the cost if needing long-term care.
Lifetime income product Monthly income for the rest of your life	**0** RMB	
Savings account Remaining retirement savings	**500,000** RMB	

Your Pension will also provide a monthly income of 1000 RMB, and Public Health Insurance will cover half of the medical expenditures for critical illness. You do not have any insurance for long-term care.

Figure 3.2: Illustrative screenshot of Task 1 from Stage 1 of the choice task (translated into English)

allocations thoroughly and in a balanced way. An example of one of the 12 choice sets is depicted in Figure 3.3.

Upon completing the Stage 1 and 2 choice tasks, participants were asked to rate the task difficulty as a measure of cognitive load. Participants then moved to Module 3, where they were asked to rank four additional attributes separately for each life annuity, CII and LTCI. The details of Module 3 are provided in Appendix 3.6.1.



Choice set 2/12

Of the three retirement product allocations below, which one do you prefer MOST, and which one do you prefer LEAST?

Hover your mouse over the blue text for more information.

	Product allocation A	Product allocation B	Product allocation C
Critical illness cash product One-off payment if **critically ill**	75,000	75,000	150,000
Long-term care income product Monthly income when needing **long-term care**	0	1500	3000
Lifetime income product Monthly income for the rest of your life	624	764	1164
Savings account Remaining retirement savings	280,713	216,609	36,642

	A	B	C
MOST preferred	○	○	○
LEAST preferred	○	○	○

49%

Next >>

Figure 3.3: Illustrative screenshot of Stage 2 preference tasks (translated into English)

3.2.4 Collection of personal characteristics

Module 4 asked participants about their personal characteristics:

- exposure to health risks, consumption attitudes in retirement and in different health states (Wu et al., 2018b);
- preferences, including risk attitude (Dohmen et al., 2011) and time preference (Fisher and Montalto, 2011; Jacobs-Lawson and Hershey, 2005), financial literacy (Lusardi and Mitchell, 2011), numeracy (Lipkus et al., 2001), and psychological personality traits (Agnew et al., 2016; Borghans et al., 2008); and
- other demographic and socioeconomic factors suggested by previous research (e.g., Bockweg et al., 2017).

To study the influence of COVID-19 on the choice of health-related and longevity insurance,[13] we included questions about COVID-19 related experiences and expectations.[14] Taking guidance from questions on COVID-19 implemented by the World Health Organization (2020), we started with questions about participants' experiences with the virus in their immediate social environment and their mental stress resulting from the virus. Next, we asked about insurance purchase behaviour and the main reason for purchasing and risk-taking behaviour, such as avoiding travelling, shopping, or dining in a restaurant following the loosening of the lockdown. Finally, we asked participants about their financial status, such as changes in income and savings, and their expectations about economic growth following the COVID-19 pandemic. The questions about the experiences and attitudes of COVID-19 were blended into the questions on health experience and socioeconomic status. Finally, an instructional manipulation check (IMC) from Oppenheimer et al. (2009) was included to test participants' inattention.

3.3 Descriptive statistics

This section starts with summary statistics of participant characteristics, reporting the choice task outcomes, specifically the preferences for the nine portfolio allocations (Stage 2 of Module 2) and the choice of annuitisation with fixed CII and LTCI from the nine tasks (Stage 1 of Module 2). Afterwards, we report responses to questions about COVID-19 (Module 5) and the survey quality.

[13] COVID-19 may affect people's preferences, mental health and behaviour. For example, survey respondents in Wuhan demonstrated an increase in risk aversion during the lockdown period (Bu et al., 2020). Mental health among Europeans may have been severely affected by the pandemic and lockdown (Rossi et al., 2020). Moreover, individuals in the US exhibited voluntary disengagement from commerce activities due to concern regarding disease infection (Goolsbee and Syverson, 2020).

[14] As the survey did not collect the preferences before and after commencement of the COVID-19 pandemic, the relationships identified with respect to the impact of COVID-19 are associations only and should not be interpreted as causal.

3.3.1 Participants' characteristics

Table 3.1 reports the key demographic summary statistics of the survey and compares sample characteristics with the matched sample from the 2015 wave of the CHARLS data.[15] We report statistics for the CHARLS participants ages 45 to 69 with urban Hukou who were not retired. Overall, the sample is similar to the nationally representative CHARLS sample except that our sample had a lower proportion of males (50% rather than 62.7%) and was wealthier and more educated than the CHARLS sample. This difference is likely due to the following reasons: a) We set an equal quota for gender in the survey. b) The survey focused on the 52 major cities in China. c) We over-sampled the wealthier population to achieve a more balanced design for efficiency. Finally, d) the online sampling method attracted a wealthier population, whereas the CHARLS sample used face-to-face in-home interviews.

The detailed variable definitions and summary statistics are provided in Appendix 3.6.1. We coded most discrete variables as binary variables. We converted most ordinal variables into binary variables where 1 indicated that the participant's response was above the sample median. In addition, we standardised the remaining variables whose scales do not allow for a meaningful economic interpretation with a mean of 0 and a standard deviation of 1. For all categorical variables, the variable construction keeps the number of observations in each category at no less than 10% of the sample size, and we exclude variables with insufficient variation from the analysis. The entire sample was included for analysis.

3.3.2 Preferences for portfolios of retirement insurance products

Before reporting the outcome of the Stage 2 choice task (i.e., participants indicate their preferences for retirement portfolios selected in Stage 1), we first summarise the results of the quiz testing product understanding (for which participants received a bonus payment

[15] We used the Harmonised CHARLS dataset provided by the Program on Global Aging, Health & Policy, University of Southern California (see `https://g2aging.org`).

Table 3.1: Participant characteristics: Comparison with CHARLS 2015 data

	Survey (Ages 45-69)	CHARLS (Ages 45-69, not retired, urban Hukou)
Age (mean)	54.4	54.2
Male	50%	62.7%
Married	99%	94.2%
Household income (median)	CNY 100,000 to 109,999 per year	CNY 40,160
Household debt (median)	CNY 2,000 to 9,999	0
Highest education attained		
No schooling	6.9%	12.8%
Primary school	6.2%	27.5%
Junior middle school	24.8%	24.2%
High school	37.4%	17.4%
College degree or diploma	13.4%	13.7%
Bachelor's degree	11.1%	4.1%
Master's degree or above	0.2%	0.3%
Current work status		
Employed by someone else	64.6%	57.3%
Self-employed	31.9%	42.7%
Unemployed	3.5%	0%
Urban Hukou	94.3%	100%
Number of children (mean)	1.6	1.78
Number of observations	1000	1,791

Notes: CHARLS refers to the 2015 wave of the China Health and Retirement Longitudinal Study (based on the Harmonised CHARLS dataset).

depending on their performance). Three questions were asked on each of the three retirement insurance products: life annuity, CII, and LTCI, and one question was asked on the savings account. All questions were in the true-false format. Table 3.2 demonstrates that the survey participants had a good understanding of all financial retirement products presented in the survey. The understanding was highest for the annuity, with 72.2% of participants correctly answering all three questions and was slightly worse for the two health-related insurance products. Moreover, 38.5% of participants correctly answered all questions.

Table 3.2: Quiz of product understanding

	Percentage of the participants answering all questions correctly
Annuity	72.2%
Critical illness insurance	67.2%
Long-term care insurance	62.2%
Savings account	72.9%
All products	38.5%

Next, we report the results from Stage 2 of the allocation task, where participants were asked to choose their 'most' (best) and 'least' (worst) preferred portfolios of retirement insurance products (from the portfolios selected in Stage 1). We report the overall preferences for the nine portfolios using three measures: i) the average of the B-W scores, ii) the ratio of the B-W scores, and iii) the standard deviation of the individual scores (Flynn et al., 2007; Louviere et al., 2015). The average B-W score for each portfolio of retirement insurance products is calculated by subtracting the number of times the portfolio is selected as the 'least' preferred portfolio from the number of times the portfolio is selected as the 'most' preferred portfolio across all choice tasks and survey participants, averaged by the number of times that each portfolio is presented to the participants.

A higher average score indicates that the overall preference for the respective portfolio is higher than others. Table 3.3 reports the average B-W preferences for the nine portfolios. A balanced design was adopted such that each portfolio was presented to each participant the same number of times. We observed a trend in which the most preferred retirement portfolios were those with more cover for OOP health-related costs. The most preferred portfolio was that chosen in Task 6 (Portfolio 6, with similar notation for other portfolios based on the task number), where 50% of the expected OOP costs for CI and LTC were covered, and the remaining retirement wealth was allocated to an annuity (CNY 711, about 19.6% of the average disposable income in urban China) and a savings account. This portfolio was selected as the most preferred portfolio a total of 1,530 times, which was about 50% more than times that Portfolio 1 was chosen (no cover for OOP costs). The average B-W score is 0.093 for Portfolio 6, compared with -0.183 for Portfolio 1. As well, the average B-W scores of the nine portfolios are statistically significant.

Table 3.3: Preference for retirement insurance portfolios by Best-Worst measures

Portfolio ID	CI, LTC Cover	Monthly annuity	Total Best	Total Worst	Average B-W Scores	Ratio scores	Relative Pref.	Stdev. of B-W Scores
6	50%, 50%	711	1530	1159	0.093	1.149	100.0%	0.440
8	50%, 100%	652	1443	1101	0.086	1.145	99.6%	0.456
9	100%, 100%	590	1401	1076	0.081	1.141	99.3%	0.510
7	100%, 50%	651	1417	1125	0.073	1.122	97.7%	0.438
5	0%, 100%	666	1384	1247	0.034	1.054	91.7%	0.371
4	0%, 50%	718	1278	1441	-0.041	0.942	82.0%	0.393
3	100%, 0%	657	1289	1486	-0.049	0.931	81.1%	0.423
2	50%, 0%	665	1209	1586	-0.094	0.873	76.0%	0.481
1	0%, 0%	665	1049	1779	-0.183	0.768	66.8%	0.550

Notes: The nine portfolios were chosen in the Stage 1 tasks, and each of them had a fixed cover for critical illness (CI) and long-term care (LTC) costs. The preferences were ranked according to Best-Worst (B-W) measures.

The ratio score for each portfolio is calculated as the square root of the total number of times the portfolio is selected as the most preferred portfolio divided by the total number of times the portfolio is selected as the least preferred portfolio. The relative preferences are based on the ratio scores with the most preferred portfolio as a benchmark indexed at 100%. The key B-W results are reported in Table 3.3, indicating that the probabilities of choosing the most preferred portfolios (i.e., those covering at least 50% of the OOP costs for both CI and LTC) are nearly identical (99.6% for Portfolio 8, 99.3% for Portfolio 9, and 97.7% for Portfolio 7, compared with the preference for Portfolio 6). In contrast, the relative preference for the portfolio without cover for OOP health-related costs (Task 1) was lowest at 66.8%.

The standard deviation of the individual B-W score for each portfolio allows us to investigate the heterogeneity of the portfolio preferences. The portfolio providing 100% cover for the OOP LTC costs exhibits the least variation across survey participants (0.37). In contrast, the highest variation is for Portfolio 1, in which no OOP health-related costs are covered (0.55), followed by 0.51 for Portfolio 9, in which 100% of the expected OOP costs for CI and LTC are covered. For Portfolio 6, the most preferred portfolio, the standard deviation is 0.44. These results suggest that preference for retirement portfolios with health-contingent insurance products is highly heterogeneous among the participants. We examine the influence of individual characteristics on choices of retirement portfolios in Section 3.4.1.

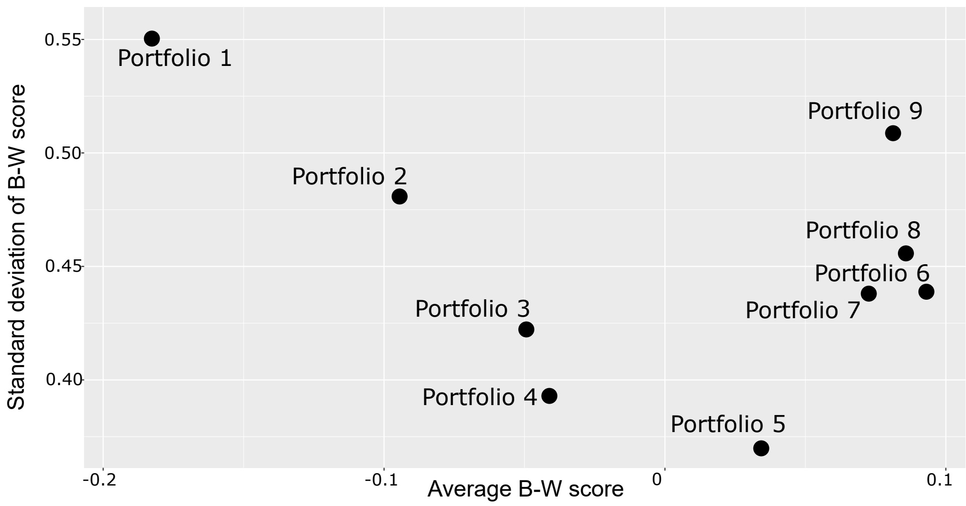


Figure 3.4: The average and standard deviation of B-W scores for the nine portfolios

Notes: The nine portfolios were chosen in the Stage 1 choice tasks, each with a different predetermined cover for critical illness and long-term care costs. B-W score: Best-Worst score.

Figure 3.4 summarises the preferences for the nine portfolios of retirement insurance products and the savings account by the average and standard deviation of their B-W scores. Portfolios 6 to 9 are the most preferred, whereas Portfolio 1 is the least preferred. However, participants demonstrated the highest variation of preferences for Portfolios 1 and 9, suggesting that different individual backgrounds could drive heterogeneous preferences. For example, the preferences are highly influenced by retirement wealth. For those with a lower retirement wealth, the preferences were more evenly distributed for portfolios with incomplete cover for the expected OOP health-related costs, and the most preferred portfolio was Portfolio 6. For those with a higher retirement wealth, the preferences leaned towards products with more cover for OOP health-related costs. For instance, for those with a retirement wealth of CNY 1,000,000, the most preferred portfolio was Portfolio 9, which was most preferred twice as many times as Portfolio 1.

In Chapter 4, we constructed a life-cycle model to derive the optimal retirement portfolio, including the same life annuity, CII and LTCI considered in this chapter, for retirees with four different wealth (CNY 1 million and CNY 150,000) and pension (CNY 3,000 and CNY 1,000) combinations. The results showed that the optimal portfolio included a substantial amount of CII. For retirees with an average pension of CNY 3,000, we find that at least 30% of retirement wealth is allocated to CII, while at least 40% is allocated to a life annuity for those with a low pension (CNY 1,000). The demand for LTCI is between 5% and 15% of retirement savings for retirees with different wealth and pension amounts. In the experimental survey, on average, the most preferred portfolio included half CII cover, half LTCI cover, and an annuity income of about CNY 700 per month. The average wealth and pension of the participants were about CNY 460,000 and CNY 3,000. For this wealth and pension level, our life-cycle model suggests that the optimal portfolio allocation includes about 4% to a life annuity, 62% to CII and 10% to LTCI. These results reflect a consistency between the stated demand and the optimal demand for LTCI. However, the stated CII demand was lower, and the stated annuity demand was higher, compared with their optimal amounts, respectively.

3.3.3 Annuity demand and release of precautionary savings

Participants completed nine slider tasks in Stage 1 of the allocation task, each with a different cover for the OOP health-related costs (see the table in the Choice Task part in Figure 3.1). They were asked to choose their preferred allocation between a life annuity and savings account.

Figure 3.5 presents the differences between the chosen annuity amount from Task 1 and

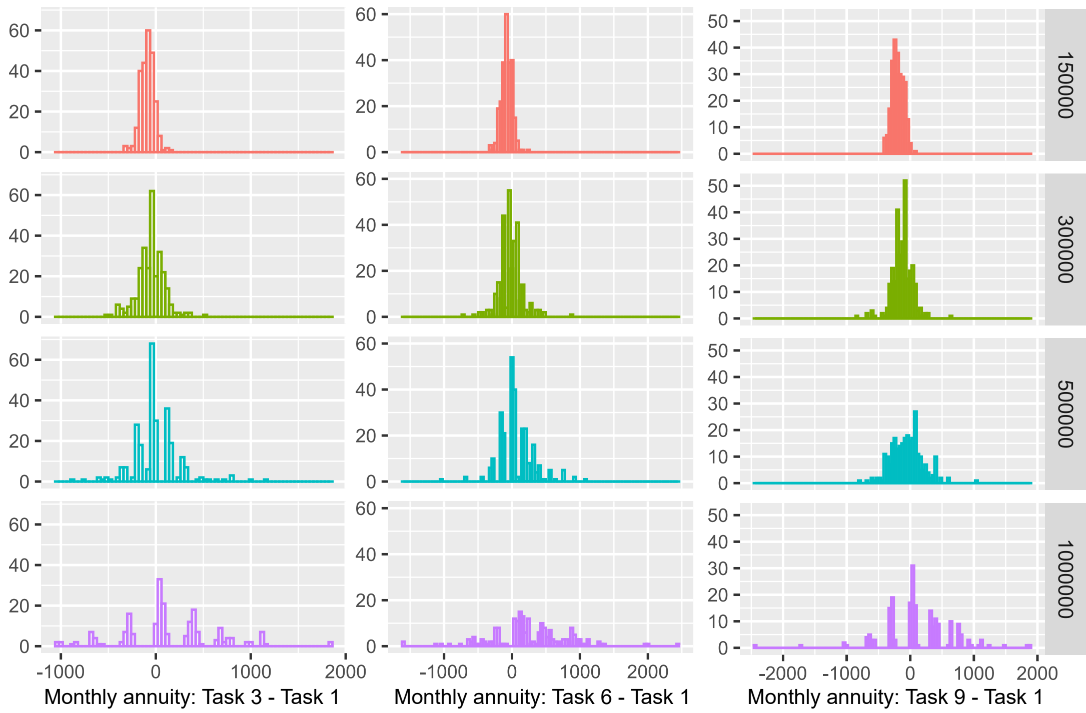


Figure 3.5: Difference in monthly annuity between Task 1 and each of Tasks 3, 6, and 9 by retirement wealth

Notes: The four allocation tasks were from Stage 1, each with a different pre-determined cover for expected out-of-pocket costs of critical illness (CI) and long-term care (LTC): Task 1 (CI: 0%, LTC: 0%); Task 3 (CI: 100%, LTC: 0%); Task 6 (CI: 50%, LTC: 50%); Task 9 (CI: 100%, LTC: 100%). Participants chose their preferred allocation between a life annuity and savings account in each of the tasks.

three other tasks to examine whether access to health-contingent insurance can release precautionary savings to purchase an annuity. For illustrative purposes, we only included Task 3 (50% cover for expected OOP CI costs), Task 6 (50% cover for expected OOP costs for CI and LTC), and Task 9 (100% cover for expected OOP costs for CI and LTC) to compare with Task 1. Under wealth constraints, the annuity demand decreased, which was most evident for those with CNY 150,000 retirement wealth in Task 9. For those with higher wealth, more participants chose a higher annuity, and the increase was most evident for those with CNY 1,000,000 of retirement wealth in Task 6. Overall, the treatment effect of access to health-contingent insurance on annuity demand roughly followed a normal distribution with its mean varying around zero. These results for annuity demand revealed that the average treatment effect is likely to be small and that the annuity demand varied substantially after treatment. The treatment caused a substantial increase in annuity demand for specific participants, whereas the same treatment could reduce the demand for others.

In conclusion, Figure 3.5 shows that the treatment effect of different health cover on releasing the precautionary savings for annuity purchase varies substantially among the participants. Overall, the average effects of different product bundling approaches are small. In Section 3.4.2, we formally test which of the eight health cover combinations effectively release precautionary savings to purchase annuities and to what extent.

3.3.4 COVID-19 related experience and beliefs

Various measures were collected to explore the influence of COVID-19 on the allocation of retirement wealth to the three retirement insurance products and savings account. This section reports summary statistics for these variables. About 80.8% of participants reported that their immediate social environment had not been affected by COVID-19, and 0.6% reported a confirmed case. Moreover, 6.8% reported observing suspicious cases, and 10.5% reported observing tests with negative results.

Question a in Table 3.4 reports four measures to gauge the influence of COVID-19 on individual mental health measured on a seven-point scale. More than 70% of participants reported that COVID-19 did not affect their mental health. This result is surprising but reasonable for two reasons. First, the survey was conducted during the end of August to September, which was several months after the end of the lockdowns. Second, the outbreak of the second wave in June and July in Beijing had been controlled promptly by the time the survey was administered, and there was no sign of a third wave at that time. The other three mental health measures exhibited a similar pattern, with more than 50% indicating a positive attitude and about 20% indicating a negative attitude.

Question b in Table 3.4 reports the influence of COVID-19 on personal income and savings. The results for both are similar: about 40% experienced a reduction, about 45% had about the same income or savings, and the rest experienced an increase following the spread of COVID-19.

We further collected participant expectations of the economic effects of COVID-19 (Table 3.4, Question c). Consistent with previous findings, only 28% reported concern about losing personal income. However, we observed a significant concern for small companies closing (40%) and for an economic recession in China (44%). These responses were likely because the participants were close to retirement and had higher income security than younger cohorts.

We also assessed participants' risky behaviour since the loosening of the lockdown. Question d in Table 3.4 reports that more than 50% of the sample always or often avoided seeing relatives, dining in restaurants with friends, direct contact with doors or elevator buttons, crowded locations, and travelling. In particular, 53.6% of participants always avoided travelling, and more than 20% always avoided any of these activities.

Substantial demand for health-related insurance occurred following the outbreak of COVID-19. In particular, 44.2% of participants reported that they purchased CII, followed by medical insurance (22.8%), COVID-19 insurance (19.5%),[16] LTCI (13.9%) and other health-related insurance (11.7%). In contrast, the demand for annuities or commercial pension products was low (3.9%), and 37.6% of participants bought no insurance. In addition, 71% of participants reported that their main reason for insurance purchase was 'awareness of health risks in general' compared with risks of COVID-19 (16%), price (6%), direct recommendation (5%) and peer effects (3%).

3.3.5 Survey clarity and task difficulty

The portfolio allocation we asked participants to consider requires individuals to weigh multiple dimensions of retirement risks and retirement insurance products. To address

[16]It was not until February 2020 that China's government decided to provide free COVID-19 insurance to those enrolled in public health insurance programs. The commercial companies provided free COVID-19 insurance as well.

Table 3.4: Summary of experiences with and attitudes towards COVID-19

a. How does the novel coronavirus make you feel?	Negative (1-3)	Neutral (4)	Positive (5-7)
1: Worry about my health / 7: Not worry about my health	14%	9%	77%
1: Makes me feel helpless / 7: Can combat with my own action	26%	17%	58%
1: Stressful / 7: Not stressful	22%	13%	65%
1: Making me depressed / 7: Does not affect my mood	25%	16%	59%
b. How has your income and savings changed following the spread of the novel coronavirus?	**Increased**	**Similar**	**Decreased**
Income	14%	46%	40%
Savings	18%	45%	38%
c. The novel coronavirus has widespread economic effects. At the moment, how much do you worry about:	**Don't worry**	**Neutral**	**Worry**
Losing your main source of income	57%	16%	28%
Small companies closing down	46%	14%	40%
An economic recession in China	28%	28%	44%
d. Since the lockdown measures have been loosened, have you done the following?	**Always avoided**	**Often avoided**	**Sometimes or never avoided**
Avoided seeing relatives	22%	31%	47%
Avoided restaurants	26%	41%	33%
Avoided direct contact with doors or elevator buttons	23%	37%	41%
Avoided crowded locations like shopping malls	28%	41%	32%
Avoided travelling	54%	29%	18%

potential task complexity, we paid close attention to simplifying the language and minimising the amount of information presented. Overall, 71.7% of participants considered the survey completely or mostly clear, and only 3.5% considered it completely or mostly confusing. Regarding the choice tasks, 31% of participants considered the tasks hard or very hard. This result was expected because the survey presented a considerable amount of product information, and the Stage 1 choice tasks required participants to select preferred amounts based on information supplied interactively. The median completion time was 48 minutes, and 85.6% of participants passed the IMC.[17]

3.4 Regression results and discussion

The overall aim of our study is to identify preferences for portfolios of retirement insurance products. In doing so, we designed a two-stage experimental setup in which we first obtained stated preferences for annuities with (nine) given combinations of CII and LTCI (0% to 100% cover for OOP costs) and then sought the most and least preferred of the chosen portfolios. We also collected extensive data on personal characteristics, preferences, and experiences with and attitudes towards COVID-19.

In this section, we report three sets of regression results. In Section 3.4.1, we use a multinomial logit model (Model A) to explain the preferred choices of the alternative portfolios of retirement insurance products by personal characteristics and preferences. In Section 3.4.2, we use a linear mixed model (Model B) to explore factors associated with annuity demand. We first report the extent to which access to health-contingent insurance (specifically CII or LTCI) can release precautionary savings for purchasing longevity insurance (i.e., life annuities). We then report how personal characteristics and preferences influence annuity demand. Finally, in Section 3.4.3, we report the influence of COVID-19 on

[17]For the IMC, we repeated the question about wealth status, which also appeared at the beginning of the survey. The participants failed the attention test if they provided inconsistent answers or failed to recognise that the question been asked earlier. In total, 98.4% of participants reported consistent answers, and 86.2% recognised they had previously answered the question. The survey completion time ranged from 21 to 709 minutes (resuming from where one left off was allowed). Finally, 99% of participants completed the survey within one hour, and eight participants took more than 150 minutes.

portfolio choice drawing on results from Models A and B.

In Model A, we consider a multinomial model that only includes variables of individual background- and portfolio-specific coefficients. The value or utility of portfolio t for individual i is the following:

$$V_{i,t} = \alpha_t + \mathbf{X}_i \kappa_{\mathbf{t}} + \epsilon_{i,t}, \tag{3.1}$$

and the probability of choosing Portfolio A, among Portfolios A, B, and C in a given B-W task s (Stage 2) is as follows:

$$\text{Prob}(\text{Choice}_i = \text{Portfolio}_A) = \frac{e^{V_{i,A}}}{e^{V_{i,A}} + e^{V_{i,B}} + e^{V_{i,C}}}. \tag{3.2}$$

The dependent variable is whether each of the portfolios from the 12 B-W tasks (Stage 2) is chosen by an individual i. The error terms are assumed to be independently and identically distributed (i.i.d.) and to follow a Gumbel distribution. Moreover, $\mathbf{X}_i$ is a vector of covariates measuring the influence of COVID-19 on mental health, personal finance, economic concerns and risk-taking behaviour since the loosening of the lockdown, and covariates have been identified as relevant to retirement insurance decisions, such as personality traits, financial capabilities, retirement expectations, health- and care-related experience, and demographic and socioeconomic variables (e.g., Agnew et al., 2016; Bockweg et al., 2017; Hanewald et al., 2020; Wu et al., 2018b).[18] In addition, $\kappa_{\mathbf{t}}$ is the portfolio-specific coefficient vector of the individual covariates. All coefficients for Portfolio 1 (zero cover for OOP CI and LTC costs) were set to zero for identification purposes. We report robust standard errors clustered at the individual level.

[18]While we do not include stock market participation as a choice variable (for the reasons described earlier), we do include the variable "Financial product familiarity", which measures a participant's access to 14 financial products, including stocks and stock funds as a control in the regressions. Furthermore, we use a panel model with individual random effects to control for unobserved individual-specific effects, such as stock market participation and homeownership.

In Model B, we estimate the following equation:

$$\text{Annuity}_{i,t} = \alpha_0 + \beta_t \text{Task}_t + \mathbf{X}_i \kappa + \lambda_i + \epsilon_{i,t}, \tag{3.3}$$

where the dependent variable $\text{Annuity}_{i,t}$ is the amount of monthly annuity income chosen by individual i in each choice task t from Stage 1. The error terms are assumed to be i.i.d. distributed and to follow a normal distribution. Task_t ($t = 1 \ldots 9$) are the dummy coded treatment variables for the nine choice tasks in Stage 1 (each with different set amounts of CII and LTCI), and the reference category is Task 1 that offers zero cover for OOP health costs. The Task_t treatment variables allow us to explore which health cover options are more effective in releasing precautionary savings for annuity purchase, and β_t is the coefficient, respectively. As described in Model A, $\mathbf{X}_i$ is the same individual covariate vector, and κ is the coefficient vector. Additionally, λ_i is the individual random intercept.

For both models, we also included two measures of survey quality: the IMC and survey clarity. We considered the effects with a p-value of less than 5% to be statistically significant.

3.4.1 Choice of retirement portfolios with health-contingent insurance

In this section, we analyse the preference for portfolios with health-contingent insurance products by personal characteristics and preferences using the multinomial model (Model A), as described at the beginning of Section 3.4. These portfolios comprise nine fixed levels of cover for expected OOP costs for CI and LTC and the preferred amounts of a life annuity and savings account, given the fixed level of health cover. The B-W measures in Section 3.3.2 indicate that participants prefer portfolios including more cover for health costs, whereas significant variations among the portfolio preferences are also observed. The dependent variable is whether each of the portfolios is most preferred by a participant based on a B-W task. The reference portfolio is Portfolio 1, which does not cover the expected OOP costs for CI and LTC (CI: 0%, LTC: 0%). Table 3.5 reports the regression results. We discuss the specific effects of the COVID-19 experiences and attitudes on portfolio choice in Section 3.4.3.

Wealth and public pension income

Past studies have found that higher income and wealth often lead to a higher demand for health insurance (e.g., Ahmed et al., 2016; Ying et al., 2007), and LTCI (e.g., Allaire et al., 2016; Brau and Lippi Bruni, 2008; Wang et al., 2017). Compared with a wealth of CNY 150,000, our results reveal that a higher wealth for retirement portfolio allocation is associated with a higher probability to choose portfolios with more health-contingent insurance. For example, when the hypothetical retirement wealth is CNY 1,000,000, the participant preferred Portfolios 5 (CI: 0%, LTC: 100%) to 9 (CI: 100%, LTC: 100%) over Portfolio 1 ($p < 0.01$, Table 3.5, Columns 5 to 9), and the relative preferences increased when more OOP costs were covered.

However, compared with receipt of a (public) pension of CNY 2,000 or less, the receipt of a (public) pension of CNY 3,500 lowered the preference for Portfolios 4 (CI: 0%, LTC: 50%), 5 (CI: 0%, LTC: 100%) and 6 (CI: 50%, LTC: 50%) compared to Portfolio 1 ($p < 0.01$, Table 3.5, Columns 4 to 6). A plausible explanation for this negative association could be using high income to fund uncertain health costs occurring later in life (e.g., Pang and Warshawsky, 2010; Peijnenburg et al., 2017). Overall, we found positive associations for wealth but a negative association for income on the preferences for health-contingent insurance.

Understanding of retirement insurance products and financial capabilities

The complexity of retirement insurance products and a lack of understanding of product characteristics are associated with a sub-optimal level of insurance demand (Bhargava et al., 2017; Brown et al., 2019). Participants with better product understanding than the sample median had a higher probability of choosing Portfolio 6 (CI: 50%, LTC: 50%) and Portfolio 9 (CI: 100%, LTC: 100%) ($p < 0.05$). This finding contrasts that by Wu et al. (2018b) that understanding life annuity or LTCI is negatively associated with stated preferences for a life care annuity.

Financial literacy and numeracy skills are essential for retirement planning, although empirical studies have found mixed results (e.g., Banks and Oldfield, 2007; Fernandes et al., 2014; Lusardi and Mitchell, 2011; Van Rooij et al., 2011). Participants with better financial competence (based on financial literacy and numeracy skills) than the sample median were likely to have a higher preference for portfolios containing more health cover ($p < 0.05$, Table 3.5, Columns 3 to 9). This outcome is different from that found by Wu et al. (2018b), where neither financial literacy nor numeracy skills influence the demand for life care annuity. Higher familiarity with financial products in China's market is linked to a higher likelihood to choose portfolios covering OOP costs for both CI and LTC ($p < 0.05$, Table 3.5, Columns 6, 8 and 9). In contrast, higher subjective financial literacy is linked to a lower likelihood ($p < 0.05$, Table 3.5, Columns 7 and 9).

Demographic and socioeconomic factors

Age is negatively associated with the stated demand for health insurance in low- and middle-income countries (Nosratnejad et al., 2016) and for LTCI in the US (Allaire et al., 2016), whereas a positive association between age and LTCI was found in Spain (Brau and Lippi Bruni, 2008). In China, a negative association exists between age and the demand for CII (Ying et al., 2007) or LTCI (Wang et al., 2017). We do not find evidence indicated that age influences the preference of the eight portfolios (each with some cover of CII and LTCI) over Portfolio 1 (with no cover of CII or LTCI).

Married Chinese individuals tend to spend less on formal care but more on medical equipment (Li et al., 2013b). However, our result demonstrates that it does not link to the portfolio choice, consistent with the findings on the demand for LTCI and CII in China (Wang et al., 2017; Ying et al., 2007).

Higher education is often associated with a higher demand for CII or LTCI (Wang et al., 2017; Ying et al., 2007). However, a negative association occurs among informal workers in urban Bangladesh for health insurance (Ahmed et al., 2016). Our results are in the middle and show that education does not affect the preference for a retirement portfolio with health-contingent insurance products.

Living in a Tier 1 city, such as Beijing or Shanghai, or being employed by a state-related employer did not affect the preference for a retirement portfolio with health-contingent insurance products. These findings are consistent with those of Hanewald et al. (2020) in that neither affects the demand for reverse mortgages for retirement in China.

Females in China exhibit lower demand for CII (Ying et al., 2007). However, no influence of gender was found for LTCI demand (Wang et al., 2017). Our study agrees that gender does not affect the demand for health-contingent insurance.

Overall, the demographics and socioeconomic factors considered in this study (age, marital status, education, living in Tier 1 cities, state-related employment, and gender) are not associated with the preferences for health-contingent insurance.

Personality traits and preferences

The empirical literature contains highly inconsistent results regarding risk aversion and the demand for LTCI (Chatterjee and Fan, 2017; Gottlieb and Mitchell, 2020). Our results reveal that the participants who reported a higher risk tolerance in financial matters were more likely to prefer portfolios without cover for OOP health-related costs ($p < 0.05$, Table 3.5, Columns, 2, 4 and 7 to 9). Participants who were more conscientious than the sample median were more likely to choose portfolios with more health-contingent insurance ($p < 0.05$, Table 3.5, Columns 4, 6 to 9). Unlike another study (Wu et al., 2018b), where the health state-dependent utility does not influence demand for life care annuity, we discovered that if the participants were more likely to spend more while they were in bad health, they were more likely to prefer a portfolio with less health-contingent insurance ($p < 0.05$, Table 3.5, Columns 4 to 9). However, we did not find opposite effects of the health state-dependent preference for consumption between the portfolios excluding CII (Table 3.5, Columns 4 and 5) and the portfolios excluding LTCI (Table 3.5, Columns 2 and 3), which contrasts the evidence in China found by Wang and Wang (2020) that people have opposite preferences to weight consumption in CI and LTC states. Similar to Wu et al. (2018b), we did not find evidence that patience is associated with choices of the portfolios that include health-contingent insurance. In summary, demand for health-contingent insurance is negatively associated with risk tolerance in financial matters while positively for conscientiousness, and a higher preference to spend more in poor health states is linked to lower demand for health-contingent insurance.[19]

Health- and care-related experience

Many studies in developed countries have demonstrated that private information is associated with demand for health insurance and LTCI (e.g., Braun et al., 2019; Brown et al., 2012; Finkelstein and McGarry, 2006) and can be significant enough to prevent the existence of a large insurance segment of LTC, disability and life insurance (Hendren, 2013). In general, we find that participants' self and family health experiences are not associated with the preferences for a retirement portfolio with health-contingent insurance. For example, the effects were minor and mostly statistically insignificant for participants with an unhealthy BMI, longer subjective life expectancy, and whose family members had a CI or ADL limitations. This result is consistent with the findings that chronic conditions do not affect the demand for LTCI (Wang et al., 2017) or CII (Ying et al., 2007). However, participants provided active care before were likely to have a lower preference for portfolios including health-contingent insurance ($p < 0.05$, Table 3.5, Columns 3 and 6 to 9). In the present study, the findings reveal that most factors about considered private health information (except having previously provided active care) are not associated with the demand for health-contingent insurance.

Retirement planning

Kahneman et al. (1991) point out that people who have made financial plans in reality are subject to the status quo effect. We found that participants who intended to spend more

[19]The results for state-contingent utility were unlikely caused by budget constraints that include health expenses. The associations between the state-dependent utility and the demand for health-contingent insurance were significant in Portfolios 4 - 9, and they had a different pattern compared to other personality and preference factors while facing the same budget constraint. For example, for the patience factor, we did not observe any significant effect in any scenario. For bequest motives, only three scenarios showed significant effects. For conscientiousness, we found evidence of many positive associations, contrary to the negative associations for state-dependent utility. For risk aversion, we find that the least budget-constrained scenarios (Portfolio 2 and 4) showed significant results. If the effect of budget constraint were the major cause, it would likely generate similar results for these factors. Therefore, we conclude that state-dependent utility is significantly associated with the demand for health-contingent insurance.

during retirement than before were likely to choose portfolios with less health-contingent insurance ($p < 0.05$, Table 3.5, Columns 5, 7 to 9). A longer time horizon for their households to plan savings and consumption is linked to a higher preference for Portfolio 9 (CI: 100%, LTC: 100%; $p < 0.05$, Table 3.5, Column 9).

Inter-generational aspects

Children and bequest motives are crucial for LTC. For example, daughters are often the principal care providers for the family and influence LTCI demand (Jakobsson et al., 2016; Shen et al., 2014). Moreover, having LTCI influences the expectation of informal care and strategic bequest motives (Coe et al., 2015). We find that the family status of participants (e.g., those who had one or no children, had a daughter, or had at least one child who lived in the same house) did not influence the demand for health-contingent insurance. However, stronger intended bequest motives are linked to a higher preference for Portfolios 7 (CI: 100%, LTC: 50%) and 8 (CI: 50%, LTC: 100%; $p < 0.05$, Table 3.5, Columns 7 and 8), which contrasts the negative association for annuity in Section 3.4.2.2. These results suggest that people with higher-than-average intended bequest motives in China are likely to use insurance to cover their uncertain health-related expenditures rather than relying on precautionary savings on their own to leave a bequest.

Table 3.5: Multinomial regression to investigate the portfolio preference with health-contingent insurance

	Model A							
	Dependent variable: Choice of retirement portfolio (ref. Portfolio 1)							
	Portfolio 2	Portfolio 3	Portfolio 4	Portfolio 5	Portfolio 6	Portfolio 7	Portfolio 8	Portfolio 9
Preferences by B-W scores (Table 3.3)	8th	7th	6th	5th	1st	4th	2nd	3rd
CII cover	50%	100%	0%	0%	50%	100%	50%	100%
LTCI cover	0%	0%	50%	100%	50%	50%	100%	100%
Wealth and public pension income								
Wealth: 300,000 (ref. 150,000)	-0.07	0.01	-0.18	-0.01	0.14	0.31**	0.23	0.47***
	(0.15)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.15)	(0.15)
Wealth: 500,000	0.00	0.17	0.04	0.22	0.28*	0.47***	0.59***	0.77***
	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)
Wealth: 1,000,000	0.12	0.35*	0.22	0.55***	0.78***	0.90***	1.00***	1.41***
	(0.19)	(0.19)	(0.19)	(0.18)	(0.18)	(0.18)	(0.19)	(0.19)
Pension: 3,000 (ref. 2,000 or less [1])	-0.02	0.08	-0.08	-0.03	-0.18	0.01	0.02	-0.01
	(0.15)	(0.15)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.15)
Pension: 3,500	-0.16	-0.09	-0.31**	-0.37**	-0.47***	-0.19	-0.24	-0.27*
	(0.16)	(0.16)	(0.16)	(0.15)	(0.15)	(0.15)	(0.15)	(0.16)
Understanding of retirement insurance products and financial capabilities								
Product understanding	-0.20*	0.03	0.08	0.18*	0.22**	0.16	0.07	0.36***
	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)
Financial competence	0.18	0.25**	0.46***	0.45***	0.53***	0.75***	0.87***	0.98***
	(0.12)	(0.12)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)
Financial product familiarity	0.05	0.17	0.05	0.13	0.25**	0.20*	0.32***	0.33***
	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)
Subjective financial literacy	-0.04	-0.10	-0.10	-0.01	-0.20*	-0.24**	-0.14	-0.29***
	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)
Demographic and socioeconomic factors								
Age Group	0.01	-0.01	0.03	0.09	-0.02	-0.03	-0.02	-0.06
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)

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Continuation of Table 3.5

	Portfolio 2	Portfolio 3	Portfolio 4	Portfolio 5	Portfolio 6	Portfolio 7	Portfolio 8	Portfolio 9
Preferences by B-W scores (Table 3.3)	8th	7th	6th	5th	1st	4th	2nd	3rd
CII cover	50%	100%	0%	0%	50%	100%	50%	100%
LTCI cover	0%	0%	50%	100%	50%	50%	100%	100%
Female	-0.09	-0.26	-0.17	0.00	-0.11	-0.18	-0.20	-0.25
	(0.17)	(0.17)	(0.17)	(0.16)	(0.16)	(0.17)	(0.17)	(0.17)
Tier 1	0.02	-0.04	0.02	-0.02	-0.14	-0.16	-0.10	-0.06
	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)
State employer	0.09	0.14	0.14	0.15	0.16	0.04	0.05	0.19
	(0.12)	(0.12)	(0.12)	(0.11)	(0.12)	(0.12)	(0.12)	(0.12)
College and above	0.08	0.18	0.11	0.17	0.10	0.06	-0.14	-0.03
	(0.16)	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)
High school	0.16	0.11	0.07	0.13	0.18	0.03	-0.04	0.05
	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)
Personal traits and preferences								
Conscientiousness	0.17	0.19	0.27**	0.21*	0.46***	0.40***	0.45***	0.36***
	(0.12)	(0.12)	(0.12)	(0.11)	(0.12)	(0.11)	(0.12)	(0.12)
Risk tolerance (financial)	-0.15**	-0.08	-0.19***	-0.11*	-0.10	-0.19***	-0.24***	-0.27***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Patience	0.05	-0.04	0.06	-0.06	-0.09	-0.06	0.00	0.02
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
State-dependent consumption	0.00	-0.03	-0.05**	-0.05***	-0.11***	-0.10***	-0.15***	-0.18***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Health- and care-related experience								
Unhealthy BMI	0.23*	0.11	0.12	0.05	0.15	0.02	0.09	0.11
	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)
Longer subjective life expectancy	-0.01	0.06	0.01	-0.01	0.15	0.18*	0.06	0.02
	(0.11)	(0.11)	(0.11)	(0.10)	(0.10)	(0.11)	(0.11)	(0.11)
Family with critical illness	-0.04	-0.09	0.06	-0.16	-0.15	-0.22*	-0.30**	-0.07
	(0.14)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)	(0.14)

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Continuation of Table 3.5

	Portfolio 2	Portfolio 3	Portfolio 4	Portfolio 5	Portfolio 6	Portfolio 7	Portfolio 8	Portfolio 9
Preferences by B-W scores (Table 3.3)	8th	7th	6th	5th	1st	4th	2nd	3rd
CII cover	50%	100%	0%	0%	50%	100%	50%	100%
LTCI cover	0%	0%	50%	100%	50%	50%	100%	100%
Family with ADL limitations	-0.21	-0.08	-0.24*	-0.15	-0.11	-0.15	-0.06	-0.38***
	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)
Provided active care	-0.07	-0.38***	-0.18	-0.12	-0.46***	-0.50***	-0.54***	-0.33**
	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)
Retirement planning								
Spend more	-0.16	-0.06	-0.12	-0.21**	-0.17*	-0.25**	-0.22**	-0.22**
	(0.11)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.11)
Long plan horizon	-0.12	-0.11	0.03	0.00	0.03	0.05	0.19	0.24**
	(0.12)	(0.12)	(0.12)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)
Inter-generational aspects								
1 or less child	-0.31**	-0.10	-0.07	0.04	-0.11	-0.01	0.00	0.14
	(0.14)	(0.14)	(0.14)	(0.13)	(0.13)	(0.13)	(0.14)	(0.14)
Has a daughter	-0.25*	-0.12	-0.11	-0.05	-0.03	-0.12	-0.03	-0.03
	(0.14)	(0.14)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)
Live in the same house	0.09	0.05	0.13	0.08	0.26**	0.14	0.03	0.06
	(0.13)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)
Bequest motives	0.01	0.03	-0.01	0.00	0.03	0.07**	0.08***	0.05*
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Impact of COVID-19								
COVID-19 mental health	-0.22*	-0.17	-0.17	-0.26**	-0.31***	-0.29***	-0.32***	-0.22**
	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)
COVID-19 finance situation	0.07	-0.15	-0.16	-0.04	-0.07	-0.23*	-0.13	-0.25*
	(0.13)	(0.13)	(0.13)	(0.12)	(0.13)	(0.13)	(0.13)	(0.13)

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Continuation of Table 3.5

	Portfolio 2	Portfolio 3	Portfolio 4	Portfolio 5	Portfolio 6	Portfolio 7	Portfolio 8	Portfolio 9
Preferences by B-W scores (Table 3.3)	8th	7th	6th	5th	1st	4th	2nd	3rd
CII cover	50%	100%	0%	0%	50%	100%	50%	100%
LTCI cover	0%	0%	50%	100%	50%	50%	100%	100%
During COVID-19 purchased: CII	-0.09	-0.23*	0.03	-0.07	-0.13	-0.14	0.04	0.13
	(0.13)	(0.13)	(0.13)	(0.12)	(0.13)	(0.12)	(0.13)	(0.13)
... COVID-19 insurance	-0.01	0.11	0.24	0.19	0.13	0.13	0.25	0.59***
	(0.16)	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)
... other health insurance	0.15	-0.06	0.14	-0.07	-0.03	0.02	0.09	0.05
	(0.18)	(0.18)	(0.18)	(0.18)	(0.18)	(0.18)	(0.18)	(0.18)
COVID-19 worry: small companies	-0.01	0.01	0.07	0.10**	0.00	0.06	0.11**	0.09*
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
... economy recession	0.08	0.08	0.07	0.07	0.09	0.10*	0.10*	0.07
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
... own income	0.00	-0.05	0.03	-0.10**	-0.02	-0.04	-0.03	-0.02
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
COVID-19 risky behaviour	-0.08	0.00	-0.15	-0.16	-0.11	-0.22**	-0.30***	-0.31***
	(0.11)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)
Survey measures								
IMC passed	-0.12	-0.16	-0.09	-0.17	-0.13	-0.01	-0.21	-0.12
	(0.15)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.15)	(0.15)
Survey clarity	-0.06	0.00	0.18	-0.01	-0.04	0.11	0.15	0.19
	(0.12)	(0.12)	(0.12)	(0.11)	(0.12)	(0.12)	(0.12)	(0.12)
Constant	0.71	0.54	0.48	0.37	0.86**	0.39	0.50	0.06
	(0.45)	(0.44)	(0.43)	(0.43)	(0.43)	(0.43)	(0.44)	(0.44)
Observations	12,000							
McFadden R^2	0.52							
Likelihood ratio test	chi-square = 27562, $p < 2.22e\text{-}16$***							

Notes: The table lists the multinomial regression results of nine retirement portfolios from Task 1 to Task 9. The reference portfolio is the one from Task 1. Clustered standard errors at individual level are used to account for the correlation between the preferences across different choice tasks presented to the same individual. Variables are defined in Appendix 3.6.1. BMI: body mass index; ADL: activities of daily living; IMC: instructional manipulation check. *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

[1] The reference category of public pension is combined by the following three pension categories: CNY 2,000, CNY 1,000 and CNY 500.

3.4.2 Factors influencing annuity demand

We first report whether access to health-contingent insurance affects the demand for longevity insurance (Section 3.4.2.1). Next, we describe how personal characteristics and preferences are associated with the demand for longevity insurance (Section 3.4.2.2). We discuss the specific influence of COVID-19 on annuity demand in Section 3.4.3.

3.4.2.1 Does access to health-contingent insurance affect annuity demand?

In this section, we explore whether access to CII or LTCI affects the demand for life annuities. Table 3.6, Panel A reports the regression results for the choice task treatment variables from Model B. Nine choice tasks were given to participants to allocate their savings at retirement between a life annuity and savings account, each with a different pre-determined cover of CII and LTCI. The reference is Task 1, where the predetermined cover is no CII or LTCI.

Access to health-related insurance products can increase annuity demand, and the size of the effect is influenced by the extent of health cover and by a retiree's financial budget. Compared with no private insurance for CI and LTC costs (Task 1), on average, purchasing insurance to cover 50% of the expected OOP CI costs (Task 2), or 50% of the expected OOP LTC costs (Task 4), or 50% of the total OOP health-related costs (Task 6) increases the amount of life annuity chosen by about CNY 45 per month ($p < 0.01$). However, purchasing 100% cover for the expected OOP health-related costs (Task 9) decreases the monthly annuity by about CNY 75 ($p < 0.01$). This outcome is likely because the remaining savings that a participant could use for annuitisation decreases significantly after purchasing the predetermined full cover of CII and LTCI. The remaining choice tasks (with different covers of CII and LTCI) are not statistically significant.

Past studies have noted that the concern for uncertain health-related costs in retirement is a key factor influencing annuity demand (e.g., Pang and Warshawsky, 2010; Peijnenburg et al., 2017; Reichling and Smetters, 2015). Pang and Warshawsky (2010) demonstrated that considering uncertain health spending induces a portfolio shift to safer assets, such as annuities, because annuities are more efficient than bonds due to their mortality credit. Peijnenburg et al. (2017) proposed that the low voluntary annuitisation observed empirically can be primarily explained by concern for medical expenditures, and the timing of medical expenditure is crucial. A medical cost shock early in retirement decreases annuity demand, whereas a shock late in life increases annuity demand. Reichling and Smetters (2015) suggested that a low or even negative amount of annuity is optimal if considering stochastic mortality and correlated medical costs. However, none of them considered the influence of health-related insurance in a retirement portfolio.

The results confirm that access to health-related insurance (CII or LTCI) can release precautionary savings for purchasing life annuities. However, there is likely no highly effective method to increase the average annuity demand substantially for a whole population. Considering an individual's background when developing a financial retirement plan is crucial.

3.4.2.2 Impact of personal characteristics and preferences on annuity demand

This section presents the associations of personal characteristics and preferences on annuity demand using data from all nine tasks. The regression results are reported in Table 3.6, Panel B. In Appendix 3.6.2, we provide separate regression results for the same associations for each of the nine tasks.

Wealth and public pension income

A higher available wealth for allocation to retirement insurance products of CNY 300,000, CNY 500,000 or CNY 1,000,000 is associated with a substantial increase in annuity demand by at least CNY 150, CNY 400 or CNY 1,000 per month, respectively ($p < 0.01$). This result is consistent with prior empirical literature finding a positive association between wealth and annuity demand (e.g., Inkmann et al., 2011). A higher (public) pension of CNY 3,000 and CNY 3,500 is associated with an increased annuity demand by CNY

Table 3.6: Factors influencing annuity demand

	Model B Dependent variable: Monthly annuity
Panel A:	
Cover for OOP CI and LTC costs (ref. Task 1: Zero)	
Task 2: 50% CII	44.8*** (9.5)
Task 3: 100% CII	-8.2 (9.5)
Task 4: 50% LTCI	52.8*** (9.5)
Task 5: 100% LTCI	0.9 (9.5)
Task 6: 50% CII + 50% LTCI	45.3*** (9.5)
Task 7: 100% CII + 50% LTCI	-14.4 (9.5)
Task 8: 50% CII + 100% LTCI	-13.2 (9.5)
Task 9: 100% CII + 100% LTCI	-75.5*** (9.5)
Panel B:	
Wealth and public pension income	
Wealth: 300,000 (ref. 150,000)	215.1*** (32.8)
Wealth: 500,000	558.7*** (36.1)
Wealth: 1,000,000	1,358.4*** (40.8)
Pension: 3,000 (ref. 2,000 or less [1])	175.2*** (32.4)
Pension: 3,500	204.8*** (34.6)
Understanding of retirement insurance products and financial capabilities	
Product understanding	-55.2** (24.5)
Financial competence	-57.7** (25.1)
Financial product familiarity	-32.3 (25.1)
Subjective financial literacy	4.3 (24.7)
Demographic and socioeconomic factors	
Age Group	35.7** (17.3)
Female	-76.4** (37.7)
Tier 1	-42.2 (29.3)
State employer	-58.0** (26.0)
College and above	58.8* (33.9)
High school	62.6** (31.4)
Personal traits and preferences	
Conscientiousness	76.0*** (26.0)
Risk tolerance (financial)	33.9** (13.2)
Patience	17.7 (13.2)
State-dependent consumption	8.9* (4.7)
Health- and care-related experience	
Unhealthy BMI (ref. normal BMI)	-62.7** (26.6)
Longer subjective life expectancy	-6.3 (23.7)
Family with critical illness	-64.8** (30.8)
Family with ADL limitations	14.5 (31.7)
Provided active care	60.9** (30.6)

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Continuation of Table 3.6

Retirement planning	
Spend more	52.0** (23.6)
Long plan horizon	-4.7 (25.7)
Inter-generational aspects	
1 or less child	22.0 (30.9)
Has a daughter	31.5 (30.0)
Live in the same house	72.4*** (26.7)
Bequest motives	-17.0*** (6.3)
Impact of COVID-19	
COVID-19 mental health	-68.8*** (24.6)
COVID-19 finance situation	44.3 (29.1)
During COVID-19 purchased: CII	-24.3 (28.9)
... COVID-19 insurance	-88.8*** (33.6)
... other health insurance	-48.6 (40.6)
COVID-19 worry: small companies	21.2* (11.7)
... economy recession	-21.4* (12.2)
... own income	23.4** (11.9)
COVID-19 risky behaviour	-23.8 (23.1)
Survey measures	
IMC passed	-37.9 (32.3)
Survey clarity	-12.5 (26.7)
Constant	78.7 (97.4)
Number of observations	9,000

Notes: The table reports the regression results of the chosen monthly annuity on treatments, i.e., alternative cover of critical illness insurance (CII) and long-term care insurance (LTCI), and covariates. Variables are defined in Appendix 3.6.1. Standard errors are in parentheses. BMI: body mass index; ADL: activities of daily living; IMC: instructional manipulation check. *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

[1] The reference category of public pension is combined by the following three pension categories: CNY 2,000, CNY 1,000 and CNY 500.

140 and CNY 250 ($p < 0.01$), respectively, consistent with the empirical fact that high-income people have higher annuity demand (Pashchenko, 2013). These results also imply the potential to use regular retirement income to build a buffer to self-insure part of the health-related OOP costs (e.g., Pang and Warshawsky, 2010; Peijnenburg et al., 2017). Overall, the results confirm that a higher annuity demand is positively associated with retirement wealth and (public) pension access.

Understanding of retirement insurance products and financial capabilities

In the choice tasks, a negative association occurred between product understanding and annuity demand. The demand for the annuity decreased by about CNY 55 per month if participants scored higher than the sample median on the product knowledge quiz ($p < 0.05$). Further, the influence was negative across all tasks but less significant when the level of health insurance cover was lower (Appendix 3.6.2). These findings contrast with those from Lee et al. (2019), who noted a positive association with an annuity, whereas they are similar to those from Wu et al. (2018b), who reported a negative association for a life care annuity. Why participants who understand annuities better prefer lower annuities is unclear. However, in Appendix 3.6.1 we find that, among the four annuity attributes not offered in the choice tasks, 39% of participants think annuities providing guaranteed payments within fixed periods are the most important, and 33% focused on the income path of the annuity payments. Lee et al. (2019) also found that adults in Hong Kong prefer period annuities and fixed annuity payments. Another plausible explanation is that many people in China may tend to underestimate longevity risk due to a combination of the unprecedentedly fast growth in life expectancy and the tradition to rely on government and family.

Participants with better financial competence (based on their responses to financial literacy and numeracy questions) than the sample median were likely to demand about CNY 58 less in an annuity per month ($p < 0.05$). This finding contrasts the findings by Hanewald et al. (2020), where financial competence is positively associated with the interest in a reverse mortgage for homeowners ages 45 to 69. Familiarity with financial products in China's market and subjective financial literacy do not demonstrate a statistically significant association (at the 0.05 level) with annuity demand. Overall, indicators of product understanding and financial competence are negatively associated with annuity demand.

Demographic and socioeconomic factors

Participants who were older and had a high school education were more likely to choose a higher annuity by about CNY 36 ($p < 0.05$) and about CNY 63 ($p < 0.05$) per month, respectively. However, age was insignificant for choice Tasks 6 to 9 when both CII and LTCI were purchased (Appendix 3.6.2, Columns 7 to 10).

The participants who were female or had state-related employment in the government, at public institutes, or in state-owned companies were linked to a lower annuity demand by about CNY 76 ($p < 0.05$) and CNY 58 ($p < 0.05$) per month, respectively. In the choice tasks, all insurance products were priced accordingly to gender and age in an actuarially fair way with an additional 15% loading, and the prices were higher for females. Thus, the remaining savings associated with the predetermined health insurance cover for female participants to purchase an annuity were also lower and could systematically lead to less annuitisation. A significant negative effect of having a state-related employer is perplexing because, in the choice tasks, we set participants from different backgrounds with the same social insurance for urban employees. This result suggests that having state-related social insurance, such as a government pension, is highly negative on annuity demand, likely caused by a generous income offered by pensions for government workers.

Personality traits and preferences

Participants with higher risk tolerance in financial matters were more likely to have a higher annuity demand (about CNY 34, $p < 0.05$), whereas classic economic theory predicts that more risk-averse individuals tend to purchase more insurance. The finding is interesting because we used a consumption rather than investment framing when describing the life annuity product (e.g., Beshears et al., 2014; Brown et al., 2008). One potential explanation is that the insurance practice in China usually frames annuity-alike products as investment products; therefore, individuals may be accustomed to considering annuities to be risky products. A similar result is found for life insurance and LTCI for many European countries (Eling et al., 2021).

A higher annuity demand exists for participants who are more likely to spend more in poor health (about CNY 9, $p < 0.1$), and it became statistically significant at the 0.05 level when 50% of the OOP health-related costs were covered (Appendix 3.6.2, Column 7). This outcome suggests that the health state-dependent consumption preference can increase annuity demand when access to a specific cover for health costs is provided.

Otherwise, more conscientious participants were more likely to purchase a higher annuity (CNY 76, $p < 0.01$). However, patience is not statistically significant, which differs from the studies finding that patience is negatively associated with taking a lump-sum for retirement benefits in the Netherlands (Bockweg et al., 2017) and is positively associated with reverse mortgages in China (Hanewald et al., 2020). Overall, risk tolerance in financial matters and conscientiousness are positively associated with annuity demand, while health state-dependent consumption preference and patience exhibit limited influence.

Health- and care-related experience

Participants who had an unhealthy BMI or whose family members and relatives had a CI were likely to reduce the annuity amount by about CNY 63 ($p < 0.05$) and CNY 65 ($p < 0.05$) per month, respectively, whereas if the participants had provided active care before the annuity demand was likely to increase by about CNY 61 ($p < 0.05$). We observed a positive but insignificant effect for families with ADL limitations. In contrast, a minor negative but insignificant effect was observed if participants reported a longer subjective life expectancy compared with the national average, conditioned on a participant's age and gender.

In summary, objective health measures, such as the BMI level and illness within a family, are negatively associated with annuity demand, whereas the experience of providing active care has a positive effect. These results suggest a potential for selection in the annuity market, which contrasts with the findings in Section 3.4.1 where health-related factors are not associated with the demand for the CII and LTCI.

Retirement planning

As expected, participants who intended to spend more during retirement than before were likely to choose more annuity (about CNY 52, $p < 0.05$). However, the influence of the time horizon to plan savings and consumption on annuity demand is not significant.

Inter-generational aspects

Retirement financial planning often involves children and bequest motives. However, higher demand for an annuity (about CNY 72, $p < 0.01$) was estimated for participants with at least one child living in the same household. As expected, stronger bequest motives are linked to a lower annuity (about CNY 15, $p < 0.01$).

3.4.3 Influence of COVID-19 on longevity insurance and portfolio choices with health-contingent insurance products

This section first presents the influence of COVID-19 on the portfolio choice with health-contingent insurance products from Model A and then reports the influence of COVID-19 related experiences and attitudes on the annuity demand from Model B. A summary is provided at the end of this section.

3.4.3.1 Influence of COVID-19 on retirement portfolios choices with health-contingent insurance Products

Table 3.5 (bottom) lists the association between the influence of COVID-19 and portfolio choice with health-contingent insurance. Participants who reported worse mental health due to COVID-19 than the sample median had a lower preference for portfolios containing more health-contingent insurance ($p < 0.05$, Table 3.5, Columns 5 to 9). Compared with the participants who purchased no health-related insurance following the spread of COVID-19, participants who purchased COVID-19 insurance had a higher likelihood to choose a portfolio that fully covers expected OOP costs for CI and LTC ($p < 0.01$, Table 3.5, Column 9). However, whether they purchased CII, medical insurance, or LTCI did not affect the health-contingent portfolio choice. Participants who expressed more risky behaviour related to COVID-19 than the sample average had a lower preference for retirement portfolios that offer at least 50% cover of both CII and LTCI ($p < 0.05$, Table 3.5, Columns 7 to 9). Worries about income were negatively associated with the likelihood to choose a portfolio with 100% cover for LTC risks ($p < 0.05$, Table 3.5, Column 5). In contrast, worries about small companies were positively associated with the preference of a portfolio with 100% cover for LTC risks ($p < 0.05$, Table 3.5, Columns 5 and 8). We did not find sufficient evidence that the financial situation due to COVID-19 and attitudes towards the economic recession under COVID-19 affect the portfolio choice with health-contingent insurance.

3.4.3.2 Impact of COVID-19 on annuity demand

Table 3.5 (bottom) presents how the influence of COVID-19 is linked to annuity demand. Participants who reported worse mental health due to COVID-19 than the sample median had a lower annuity demand by about CNY 69 ($p < 0.01$). Compared with participants who did not purchase any health-related insurance following the spread of COVID-19, participants who purchased COVID-19 insurance had a lower annuity demand by about CNY 89 ($p < 0.01$). However, whether they purchased CII, medical insurance, or LTCI did not affect annuity demand in general, except that in Task 4, where 50% of the OOP costs for LTC were covered (Column 4 in Appendix 3.6.2), we noticed a sizeable negative influence (about CNY 124, $p < 0.01$) on annuity demand if other health insurance was purchased. These results imply a characteristic difference between the group of participants that purchased COVID-19 insurance and the other participants. The results also suggest that insufficient evidence exists for those having purchased CII, LTCI, or medical insurance that they also had a lower annuity demand than those who did not purchase any health-related insurance. Whether participants conducted more risky behaviour related to COVID-19 than the sample average did not affect annuity demand. Finally, worries about income were positively correlated with annuity demand (about CNY 23, $p < 0.05$).

Overall, mental health problems due to COVID-19 were negatively associated with demand for both longevity and health-contingent insurance products. Participants who purchased COVID-19 insurance had a lower annuity demand but exhibited a higher demand for full cover for CI and LTC risks. Undertaking risky behaviour related to COVID-19 was linked to a lower preference for portfolios with high cover of health-contingent insurance. Worries about income were positively associated with annuity demand and negatively associated with health-contingent insurance.

3.5 Conclusions

We conducted an online study of stated choices in China to explore the preferences for portfolios of retirement insurance products comprising a life annuity, CII, LTCI, and savings account in the wake of the COVID-19 outbreak. We collected a comprehensive set of variables measuring the influence of COVID-19 on individuals and covariates related to retirement planning. The results are summarised as follows:

- The composition of preferred portfolios of retirement insurance products is highly dependent on individual characteristics. On average, the most preferred retirement portfolio includes health-contingent insurance covering 50% of the expected OOP costs for CI and LTC and a monthly annuity income of about 19.6% of the average disposable income in urban China, with the remaining retirement wealth placed in a savings account.
- Preference for a retirement portfolio with health-contingent insurance products highly depends on individual characteristics. Wealth, understanding of retirement insurance products, financial capabilities and conscientiousness are linked to a higher preference for retirement portfolios with more cover of health-contingent insurance. Higher risk tolerance in financial matters, intention to spend more in retirement

and a higher preference to spend more in poor health states are linked to a lower preference for health-contingent insurance. However, we find a negative association for higher income while a positive association for bequest motives on the preferences for health-contingent insurance.

- Access to health-contingent insurance (in the form of CII and LTCI) can release precautionary savings to enable the purchase of life annuities, and the effects depend on the extent of the health insurance cover.
- Annuity demand is strongly associated with personal characteristics. Wealth, income, age, education, conscientiousness, intention to spend more in retirement, and living with children are positively associated with annuity demand. Working in government and related institutions and having family with CII, an unhealthy BMI, and bequest motives are linked to a lower annuity demand. However, higher risk tolerance in financial matters is linked to a higher annuity demand, whereas a better understanding of retirement insurance products and better financial capabilities are linked to a lower annuity demand.
- Experiences with and attitudes towards COVID-19 are associated with both annuity demand and preferences for retirement portfolios including health-contingent insurance products. Having purchased COVID-19 insurance is associated with lower annuity demand but a higher preference for portfolios with a full cover for health-related risks. A worse mental health status due to COVID-19 is associated with lower annuity demand and lower preferences for health-contingent insurance. Undertaking more risky behaviour related to COVID-19 is negatively associated with the preference for more cover for health-related OOP costs but is not associated with annuity demand.

The results confirm the importance of uncertain health-related costs on retirement insurance decisions. After controlling for individual backgrounds, purchasing cover for 50% of the expected OOP costs for either CI or LTC, or 50% cover for both, compared with no cover, is likely to increase monthly annuity demand by about 1.2% to 1.5% of the average disposable income in urban China. However, purchasing 100% cover for these OOP costs is likely to reduce annuity demand by about 2.1% of the average disposable income in urban China due to the limited amount of wealth at retirement available for portfolio allocation.

This study identifies a wide range of factors associated with annuity demand and preferences for health-contingent insurance. This outcome highlights the importance of individual heterogeneity in retirement planning. Several factors also have opposing influences on longevity insurance and health-related insurance. For example, risk tolerance in financial matters and intention to spend more in retirement exhibit a positive association with annuity demand but a negative one for health-contingent insurance. Understanding retirement insurance products, financial capabilities, and bequest motives are positively associated with demand for health-contingent insurance but negatively associated with annuity demand. In addition, family with CI and unhealthy BMI are linked to a lower annuity demand, whereas most health status and experience factors do not significantly affect health-contingent insurance.

These findings provide insight for policymakers and insurers. This study can inform policy development in the context of the 14th Five-Year Plan (2021 to 2025), which promotes the development of commercial insurance focusing on insurance products targeting CII, LTCI, and diversified commercial annuities and account-based pensions. Moreover, the China Banking and Insurance Regulatory Commission plans to work with government agencies to promote commercial insurance in social services. The goal is to expand the commercial health insurance market to over CNY 2 trillion and accumulate at least CNY 6 trillion commercial pension liability reserves by 2025. For policymakers, the results suggest that a demand exists to insure around 50% of the uncertain OOP health costs due to CI and LTC and that a substantial demand exists for regular income of around 19.6% of the average disposable income in urban China. These results provide empirical evidence to inform policymakers about the expansion of social insurance and cooperation with private insurers.

For insurers, the findings provide insight into the design of bundled longevity and health insurance products. We identified a wide range of factors, including COVID-19 related experiences and attitudes, to explain retirement insurance demand, assisting advisers in providing better risk management services. First, an increased annuity demand exists for individuals with 50% cover for the expected OOP costs of CI and LTC. Second, potential selection exists in longevity insurance but not in health-contingent insurance. Bundling longevity and health insurance products can mitigate the influence of adverse selection. Third, many factors, such as attitude towards retirement planning, bequest motives, risk tolerance in financial matters, and understanding retirement insurance and financial capacities, exhibit opposite influences on the demand for longevity insurance and health-contingent insurance. This outcome implies that, without considering one's health status, an individual's characteristics and preferences alone could separate the market for annuities and health insurance. Fourth, COVID-19 insurance owners may have a unique realisation of risk aversion, as they strongly prefer the full cover of health costs, with a considerable negative annuity demand. Last, the results suggest that individuals treat life annuities as investment products and consider them risky and less attractive, whereas they perceive health insurance as risk management products. Insurers may switch to a consumption framing for annuities to make them more appealing.

3.6 Appendix to Chapter 3

3.6.1 Preferences for additional product attributes

In Module 3 of the survey, participants were asked to rank four additional attributes separately for the life annuity, CII, and LTCI. The four attributes included two generic attributes (i.e., the opportunity to receive a 10% discount on the premium and a partial refund when the policyholder passes away) and two product-specific attributes for each of the three retirement insurance products. They were selected from six product-specific attributes that had been identified in the focus group testing. Table 3.7 lists the four additional attributes for each of the three retirement insurance products.

Table 3.7: Product attributes for the three retirement insurance products

	Additional product attributes
Annuity	Different income patterns (e.g., payments increase or decrease over time)
	Fixed contract length (e.g., 10 years with guaranteed payments even if the policyholder passes away)
	Price discount of 10%
	Some refund when the policyholder passes away
CII	More diseases covered
	Product can be bought by paying annually rather than a one-off payment
	Price discount of 10%
	Some refund when the policyholder passes away
LTCI	Product offers payments when the policyholder needs help with one or more (rather than three or more) of the following six activities: bathing, dressing, toileting, getting into or out of bed, continence, and feeding
	Product offers one single payment instead of regular monthly payments
	Price discount of 10%
	Some refund when the policyholder passes away

Notes: CII: critical illness insurance; LTCI: long-term care insurance.

Table 3.8 reports the percentage of each product attribute ranked first. Significant diversity exists in how participants viewed the importance of each attribute, which was likely caused by different individual backgrounds. However, most participants considered product-specific attributes, such as disease cover concerning CII, more important than the generic attributes, such as a discount of 10% or a refund when the policyholder passes away. In particular, 39% of the participants considered 'fixed contract length' the most critical feature for an annuity. This result partly reflects a preference for a period-certain annuity, which is similarly observed in the Hong Kong market (Lee et al., 2019). Moreover, 32.7% considered the income pattern of the annuity payout to be the most vital feature, which is in line with the findings by Beshears et al. (2014) for the US market. For CII, the disease cover and annual premium were ranked as the most important features to consider, reflecting a high demand for the full cover of health risks and the concern regarding a high one-off insurance premium. The results are consistent with the findings by Swiss Re (2016), where a face-to-face discrete choice experiment was conducted in China. For LTCI, 40% of participants considered one or more rather than three or more of the six ADLs to be the eligibility to receive an insurance payout. Further, 36.1% considered that a lump-sum payment instead of monthly income better reflected their needs. The preference for a broader cover for disease and care is consistent with the result that 71% of the participants who purchased insurance since COVID-19 reported that concern about health risks was the main reason for their insurance decision. However, more research is needed to understand why a substantial proportion of participants considered a lump-sum payment for LTC to be the top priority.

Table 3.8: Preferences for attributes of the three retirement insurance products

	Additional product attributes	Percentage ranking 1st
Annuity	Different income patterns	33%
	Fixed contract length	39%
	Price discount of 10%	15%
	Some refund when passing away	13%
CII	More diseases coverage	39%
	Annual premium	38%
	Price discount of 10%	13%
	Some refund when passing away	10%
LTCI	One or more activities	40%
	Lump-sum payment	36%
	Price discount of 10%	14%
	Some refund when passing away	10%

Notes: The detailed definitions of the product attributes are provided in Table 3.7. CII: critical illness insurance; LTCI: long-term care insurance.

Variable definitions and summary statistics

Definitions

Table 3.9: Variable definitions

Variable	Description
Monthly annuity	A numerical variable that equals to the chosen monthly annuity income in a Task by the participant.
Task 2 - 9	An indicator variable that equals one if the annuity income is from the corresponding task, and zero otherwise (reference category: Task 1). Task 1: None of the expected OOP cost for CI or LTC is covered. Task 2: 50% of the expected OOP CI cost is covered. Task 3: 100% of the expected OOP CI cost is covered. Task 4: 50% of the expected OOP LTC cost is covered. Task 5: 100% of the expected OOP LTC cost is covered. Task 6: 50% of the expected OOP CI cost. 50% of the expected OOP LTC cost is covered. Task 7: 100% of the expected OOP CI cost is covered. 50% of the expected OOP LTC cost is covered. Task 8: 50% of the expected OOP CI cost is covered. 100% of the expected OOP LTC cost is covered. Task 9: 100% of the expected OOP cost for CI and LTC is covered.
Wealth and public pension income	
Wealth: 1,000,000 / 500,000 / 300, 000	An indicator variable that equals one if the participant's retirement savings for insurance purchase is CNY 1,000,000, 500,000 or 300,000, respectively, and zero otherwise (reference category: 150,000).
Pension: 3,500 / 3,000	An indicator variable that equals one if the participant's pension in the experimental tasks is CNY 3,500 or 3,000, respectively, and zero otherwise (reference category: CNY 2,000 or below - combined with CNY 1,000 and CNY 500).
Understanding of retirement insurance products and financial capabilities	
Product understanding	A categorical variable that equals one if the participant's number of correct answers on the ten questions for the introduced products is above the sample median, and zero otherwise.

Continued on next page

Continuation of Table 3.9

Financial competence	An indicator variable that equals one if the participant's number of corrected answers on three numeracy questions and three financial literacy questions is above the sample median, and zero otherwise. Questions test fractions, percentages, probabilities, simple interest, inflation, and diversification.
Financial product familiarity	An indicator variable that equals one if the reported number of 14 financial products that the participant's household own is more than the sample median, and zero otherwise.
Subjective financial literacy	An indicator variable that equals one if the participant's reported financial knowledge based on a five-point scale (0 = Very good . . . 5 = Very poor) is higher than the sample median, and zero otherwise.
Demographic and economic factors	
Age group	A polychotomous variable that equals to one if the participant's age is 45-49 and rising by one in five-year steps.
Female	An indicator variable that equals one if the participant is female, and zero otherwise.
Tier 1	An indicator variable that equals one if the participant lives in a Tier 1 city, and zero otherwise.
State employer	Indicator variable that equals one if the participant is currently employed by the government, a public institute, or a state-owned company, and zero otherwise.
College and above	An indicator variable that equals one if the participant's highest level of education attained is college, diploma or above, and zero otherwise.
High school	An indicator variable that equals one if the participant's highest level of education attained is high school, and zero otherwise.
	Continued on next page
Personal traits and preferences	
Conscientiousness	An indicator variable that equals one if the participant's conscientiousness score is above the sample median, and zero otherwise. Participants rated themselves as organised, responsible, hardworking, careless (revere coded), and thoughtful on a four-point scale.
Risk tolerance (financial)	A numerical variable that reflects the participant's self-rated willingness to take risk in financial matters on an eleven-point scale (0 = Not prepared to take risks ... 10 = Fully prepared to take risks). The variable has been standardised.
Patience	A numerical variable that reflects the participant's self-rated patience on an eleven-point scale (0 = Very impatient ... 10 = Very patient). The variable has been standardised.

Continued on next page

Continuation of Table 3.9

Health-state consumption	A numerical variable that reflects the participant's self-rated preferences on consumption in different health states on an eleven-point scale (0 = Person A: Spend as much as possible while being in good health and spend little while being in bad health ... 10 = Person B: Spend as much as possible while being in bad health and spend little while being in good health). The variable has been standardised.
Health- and care-related experience	
Unhealthy BMI	An indicator variable that equals one if the participant's BMI based on self-reported weight and height is unhealthy according to the Chinese BMI reference, and zero otherwise.
Subjective life expectancy	An indicator variable that equals one if the participant's subjective life expectancy is higher than the expected life expectancy given in the question conditioning on the participant's age and gender, and zero otherwise.
Family with CI	An indicator variable that equals one if the participant's family members have been diagnosed with a CI, and zero otherwise.
Family with ADL limitations	An indicator variable that equals one if the participant's family members need help for at least one of the six activities of daily living (ADL), and zero otherwise.
Provided active care	An indicator variable that equals one if the participant has provided active care for elderly members or relatives, and zero otherwise.
Retirement planning	
Spend more	An indicator variable that equals one if the participant reports his household will spend more after retirement than before, and zero otherwise.
Long plan horizon	An indicator variable that equals one if the participant reports the next five to ten years or more than ten years are most important for his household to plan expenditures and savings, and zero otherwise.
Intergenerational aspects	
1 or less child	An indicator variable that equals one if the participant has only one child or no child, and zero otherwise.
Daughter	An indicator variable that equals one if the participant has a daughter, and zero otherwise.
Same house	An indicator variable that equals one if the participant has a child living in the same house, and zero otherwise.
Bequest motives	A numerical variable that reflects the participant's self-rated bequest intention based on an eleven-point scale (0 = Certainly not ... 10 = Certainly yes). The variable has been standardised.

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Continuation of Table 3.9

Impact of COVID-19	
COVID-19 mental health	An indicator variable that equals one if the participant's mental health to COVID-19 is worse than the sample median, and zero otherwise. Participants answered how COVID-19 makes them feel based on the worries about own health, helplessness, stress and depress on a seven-point scale.
COVID-19 finance situation	An indicator variable that equals one if the participant's finance situation following COVID-19 is better than the sample median, and zero otherwise. Participants answered how COVID-19 affects their savings and income based on a five-point scale.
During COVID-19 purchased: CII ... COVID-19 insurance ... other health insurance	An indicator variable that equals one if the participant has purchased the following insurance since the spread of COVID-19: COVID-19 insurance, CII but without COVID-19 insurance, and other health-related insurance such as LTCI and medical insurance, respectively (reference: no health-related insurance purchased).
COVID-19 worry: small companies	A numerical variable that reflects the participant's self-rated worries to small companies closing down on a seven-point scale (1 = Don't worry at all ... 7 = Worry a lot). The variable has been standardised.
... Economy recession	A numerical variable that reflects the participant's self-rated worries to an economic recession in China on a seven-point scale (1 = Don't worry at all ... 7 = Worry a lot). The variable has been standardised.
... own income	A numerical variable that reflects the participant's self-rated worries to lose own main source of income on a seven-point scale (1 = Don't worry at all ... 7 = Worry a lot). The variable has been standardised.
COVID-19 risky behaviour	An indicator variable that equals one if the participant's risky behaviour following COVID-19 is higher than the sample median, and zero otherwise. Participants answered since the loosened lockdown measures had they avoided the following five activities: seeing relatives outside their home, having meals in a restaurant with a friend, direct contact with doors or elevators buttons, crowded locations like shopping malls, and travelling based on four-point scale (1 = Always avoided ... 4 = Never avoided) and a 'Does not apply' option was provided.
Survey measures	
IMC passed	An indicator variable that equals one if the participant passed the instructional manipulation check (provided a consistent answer for the household income question, and reported had seen the question before), and zero otherwise.
Survey clarity	An indicator variable that equals one if the participant's rating of the survey's clarity on a six-point scale (1 = completely clear ... 6 = completely confusing) is above the sample median, and zero otherwise.

Summary statistics

Table 3.10: Summary statistics

	Min	Pctl(25)	Median	Pctl(75)	Max	Mean	St. Dev.
Wealth and public pension income							
Wealth: 300,000	0	0	0	1	1	0.29	0.45
Wealth: 500,000	0	0	0	1	1	0.26	0.44
Wealth: 1,000,000	0	0	0	0	1	0.2	0.4
Pension: 3,000	0	0	0.5	1	1	0.5	0.5
Pension: 3,500	0	0	0	1	1	0.33	0.47
Understanding of retirement insurance products and financial capabilities							
Product understanding	0	0	0	1	1	0.39	0.49
Financial competence	0	0	0	1	1	0.41	0.49
Financial product familiarity	0	0	0	1	1	0.31	0.46
Subjective financial literacy	0	0	0	1	1	0.4	0.49
Demographic and socioeconomic factors							
Age group	1	1.8	3	3	5	2.58	1.16
Female	0	0	0.5	1	1	0.5	0.5
Tier 1	0	0	0	0	1	0.2	0.4
State employer	0	0	0	1	1	0.27	0.45
Beyond high school	0	0	0	0	1	0.25	0.43
High school	0	0	0	1	1	0.37	0.48
Personal traits and preferences							
Conscientiousness	0	0	0	1	1	0.39	0.49
Risk tolerance (financial)	-4.11	-0.71	0.43	0.43	1.56	0	1
Patience	-4.58	-0.32	0.28	0.89	1.5	0	1
Health-state consumption	-2.49	-0.86	0.37	0.78	1.6	0	1
Health- and care-related experience							

Continued on next page

Continuation of Table 3.10

	Min	Pctl(25)	Median	Pctl(75)	Max	Mean	St. Dev.
Unhealthy BMI	0	0	0	1	1	0.46	0.6
Longer subjective life expectancy	0	0	0	0g	1	0.23	0.42
Family with critical illness	0	0	0	0	1	0.24	0.43
Family with ADL limitations	0	0	0	0	1	0.23	0.42
Provided active care	0	0	0	0	1	0.18	0.38
Provided active care	0	0	0	0	1	0.18	0.38
Retirement planning							
Spend more	0	0	0	1	1	0.35	0.48
Long plan horizon	0	0	0	1	1	0.26	0.44
Inter-generational aspects							
1 or less child	0	0	0	1	1	0.46	0.5
Daughter	0	0	1	1	1	0.57	0.5
Same house	0	0	0	0	1	0.25	0.43
Bequest motives	-3.77	-0.25	0.25	0.75	1.26	0	1
Impact of COVID-19							
COVID-19 mental health	0	0	0	1	1	0.47	0.5
COVID-19 finance situation	0	0	0	0	1	0.2	0.4
During COVID-19 purchased: CII	-1.81	-0.59	0.02	0.63	1.85	0	1
... COVID-19 insurance	-2.24	-0.91	-0.24	1.09	1.76	0	1
... other health insurance	-1.6	-0.98	-0.37	0.86	2.09	0	1
COVID-19 worry: small companies	0	0	0	1	1	0.48	0.5
... Economy recession	0	0	0	1	1	0.47	0.5
... own income	0	0	0	0	1	0.2	0.4
COVID-19 risky behaviour	-1.81	-0.59	0.02	0.63	1.85	0	1
Survey measures							
IMC passed	0	1	1	1	1	0.86	0.35
Survey clarity	0	0	1	1	1	0.72	0.45

Notes: BMI: body mass index; ADL: activities of daily living; CII: critical illness insurance; IMC: instructional manipulation check.

3.6.2 Additional regression results by tasks from Stage 1

Table 3.11: Regression results for relationships between monthly annuity and individual characteristics by each of the nine tasks in Stage 1

	Dependent variable: Monthly annuity								
	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Task 9
CII cover	0%	50%	100%	0%	0%	50%	100%	50%	100%
LTCI cover	0%	0%	0%	50%	100%	50%	50%	100%	100%
Wealth and public pension income									
Wealth: 300,000	159.9***	191.8***	209.8***	196.4***	218.5***	224.3***	251.2***	242.1***	242.0***
(ref. 150,000)	(34.8)	(38.8)	(37.8)	(40.6)	(37.1)	(38.8)	(37.2)	(39.4)	(35.2)
Wealth: 500,000	448.0***	534.6***	544.3***	520.9***	541.0***	579.3***	613.7***	629.9***	616.8***
	(38.3)	(42.7)	(41.5)	(44.7)	(40.8)	(42.7)	(40.9)	(43.3)	(38.7)
Wealth: 1,000,000	1,090.0***	1,336.0***	1,343.0***	1,340.0***	1,368.0***	1,444.0***	1,444.0***	1,419.0***	1,441.0***
	(43.3)	(48.3)	(47.0)	(50.5)	(46.2)	(48.3)	(46.3)	(49.0)	(43.8)
Pension: 3,000	156.5***	167.8***	177.8***	204.6***	150.9***	213.9***	161.7***	201.4***	142.7***
(ref. 2,000 or less)	(34.4)	(38.4)	(37.3)	(40.1)	(36.6)	(38.3)	(36.8)	(38.9)	(34.7)
Pension: 3,500	212.4***	194.7***	210.4***	222.2***	170.8***	252.9***	181.7***	215.8***	182.2***
	(36.8)	(41.0)	(39.9)	(42.9)	(39.2)	(41.0)	(39.3)	(41.6)	(37.1)
Understanding of retirement insurance products and financial capabilities									
Product	-21.5	-46.8	-48.6*	-76.2**	-46.0*	-65.2**	-51.9*	-75.8***	-64.8**
understanding	(26.0)	(29.0)	(28.1)	(30.3)	(27.7)	(28.9)	(27.7)	(29.4)	(26.2)
Financial	-19.4	-57.5*	-19.2	-83.2***	-78.4***	-54.4*	-71.5**	-66.4**	-69.7***
competence	(26.7)	(29.8)	(28.9)	(31.1)	(28.4)	(29.7)	(28.5)	(30.2)	(27.0)
Financial product	-25	-42.5	-38.2	-33.3	-33.9	-36.3	-20.9	-42.4	-18
familiarity	(26.7)	(29.8)	(28.9)	(31.1)	(28.4)	(29.7)	(28.5)	(30.2)	(26.9)
Subjective	-9.5	0.1	25.8	27	17.5	0.7	-30.5	1.1	6.6
financial literacy	(26.3)	(29.3)	(28.4)	(30.6)	(27.9)	(29.2)	(28.0)	(29.7)	(26.5)

Continued on next page

Continuation of Table 3.11

	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Task 9
CII cover	0%	50%	100%	0%	0%	50%	100%	50%	100%
LTCI cover	0%	0%	0%	50%	100%	50%	50%	100%	100%
Demographic and socioeconomic factors									
Age group	44.9**	45.0**	47.5**	61.7***	45.4**	23.5	16.6	22.1	14.5
	(18.4)	(20.5)	(19.9)	(21.4)	(19.5)	(20.4)	(19.6)	(20.7)	(18.5)
Female	-39.7	-45.1	-17.8	-60.7	-95.3**	-112.6**	-108.8**	-116.3**	-91.3**
	(40.1)	(44.7)	(43.5)	(46.7)	(42.7)	(44.7)	(42.8)	(45.3)	(40.5)
Tier 1	-41.2	-47	-42.2	-41.6	-38	-51	-31.7	-53.2	-33.7
	(31.2)	(34.7)	(33.8)	(36.3)	(33.2)	(34.7)	(33.3)	(35.2)	(31.5)
State employer	-52.6*	-61.1**	-48.7	-77.4**	-47.2	-69.5**	-51.1*	-67.8**	-46.5*
	(27.6)	(30.7)	(29.9)	(32.1)	(29.4)	(30.7)	(29.4)	(31.2)	(27.8)
Beyond high school	76.6**	84.2**	45.2	37.3	67.7*	80.9**	71.2*	35.8	30.5
	(36.0)	(40.2)	(39.1)	(42.0)	(38.4)	(40.1)	(38.5)	(40.7)	(36.4)
High school	54.2	56.5	64.5*	46	79.5**	71.0*	77.2**	56.8	58.0*
	(33.3)	(37.1)	(36.1)	(38.8)	(35.5)	(37.1)	(35.6)	(37.6)	(33.6)
Personal traits and preferences									
Conscientiousness	56.1**	70.5**	80.8***	102.0***	63.6**	112.9***	76.4***	59.1*	62.4**
	(27.7)	(30.8)	(30.0)	(32.2)	(29.4)	(30.8)	(29.5)	(31.3)	(27.9)
Risk tolerance	36.4***	32.2**	43.3***	30.9*	29.6**	43.8***	22.8	42.4***	23.4
(financial)	(14.1)	(15.7)	(15.2)	(16.4)	(15.0)	(15.7)	(15.0)	(15.9)	(14.2)
Patience	24.1*	27.2*	7.5	10.6	25.6*	14.2	22.2	11.2	16.6
	(14.0)	(15.6)	(15.2)	(16.3)	(14.9)	(15.6)	(15.0)	(15.8)	(14.1)
Health-state	8.3	8.4	7.6	7.8	10.3*	11.4**	10.1*	10.5*	5.5
consumption	(5.0)	(5.6)	(5.5)	(5.9)	(5.4)	(5.6)	(5.4)	(5.7)	(5.1)
Health- and care-related experience									
Unhealthy BMI	-100.8***	-78.5**	-46.8	-47.6	-54.6*	-58.5*	-65.1**	-65.2**	-47.3*
	(28.2)	(31.5)	(30.6)	(32.9)	(30)	(31.4)	(30.1)	(31.9)	(28.5)

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Continuation of Table 3.11

	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Task 9
CII cover	0%	50%	100%	0%	0%	50%	100%	50%	100%
LTCI cover	0%	0%	0%	50%	100%	50%	50%	100%	100%
Longer subjective	-9.2	-21.2	-10.8	-2.1	-21.4	0.2	-1.3	0.6	8.1
life expectancy	(25.1)	(28.0)	(27.2)	(29.3)	(26.8)	(28.0)	(26.8)	(28.4)	(25.4)
Family with critical	-57.1*	-62.9*	-66.4*	-49.3	-67.5*	-71.6**	-67.5*	-72.0*	-68.7**
illness	(32.7)	(36.4)	(35.4)	(38.1)	(34.8)	(36.4)	(34.9)	(36.9)	(33.0)
	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Task 9
Family with ADL	8.5	10.2	21.4	-10.1	15.3	46.1	3.6	20.3	15
limitations	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)
Provided active care	55.0*	55.5	47.8	93.2**	56.1	72.7**	55.3	70.8*	42.1
	(32.5)	(36.3)	(35.2)	(37.9)	(34.6)	(36.2)	(34.7)	(36.8)	(32.8)
Retirement planning									
Spend more	40.6	29.9	37.2	58.2**	60.3**	65.7**	69.8***	67.4**	38.7
	(25.1)	(28.0)	(27.2)	(29.2)	(26.7)	(27.9)	(26.8)	(28.3)	(25.3)
Long plan horizon	-8.4	-0.9	4	0	-1.3	17.6	-27.4	-33.1	7.2
	(27.3)	(30.5)	(29.6)	(31.9)	(29.1)	(30.4)	(29.2)	(30.9)	(27.6)
Inter-generational aspects									
1 or less child	-3.2	15.9	0.8	38	54.9	46	1.5	11.5	32.7
	(32.9)	(36.6)	(35.6)	(38.3)	(35.0)	(36.6)	(35.1)	(37.1)	(33.2)
Daughter	22.5	30.4	17.6	33.3	48.4	29.7	33.3	40.7	27.9
	(31.8)	(35.5)	(34.5)	(37.1)	(33.9)	(35.5)	(34.0)	(36.0)	(32.1)
Same house	76.4***	60.1*	68.2**	34.1	104.3***	76.7**	90.5***	102.6***	38.2
	(28.4)	(31.7)	(30.8)	(33.1)	(30.3)	(31.6)	(30.3)	(32.1)	(28.7)
Bequest motives	-20.7***	-17.2**	-18.2**	-15.1*	-17.5**	-20.9***	-15.6**	-18.7**	-9
	(6.6)	(7.4)	(7.2)	(7.7)	(7.1)	(7.4)	(7.1)	(7.5)	(6.7)

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Continuation of Table 3.11

	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Task 9
CII cover	0%	50%	100%	0%	0%	50%	100%	50%	100%
LTCI cover	0%	0%	0%	50%	100%	50%	50%	100%	100%
Impact of COVID-19									
COVID-19 mental health	-56.6**	-76.5***	-77.8***	-61.6**	-43.2	-84.1***	-103.3***	-64.3**	-51.8**
	(26.1)	(29.1)	(28.3)	(30.4)	(27.8)	(29.1)	(27.9)	(29.5)	(26.3)
COVID-19 finance situation	23.4	55.4	47.1	64.2*	39.6	34.2	40.8	43.8	50.2
	(31.0)	(34.5)	(33.5)	(36.1)	(33.0)	(34.5)	(33.1)	(35.0)	(31.3)
During COVID-19	6.7	-33.8	-52.9	-65.6*	-11.5	-14.7	-21.4	-6.4	-19.1
purchased: CII	(30.6)	(34.1)	(33.2)	(35.7)	(32.6)	(34.1)	(32.7)	(34.6)	(30.9)
... COVID-19	-42.6	-90.5**	-135.8***	-149.5***	-105.8***	-99.5**	-56.3	-52.3	-66.7*
	(35.7)	(39.8)	(38.7)	(41.6)	(38.0)	(39.7)	(38.1)	(40.3)	(36)
... other health insurance	-25.3	-15.6	-84.7*	-124.0**	-72.3	-14.6	-47.6	-30.4	-23
	(43.2)	(48.1)	(46.8)	(50.3)	(45.9)	(48.1)	(46.1)	(48.8)	(43.6)
COVID-19 worry:	19	19.1	24.9*	14.4	8.5	27.7**	27.7**	25.4*	24.2*
small companies	(12.4)	(13.8)	(13.4)	(14.4)	(13.2)	(13.8)	(13.2)	(14.0)	(12.5)
... economy recession	-18.5	-9.2	-24.1*	-17.3	-33.8**	-16.5	-24.5*	-28.6*	-20
	(12.9)	(14.4)	(14)	(15.1)	(13.8)	(14.4)	(13.8)	(14.6)	(13.1)
... own income	18.9	23.1	29.5**	26.0*	17.2	29.4**	17.4	28.4**	20.9
	(12.7)	(14.1)	(13.7)	(14.7)	(13.5)	(14.1)	(13.5)	(14.3)	(12.8)
COVID-19 risky behaviour	-40.8*	-23.4	-31	-0.2	-21.2	-23.9	-25.1	-32	-16.5
	(24.6)	(27.4)	(26.6)	(28.6)	(26.2)	(27.4)	(26.2)	(27.8)	(24.8)

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Continuation of Table 3.11

	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Task 9
CII cover	0%	50%	100%	0%	0%	50%	100%	50%	100%
LTCI cover	0%	0%	0%	50%	100%	50%	50%	100%	100%
Survey measures									
IMC passed	-26	-49.8	-15.8	-42.9	-33.5	-58.1	-39.3	-66.2*	-9.2
	(34.3)	(38.2)	(37.1)	(40.0)	(36.5)	(38.2)	(36.6)	(38.7)	(34.6)
Survey clarity	11.5	-23.4	-37.9	-1.9	-14.9	-21.3	-12.8	4.6	-15.8
	(28.3)	(31.6)	(30.7)	(33.0)	(30.2)	(31.6)	(30.3)	(32.0)	(28.6)
Constant	127.4	156.3	48.1	68	36.5	100.5	111.8	90.4	1.5
	(103.3)	(115.2)	(111.9)	(120.4)	(110.0)	(115.0)	(110.3)	(116.7)	(104.3)
Observations	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Adjusted R^2	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.6	0.7

Notes: The table lists the regression results of the chosen monthly annuity from each treatment, i.e., alternative cover of critical illness insurance (CII) and long-term care insurance (LTCI), and covariates. Variables are defined in Appendix 3.6.1. Standard errors are in parentheses. BMI: body mass index; ADL: activities of daily living; IMC: instructional manipulation check. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

[1] The reference category of public pension is combined by the following three pension categories: CNY 2,000, CNY 1,000 and CNY 500.

3.6.3 Pricing of insurance products

In the survey, the life annuity, critical illness insurance, and long-term care insurance were priced for individuals at the hypothetical retirement age 55 (for females) or age 60 (for males) by making a one-off payment. We priced the three products in an actuarially fair way based on gender and age. We assumed a constant 3.5% nominal interest rate[20] and a constant 2% inflation rate[21] for each year in the future. In addition, we assumed a 15% loading for all products, which is consistent with Mitchell et al. (1999) for longevity insurance and Karaca-Mandic et al. (2011) for health insurance.[22]

We used the industry standard mortality and incidence rates provided by the CBIRC for annuities and critical illness insurance products. For the life annuity, we used the mortality curves for pension business for males and females starting at age 60 and 55, respectively. For the critical illness insurance, we used the incidence rate curves for 25 diseases for males and females starting at age 60 and 55, respectively. And, for the mortality profiles needed to price critical illness insurance, we use the industry mortality curves for the health insurance business.[23] The insured period is lifetime for all three products. However, for critical illness insurance the contract ends if the payment is made, and for long-term care insurance, the payments will only be made when the insured cannot perform three or more ADLs.[24] For simplicity and a cleaner interpretation, we assumed that these curves are unchanged in the future.[25]

[20]This is a standard assumption for pricing under China's insurance regulation.

[21]This is approximately an average of the national CPI values during the period 2010-2019.

[22]However, the insurance loading is typically higher in China, for example, a security surcharge costs about 10% - 30% of the pure premium (Zhang et al., 2021).

[23]Chinese insurance companies can also use the mortality curves for pension business to achieve a more defensive price.

[24]Instead of a lifetime cover of the critical illness insurance, we have also tested the price with a shorter cover, that is, age 60-80 for males, and age 55-85 for females. The differences compared with a lifetime cover are not substantial as the cumulative survival chances at later ages are small enough to mitigate a higher chance of incidence.

[25]The incidence curve for critical illness insurance is subject to update in 2020 according to CBRIC. However, the final update had not been released by the time of the survey was conducted.

However, for long-term care insurance, industry standard transition curves are not available. We estimated the health transition rates based on data from CHARLS survey. We used all available CHARLS data: 2011, 2013, and 2015. A two-year transition at each age for both genders was observable by the longitudinal survey design with initial waves in 2011 or 2013 and their follow-up waves in 2013 or 2015, respectively. As the sample size was limited at certain ages, we pooled the two-year transition data from 2011 to 2013 and 2013 to 2015 and estimated the one-year transition at each age for each gender, assuming the transitions rates were stable from 2011 to 2015. We only used data for respondents in the initial years (2011 or 2013) that were at least 35 years old.[26] We excluded observations with missing ADL status or death information.

We defined four health states: Healthy, Fair (one or two ADLs), Disabled (three or more ADLs, LTCI payable), and Dead. The recovery from states Fair or Disabled are allowed and Dead is an absorbing state. We model the health transitions in a Markov framework. To estimate health transition probabilities, we used a multinomial logit model based on a series of tests.[27] The model was estimated separately for female and male populations. The dependent variable is each respondent's health state observed in the follow-up wave (2013 or 2015), and the explanatory variables are the respondent's age and health state in the initial wave (2011 or 2013).[28]

Based on the fitted multinomial logit model we predicted the two-year transition rates for females (males) starting from age 55 (60) and further converted them to the one-year

[26] We have conducted sensitivity tests using a subset with ages between 45-84, and a subset with a ten-year age group starting from 35-45, as well as other similar restrictions on age. The impact on product pricing was not substantial.

[27] We considered a probit model, which had been used to estimate the transition probabilities in a similar context in the US by Yogo (2016) and Koijen et al. (2016). We also have tested ordered logit, probit, complementary log–log models, and the multinomial logit model has the best performance in terms of AIC and deviance residuals. We also have tested generalised linear models and non-parametric smoothing techniques for each of the possible transitions and we do not find substantial differences in terms of price.

[28] We do not distinguish between urban and rural population for pricing, as the insurance price is the same for them in China.

transition probability matrix. Both females and males are assumed dead at age 105.

As in the case of the life annuity and the critical illness insurance, we assumed that the estimated transition rates for long-term care were stable in the future. The price of the long-term care insurance was determined recursively according to the industry standard.

For bundled products, for example, a life annuity bundled with long-term care insurance, we assumed the impact of adverse selection observed in separate longevity and health insurance markets can be reduced. The exact amount of reduction of adverse selection is not available in China. However, we can approximate it by calculating the pricing difference of the annuities with respect to the three industry mortality curves (one for pension with low mortality rates, one for health insurance with high mortality rates, and one for savings products with median mortality rates). We find that the average pricing difference across ages by using the high mortality curve and the median mortality curve, and by using the low mortality curve and the median mortality curve, is about 10%. We therefore assume that joint insurance markets could yield an approximately 10% discount if any two products are bought together, and we further assume a 15% discount if all three products are bought together.

Chapter 4

Optimal portfolio choice with longevity, critical illness insurance and long-term care insurance

4.1 Introduction

Longer life expectancies in developed countries have profound economic impacts on public insurance systems and individual retirement planning. However, many developing countries, such as China, are also facing rapid population ageing. By the end of 2019, 18.1% of the Chinese population was aged 60 years or above (254 million), and this ratio is projected to increase to 35% (480 million) in 2050 (United Nations, 2019). After a series of social insurance reforms,[1] China's public pension and health insurance provides universal but basic coverage. The adequacy of retirement income is an issue as the replacement rate of mandatory pension schemes has fallen from over 80% in 1995 to 40% (Zhu and Walker,

[1]Several studies make suggestions for reforms of the social security system in China: the pension system (Barr and Diamond, 2010; Fang and Feng, 2020), the healthcare system (Sun et al., 2017), and the long-term care system (Lu et al., 2015; Yang et al., 2016).

2018). The chance of having catastrophic costs is high (Liu et al., 2017b; Zhang et al., 2017a; Zhu et al., 2016), and even the richest 20% experienced financial hardship during 2011–2013 (Li and Feng, 2017) because public health insurance provides only limited coverage of advanced medical treatments and drugs for critical illness. China has conducted pilot long-term care programmes in different cities since 2012, but the availability is limited in most cities, and the financing of long-term care insurance remains an issue (Huang et al., 2019c).[2]

The eldercare traditionally provided by families has been weakened by the change in family structure, which is partly due to the one-child policy, and the large-scale rural-urban migration (Zhen et al., 2015). Facing limited cover by public insurance, individuals need ways to manage their retirement risks, and private insurance can help with this. However, China's private insurance market rarely offers long-term health insurance products for adults over 60 years old. In 2020, China's State Council emphasised the need to improve the quality and scale of private insurance with a focus on insurance to cover medical costs, annuities and account-based pensions, and long-term care insurance. It also highlighted the role of commercial insurance in social services (CBIRC, 2020; Xinhua, 2020).

In this study, we investigate the optimal portfolio for a retiree in urban China. China is an example of a rapidly ageing developing country with a less than well-developed public insurance system and an immature financial market. We assume the retiree is covered by a basic public pension and health insurance, and we develop a life-cycle model where the retiree faces uncertain longevity, critical illness risk, and long-term care risk, with uncertain medical and care expenditures associated with these risks. The retiree chooses consumption and allocates his retirement wealth among a portfolio of life annuities, critical illness insurance, long-term care insurance, and a savings account to maximise his expected lifetime utility. The critical illness insurance provides a lump-sum benefit when the insured is diagnosed with a critical illness. The long-term care insurance provides regular income

[2] Chapter 2.1 provides a brief background of China's public and private insurance in retirement.

when the insured is long-term care dependent. We also consider a state-dependent utility function under which the utility of non-medical consumption depends on the retiree's current health state. We show the optimal portfolios and welfare gains for retirees with different levels of wealth and pension benefits because there is a large economic inequality among older Chinese (e.g., Hanewald et al., 2021).

We find that in a developing country like China, there is a demand for all three insurance products considered in this analysis, and critical illness insurance is an important component in retirement planning. Specifically, we predict that for retirees with an average pension (of CNY 3,000[3] per month in 2020) at least 30% of retirement savings is allocated to critical illness insurance. Retirees with a low pension of CNY 1,000 per month should annuitise fully if they have low retirement savings (CNY 150,000) and almost half of their wealth if they have high retirement savings (CNY 1 million). There is a small demand (5% to 15%) for long-term care insurance at all levels of wealth and pensions considered in this analysis. The optimal portfolios predicted for retirees with different levels of public pensions and retirement savings provide substantial welfare gains compared with having no private insurance. The welfare gains with the optimal portfolios for retirees with different economic backgrounds range from approximately 10% to more than 100% of their initial retirement savings. In addition, the welfare gain is higher for retirees with less wealth or pension income and suggest that optimal insurance with health-contingent and longevity insurance products assist in reducing inequality among older individuals.

We are the first to consider life annuities, critical illness insurance, and long-term care insurance together in a life-cycle framework for retirement planning. Prior studies are mostly set in a developed-country context and focus on annuities or long-term care insurance (e.g., Ameriks et al., 2020; Koijen et al., 2016; Pang and Warshawsky, 2010; Peijnenburg et al., 2017). However, in developing countries, critical illness insurance is important because government health insurance only provides basic coverage. This chapter provides an im-

[3] 1 USD equalled 6.8 CNY in September 2020.

portant contribution by comprehensively studying insurance demand as a portfolio choice, as suggested by Koijen et al. (2016). The annuity income, lump-sum payment, and regular income provided by the three insurance products included in our study can be used for any purpose; hence there may be substitution and complementary effects among these products. In addition, there may be trade-offs among the retirement insurance products since individuals have limited wealth for portfolio allocation at retirement. These have profound economic consequences for retirement planning, and it is not possible to estimate the true demand for one insurance product without considering the other options.

Compared with the literature on annuity demand focusing on stochastic mortality developments and correlated health costs (e.g., Ai et al., 2017; Reichling and Smetters, 2015), we explicitly consider two poorer health states – being critically ill and needing long-term care – in a health transition matrix. We model their cost distributions in a life-cycle model to find the optimal insurance demand. Our results also provide a reference for studies that elicit stated preferences for retirement portfolio allocation that includes longevity and health-contingent insurance, for example, Wu et al. (2018b) and the hypothetical survey in Chapter 3.

Another important contribution is that we include state-dependent utility in our model. This relates our study to the literature on the state-dependent utility of consumption, that is, whether the utility of consumption is higher or lower in a poor than in a healthy state (e.g., Edwards, 2008; Finkelstein et al., 2013; Gerking et al., 2017; Gyrd-Hansen, 2017; Tengstam, 2014; Viscusi and Evans, 1990). Empirical results for China are limited. Wang and Wang (2020) estimate a linear probability model and find a higher utility of non-medical consumption for older individuals in China with several chronic diseases but a lower utility for those who are unable to perform various daily activities. Prior literature (Koijen et al., 2016; Peijnenburg et al., 2017) considers only one state of poor health in studying retirement planning with a state-dependent utility function. We are the first to consider two states of poor health and simultaneously allow those states both a lower and a higher weighting on the utility of consumption in a life-cycle model. We find that annuity demand increases from zero to at least 10% of initial retirement savings for the wealthiest retirees after considering their health-dependent utility of consumption. This is the case regardless of whether a higher or lower weight is assumed for poorer health states. This finding differs from Peijnenburg et al. (2017), who find annuity demand is not sensitive to the assumption of a state-dependent utility in the US. We find that, for retirees with higher pensions or savings, a higher weighting on the utility of consumption in the poorer health states often results in greater demand for health-related insurance, while lower weights often decrease that demand. For retirees with low wealth or pension levels, the optimal portfolio is mainly driven by their financial constraints (i.e., insufficient wealth or pension); considering the impact of health state on the utility of consumption modifies the results somewhat.

For developing countries with large economic variations among individuals, our results suggest that, when planning for social insurance expansion, these countries should start to implement a basic layer of long-term care services for all people. Furthermore, the focus should be on providing insurance coverage for large expenditures due to critical illness for those with average pensions and providing enough regular income for those with a low pension. For insurance companies, our results highlight, firstly, the importance of targeting and providing theoretically optimal insurance levels in a portfolio context that better supports financial advisory services. Secondly, bundled longevity and health-contingent insurance products can increase annuity demand for more affluent retirees.

In Section 4.2, we describe the life-cycle model of consumption and portfolio allocation for retirement and explain how we calibrate the model parameters. In Section 4.3, we present the benchmark results for retirees with different levels of public pensions and retirement savings. In Section 4.4, we analyse the sensitivity of the results to changes in key model parameters. We discuss the practical implications for policymakers and the insurance industry in Section 4.5, and Section 4.6 concludes.

4.2 Model

This section describes the life-cycle model during the retirement phase in China. A male individual aged 60 is assumed to have public insurance and retirement savings. This individual faces the risk of critical illness, long-term care dependence, uncertain longevity and random health-related costs. They can choose from a life annuity, critical illness insurance, long-term care insurance, and a savings account to maximise their expected lifetime utility of consumption. In this section, we first describe the individual profiles and public insurance. We then describe the insurance products and the financial market. Thereafter, we describe the calibration of the health transitions and estimation of the health-related costs. Finally, we introduce the life-cycle model and the individual's optimisation problem.

4.2.1 Individual profiles and government insurance

We assume that the individual is an urban retiree and is covered by Basic Old Age Insurance (BOAI), that is, public insurance for employees with a formal job in China. Further, we assume that the individual does not have access to a government-employee pension. This type of retiree represents more than 90% of the BOAI participants and around 45% of all public-pension participants in China, including the participants in the Resident Pension Scheme for non-employed urban or rural residents (Chen and Turner, 2021).

The individual retires with a retirement savings of M and receives an annual income P_t at period t from the public pension program. We study the optimal retirement portfolio problem for four types of individuals with different economic backgrounds: i) high retirement savings and an average pension income, ii) high retirement savings and a low level of pension income, iii) low retirement savings and an average pension income, and iv) low retirement savings and a low level of pension income. The wealth values are calibrated around the 30th and 80th percentile of the wealth distributions based on the China Health and Retirement Longitudinal Survey (CHARLS) data. We set the pension amounts following Zhu and Walker (2018) and use the average monthly pension levels published by local governments to represent a low and an average pension for retirees with BOAI. We also exclude retirees with lower levels of savings or pension as the portfolio allocation results will largely be restricted by their limited economic resources.

Public health insurance is assumed to be the same across all four types of individuals with different economic backgrounds since the benefits of the Employee Medical Insurance is almost identical to its participants.[4] Therefore, the health-related cost in our model is driven by the out-of-pocket portion described in Section 4.2.4.

We assume there is a consumption floor in our model. The value of the floor is based on the government subsidy 'Dibao' – a monthly subsidy for those without sufficient income for necessities. The average of this monthly subsidy is CNY 687, according to official provincial data published in 2020 (Ministry of Civil Affairs, 2020).

4.2.2 Insurance products and financial market

At the start of the model period (at retirement), the individual can purchase a life annuity, critical illness insurance, and long-term care insurance. We do not allow the individual to purchase insurance before retirement because the aim is to focus on retirement insurance allocation choices of people close to retirement age who would use their savings accumulated at retirement. Another reason is to keep the model simple and focus on the retirement phase only.[5] The individual is not allowed to sell or terminate the insurance

[4] The accumulated amounts in the Individual Medical Account from the Employee Medical Insurance depend on salary path. However, the contribution period is limited for the current generation close to retirement. Therefore we assume its impact is minimal.

[5] Assuming multiple payments from a younger age or after retirement, other factors unchanged, the insurance demand is likely to increase for four reasons. First, compared with a one-time payment, multiple payments will make insurance more affordable. Second, the impact of illiquidity from a large one-time payment will be reduced. Third, there is a wage-based tax advantage for the purchase of annuities and health-related insurance. Fourth, a larger risk pooling could lower the price of insurance products.

contracts or purchase additional coverage in the future. This is because i) health-related long-term insurance such as critical illness insurance and long-term care insurance is typically not available for purchase in China after the age of 60, and ii) delayed annuitisation is rare, even in developed countries (e.g., Johnson et al., 2004; Peijnenburg et al., 2016; Turra and Mitchell, 2008). The life annuity pays a fixed amount of real income Annuity_t at each period t until death. Critical illness insurance provides a real lump sum payment CII_t when the insured is in the critically ill state, that is, diagnosed with one of 25 critical conditions (e.g., cancer, stroke, or heart attack),[6] for the first time at period t. Long-term care insurance provides a fixed amount of real income LTCI_t in each period for which the insured is in the long-term care state; that is, it is payable when the insured cannot without difficulty perform three or more of the following six activities of daily living (ADLs): bathing, dressing, eating, toileting, continence, transferring in and out of bed.[7]

The payments from the insurance products can be used for consumption and health-related costs. For example, the annuity income can be saved to cover health costs later. Both the annuity and the critical illness insurance are priced in an actuarially fair way according to age using official tables in China.[8] Since there are no official tables for the long-term care insurance, we have based our estimates for long-term care insurance on the CHARLS data.[9] The pricing details for long-term care insurance are described in Appendix 4.7.1. In addition, we assume a 15% insurance loading for all retirement insurance products.

[6]The 25 conditions were standard according to the China Bank and Insurance Regulatory Commission (CBIRC) before an update of the standard in 2020. The official update had not been released by the time the survey in Chapter 3 was distributed. We want to compare the stated and the optimal demand for the three insurance products.

[7]In China, failing to perform at least three ADLs is usually required to qualify for private long-term care insurance payments.

[8]We use the mortality table for pension business provided by the CBIRC to price annuity, and we use the CBIRC table for critical illness incidence rates and the CBIRC mortality table for health insurance business to price critical illness insurance.

[9]The insurance industry in China prices annuity and critical illness insurance separately based on regulated official tables. For long-term care insurance, both the census data and the longitudinal surveys like the CHARLS in China have been used to estimate the health transitions relevant for pricing. However, the definitions of long-term care state are not consistent.

This loading assumption is slightly higher for life insurance in China. Wan et al. (2017) find that the money's worth ratio for commercial pensions is at least 90%. However, the 15% loading is somewhat low for health insurance in China – the administrative costs for health insurance in China are between 15% and 20%, and there is an additional 10% to 30% security surcharge (Zhang et al., 2021). However, the retirement insurance products in our study are generally not available in the market, and we want to examine the potential of these products for social insurance expansion. Therefore, we assume the same loading for all products. We investigate the impact of different pricing assumptions for product bundling in Section 4.4.3.

The individual can use a savings account that earns a risk-free rate. We include a savings account rather than stocks in our retirement portfolio for three reasons. First, retirees in China tend to save in low return savings accounts rather than invest in the stock market which is more typical in developed countries. The average stock market participation rate in China is about 8%, compared to 50% in the US (Chen and Ji, 2017) and is even lower among the elderly. Data collected in the latest CHARLS in 2018 shows that less than 5% of people aged 50-69, still working and living in an urban area (our sub-population of interest) participate in the stock market. Second, we wanted to be able to compare the results from the life-cycle model in this chapter with the stated choices presented in Chapter 3. Given that we already include three retirement insurance products, we decided against adding further complexity to that model with the inclusion of risky assets.

Throughout this chapter, we assume a real interest rate of 2% per year and set the real discount rate for insurance pricing at 1.5%, in line with insurance regulation in China. The average real interest rate in China from 2010 to 2019 was 2.04%, according to the World Bank (2021). The real discount rate is lower than the real interest rate because the China Banking and Insurance Regulatory Commission (CBIRC) requires that the nominal pricing interest rate cannot be set higher than 3.5% for long-term insurance, and we assume an inflation rate of 2% based on a ten-year average of China's national consumer price index (CPI).[10]

4.2.3 Health transitions models

In our model, the individual's health status is assumed to be objective and verifiable by the insurance company, and we do not assume any residual subjective health information that can influence the demand for insurance. In each year t, an individual's health status is one of the four states $H_t \in \{1, 2, 3, 4\}$, where $H_t = 1$ corresponds to healthy, $H_t = 2$ corresponds to the critically ill state, $H_t = 3$ corresponds to the long-term care state, and $H_t = 4$ corresponds to death.

Following Yogo (2016) and Koijen et al. (2016), we use a Markov process to model the health evolution over time. We denote the 4×4 transition probability matrix at period t by $\boldsymbol{P}_t$, where its element $\pi_t(i, j)$ denotes the transition probability from the health state $H_t = i$ in period t to the health state $H_{t+1} = j$ in period $t + 1$:

$$\pi_t(i, j) = \text{Prob}(H_{t+1} = j | H_t = i). \tag{4.1}$$

This stylised health model allows us to study the impact of three key risks faced by retirees: longevity, critical illness, and long-term care risk. In our benchmark health transition model, we assume that there is no recovery to the healthy state from being critically ill or needing long-term care because there is limited data to estimate the recovery rates and past studies suggest low rates of recovery from long-term care (Hanewald et al., 2019). We also assume that there are transitions between the states of being critically ill and requiring long-term care. Since there is limited data to estimate such transitions, we assume that the transition probabilities between those states are the same as those from the healthy state to the critically ill or from the healthy to the long-term care state, respectively. We

[10] It should be noted that the difference between the real interest rate (2%) and the real discount rate (1.5%) influence the results in favour of allocations to the savings account.

test the sensitivity of this assumption in Section 4.4.2.

The transition probabilities are calibrated using official tables for mortality and critical illness and estimates for long-term care related transitions based on the CHARLS data. We set the age-specific transition probability from healthy to critically ill, using the critical-illness incidence rates provided by CBIRC. We set the age-specific probability of death from the healthy state by an adjusted CBIRC mortality curve for the pension industry. The adjustment is made to exclude the deaths resulting from the critically ill or long-term care state, and we follow the insurance practice (Partner Re, 2016) to calculate this adjusted mortality curve. Long-term care transitions are calibrated with the CHARLS data. We tested the ordered probit model used in Koijen et al. (2016) and Yogo (2016) and also tested ordered logit and multinomial logit models and the formulation with the complementary log-log link function. We selected a multinomial logit model based on the Akaike Information Criterion to estimate the long-term care transition rates for the male data. The technical details are provided in Appendix 4.7.1.[11] Appendix 4.2 summarises the calibration method for each health transition in our model. A better approach would be to estimate the full transition model based on the same data. However, longitudinal surveys like the CHARLS in China do not provide sufficient information to accurately identify the critically ill state. Furthermore, the exposure times for the critically ill and long-term care states are inadequate to generate reliable estimates. In Section 4.4.2, we investigate the sensitivity of the assumptions for health transitions.

4.2.4 Health costs

This section describes the health costs associated with critical illness and long-term care in China and how we model these. We explained in Chapter 2.1 that China's public insurance partially covers the costs of major diseases, but there is no widely available

[11] These transition probabilities are period transition rates, the cohort transition rates are not available due to data limitation.

coverage for long-term care expenditures (other than 49 pilot programmes for long-term care insurance). In our model, the costs of critical illness at period t, CostCI_t, and the costs of long-term care at period t, CostLTC_t, are both paid out-of-pocket. Their calibration is based on empirical studies and industry reports. We assume that the health-related costs such as medical services do not qualify as consumption and hence will not directly generate utility.

4.2.4.1 Costs of critical illness

The costs of critical illness in China are often immediate and catastrophic to families. The costs in the first year after diagnosis are often extensive because of urgent life-extending treatments and hospitalisation. To model the distribution of the out-of-pocket costs of critical illness, we follow previous studies and use a lognormal distribution to model the costs of critical illness (e.g., Wu et al., 2018a; Zhang et al., 2019). This distribution captures the fact that the cost distribution is typically right-skewed with a large variation.[12]

To calibrate the lognormal distribution for the out-of-pocket costs of critical illness, we use individual medical expenditure data recorded directly by healthcare systems like hospitals rather than through household surveys. This is because household survey data is likely to underestimate the costs because those with critical illnesses are less likely to be survey participants, and surveys like the CHARLS do not provide sufficient details of disease severity, and there are insufficient cost details to measure the full expenditures due to critical illness. We estimate the expected value of the lognormal distribution according to the reported average median values of the out-of-pocket costs for critical illness in Beijing (the capital of China) and Zhaoqing (an inland city with a larger reimbursement rate and a larger cap amount than that of an average city in China) in 2014 (Fang et al., 2018).

[12] The exact costs for critical illnesses are often difficult to access. The average individual inpatient cost is much larger than the median (Zhang et al., 2019), and the variation of the coefficient for personal health expenditure is approximately 7 (Zhao, 2019).

We further adjust the cost to 2020 prices using medical cost inflation net of general CPI from 2015 to 2020 in China.[13] The adjusted cost is assumed to represent a sufficient level of medical expenditure to access adequate medical services.For example, the total medical expenditure for a COVID-19 infected patient with severe symptoms is, on average, approximately CNY 400,000, and this amount is considered adequate. Assuming a 50% reimbursement rate (if the government did not choose to fully cover the expense), the out-of-pocket cost is around CNY 200,000, which is comparable to the median expenditure of around CNY 150,000 in Beijing in 2014 (Fang et al., 2018). To calibrate the standard deviation, we rely on individual-level inpatient billings recorded by the healthcare system and more than 20,000 hospitalisation cases provided by Wu et al. (2018a). The data does not include an individual's age or disease severity, but the total time for inpatient care is recorded. We include in the estimation sample only those individuals with an inpatient time of more than 25 days, which is about the average length of inpatient time for those aged over 60 (Yin et al., 2019). The calibrated lognormal distribution for the out-of-pocket expenditure on critical illness is:

$$\text{CostCI} \sim \text{Lognormal}\Big(11.86,\, 0.92^2\Big). \tag{4.2}$$

We further assume a maximum out-of-pocket cost of CNY 800,000. This value is based on an approved reimbursement of CNY 1,500,000 from private medical insurance in 2019.[14]

[13] Willis Towers Watson Global Medical Trends Survey Report 2016, 2017, 2020. See at `https://www.willistowerswatson.com/en-US/Insights/2019/11/2020-global-medical-trends-survey-report`.

[14] Due to a lack of data, we do not incorporate an auto-regressive process for the out-of-pocket costs for critical illness. In the case that such a feature is adopted, the demand for critical illness insurance is likely to be lower due to lower costs in the future.

4.2.4.2 Costs of long-term care

We calibrate the costs of long-term care based on data from the CHARLS Wave 3, collected in 2015.[15] The data includes the hours of informal care received as well as the monthly wage for a nurse. In 2020, the minimum hourly wage ranged from CNY 13 in Hunan province (an average inland province) to CNY 24 in Beijing.[16] We assume an hourly wage of CNY 20 to estimate the cost of informal care. This approximates the cost for paying a home-health aide, and we add that to the wage for a nurse to calculate the total monthly expenditure for long-term care.

For the cost estimation, we exclude the observations that were long-term-care dependent but reported a zero cost (e.g., receiving no informal care or hiring a nurse). We find that a linear model captures the association between the logarithm of the total monthly long-term care expenditure and age of the survey participants reasonably well, and the residual plot of the log-linear model shows there is no evidence of heteroscedasticity. The estimated monthly cost of long-term care has the following lognormal distribution with respect to age:

$$\text{CostLTC(Age)} \sim \text{Lognormal}\Big(6.1313 + 0.0189 \times \text{Age},\ 1.459^2\Big). \tag{4.3}$$

We also assume a maximum monthly long-term care cost of CNY 8,000, which is more than twice the average long-term care cost of the calibrated lognormal distribution and is higher than the cost for institutional care, which is about CNY 5,000 according to (Lu et al., 2017). Finally, we multiply the monthly cost by twelve to derive the annual cost of long-term care.

[15] The 2018 data was not available during the model calibration process, and we want to compare our results to the empirical study in Chapter 3 which uses the same data for pricing.

[16] See at `https://global.chinadaily.com.cn/a/202004/28/WS5ea79cd1a310a8b2411524ac.html`.

4.2.5 Preferences

Empirical studies find that the utility of consumption depends on an individual's state of health (e.g., Finkelstein et al., 2013; Gerking et al., 2017; Gyrd-Hansen, 2017). Wang and Wang (2020) confirm this for China. Therefore, in our benchmark scenario, we assume individual preferences are represented by a time-separable and state-dependent utility function similarly to Koijen et al. (2016) and Peijnenburg et al. (2017),

$$u(c_t|H_t) = \eta_{H_t} c_t^{1-\gamma}/(1-\gamma), \tag{4.4}$$

where c_t is the consumption in year t, γ is the risk aversion coefficient (e.g., Davidoff et al., 2005; Yaari, 1965), η_{H_t} is a constant parameter weighting the impact of the individual health state on the utility of consumption c_t. This function distinguishes the utilities of consumption for the individual in different health states, as suggested by Finkelstein et al. (2013). This is a natural extension of Peijnenburg et al. (2017) to allow for different state-dependent utilities with more than one unhealthy state. Another way to specify a state-dependent utility is to assume that consumption, rather than utility, is discounted in different health states (Laitner et al., 2018). In this chapter, we follow the former approach to incorporating state-dependent utility because i) in our model, the individual chooses consumption after paying health-related costs and, therefore, consumption does not need to be discounted to reflect non-medical consumption, and ii) we are interested in the impact of the state of health on consumption and portfolio choice. Note that the state-dependent utility given in Equation (4.4) reduces to the standard case without state-dependent utility once $\eta_{H_t} = 1$, and we study this case in Section 4.4.1.[17]

[17] Other studies question the validity of time-separable utility and use recursive preferences (Epstein and Zin, 1989), which separate the relative risk aversion from the elasticity of inter-temporal substitution, see, e.g., Cocco et al. (2005), Pang and Warshawsky (2010), and Blake et al. (2014).

We use $v()$ to value bequest motives:

$$v(M) = b\frac{M^{1-\gamma}}{1-\gamma}, \tag{4.5}$$

where M is the bequest wealth and b is the strength of the bequest motive. This bequest function is used in simulation to identify optimal portfolio allocation (e.g., Friedman and Warshawsky, 1990; Shen and Sherris, 2018) and in empirical studies (e.g., Iskhakov and Keane, 2021). Its form can be generalised into our state-dependent utility framework by considering death as the terminal poor-health state.[18]

In our benchmark case, we calibrate the time preference or the subjective discount factor $\beta = 0.999$ and risk aversion $\gamma = 3$ to represent high patience and average risk aversion among Chinese people. We base these values on İmrohoroğlu and Zhao (2018), who study long-term care risks and family insurance in China. They are comparable to those used in the US-focused literature. For example, in Peijnenburg et al. (2017), these values have been set as 0.96 (time preference) and 5 (risk aversion) with the same utility function. Feldstein and Ranguelova (2001) suggest that a coefficient of relative risk aversion between 2 and 3 is reasonable. We set the strength of the bequest motive $b = 50$ to reflect a relatively strong bequest motive following Friedman and Warshawsky (1990). Regarding the parameter for state-dependent utility, the results of empirical studies are mixed: for example, studies in developed countries find either a higher or a lower value of consumption when health deteriorates (Edwards, 2008; Finkelstein et al., 2013; Gerking et al., 2017; Gyrd-Hansen, 2017; Tengstam, 2014; Viscusi and Evans, 1990). There are limited empirical results for China. Wang and Wang (2020) estimate that, for older Chinese, the value of non-medical consumption is around 20% higher when an individual has several chronic diseases and around 30% lower if they are limited by three or more ADLs. Therefore, for η_{H_t} we use 1.2 and 0.7 if an individual is critically ill or needs long-term care, respectively. We test the sensitivity of the results to different values of the preference parameters in Section 4.4.

[18] Other studies use luxury-bequest motives, see, e.g., Lockwood (2012) and Ameriks et al. (2020).

4.2.6 An individual's optimisation problem

We model the decision of a healthy individual who, at retirement, decides to use a portion of his wealth to buy a life annuity, critical illness insurance, and long-term care insurance and chooses his consumption at each future year until death. His objective is to maximise the expected lifetime utility of consumption in retirement given by the following value function:

$$V = E_0\left\{\sum_{t=0}^{T-1}\sum_{j=1}^{3}\beta^t p_t(H_t = j)[u(c_t|H_t = j) + \beta\pi_t(H_t = j, 4)v(M_{t+1})]\right\}, \tag{4.6}$$

where E_0 is the expectation operator at the initial period $t = 0$; $u(c_t|H_t)$ is the state-dependent utility of consumption defined in Equation (4); $p_s(H_t)$ is the probability that the individual's health status is H_t (excluding the dead state) at period t;[19] and $\pi_t(H_t, 4)$ is the transition probability from H_t to death at period t; Consumption c_t at each period depends on the proportions of the initial retirement wealth M $\omega_{\mathrm{a}}, \omega_{\mathrm{c}}$, and ω_{l} allocated to purchase a regular annuity income $\mathrm{Annuity}_t(\omega_{\mathrm{a}})$, a lump sum payment for critical illness $\mathrm{CII}_t(\omega_{\mathrm{c}})$, and a regular income for long-term care $\mathrm{LTCI}_t(\omega_{\mathrm{l}})$, respectively. For a simpler notation, in the remainder of this chapter, we omit the notations for the allocated proportions for the corresponding insurance payouts. For example, we use $\mathrm{Annuity}_t$ for $\mathrm{Annuity}_t(\omega_{\mathrm{a}})$.

In each period, we assume the following constraints for retirement planning: the individual cannot sell or cancel the insurance contracts,[20] borrowing is not allowed, and the consumption floor is the government subsidy S. Given the insurance allocation made in the initial period, from period t to $t + 1$, an individual starts with available retirement wealth M_t, and receives pension P_t and annuity income $\mathrm{Annuity}_t$. Depending on the re-

[19] In standard models with two health states: alive or dead, only the survival probability is needed, while for models with multiple health states, the survival probability is the total probabilities of being alive in different health states.

[20] See Section 4.2.2 for the rationale of making a one-time choice.

alised health status H_t, the individual incurs costs for critical illness CostCI_t if they are critically ill and receive a lump sum payment CII_t if the period t is also the first time they are diagnosed with a critical illness. Alternatively, they incur long-term care costs $\mathrm{CostLTC}_t$ and receive long-term care income LTCI_t if they cannot perform three or more of the six ADLs without difficulty.

Next, the individual chooses consumption c_t based on their current cash on hand A_t. His remaining wealth goes to a savings account growing at a real risk-free rate R and becomes the available wealth M_{t+1} in the next period. After the individual chooses consumption in the last period, any remaining wealth in the next period becomes his bequest.

The optimal retirement portfolio problem can be redefined with the following Bellman equation, subject to the constraints introduced earlier and the conditions for insurance payments and health costs described in Sections 4.2.2 and 4.2.4. We solve the optimisation problem numerically by backward induction with the endogenous gridpoint method (EGM) of Carroll (2006). The solution methods are provided in Appendix 4.7.2.

$$
\begin{aligned}
V_t(M_t, H_t) = \max_{c_t, \omega_\mathrm{a}, \omega_\mathrm{c}, \omega_\mathrm{l}} E_t \Big\{ u(c_t|H_t) + \beta \Big[\sum_{j=1}^{3} \pi_t(H_t, j) V_{t+1}(M_{t+1}, H_{t+1} = j) \\
+ \pi_t(H_t, 4) v(M_{t+1}) \Big] \Big\}, \qquad (4.7)
\end{aligned}
$$

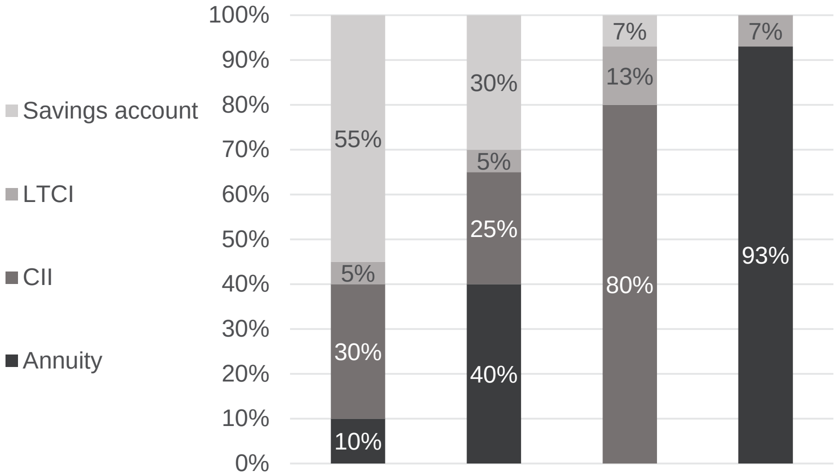
$$
\begin{aligned}
\text{s.t.} \\
A_t &= M_t + P_t + \mathrm{Annuity}_t + \mathrm{CII}_t + \mathrm{LTCI}_t - \mathrm{CostCI}_t - \mathrm{CostLTC}_t - c_t, \\
M_{t+1} &= R \cdot A_t, \\
A_t &\geqslant 0, \\
c_t &\geqslant S, \\
\omega_\mathrm{a}, \omega_\mathrm{a}, \omega_\mathrm{l} &\geq 0, \\
\omega_\mathrm{a} + \omega_\mathrm{c} + \omega_\mathrm{l} &\leqslant 1.
\end{aligned}
$$

We use simulations to determine the optimal portfolio allocation for an individual. For each retirement portfolio allocation, we calculate the average lifetime utility obtained with 10,000 Monte-Carlo path simulations based on the solved optimal consumption functions. The optimal retirement portfolio is that with the largest average utility.

We calculate the welfare gains from optimal insurance for an individual as the percentage increase of retirement savings without insurance. We first use simulations to obtain the average lifetime utilities without insurance for an equally spaced sequence of six retirement savings ranging from 100% to 200% of the individual's retirement savings. We then use splines to connect them to obtain a utility curve with respect to retirement savings. The value of retirement savings equalling the utility achieved with optimal insurance reflects the wealth needed to generate the same utility without insurance. We calculate the percentage increase of retirement savings and designate this as the welfare gain for an individual with optimal insurance. We use the notation '>100%' to denote that the retirement savings needed to generate the same utility with optimal insurance is more than twice the initial retirement savings, and the exact value is beyond this range (extrapolation of the splines outside the fitting range is not used because of potential bias).

4.3 Results

In this section, we provide the optimal portfolio choices and welfare gains predicted by simulations with the calibrated life-cycle model. We report the optimal proportions of retirement savings allocated to a life annuity, critical illness insurance, and long-term care insurance when all three insurance products are available for purchase at retirement. We examine the results for four types of individuals with different combinations of retirement savings (high: CNY 1 million, low: CNY 150,000) and monthly pension amounts (average: CNY 3,000, low: CNY 1,000).



Case	A	B	C	D
Retirement savings	1 million	1 million	150,000	150,000
Pension	3,000	1,000	3,000	1,000
Utility gain (% of wealth)	12%	32%	39%	65%

Figure 4.1: Optimal portfolio when three insurance products are available to purchase

Notes: Results are for males at age 60 at specified wealth and pension profiles (Cases A, B, C and D). LTCI: long-term care insurance; CII: critical illness insurance.

Figure 4.1 shows that, for a male retiring at age 60 with CNY 1 million in retirement savings and a monthly pension of CNY 3,000 (Case A), the optimal allocation is 10% to the life annuity, 30% to critical illness insurance, and 5% to long-term care insurance. The remaining retirement savings are 55%. The expected lifetime welfare gain with optimal insurance, compared to the case without insurance, is 12% of their initial retirement savings. This means that for a male just retired with CNY 1 million in retirement savings and a CNY 3,000 pension, the expected lifetime utility from the optimal portfolio with three insurance products is equivalent to that from a portfolio with CNY 1,120,000 savings without any private insurance.

For a retiree with the same high-level retirement savings of CNY 1 million but a lower monthly pension of CNY 1,000 (Case B), the optimal portfolio allocation comprises 40% annuity, 25% critical illness insurance, 5% long-term care insurance, and 30% retirement savings. Compared with the high-pension scenario, in this scenario, the annuity demand increases significantly from 10% to 40% of the CNY 1 million wealth. In both portfolios, at least 30% of wealth is held in a savings account. The welfare gain with the optimal portfolio is 32% for retirees with high wealth but a low pension.

In the case that a retiree is not wealthy and at retirement has limited savings of CNY 150,000 and an average pension of CNY 3,000 (Case C), our results suggest that they should allocate most of their retirement savings to health-related insurance products. Specifically, they should spend 80% on critical illness insurance, 13% on long-term care insurance, and zero on an annuity. This suggests that with limited wealth and an average pension, the retiree should focus on insurance for out-of-pocket health-related costs rather than purchasing products that provide a higher regular income. The welfare gain with optimal insurance is 39% for retirees with low wealth but an average pension.

However, if the retiree has only limited retirement savings of CNY 150,000 and a low pension of CNY 1,000 (Case D), they should spend 93% of their savings on an annuity and the remaining 7% on long-term care insurance but buy no critical illness insurance. This suggests that a retiree with limited regular income will have a larger welfare gain by purchasing a higher regular income in the form of an annuity, rather than insuring against catastrophic medical costs. The welfare gain for retirees with low wealth and a low pension and optimal insurance is 65%, which is the largest gain among the four retiree profiles.

Overall, our results show that a substantial portion of retirement savings should be allocated to an annuity and critical illness insurance for retirees with various financial resources. A regular income stream is important for those with a low pension, and the demand for critical illness insurance is high for those with an average pension or a high level of retirement savings. We find that for all four types of retirees, there is a low demand for long-term care insurance (between 5% to 13%). This finding is contrary to that for an annuity and critical illness insurance, where we predict zero demand for an annuity by retirees with savings of CNY 150,000 and an average pension, and zero demand for critical illness insurance by retirees with the same retirement savings but a pension of CNY 1,000. This signals the unique role of long-term care insurance in retirement planning.

In addition, we find that the relative lifetime welfare gain with optimal insurance is much larger for retirees with lower wealth than for those with higher wealth and for retirees with a lower pension than those with a higher pension. This means that retirement planning is more important for those with lower wealth and income, and can help bridge the economic-status gap built up during employment, thereby reducing potential wealth inequality, and its impact, in retirement.

4.4 Sensitivity analysis

In this section, we conduct additional analysis to investigate how different assumptions regarding the state-dependent utility, health transition matrix, product pricing, risk aversion, time preference, bequest motives, and government subsidies might impact the optimal retirement portfolio.

4.4.1 State-dependent utility

In our benchmark scenarios, we set the weights for the utility of consumption to $\eta_{H_t=2} = 1.2$ if the retiree is critically ill and to $\eta_{H_t=3} = 0.7$ if he needs long-term care. These weights are set in line with Wang and Wang (2020), who find a 20% higher utility of consumption for those diagnosed with a critical illness but a 30% lower utility of consumption for those in a long-term care state, based on the CHARLS data from 2011 to 2015. However, the results of empirical studies in other countries differ on whether the utility of consumption will be lower or higher if health deteriorates (Edwards, 2008; Finkelstein et al., 2013; Gerking et al., 2017; Gyrd-Hansen, 2017; Tengstam, 2014; Viscusi and Evans, 1990).

We test the benchmark results with three assumptions about the weight parameter η_{H_t} in poorer health states to further understand the impact of state-dependent utility on the optimal retirement portfolio. Under the first assumption, utility is not state-dependent; that is, the utility of consumption is the same in the healthy, the critically ill, and the long-term care state. Under the second assumption, there are lower weights in poorer health states than in the healthy state, while under the third assumption, these weights are higher. For the scenario with lower weights in poorer health states, we choose η_{H_t} equals 0.8 following Peijnenburg et al. (2017), in which the utility weight for consumption in poor health is 0.8. For the scenario with higher weights, and similarly to Peijnenburg et al. (2017), we set η_{H_t} to 1.2. In each case, we assume that the utility of consumption weights in the poor-health states are both lower (or both higher) than in the healthy state.[21]

Figure 4.2 shows that the results for the optimal portfolio under the alternative assumptions for state-dependent utility are relatively similar to the benchmark results.[22] For example, we find that there is substantial demand for critical illness insurance by retirees with an average pension or high savings, high demand for annuities by retirees with a low pension, and a small demand for long-term care insurance across all economic backgrounds. However, one clear difference is that the annuity demand increases from zero to at least 10% of initial retirement wealth if considering state-dependent utility for those with higher pensions and retirement wealth. In addition, different weights for the utility of consumption in poorer health states trigger different trade-offs between longevity and health-related insurance products, depending on the levels of pension and wealth. First, for retirees with CNY 1 million in retirement savings and a CNY 3,000 pension, the al-

[21] We also test another four scenarios with η_{H_t} equalling 0.6 and 1.4. The results are similar and available upon request.

[22] Please note that the utility weights for the LTC state and the CI state are 0.7 and 1.2 in our benchmark case (Panel a). Compared with Panel b – no state-dependent utility, the differences are 0.3 for the LTC state and 0.2 for the CI state. We use these utility weights calibrated by a recent study (Wang and Wang, 2020) to derive our best estimates of optimal insurance amounts. The sensitivity of the utility weights can be examined by comparing Panel b with Panels c and d in Figure 4.2.

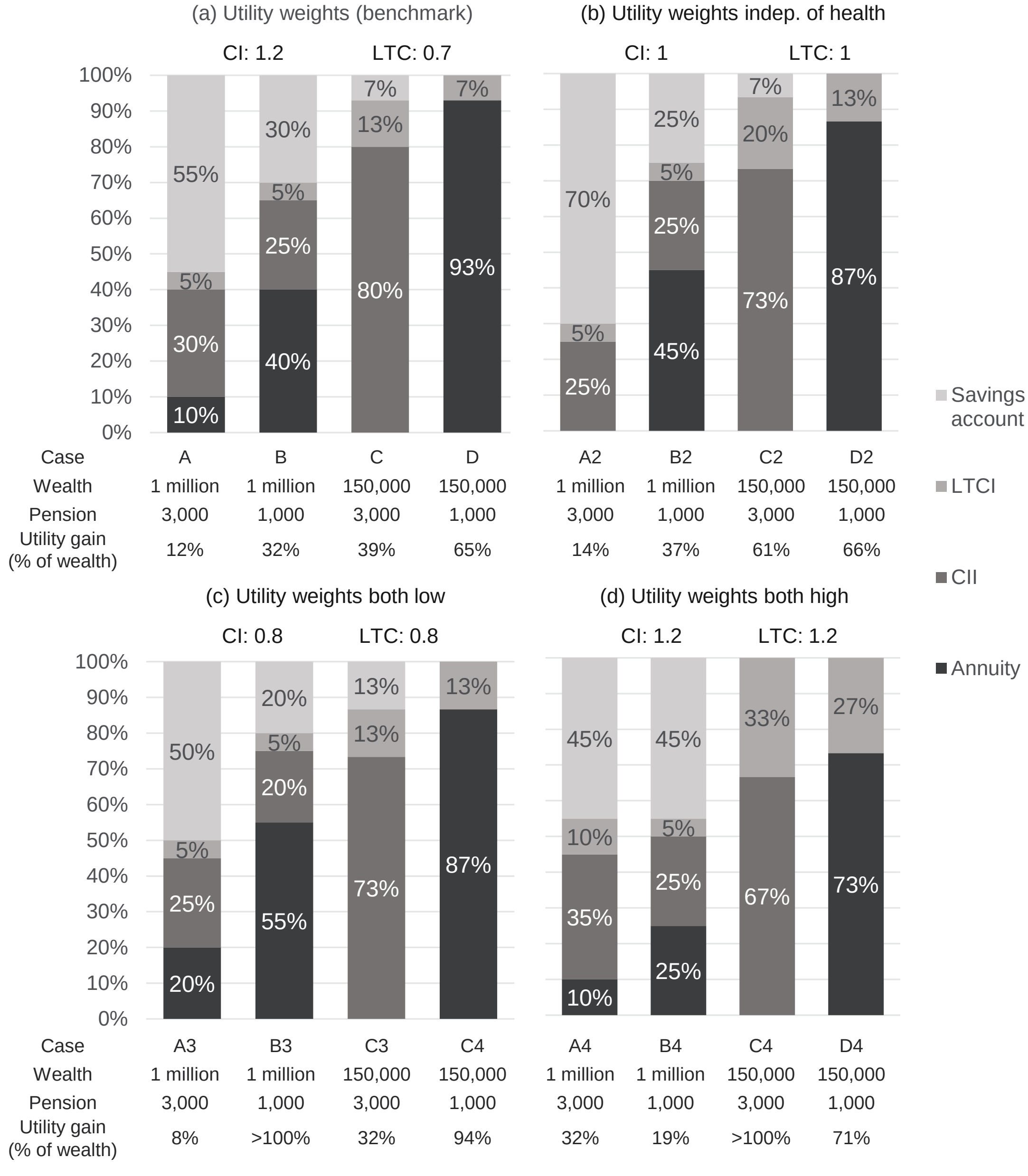


Figure 4.2: Optimal portfolio with state-dependent utility

Notes: Panels a, b, c and d assume different utility weights at the critical illness (CI) and the long-term care (LTC) states. For example, utility weights at Panel b are 1 - the same as in the healthy state, while utility weights at Panel c are 0.8 for both CI and LTC states - lower than in the healthy state. Results are for males at age 60 at specified wealth and pension profiles (Cases A, B, C and D). LTCI: long-term care insurance; CII: critical illness insurance.

location to critical illness insurance (long-term care insurance) increases from 25% (5%) when both weights equal 1 and to 35% (10%) when both weights equal 1.2. However, if both weights are lowered to 0.8, the demand for health-contingent insurance is stable, but the annuity demand increases from zero to 20%. Second, for retirees with CNY 1 million in retirement savings and a CNY 1,000 pension, the results are generally stable, except the demand for annuities drops from 45% to 25% when both the weights are higher in the poorer health states. Third, for retirees with CNY 150,000 in wealth and a CNY 3,000 pension, the results are robust, but when both weights are higher in the poor-health states, the long-term care demand increases from 20% to 33%, while demand for critical illness insurance drops from 73% to 67% and demand for savings drops from 7% to 0. Fourth, for retirees with CNY 150,000 in wealth and a CNY 1,000 pension, regardless of the weights in poorer health states, the annuity demand is high, and the demand for critical illness insurance remains low. However, the demand for long-term care insurance increases at the expense of the demand for annuities if both weights are higher in poorer health states.

In addition, there are mixed results for the utility gain from optimal insurance with respect to state-dependent utility. Retirees with an average pension have the largest welfare gain with optimal insurance if both utilities of consumption are higher in poorer health states. Retirees with a low pension have the largest welfare gain if their utilities of consumption are lower in both poorer health states.

4.4.2 Health transitions

Health transition assumptions are important for retirement planning. In this section, we focus on the sensitivity of the transitions between the critically ill and the long-term care states. This is because the costs and insurance coverage for critical illness and long-term care are key elements in our model. In addition, past studies regarding the transitions between these two poorer health states are limited. In our benchmark case, because of

Table 4.1: Three additional assumptions of health transition processes

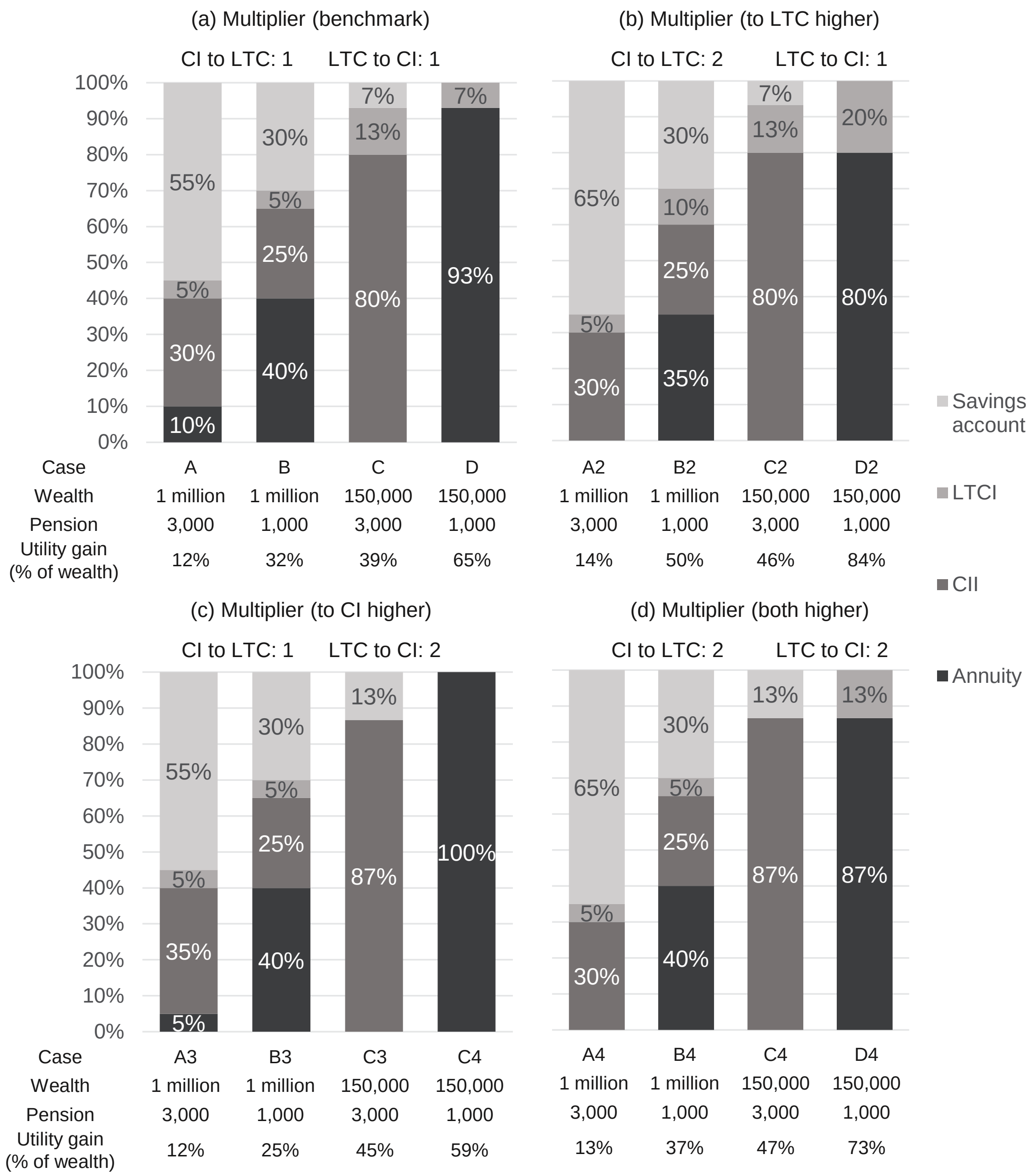
	Assumptions of transitions between critically ill (CI) and needing long-term care (LTC) states
Scenario 1	CI state to LTC state = Healthy to LTC state
(benchmark)	LTC state to CI state = Healthy to CI state
Scenario 2	CI state to LTC state = Healthy to LTC state $\times$ 2
	LTC state to CI state = Healthy to CI state $\times$ 1
Scenario 3	CI state to LTC state = Healthy to LTC state $\times$ 1
	LTC state to CI state = Healthy to CI state $\times$ 2
Scenario 4	CI state to LTC state = Healthy to LTC state $\times$ 2
	LTC state to CI state = Healthy to CI state $\times$ 2

Notes: From Scenario 2 to 4, we set the long-term care (critical illness) incidence rates in the critically ill (long-term care) state to be a multiple of that in the healthy state. For example, in Scenario 2, the transition from the CI state to the LTC state is twice the transition from the healthy state to the LTC state, while the transition from the LTC state to the CI state is the same as in the benchmark case.

limited data, we assumed that the age-specific probabilities for the transition from the critically ill to the long-term care state and from the long-term care to the critically ill state are the same as for the transitions from the healthy state to each of the two poorer health states.

We consider three additional assumptions for the transitions between the poorer health states to reflect a higher chance of transition from one poor state of health to another than that from a healthy to a poor state. In Scenario 2, we assume that the long-term care incidence rate while in the critically ill state is twice the incidence rate in the healthy state. In Scenario 3, we assume that the critical illness incidence rate while in the long-term care state is twice the incidence rate in the healthy state. In Scenario 4, we assume that the previous two hold simultaneously. Table 4.1 summarises the assumptions of health transitions. The calibration procedure for the remaining health transition matrix is the same as in the benchmark case.

In Figure 4.3, we compare the optimal insurance under the health transitions in Scenarios 2–4 with the benchmark results for retirees with different levels of public pensions and



Case	A	B	C	D	A2	B2	C2	D2
Wealth	1 million	1 million	150,000	150,000	1 million	1 million	150,000	150,000
Pension	3,000	1,000	3,000	1,000	3,000	1,000	3,000	1,000
Utility gain (% of wealth)	12%	32%	39%	65%	14%	50%	46%	84%

Case	A3	B3	C3	C4	A4	B4	C4	D4
Wealth	1 million	1 million	150,000	150,000	1 million	1 million	150,000	150,000
Pension	3,000	1,000	3,000	1,000	3,000	1,000	3,000	1,000
Utility gain (% of wealth)	12%	25%	45%	59%	13%	37%	47%	73%

Figure 4.3: Optimal portfolio with different underlying health transition processes

Notes: Panels a, b, c and d assume different multipliers for the health transition rates between the critical illness (CI) and the long-term care (LTC) states. For example, in Panel b, the transition from the CI state to the LTC state is twice the transition from healthy to the LTC state, while the transition from the LTC state to the CI state is the same as in the benchmark case. Results are for males at age 60 at specified wealth and pension profiles (Cases A, B, C and D). LTCI: long-term care insurance; CII: critical illness insurance.

retirement savings. Overall, we find that the difference in transition assumptions between the states of poorer health slightly affect the optimal insurance demand. If the multiplier for the incidence of needing long-term care in the critically ill state is higher than the multiplier for the incidence of critical illness in the long-term care state (e.g., ‘to LTC higher’, Figure 4.3, Panel b), the demand for long-term care insurance increases for retirees with a low pension. Conversely, if the multiplier for the incidence of critical illness while in the long-term care state is higher (e.g., ‘to CI higher’, Figure 4.3, Panel c), we find there is a decrease in the demand for long-term care insurance for retirees with low savings. When both incidences in the poorer health states increase (e.g., ‘both higher’, Figure 4.3, Panel d), the annuity demand decreases from 10% to zero for retirees with an average pension and high wealth, and from 93% to 87% for those with a low pension and low wealth; the results of health-contingent insurance demand are stable for those with high wealth, but are mixed for retirees with other economic backgrounds. We find the demand for long-term care insurance (13%) disappears and converts into demand for critical illness insurance (7%) and savings (6%) for those with an average pension and low wealth (Case C in Panel a vs Case C4 in Panel d), while part of the demand for an annuity (6%) turns into demand for long-term care insurance for those with a low pension and low wealth (Case D in Panel a vs Case D4 in Panel d).

Overall, the optimal portfolios for retirees with each economic background are consistent with our benchmark results, and the results for retirees with a low pension and high wealth are the least affected by the additional transition assumptions. The welfare gains or reductions depend on the specifics of each scenario but are generally stable when compared with the benchmark case.

4.4.3 Product pricing

In our benchmark scenario, all insurance products are priced separately. For example, the annuity price is derived from the official mortality curve for pension business without explicitly considering the possibility of the beneficiary being critically ill or needing long-term care. This can result in a failing insurance market due to adverse selection (see, e.g., Finkelstein and Poterba, 2002, 2004; Laitner et al., 2018). We consider a 'joint' pricing approach based on a health transition table covering all health states relevant to the three insurance products to examine the impact of pricing on the optimal portfolio. This pricing approach allows us to consider the potential of a bundled longevity and health-contingent insurance product that life annuities, critical illness insurance, and long-term care insurance are three components or products. The prices of the three insurance components are the expected present values of the sum of the discounted future insurance payments based on 2,000,000 simulated health projections, and we add the same 15% loading to each insurance product. The details are provided in Appendix 4.7.1.

First, we use the joint health transition matrix to price all three retirement insurance products and compare the results to those of the benchmark case. We then check how the results change with different underlying health transition matrices (the health transitions matrices for pricing and for evaluation of optimal insurance are different, hereafter, unmatched). Next, we check how the results change when the matrix for pricing matches the underlying health transition matrix across the health-transition assumptions (pricing and evaluation matched). We use the same three additional health-transition assumptions introduced in Section 4.4.2. In the unmatched cases, the health transition matrix for pricing is the same across the scenarios with different underlying health transition matrices; that is, the matrix for pricing does not reflect the change of assumptions of incidence rates in the critically ill or long-term care states. In the matched cases, the pricing matrices are the same as the underlying matrices for evaluation. Therefore the changes resulting from transitions from the critically ill or long-term care states are incorporated in the insurance price.

In the scenario with benchmark assumptions for the underlying health transition (Figure 4.4, Panel a), we find that, contrary to the results where insurance products are priced separately (Figure 4.1), the annuity demand increases from 10% to 35% of retirement savings for retirees with an average pension and high wealth. The results are robust for the other three retiree types, and the largest percentage change from the benchmark in any insurance allocation is no larger than 7%.

In the other scenarios where the pricing matrix and the evaluation matrix are unmatched (Figure 4.4, Panels b, c and d), we find that, compared with Figure 4.3, the increase in annuity demand remains substantial (more than 30%) for those with high wealth and an average pension. The demand for critical illness insurance decreases for those with low wealth and an average pension, and the largest reduction is 20%. The demand for long-term care insurance decreases by 7% for those with low wealth and a low pension. The other optimal insurance results are generally consistent with our benchmark case.

In all scenarios, welfare increases slightly for retirees with high wealth. The results are mixed for retirees with low wealth, although the gains are still substantial. However, we find that, contrary to the benchmark case, the welfare gain is larger for retirees with high wealth and a low pension than for retirees with low wealth and an average pension.

In the case of a match between the pricing matrix and the evaluation matrix in each scenario (Figure 4.5), compared with the unmatched situations (Figure 4.4), the results in the three additional health transition scenarios are generally similar. The largest difference in insurance demand occurs for retirees with low wealth and a low pension, and full annuitisation is optimal across all health-transition assumptions in the health transition matched scenarios.

Changes in pricing impact welfare gains with optimal insurance. Comparing the results

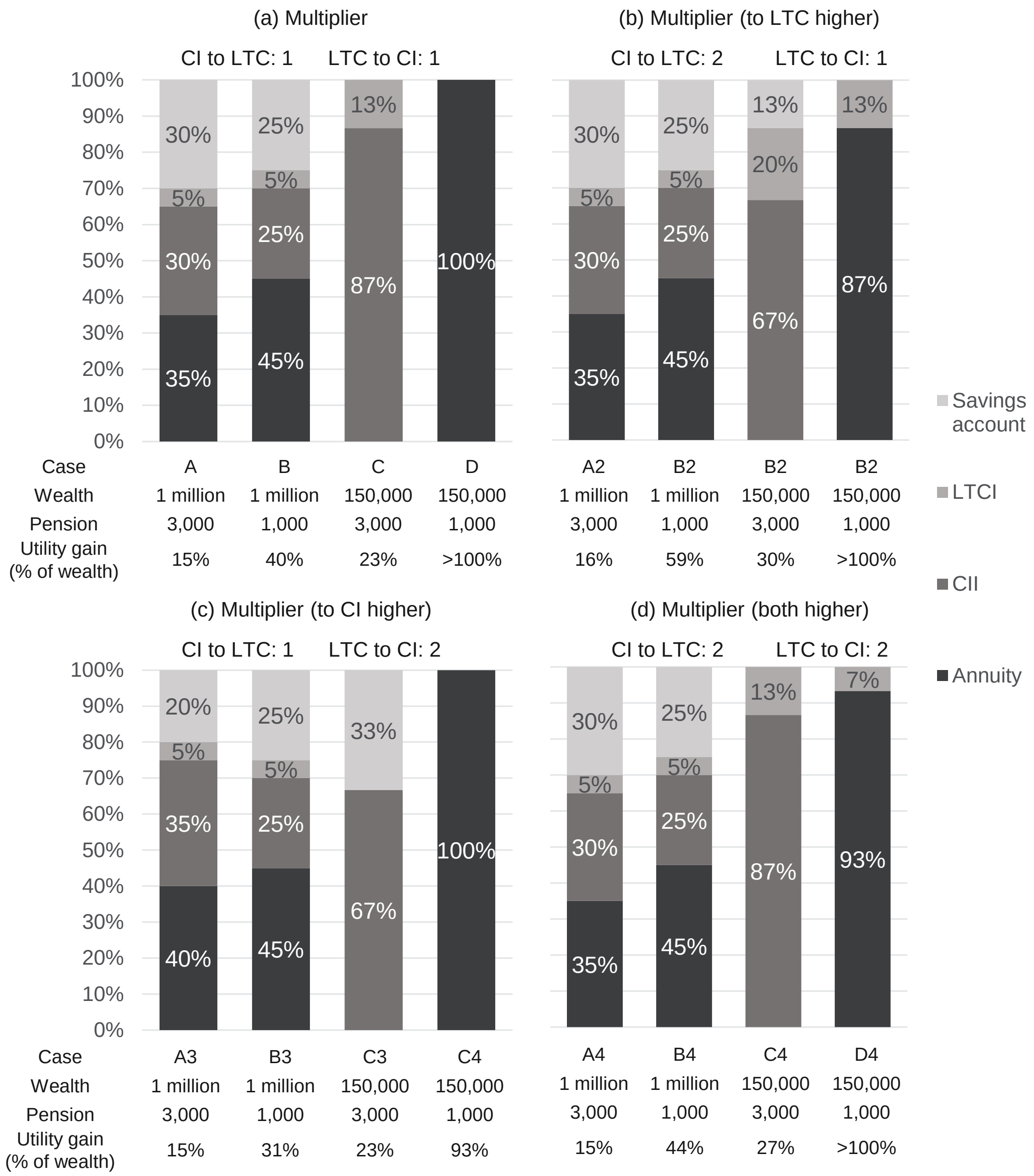


Figure 4.4: Optimal portfolio with insurance priced by the joint health transition matrix, evaluated under different underlying health transition processes

Notes: The insurance products are priced by the same joint health transition matrix, but the individual has different (unmatched) health transitions as specified in Panels a, b, c and d. Each panel assumes different multipliers for the health transition rates between the critical illness (CI) and the long-term care (LTC) states. For example, in Panel b, the transition from the CI state to the LTC state is twice the transition from healthy to the LTC state, while the transition from the LTC state to the CI state is the same as in the benchmark case. Results are for males at age 60 at specified wealth and pension profiles (Cases A, B, C and D). LTCI: long-term care insurance; CII: critical illness insurance.

from the unmatched (Figure 4.4) and the matched (Figure 4.5) cases to the sensitivity test of health transitions in Figure 4.3, we find that there is a slight change of welfare gain for retirees with high wealth, an increase for retirees with low wealth and a low pension, but a decrease for retirees with low wealth and an average pension. Overall, the welfare gains are still substantial under alternative pricing assumptions. However, we find that, contrary to the benchmark case, the welfare gain is larger for retirees with high wealth and a low pension than for retirees with low wealth and an average pension.

4.4.4 Risk aversion, time preference and bequest motives

We set the risk aversion parameter γ to 2, 4, 5 and compare the results with our benchmark case where $\gamma = 3$. We vary the subjective discount factor β to 0.985 and 0.96 (benchmark: 0.999). We then vary the strength of the bequest motives b to 0 (no bequest motives), 10, and 100 (benchmark: 50). These values are within the range of parameters in other studies of retirement insurance products (e.g., Friedman and Warshawsky, 1990; Peijnenburg et al., 2017; İmrohoroğlu and Zhao, 2018).

Figure 4.6 (a) lists the optimal allocation of retirement savings between the available insurance products with respect to risk aversion γ for retirees with CNY 1 million retirement savings and CNY 1,000 monthly pension. Overall, we find that our benchmark results for the optimal portfolio are robust and the insurance demand increases with risk aversion. The welfare gain increases with risk aversion from 9% in the least risk-averse case ($\gamma = 2$) to more than 100% in the most risk-averse case ($\gamma = 5$). Many theoretical studies suggest that insurance demand increases with risk aversion. For example, Pang and Warshawsky (2010) show that higher risk aversion leads to more annuitised wealth, Ameriks et al. (2011) find that the willingness to pay to avoid public care grows with risk aversion, and Schendel (2014) demonstrates that the optimal demand for critical illness insurance reduces when risk aversion decreases. However, Peijnenburg et al. (2017) show

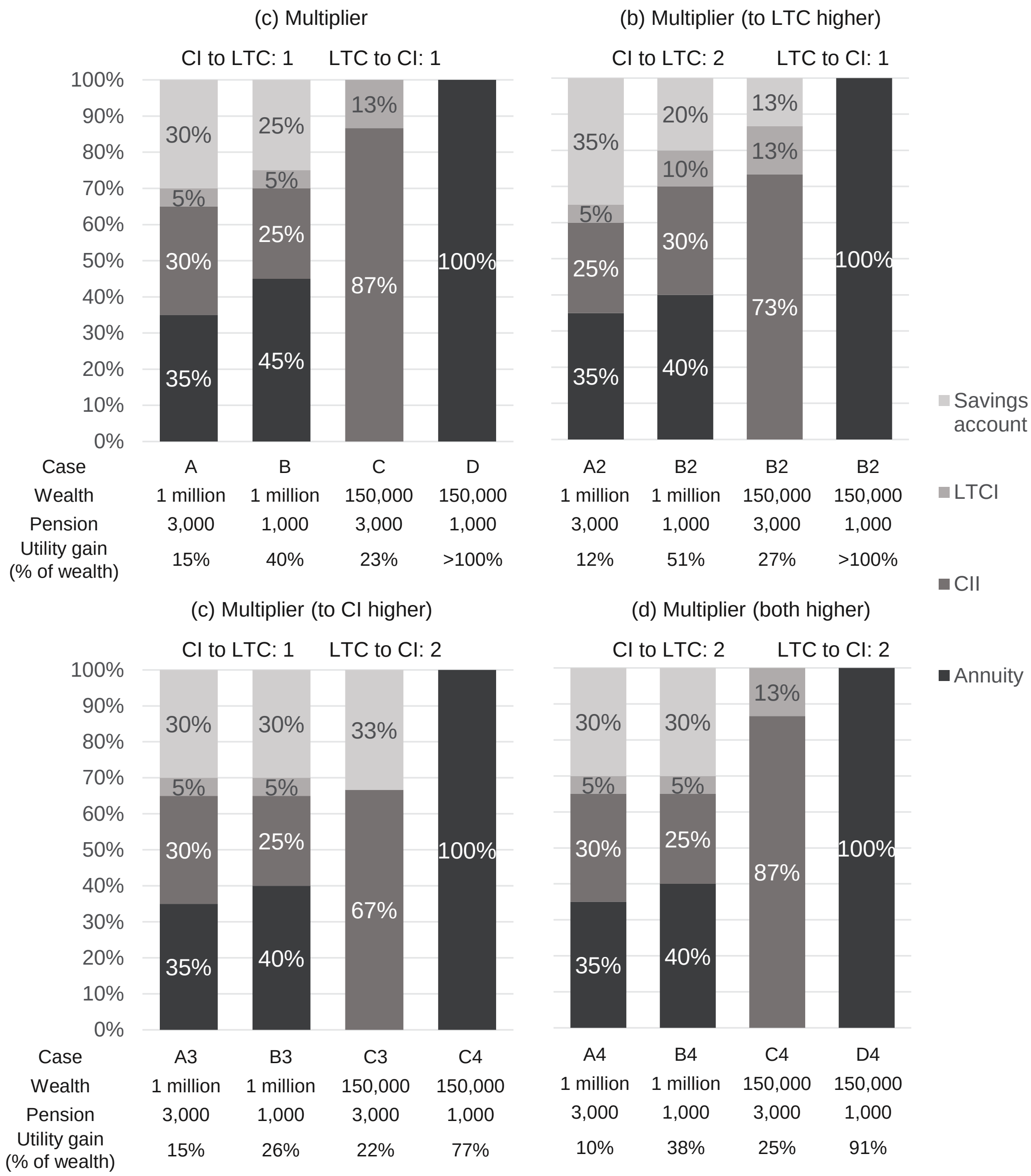


Figure 4.5: Optimal portfolio with insurance priced by a joint health transition matrix, evaluated with matched underlying health transition processes

Notes: The insurance products are priced by the same joint health transition matrix, and the individual has the same (matched) health transitions as specified in Panels a, b, c and d. Each panel assumes different multipliers for the health transition rates between the critical illness (CI) and the long-term care (LTC) states. For example, in Panel b, the transition from CI state to LTC state is twice the transition from healthy to the LTC state, while the transition from the LTC state to the CI state is the same as in the benchmark case. Results are for males at age 60 at specified wealth and pension profiles (Cases A, B, C and D). LTCI: long-term care insurance; CII: critical illness insurance.

that the optimal annuity demand from liquidised wealth stays at zero when risk aversion increases from 2 to 8, a large range of risk aversion according to Ameriks et al. (2011). As well, many empirical studies find the opposite - for example, Eling et al. (2021) show that the demand for life insurance and long-term care insurance is negatively associated with risk aversion.

The results concerning time preference (Figure 4.6, Panel b) are similar to our benchmark results. For retirees with an average pension and high wealth, we find a high demand for critical illness insurance and low demand for long-term care insurance, and their demand is stable with respect to time preference. As expected, we find that the annuity demand is higher when the retiree is more patient, and the allocation to annuity increases from zero when time preference is 0.96 to 5% ($\beta = 0.985$) and to 10% ($\beta = 0.999$). The welfare gains for retirees that are less patient are 11%, slightly lower than the 12% in the benchmark case where retirees are most patient.

Regarding the bequest motive, we find that i) the annuity demand decreases with an increase in the strength of the bequest motive for the wealthiest group (Figure 4.6, Panel c). In particular, the annuity demand reduces from 30% of their CNY 1 million retirement savings to zero when the strength of this motive changes from absent ($b = 0$) to high ($b = 100$). ii) The demand for health-related insurance is stable compared with the benchmark results, and it only increases if there are no bequest motives ($b = 0$). The welfare gain decreases if a retiree's bequest intention grows, and it decreases from 21% in the absence of a bequest motive to 11% when there is a strong bequest motive.

4.4.5 Government subsidy

Prior studies have shown that means-tested benefits provided by governments can affect portfolio choices of retirees (e.g., Bütler et al., 2017; Iskhakov et al., 2015). We test two assumptions of the government subsidy. We use the minimum monthly subsidy of CNY 491

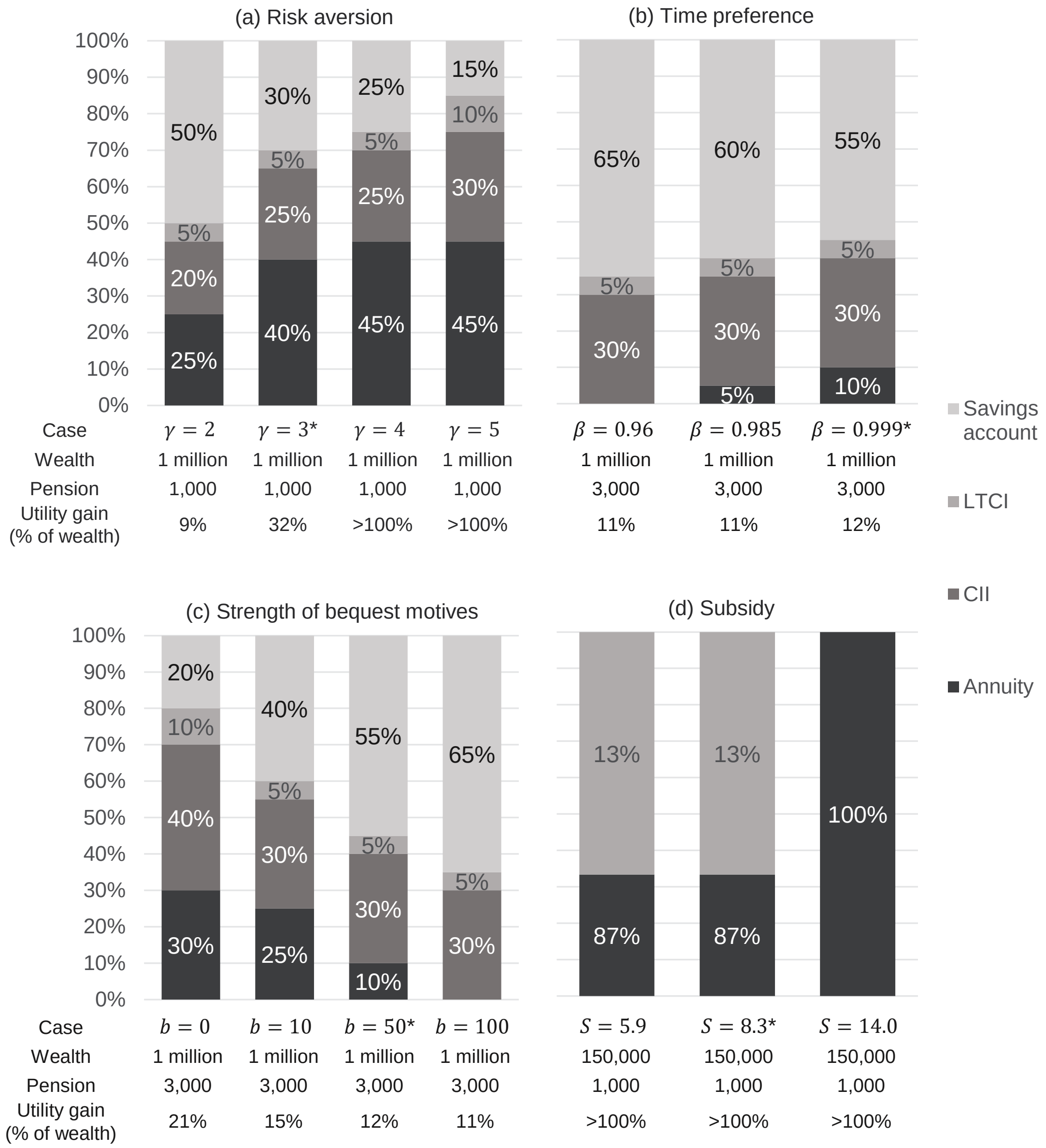


Figure 4.6: Optimal portfolio with different risk aversion γ, time preference β, bequest motives b and subsidy S

Notes: Different assumptions of the preferences parameters γ, time preference β, bequest motives b and subsidy S are specified in the cases at Panels a, b, c and d, respectively. CNY 1 million wealth with CNY 1,000 and 3,000 pensions are reported to test preferences parameters, while CNY 150,000 wealth with CNY 1,000 pension is reported for the test of government subsidy. Results are for males at age 60. Results for other profiles are available upon request. LTCI: long-term care insurance; CII: critical illness insurance.
* Benchmark case for each preference parameter.

(CNY 5,600 annually) and the maximum of CNY 1,170 (CNY 14,000 annually) published by the government in September 2020 (Ministry of Civil Affairs, 2020) to compare with our benchmark (CNY 687 monthly, CNY 8,300 annually). For retirees with a low pension and low wealth (Figure 4.6, Panel d), we find that they tend to trade the annuity for long-term care insurance when the subsidy decreases. This finding suggests that annuities can substitute for long-term care insurance when individuals receive a sufficient government subsidy. The welfare gain remains substantial for all the subsidy amounts tested. For those with a higher pension or wealth, the results generally agree with our benchmark case as the size of the subsidy amount is less relevant for the financial circumstances of these retirees.

4.5 Discussion

Our study predicts the optimal portfolio allocation for health-contingent and longevity insurance products for urban male retirees in China with four different economic backgrounds. Since 2016, China has expanded its public health insurance system, focusing on the development of long-term care insurance and the reduction of catastrophic medical expenditure. Local governments in China can refer to the optimal insurance allocations predicted by our model to reflect on the coverage provided by local insurance programmes offered by cities with different levels of economic development. For example, according to our benchmark case, in cities like Beijing and Shanghai, for a wealthy retiree with an average pension, a substantial proportion of wealth (30%) is predicted for allocation to critical illness insurance, while the predicted allocation for annuities is 10% and for long-term care insurance it is 5%. However, in less developed inland cities, for a retiree with low levels of wealth and pension income, annuitising 93% of their retirement savings is optimal. In general, for a retiree in China with an average household wealth of CNY 640,000 (Li and Fan, 2020) and an average pension of CNY 3,000, weighting our optimal portfolios in the benchmark case, the predicted optimal portfolio is 6% for an annuity, 51% for critical illness insurance, 8% for long-term care insurance, and the remaining 35% in a savings account.

In Chapter 3, we conducted an online hypothetical survey to elicit the stated preferences for retirement portfolios, including the same life annuity, critical illness insurance and long-term care insurance considered in this chapter. The results showed that the most preferred portfolio included, on average, half cover of critical illness insurance, half cover of long-term care insurance, and an annuity income of about CNY 700 per month. The average wealth and pension of the participants were about CNY 460,000 and CNY 3,000. For this wealth and pension level, our life-cycle model suggests that the optimal portfolio allocation includes about 4% to a life annuity, 62% to critical illness insurance and 10% to long-term care insurance. These results reflect a consistency between the stated demand and the optimal demand for long-term care insurance. However, the stated demand for critical illness insurance was lower, and the stated annuity demand was higher, compared with their optimal amounts, respectively.

Our results predict low demand for long-term care insurance, which appears to be inconsistent with China's effort to develop public long-term care insurance programmes. The rationale behind our results is that wealthy retirees can mostly rely on self-insurance, while for the less wealthy retirees, there are trade-offs among the three insurance products. For example, our findings suggest that the risk of critical illness has a larger impact than longevity and long-term care risk for a retiree with an average pension since 80% of their retirement savings is predicted for allocation to critical illness insurance. Similarly, those with a low pension will be better off allocating 93% of their retirement savings to an annuity and using the annuity income as a buffer for potential costs related to critical illness and long-term care. This leaves the demand for long-term care insurance relatively low. However, while the demand for long-term care insurance is small, it exists for all four types of retirees (an allocation of 5% to 13% of retirement savings).

In contrast, the demand for annuity or critical illness insurance is zero for certain types of retirees. This suggests a unique role for long-term care insurance in retirement planning and is consistent with China's long-term care insurance plan of providing basic public long-term care services. We also note that the various piloted long-term care insurance programmes have different eligibility criteria. Some are stringent and are based on ADL performance, while the criteria for others are less onerous and are based on the performance of instrumental ADLs that require more complex planning and thinking, such as shopping and cooking (Zhu and Osterle, 2019). Our definition of long-term care is similar to that in the pilot programmes with stringent criteria and is consistent with private long-term care insurance practices in China. Such definition allows our results to provide a more transparent cost and risk assessment, making it easier for the government and local communities to collaborate with insurers to design innovative solutions for long-term care services.

Our findings show a substantial demand for critical illness insurance. In 2020, the first public long-term supplementary medical insurance started in Beijing and was jointly developed by insurance companies.[23] Our model does not consider this type of supplementary medical insurance because of data limitations. However, the substantial demand for critical illness insurance predicted by our model suggests space for local governments to cooperate with insurance companies to design critical illness insurance products for the old.

Additionally, we find that the welfare gain with optimal insurance is much larger for less affluent retirees than those who are better off, and this can assist the government to provide suitable insurance to reduce inequality in retirement (Zheng et al., 2019).

For insurance companies, firstly, our findings suggest that it is important to target different population segments with the right insurance products. For example, our model

[23] See at `https://www.axa.cn/about_us/companynews/news_PR202001020_2.html`.

suggests that retirees with a low pension will use more than 40% of their retirement savings to purchase life annuities, while retirees with an average pension and high wealth will use 30% of their wealth to purchase critical illness insurance. Secondly, we show that designing bundled products for retirement insurance has the potential to make insurance products more affordable. In developing countries like China, the financial market is immature, and regulatory bodies tend to set conservative requirements to avoid solvency risks. For example, the CBIRC regulated discount rates for long-term insurance lowered from 4.025% to 3.5% in 2019. One possibility to lower the insurance price is to explore the potential of reducing the impact of adverse selection in separate insurance markets. For example, bundling longevity insurance with health-contingent insurance products may serve as a natural hedge, thus reducing the impact of adverse selection and reducing insurance premiums (e.g., Brown and Warshawsky, 2013). For example, bundling longevity insurance with health-contingent insurance products may serve as a natural hedge, thus reducing the impact of adverse selection and reducing insurance premiums. Assuming that the bundled health-contingent and longevity insurance products are priced according to the joint health transition matrix in Section 4.4.3, the price for the annuity, critical illness insurance and long-term care insurance is 78%, 121%, and 91%, respectively of that priced according to industry practice. Lastly, our findings show that bundling health-contingent and longevity insurance products can, for wealthy retirees, release precautionary savings for the purchase of an annuity. For example, the optimal allocation of retirement savings to an annuity increases from 10% to 35% for retirees with a high retirement savings of CNY 1 million and an average monthly pension of CNY 3,000.

4.6 Conclusion

This chapter developed a life-cycle model of retirement where an individual retiree with a basic pension and medical insurance chooses a portfolio consisting of a life annuity, critical illness insurance, long-term care insurance, and a savings account to maximise his lifetime utility. The model allowed for stochastic transitions between different health states and random critical illness and long-term care expenditures. We considered different weights on the utility of consumption in different health states. We predicted the optimal insurance for retirees in China with several typical retirement-saving and pension profiles. We found high demand for critical illness insurance for retirees with an average pension, high demand for annuities for retirees with a low pension, and small demand for long-term care insurance for retirees across all economic profiles considered in our study. We considered the trade-offs generated by state-dependent utility among health-contingent and longevity insurance, but the retiree's savings and pension largely determined the optimal insurance allocations. We found a substantial welfare gain with optimal insurance, and the gain was considerably larger for retirees with lower retirement savings and pensions.

During the 14th Five-Year Plan period (2021-2025), China will continue to promote the development of commercial insurance to meet people's needs for health and old-age support. Priority in insurance development is given to products targeting critical illness, long-term care insurance, and diversified commercial annuities and account-based pensions. Meanwhile, the CBIRC will work with government agencies to promote commercial insurance in social services. The goal is to expand the commercial health insurance market to over CNY 2 trillion and accumulate at least CNY 6 trillion commercial pension liability reserves by 2025. Our study suggests that China should consider regional economic development to expand social insurance. Our results suggest that, at present, China should provide basic long-term care services for all people. The government should also focus on providing insurance cover for large expenditures due to critical illness for those with an average pension and providing sufficient regular income for those with a low pension. The products we considered are priced according to insurance practice, and these results can assist local governments in deciding how to work with insurance companies to provide insurance products and services. For insurance companies, our results highlight, first, the importance of targeting, that is, marketing critical illness insurance to those with an average pension and life annuities to those with a small pension. Second, we show that designing bundled health-contingent and longevity insurance can make insurance more affordable and, for more affluent retirees, release precautionary savings to purchase an annuity.

In further work, it would be interesting to consider females, married households with correlated health transitions. Future research could also consider an extended framework to incorporate the role of children in retirement provision. Another interesting direction is to examine the stated demand for retirement insurance products. It would also be interesting to consider the role of housing as an additional source of retirement funding (see, e.g., Hanewald et al., 2020).

4.7 Appendix to Chapter 4

4.7.1 Pricing of insurance products

In our model, the life annuity, critical illness insurance, and long-term care insurance can be purchased by male individuals at age 60 by making a one-off payment. We priced the three products in an actuarially fair way based on gender and age. We assumed a real discount rate of 1.5% for each year in the future. This is because we assume a constant 3.5% nominal discount rate (the maximum discount rate allowed by the China Banking and Insurance and Regulatory Commission (CBIRC)) and a constant 2% inflation rate (approximately a ten-year average of the national CPI during 2010-2019 in China). In addition, we assume a 15% insurance loading for all retirement insurance products. This loading assumption is slightly higher for life insurance in China as Wan et al. (2017) find the money's worth ratio for commercial pension is at least 90%. However, the 15% loading is lower for health insurance as the administrative cost for health insurance in China is between 15% to 20% and there is an additional 10% to 30% security surcharge (Zhang et al., 2021).

Compared with existing retirement insurance products in China, few retirement insurance products in China have a long-term contract and are inflation-protected. Standard life annuities are rare. Most annuity-related products are paid with a regular premium during work (tax-deferred), and their designs are complex. For example, these products can include fixed large payouts at predetermined ages (e.g., 60 or 80 years old) and death benefits. Many annuities provide guaranteed rates of return for a short period such as five years and are not intended to be kept for a long duration; and they are mostly framed as wealth management financial products and are not designed for longevity risk protection.

For critical illness insurance, long-term contracts are typically only available to younger adults. The old could only purchase cover of critical illness during a short period or purchase it annually because guaranteed renewable contracts are also rare for the old. Many critical illness insurance products also set a limit for the insured amount. In addition, a few bundled annuity and critical illness insurance products are on the market. They inherit the features of the standalone insurance products, and their designs for the value of contracts used for risk protection and investment are more complex than the standalone products.

For long-term care insurance, the contracts have features like limited payments, short protection periods, different payout amounts conditional on age. In addition, they are often bundled with investment products and sometimes with annuity related products as well.

We used the official mortality rates and diseases incidence rates provided by the CBIRC to price standalone annuities and critical illness insurance products (CBIRC, 2013, 2016). For the life annuity, we used the mortality curves for pension business for males starting at age 60. For the critical illness insurance, we used the incidence rate curves and the mortality curves for health insurance business for 25 diseases for males starting at age 60 and 55. We note that insurance companies in China also use the mortality curves for pension business for a more defensive price. The insured period was lifetime for all three products. However, for critical illness insurance, the contract ended if one payment was made, and for long-term care insurance, the payments would only be made when three or more ADLs were triggered. For simplicity and a cleaner interpretation, we assumed that these curves were unchanged in the future.

For long-term care insurance, there is no industry health transition table. Therefore, we estimated the health transition rates based on data from the CHARLS survey. We used the three waves of CHARLS data in 2011, 2013, and 2015. A two-year transition, from 2011 to 2013 or from 2013 to 2015, was observable at each age for both genders by the longitudinal survey design. As the sample size for specific transitions is limited, we pooled the first (2011-2013) and the second (2013-2015) transition data together, based on which we estimated a one-year transition at each age for each gender. We only used data for respondents in the starting years (2011 or 2013) that were at least 35 years old. We conducted sensitivity tests using a subset with ages between 45-84 and using aggregated data with a 10-year age group starting from 35-45. The impact on product pricing was immaterial. We excluded observations with missing information for ADL status or death information.

We defined four health states: Healthy, Fair (1-2 ADLs), Disabled (3 or more ADLs, long-term care insurance payable), and Dead. Different from the health states used in the life-cycle model, the inclusion of a Fair state here was to control the result such that the estimation of the transition Healthy-LTC was close to the insurance population. We allowed recovery from states Fair or Disabled to Healthy, and Dead was an absorbing state. We modelled the health transitions in a Markov framework. We use a multinomial logit model to estimate the relevant health transition probabilities. We have tested a probit model, which had been used to estimate the transition probabilities in a similar context in the US by Yogo (2016) and Koijen et al. (2016), and we have tested the ordered logit, probit, and the complementary log-log models. In the end, the multinomial logit model has the best performance according to Akaike Information Criterion. The dependent variable was each respondent's health state observed in the follow-up wave (2013 or 2015), and the explanatory variables were the respondent's age and health state in the initial wave (2011 or 2013).

We predicted the two-year transition rates for males from age 60 to age 104 based on the fitted multinomial logit model, and we closed the transition table at age 105. We calculated the one-year transition probability matrix at age x based on the Markov property with the following conversion formula:

$$\boldsymbol{P}_x^{\text{2-year}} = \boldsymbol{P}_x^{\text{1-year}} \times \boldsymbol{P}_x^{\text{1-year}}, \tag{4.8}$$

where $\boldsymbol{P}_x^{\text{1-year}}$ is the probability of 1-year transition at each state at age x. As in the case of the life annuity and the critical illness insurance, we assumed that the estimated transition rates for long-term care were stable in the future.

For bundled products, we used the calibrated health transition matrix (Table 4.2) and set the post-illness mortality to be an average of the mortality from receiving adequate medical services and that from receiving a quarter of the adequate services. We assumed the same 1.5% real discount rate and the 15% loading, which were used to price the standalone insurance products. 2,000,000 simulations are used to calculate the price for each insurance component.

4.7.2 Numerical solution

The original optimisation problem in our study (Equation 4.7 in Section 4.2) has four choice variables: consumption at each period c_t, allocations for annuity ω_{a}, critical illness insurance ω_{c}, and long-term care insurance ω_{l}. However, our problem has a nested structure. To use the EGM method by (Carroll, 2006), we first solve the optimal consumption problem conditioning on exogenous insurance states, and then we conduct a grid search under budget constraints for the optimal insurance choice based on the already obtained policy functions in each exogenous insurance state. To see that, the Bellman equation in our optimisation problem is:

$$
\begin{aligned}
V_t(M_t, H_t) = \max_{c_t,\omega_{\mathrm{a}},\omega_{\mathrm{c}},\omega_{\mathrm{l}}} & E_t\Big\{u(c_t|H_t) + \beta\Big[\sum_{j=1}^{3}\pi_t(H_t, j)V_{t+1}(M_{t+1}, H_{t+1} = j) \\
& + \pi_t(H_t, 4)v(M_{t+1})\Big]\Big\}, \\
& \text{s.t.} \\
& A_t = M_t + P_t + \mathrm{Annuity}_t + \mathrm{CII}_t + \mathrm{LTCI}_t - \mathrm{CostCI}_t - \mathrm{CostLTC}_t - c_t, \\
& M_{t+1} = RA_t, \\
& A_t \geqslant 0, \\
& c_t \geqslant S, \\
& \omega_{\mathrm{a}}, \omega_{\mathrm{a}}, \omega_{\mathrm{l}} \geq 0, \\
& \omega_{\mathrm{a}} + \omega_{\mathrm{c}} + \omega_{\mathrm{l}} \leqslant 1.
\end{aligned}
$$

The optimal solution of the above problem can be obtained by solving the sub-problems in each exogenous insurance state $(\omega_{\mathrm{a}}, \omega_{\mathrm{c}}, \omega_{\mathrm{l}})$ defined below and finding their maximum:

$$
\begin{aligned}
V_t^{\omega_{\mathrm{a}},\omega_{\mathrm{c}},\omega_{\mathrm{l}}}(M_t, H_t) = \max_{c_t} E_t\Big\{ & u(c_t|H_t) + \beta\Big[\sum_{j=1}^{3} \pi_t(H_t, j) V_{t+1}(M_{t+1}, H_{t+1} = j) \\
& + \pi_t(H_t, 4) v(M_{t+1})\Big]\Big\},
\end{aligned}
$$

$$
\begin{aligned}
\text{s.t.} & \\
A_t &= M_t + P_t + \text{Annuity}_t + \text{CII}_t + \text{LTCI}_t - \text{CostCI}_t - \text{CostLTC}_t - c_t, \\
M_{t+1} &= RA_t, \\
A_t &\geqslant 0, \\
c_t &\geqslant S.
\end{aligned}
$$

We use a three-dimension grid to discretise the insurance amount from 0 to 100% of the initial wealth. We use a minimum amount of CNY 50,000 for allocation in the case of CNY 1 million retirement savings and CNY 10,000 in the case of CNY 150,000 retirement savings. Next, we solve the sub-problem for each of the exogenous insurance states to derive the optimal consumption. After that, we use 10,000 simulations to project future scenarios for an individual and calculate the realised lifetime utility of consumption for each simulation. The optimal insurance choice is the insurance state that yields the maximal average utility across all simulated scenarios and is within the budget constraint. This two-step approach essentially transforms the original problem with four control variables to #3-D-grid sub-problems where the standard 1-D EGM can be applied. We use an adaptive grid to focus on the most dedicated part that needs fine-tuning and test the size of the grid. We finally deploy the algorithm on the computing clusters provided by UNSW Katana to speed up.

4.7.3 Calibration of health transitions

Table 4.2: Calibration sources for the health transition probability matrix π_t

From	To	Notation	Calibration source
Healthy	Healthy	$\pi_t(1,1)$	1-$\pi_t(1,2) - \pi_t(1,3) - \pi_t(1,4)$
	Critically ill	$\pi_t(1,2)$	CBIRC incidence rates
	Long-term care	$\pi_t(1,3)$	CHARLS estimates
	Death	$\pi_t(1,4)$	Adjusted from CBIRC mortality rates for pension business to exclude death from other states
Critically ill	Healthy	$\pi_t(2,1)$	0
	Critically ill	$\pi_t(2,2)$	1-$\pi_t(2,1) - \pi_t(2,3) - \pi_t(2,4)$
	Long-term care	$\pi_t(2,3)$	CHARLS estimates
	Death	$\pi_t(2,4)$	Adjusted CBIRC mortality rates, and incidence rates (and associated k_x values)
Long-term care	Healthy	$\pi_t(3,1)$	0
	Critically ill	$\pi_t(3,2)$	CBIRC incidence rates
	Long-term care	$\pi_t(3,3)$	1-$\pi_t(3,1) - \pi_t(3,2) - \pi_t(3,4)$
	Death	$\pi_t(3,4)$	CHARLS estimates
Death	Healthy	$\pi_t(4,1)$	0
	Critically ill	$\pi_t(4,2)$	0
	Long-term care	$\pi_t(4,3)$	0
	Death	$\pi_t(4,4)$	1

Notes: The China Banking and Insurance Regulatory Commission (CBIRC) provides the official mortality rates and diseases incidence rates (CBIRC, 2013, 2016). The CHARLS estimates are the long-term care related transitions estimated with the China Health and Retirement Longitudinal Survey (CHARLS) in the 2011, 2013 and the 2015 waves.

Chapter 5

The effects of past and current air pollution exposure on multimorbidity, cognition and disability in China

5.1 Introduction

Multiple studies have found that air pollution is associated with a higher risk of health problems, including cardiovascular diseases, cancers, dementia (e.g., Huang et al., 2019a; Li et al., 2020; Peters et al., 2019), lower cognitive abilities (Zhang et al., 2018) and lower life expectancies (e.g., Ebenstein et al., 2017). Among different sizes of particulate matter, particles with a diameter less than 2.5 micrometres ($PM_{2.5}$) attract the most scientific attention, as they can penetrate deep into the lung and potentially reach other parts of the human body through the circulatory system (Feng et al., 2016). Approximately 4.5

billion people are exposed to $PM_{2.5}$ levels that are at least twice the guideline value set by the World Health Organisation (WHO), and most of these individuals live in developing countries (WHO, 2018). Many developing countries face rapid population ageing. However, few studies focus on the older populations in developing countries (e.g., Lv et al., 2020; Zeng et al., 2010), probably because of a lack of $PM_{2.5}$ measurements and long-term health records of older age groups. Furthermore, the links through which $PM_{2.5}$ can impact health have yet to be fully explored.

Most studies on the health effects of air pollution only consider the effect of current exposure to air pollution. However, many diseases, cognition, and disability status are expected to relate to progressive and chronic effects of $PM_{2.5}$ exposure (e.g., Lv et al., 2020). Potential experiences with $PM_{2.5}$ such as past exposure to air pollution and year-over-year (YOY) growth of air pollution exposure that measure long-term accumulative exposure and local air pollution growth rates are generally not considered in analyses. Importantly, how past air pollution exposure can modify the effect of current exposure to air pollution is largely unknown.

In developing countries with a long history of exposure to air pollution, it is important to understand the health effect of $PM_{2.5}$ for individuals that have already experienced severe air pollution to prepare more appropriate clean air policies. Notably, prior studies in developed countries have mostly assumed a linear effect of $PM_{2.5}$ exposure on health. However, the value of extrapolating these linear estimates to developing countries is questionable as the air pollution level can be five to ten times higher than in developed countries (e.g., Ebenstein et al., 2017). Exploring non-linear relationships between air pollution and health also offers important insights on the discussion of whether there is a safe threshold for air pollution exposure.

In this study, we filled these knowledge gaps by studying the effects of past and current exposure to $PM_{2.5}$ on the health of middle-aged and older adults. Specifically, we considered the health effects of both annual exposure to $PM_{2.5}$ and the YOY growth of $PM_{2.5}$ exposure, and we estimated potential non-linear associations between air pollution and health.

Our study focuses on China, which faces the pressures of heavy air pollution and an ageing population. Furthermore, the unique development pattern of China's air pollution suits the purposes of our study: China's economic growth at the start of the 21st century was accompanied by worsening air quality with $PM_{2.5}$ as the primary component of air pollutants (Lyu et al., 2016). However, in 2013, China officially started implementing a clean air policy (CAP) to protect public health from severe air pollution. Our data shows that the average $PM_{2.5}$ concentrations in major cities in China increased from 54.3 $\mu g/m^3$ in 2000 to 66.4 $\mu g/m^3$ in 2011, in contrast to a decrease from 62.4 $\mu g/m^3$ in 2013 to 42.8 $\mu g/m^3$ in 2018.[1] The long-term exposure and substantial decrease in air pollution offer us an opportunity to examine the health effects of $PM_{2.5}$ exposure.

Our study sample is from the China Health and Retirement Longitudinal Study (CHARLS), which aims to collect a nationally representative longitudinal dataset. CHARLS collects a wide array of variables regarding health, work and demographic and socioeconomic factors at the individual level from 2011 to 2018. This dataset allowed us to examine the long-term impact of $PM_{2.5}$ after removing the bias due to observed and unobserved individual factors.

We used a satellite-based $PM_{2.5}$ dataset provided by Hammer et al. (2020) and Van Donkelaar et al. (2019) to match the annual air pollution exposure to each surveyed individual's location. This dataset includes estimated annual $PM_{2.5}$ concentrations in China from 2000 to 2018, and it covers all the locations where the CHARLS participants were interviewed during the entire survey period (2011 to 2018). China's official $PM_{2.5}$ data collection began in 2012, and the coverage is insufficient to include each surveyed individual's location.

[1] Authors' calculations based on the data introduced in Section 5.2.

Furthermore, the monitors are mostly in urban areas.

We identified several important associations between $PM_{2.5}$ exposure and multimorbidity, cognition, and activities of daily living (ADL) disability. First, we found a non-linear relationship between current $PM_{2.5}$ exposure and multimorbidity but no significant effects for cognition and ADL disability. Second, we found that the YOY growth of $PM_{2.5}$ is an important factor affecting health that most previous studies have not considered. Third, past severe exposure to $PM_{2.5}$ modified the effect of current $PM_{2.5}$ exposure on multimorbidity and cognition. Fourth, the adverse effects of air pollution were greater for adults younger than 65 years old and urban residents, compared to the older adults and rural residents, respectively.

Our research contributes several important analyses not offered by prior research. First, we assessed the impacts of past and current exposure to $PM_{2.5}$, not considered by most studies (e.g., Hu et al., 2020; Zeng et al., 2010; Zhang et al., 2018). Second, we identified that YOY growth of $PM_{2.5}$ rather than the annual exposure to $PM_{2.5}$ was associated with ADL disability. This is different from Lv et al. (2020) and Zeng et al. (2010), who reported an adverse impact of $PM_{2.5}$ on ADL disability but did not consider the variable of YOY growth. Third, our study design allowed us to examine the impact of air pollution on multiple health measures to provide a comprehensive understanding of the health effects of air pollution in older individuals, while prior literature largely focused on one measure (e.g., Li et al., 2020; Lv et al., 2020; Wang et al., 2020; Zhang et al., 2018). Zeng et al. (2010) and Hu et al. (2020) are exceptions to this trend. However, unlike those two studies, our study incorporated a more accurate measure of air pollution with satellite-based $PM_{2.5}$ data. Furthermore, our sample was from a cohort study of individuals followed for eight years and included middle-aged and older adults.

Overall, we found both linear and non-linear adverse associations between $PM_{2.5}$ exposure and multimorbidity, cognition and ADL disability, and experience with past severe exposure to $PM_{2.5}$ over a long period impact the health effect of current $PM_{2.5}$. Our results suggest that China should continue its effort to reduce air pollution. However, these findings should be confirmed in future studies and interpreted with caution.

This chapter is organised as follows. Section 5.2 describes the data sources, Section 5.3 outlines the modelling strategy. Section 5.4 presents empirical results, Section 5.5 discusses the results, and Section 5.6 provides the conclusions.

5.2 Data

We first describe the study population (Section 5.2.1). We then introduce the source of air pollution data (Section 5.2.2) and define three health-related risk factors (Section 5.2.3). Finally, we introduce other variables included in our analysis (Section 5.2.4). Summary statistics of the variables are presented at the end of Section 5.2.4.

5.2.1 Study population

Our sample was obtained from CHARLS, an ongoing nationally representative longitudinal survey of middle-aged and older adults in China (Zhao et al., 2014). The national baseline survey was conducted between 2011 and 2012 on 17,692 participants, and follow-up surveys were conducted in 2013, 2015 and 2018. We used both the most recent Harmonized CHARLS conducted during the first three waves of the survey and the latest wave conducted in 2018.[2] For consistency, we constructed variables according to the definitions used by the harmonised version. CHARLS collects detailed information covering participants' socioeconomic and demographic background, health, cognition, employment, and

[2]The CHARLS data has been harmonised according to the international research model in Health and Retirement Studies (HRS) such that the constructed variables are more comparable across countries. At the time of this project, the Harmonized CHARLS (Version C of April 2018) does not include the latest survey conducted in 2018. Both the Harmonized CHARLS (first three waves) and the 2018 wave of CHARLS can be accessed from the website: `https://charls.pku.edu.cn`.

geographic location that we matched with air pollution data. CHARLS data were collected by well-trained field workers in face-to-face computer-aided personal interviews, covering 150 counties and 450 communities via a stratified sampling procedure. The Ethics Review Committee of Peking University approved CHARLS (IRB00001052–11,015).

5.2.2 Air pollution

We used a satellite-based $PM_{2.5}$ dataset provided by Hammer et al. (2020) and Van Donkelaar et al. (2019) to assess the exposure to $PM_{2.5}$ concentrations in China. This $PM_{2.5}$ dataset provides annual estimates of $PM_{2.5}$ concentrations in both urban and rural China from 2000 to 2018 with a fine grid (a spatial resolution of $0.01° \times 0.01°$, about 1.1km $\times$ 1.1km). The annual average $PM_{2.5}$ estimates are highly consistent with globally distributed ground monitors.[3]

CHARLS only publishes the locations of CHARLS participants at the prefecture-city level. A prefecture city ranks below a province and above a county in China. It usually comprises an urban centre and surrounding rural areas that are much larger than the urban centre.[4] However, the Harmonized CHARLS provides one variable indicating whether an individual lives in a rural or urban area.[5] We do not have the exact geographical information separating the urban and the rural areas inside a prefecture city, and we do not have more detailed information on a participant's location. Therefore, if a respondent lives in the rural area of one prefecture city, we estimated his/her exposure by the average of the $PM_{2.5}$ from all the grid points inside the prefecture city, we estimated his/her exposure by the average of the $PM_{2.5}$ from all the grid points inside the prefecture city.

[3] The cross-validation measure is higher than 0.90 and the accuracy is superior to all earlier global estimates. Please refer to Hammer et al. (2020) for more details.

[4] For example, Figure 5.8b shows the counties inside an example prefecture city Dalian, and Figure 5.9a shows Dalian's satellite image.

[5] According to the Harmonized CHARLS, the residence can be determined based on a respondent's residence region, which is defined as rural or urban according to China's National Bureau of Statistics.

This approach is reasonable because most areas of a prefecture-city in China are rural;[6] If the respondent lives in an urban area of that city, we determined the exposure by the maximum of the following four values: a) the $PM_{2.5}$ estimate in the grid nearest to the urban centre[7] and b) the average values of $PM_{2.5}$ estimates in the grid(s) within 1km, 2km and 5km of the urban centre.[8] We use the maximum of these average values for different sizes of areas (point, squares with a diameter of 2km, 4km, 10km) mainly to automatically adjust for cities with different sizes. For large cities like Beijing, these average values are similar. However, for small cities, the urban core area can be less than 2km in diameter, and the air pollution levels in larger areas are smaller because rural areas are included. Therefore, selecting the largest one automatically adjusts the sizes of cities. Another reason I use the maximum is to filter out the impact of hills, lakes or seas, which could have substantially lower values of $PM_{2.5}$. Therefore, we use the maximum of these average air pollution concentrations to estimate exposure to $PM_{2.5}$ for urban residents.[9]

In our baseline analysis (Model A), we constructed two variables measuring the effects of $PM_{2.5}$ exposure: 'Survey year $PM_{2.5}$' denotes the average annual $PM_{2.5}$ exposure in the four survey years (2011, 2013, 2015, and 2018), and 'Survey year growth of $PM_{2.5}$' denotes the YOY growth of $PM_{2.5}$ exposure in a given survey year, compared with the previous survey year. The growth of air pollution is potentially an important factor influencing health. For example, Hu et al. (2020) find that older adults living in areas experiencing an

[6] In Appendix 5.7.1, the satellite image 5.9a highlights that the majority of the example city Dalian at the prefecture level is still undeveloped.

[7] We defined the location of the urban centre by the longitude and the latitude provided by a search of the city's name via Google Maps. To better reflect $PM_{2.5}$ exposure in an urban area, we manually corrected the longitude and the latitude to the urban centre if the automatically returned location is in a rural area, too far away from the urban centre to be representative of an urban area, or too close to mountains, lakes or rivers.

[8] Compared with Zhang et al. (2018), our approach would generate comparable results for individual exposure at urban and less biased results for rural areas because we use grid average from the urban core areas, and our estimates for rural areas are primarily based on values in rural areas.

[9] We show the estimation procedure for exposure in a rural or urban area in the Appendix, where Figure 5.8b and Figure 5.9a show the average of $PM_{2.5}$ estimates at the county level inside the example city Dalian (a middle-sized city near the sea), Dalian's satellite image from Google Maps, and illustrations of the different grids used to estimate the exposure in an urban area, respectively.

increase in air pollution had worse health status compared with those where air pollution was relatively constant. However, this factor is under-researched. The implication of air pollution growth can be two ways. On the one hand, individuals may not have time to adjust to the level of air pollution, and thus the health impacts are larger; on the other hand, individuals having experienced a large increase in air pollution may be more aware of the air pollution in the future and actively adjust to it.

In our second analysis (Model B), we further considered the impact of past exposure to $PM_{2.5}$ before the baseline survey in 2011. This analysis allowed us to distinguish the impact of the current exposure to $PM_{2.5}$ in a survey year from past exposure to $PM_{2.5}$ (2000–2010, before the survey study). We restricted the sample to the participants who reported no history of living outside the survey locations for more than six months since 2000. Therefore, this restricted sample represented a participant who had lived in the same location from 2000 to 2018 for the majority of the time.[10] For the restricted sample, we estimated the past annual exposure to $PM_{2.5}$ for each respondent from 2000 to 2010, following the same strategy used to estimate the $PM_{2.5}$ exposure in a survey year. We categorised the experience of past $PM_{2.5}$ as severe if the average annual exposure to $PM_{2.5}$ from 2000 to 2010 exceeded 55 µg/m^3, the threshold for 'Unhealthy' or 'Highly polluted' according to air quality standards in the US and the UK, respectively. We did not use the air quality standard in China because the sample size above the 'Unhealthy' threshold was too small to estimate accurate non-linear relationships. We constructed a binary variable 'Past severe $PM_{2.5}$' to denote whether the respondent had experienced a severe $PM_{2.5}$ exposure from 2000 to 2010 and a variable 'Past largest YOY growth of $PM_{2.5}$' to denote the maximum of the YOY growths of the $PM_{2.5}$ exposure in each year from 2000 to 2010.

[10] This is due to a fast but uneven economic growth in China in which people may change their work locations and do not spend the majority of their time in one city. This can prevent us from assessing the history of $PM_{2.5}$ exposure before the survey study.

5.2.3 Health-related risk factors

The dependent variables in our study measured three important health outcomes in old age: multimorbidity, cognition and ADL disability.

5.2.3.1 Multimorbidity

In each wave, CHARLS participants reported if a doctor or any health professional had ever told them that they had any of a list of fourteen diseases.[11] Following Johnston et al. (2019), we measured multimorbidity by the total number of diagnosed diseases. This 'multimorbidity' index reflected the intensity of disease burden and had more discriminative power than the binary variable 'comorbidity' that measured whether two or more diseases were present (Johnston et al., 2019) because of a high prevalence of comorbidity among the ageing population (Calderón-Larrañaga et al., 2017; Gu et al., 2017; Zhao et al., 2021). The multimorbidity index ranged from zero to fourteen, and a larger value indicated poorer health.

5.2.3.2 Cognition

CHARLS examines participants' cognition in each survey wave. Following previous studies (Huang and Zhou, 2013; Lei et al., 2014), we constructed an overall cognition measure based on two cognition function measures: Telephone Interview of Cognitive Status (TICS) and word recall. TICS captures the mental status of individuals. The TICS or mental status questions in CHARLS contain the following items: serial seven subtraction from

[11] The diseases include hypertension, dyslipidaemia (elevation of low-density lipoprotein, triglycerides, and total cholesterol, or a low high-density lipoprotein level), diabetes or high blood sugar, cancer or malignant tumour (excluding minor skin cancers), chronic lung diseases, such as chronic bronchitis, emphysema (excluding tumour or cancer), liver diseases (excluding fatty liver, tumour or cancer), heart attack, coronary heart disease, angina, congestive heart failure, or other heart problems, stroke, kidney diseases (excluding tumour or cancer), stomach or other digestive diseases (excluding tumour or cancer), emotional, nervous, or psychiatric problems, memory-related diseases, arthritis or rheumatism and asthma.

100 (up to five times), current date identification (month, day, year and season), day of the week identification, and the ability to redraw a picture shown to the participant. Word recall measures the ability of memory recall. It is based on a respondent's performance in repeating immediately in any order ten Chinese nouns read to them before the test (immediate word recall) and to recall these words four minutes later (delayed word recall). Following Huang and Zhou (2013) and Lei et al. (2014), we aggregated answers to these questions to form the variable 'Cognition', ranging from zero to twenty-one, with a larger value representing better health.

5.2.3.3 ADL disability

CHARLS asks participants whether they experience any difficulty performing the following six activities of daily living: dressing, showering, eating, getting in and out of bed, using the toilet and continence. For each activity, CHARLS participants reported the level of difficulty with the activity, with possible answers: 1) No, I don't have any difficulty, 2) I have difficulty but can still do it, 3) Yes, I have difficulty and need help, and 4) I cannot do it. For consistency with existing literature (Lv et al., 2020; Zeng et al., 2010), we constructed a binary variable, 'ADL disability'. The response variable was one if the respondent answered 2, 3, or 4 for at least one of the six ADLs, and zero otherwise.

5.2.4 Other variables

We also included individual-level covariates such as age, gender, education, marital status, residence areas (urban or rural), occupation, BMI (body mass index), smoking status, alcohol consumption and household consumption and expenditure. Prefecture-city level information is added to control for the impact of economic development on the three health outcomes of interest. We obtained prefecture-level data from the China National Knowledge Infrastructure (CNKI) database, which includes data from Chinese yearbooks.[12] We included four variables to measure annual economic development from 2000 to 2018 at the prefecture level: GDP, GDP per capita, population density, and the number of hospital beds. We also included the growth rates for each of the four variables from 2000 to 2010 to account for variability in regional development in China, and a higher initial value was potentially associated with a lower growth rate. These variables were proxies of the prefecture-level economic development, average income, urbanisation level, and healthcare development important to the health of older individuals.

Since 2013 when the clean air policy was introduced, $PM_{2.5}$ monitors have been established gradually in urban areas, and local governments would need to meet their obligations to cut air pollution. This exogenous shock due to the clean air policy reduces the correlation between air pollution and economic development. Compared with relevant studies, we use a similar approach to Zeng et al. (2010), Zhang et al. (2018) and Lv et al. (2020) to include relevant economic variables at the city level when studying the health effect of air pollution. However, they did not control for the changes of these economic variables, and some of them do not cover the period after the introduction of the clean air policy.

5.3 Model

We used generalised additive mixed models (GAMMs) to capture potential linear and non-linear effects of the impact of $PM_{2.5}$ exposure on health in older participants. We used the same modelling strategy for the three health outcome variables: general cognition, multimorbidity, and ADL disability, to ensure that the results for the relationships between air pollution and the three health outcomes were comparable. For all models, we included a wide range of common confounding variables identified in previous studies (e.g., Hu et al., 2020; Zeng et al., 2010; Zhang et al., 2018). At the individual level, all models controlled

[12] The data can be accessed from `https://www.cnki.net`.

Table 5.1: $PM_{2.5}$ variables, characteristics of the study participants from the CHARLS study, and the city-level covariates at the baseline year: 2011

Variables	Mean or %
Number of respondents	11877
Number of counties	149
Number of cities	125
$PM_{2.5}$ variables	
Past severe $PM_{2.5}$	44.6%
Survey year $PM_{2.5}$	59.9
Survey year YOY growth of $PM_{2.5}$	9.7%
Past largest YOY growth of $PM_{2.5}$	36%
Health outcomes	
Multimorbidity	1.4
Cognition	11.1
ADL disability	15.0%
Individual level variables	
Age	57.6
Male	46.3%
Education	
Illiterate (reference)	26.9%
Basic reading and writing	22.0%
Elementary school	21.1%
Middle school	19.5%
High school and above	10.5%
Married	68.7%
Urban	34.6%
Non-agricultural work	47.2%
Higher household consumption	50.0%
Ever smoked	38.4%
Ever drank	38.6%
BMI	
Normal weight (reference)	52%
Overweight	43.2%
Underweight	5.0%
City level variables	
GDP in a survey year (1 billion CNY)	209.3
GDP per capita in a survey year (CNY)	34,724
Population density in a survey year (persons per sq. km)	454
Number of hospital beds	15,817

[a]The statistics are for the sub-sample that had lived in the same places for most of the time (Model B as described in Section 5.3).
[b]The cognition variable has missing observations and the statistics are based on 9,524 observations.
Notes: Variables at the individual level have additional missing values in the follow-up surveys and these cases were removed during model fitting. YOY: year-over-year; ADL = activities of daily living; BMI = body mass index.

for demographic factors such as age and gender, socioeconomic factors such as education, residence (rural or urban area), household consumption, and occupation (whether the primary work was non-agricultural), and health lifestyle factors such as smoking status (ever smoked or not), alcohol consumption (ever drunk or not), and body mass index category (BMI levels: normal (reference), overweight and underweight). At the city level, we included annual GDP, GDP per capita, population density, number of hospital beds, and the annual growth rates of each of these variables. Please refer to Section 5.2.4 for a detailed description of these variables. Statistical significance is considered at the $p =$ 0.05 level.

In our baseline analysis (Model A), we modelled the impact of current $PM_{2.5}$ exposure on health. We estimated two smooth functions for each health outcome, one for the impact of $PM_{2.5}$ exposure in a survey year and another for the growth of $PM_{2.5}$ exposure in a survey year:

$$Y_{i,j,t} = \alpha_0 + s_1(\text{Current\_PM}_{i,t}) + s_2(\text{Current\_growth\_PM}_{i,t}) + \mathbf{X}_{i,t}\kappa + \lambda_i + \nu_t + \eta_j + \epsilon_{i,j,t}, \tag{5.1}$$

where $Y_{i,j,t}$ was the health outcome variable (e.g., general cognition) for an individual i living in county j in a survey year t. For the error term, following (Lei et al., 2014), we assumed a normal distribution in the case of cognition and multimorbidity for straightforward interpretation. We assumed a binomial distribution with a logit link function in the case of ADL disability. $s_1(\text{Current\_PM}_{i,t})$ and $s_2(\text{Current\_growth\_PM}_{i,t})$ measured linear or non-linear effects of annual $PM_{2.5}$ exposure and its YOY growth at time t for a respondent i, respectively. Moreover, $\mathbf{X}_{i,t}$ was a vector of the individual-level and county-level variables that had been controlled for. ν_t wass the dummy for survey wave. λ_i and η_j were the individual and county random effects, respectively.

In our second analysis (Model B), we consider the impact of past exposure to $PM_{2.5}$ from 2000 to 2010. We add into Equation 5.1 a binary variable 'Past_severe_PM$_i$' denoting whether the respondent i had experienced severe $PM_{2.5}$ exposure in the past and a variable 'Past_largest_growth_PM_i' denoting the largest YOY growth of past $PM_{2.5}$ exposure. We also estimated the impact of current $PM_{2.5}$ exposure conditioning on whether the respondent had experienced severe air pollution before the survey by adding the interactions of past experience with severe $PM_{2.5}$ and the current exposure to $PM_{2.5}$. We re-parametrised the model such that the $s_1()$ in Equation 5.2 estimated the main effect of the current influence of $PM_{2.5}$ exposure for the reference group: not having experienced past severe air pollution ($\text{Past\_severe\_PM}_i = 0$), and the $s_4()$ estimated the difference from the main effect for those having an experience of severe air pollution in the past ($\text{Past\_severe\_PM}_i = 1$). Therefore, a statistically significant $s_4()$ demonstrated evidence of effect modification by the $PM_{2.5}$ exposure in the past.

$$
\begin{aligned}
Y_{i,j,t} = \alpha_0 &+ \text{Past\_severe\_PM}_i \\
&+ s_1(\text{Current\_PM}_{i,t}, \text{Past\_severe\_PM}_i = 0) \\
&+ s_2(\text{Current\_growth\_PM}_{i,t}) \\
&+ s_3(\text{Past\_largest\_growth\_PM}_i) \\
&+ s_4(\text{Diff\_Current\_PM}_{i,t}, \text{Past\_severe\_PM}_i = 1) \\
&+ \mathbf{X}_{i,t}\kappa + \lambda_i + \nu_t + \eta_j + \epsilon_{i,j,t}.
\end{aligned}
\tag{5.2}
$$

In our final analysis (Model C), for each of the three health outcomes, we identified whether a certain population segment was more sensitive to air pollution. We considered the following sub-populations: age (at least 65 years old vs younger), gender (male vs female), smoking status (ever smoked vs not smoked), residence (urban vs rural), and household consumption (higher than median vs lower than the median). We selected these factors because the vast uneven economic development between urban and rural areas in China and different socioeconomic status can potentially imply different pathways of $PM_{2.5}$ exposure and modify its health effect. Similar to Model B, for each sub-population, we estimated a main smooth function of current air pollution on each health outcome in the reference group (sub-group$_i$ = 0) and a smooth function for the difference of impact in the other group (sub-group$_i$ = 0):

$$\begin{aligned}
Y_{i,j,t} = \alpha_0 &+ s_1(\text{Current_PM}_{i,t}, \text{sub-group}_i = 0)\\
&+ s_2(\text{Current_growth_PM}_{i,t}, \text{sub-group}_i = 0)\\
&+ s_5(\text{Diff_Current_PM}_{i,t}, \text{sub-group}_i = 1)\\
&+ s_6(\text{Diff_Current_growth_PM}_{i,t}, \text{sub-group}_i = 1)\\
&+ \mathbf{X}_{i,t}\kappa + \lambda_i + \nu_t + \eta_j + \epsilon_{i,j,t}.
\end{aligned} \tag{5.3}$$

We did not consider the interactions between air pollution and all the five groups simultaneously in one model as we aimed to examine whether the health effect of $PM_{2.5}$ differed by each factor.

To compare the risk of $PM_{2.5}$ exposure on each health outcome with that of ageing, if the estimated association between a $PM_{2.5}$-related variable and a health outcome was linear, we compared the estimated coefficients for the effect of the $PM_{2.5}$-related variable and that of ageing. However, if the estimated association was non-linear, we identified the range of the $PM_{2.5}$-related variable in which the effect demonstrated a significant linear association with the health outcome and calculated the derivative over this range. This derivative was the coefficient of the effect of the $PM_{2.5}$-related variable within the corresponding range, and we could compare it with that of ageing.

5.4 Results

We report the regression results from the GAMMs for the association of $PM_{2.5}$ exposure on each of the three health outcome variables. Sections 5.4.1, 5.4.2, and 5.4.3 provide the results for multimorbidity, cognition and ADL disability, respectively. We report the estimates of non-parametric effects of $PM_{2.5}$-related variables in graphs and summarise estimates of the linear effects from Model B in Table 5.2. For each health outcome, we first report the effect of $PM_{2.5}$ exposure, then we report which groups were more sensitive to $PM_{2.5}$ for this health outcome, and finally, we report the effects of the individual-level covariates.

5.4.1 Multimorbidity

Figure 5.1 shows the estimated smooth functions from Model A and Model B for the impact of $PM_{2.5}$ exposure on multimorbidity. The results for the linear effects from Model B are summarised in Table 5.2 (Column 1).[13]

5.4.1.1 Impact of air pollution

Model A: Only current exposure to $PM_{2.5}$ considered

Figure 5.1 (a) shows a significant non-linear impact of current $PM_{2.5}$ exposure on multimorbidity.[14] Higher annual $PM_{2.5}$ levels were linked to more severe multimorbidity. The effect was statistically significant for $PM_{2.5}$ levels higher than 25 µg/m^3. Figure 5.1 (b) shows that reductions of $PM_{2.5}$ exposure in a survey year were linked to lower multimorbidity. There was no significant effect for $PM_{2.5}$ increases.

Model B: Past and current exposure to $PM_{2.5}$ considered

In our second analysis (Model B), we included both the past and the current exposure to $PM_{2.5}$ in our model. The results in Table 5.2, Column 1, show no significant effect

[13] Results of the linear effects from Model A are similar and are available upon request.

[14] Interpretations for non-linear associations are not as straightforward as for linear effects. To better understand a non-linear association, the essence is to focus on the curve's trend or derivative and examine whether the trend or the derivative is positive or negative. Whether the confidence intervals include zero is irrelevant because a vertical shift of the non-linear curve can be adjusted by an intercept, without modifying the strength of association.

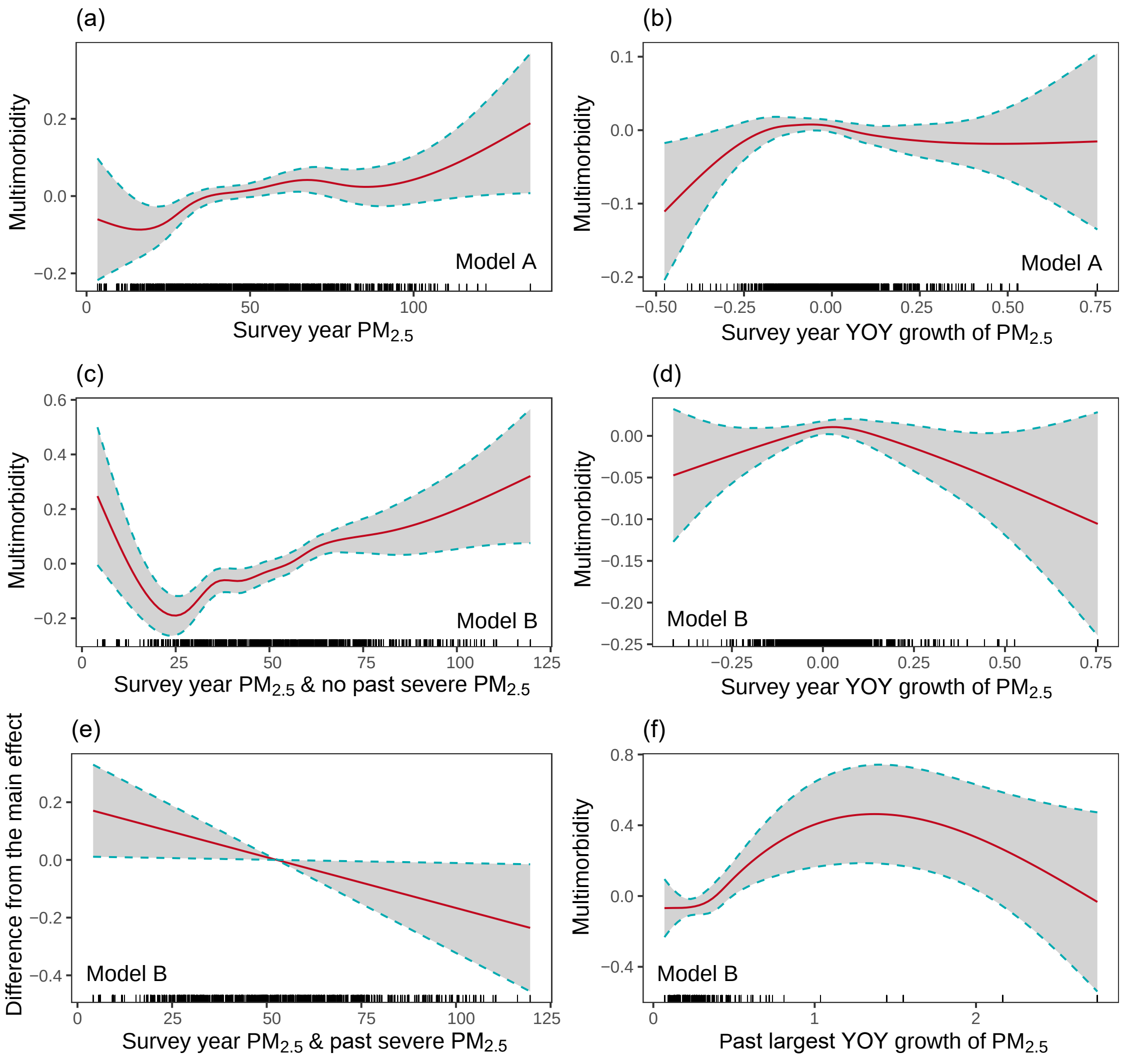


Figure 5.1: Impact of $PM_{2.5}$ exposure on multimorbidity without (Model A) and with (Model B) consideration of past $PM_{2.5}$ exposure

Notes: The shaded areas represent the 95% confidence intervals for the smooth functions. Multimorbidity: total number of diseases; $PM_{2.5}$: particles less than 2.5 micrometres in diameter; YOY: year-over-year. Participants experienced past severe $PM_{2.5}$ exposure if their average annual exposure to $PM_{2.5}$ from 2000 to 2010 exceeded 55 µg/m^3.

of past severe air pollution exposure on multimorbidity. However, Figure 5.1 (c) and (e) show that the effect of current exposure to $PM_{2.5}$ differed significantly by past exposure to $PM_{2.5}$: i) a higher $PM_{2.5}$ exposure was linked to more severe multimorbidity when the level of current $PM_{2.5}$ was higher than 25 µg/m^3 for those having not experienced past severe air pollution, and ii) this association decreased for those having experienced severe air pollution in the past. These results indicate that the severity of past $PM_{2.5}$ exposure did not affect multimorbidity *directly*. Instead, it modified the effect of current $PM_{2.5}$ exposure on multimorbidity.

Regarding the growth of $PM_{2.5}$ exposure, we found that its effect in a survey year was not statistically significant (Figure 5.1, Panel d). This result contrasts with that of Model A, in which we did not control for past exposure to $PM_{2.5}$. The largest YOY growth of the annual $PM_{2.5}$ exposure from 2000 to 2010 was adversely linked to multimorbidity before the growth reached 100%.

Effect of $PM_{2.5}$ exposure compared to that of ageing

Table 5.2, Column 1, shows that being one year older was associated with a 0.03 increase in multimorbidity. The increase from 35 µg/m^3 to 75 µg/m^3 of the current $PM_{2.5}$ exposure was associated with an increase of multimorbidity by about 0.15 for those who had not experienced past severe air pollution (Figure 5.1, Panel c). This effect size is equivalent to that of being five years older. Similarly, the largest YOY growth of annual $PM_{2.5}$ in the past from 0% to 100% was linked to an increase of multimorbidity by about 0.3 (Figure 5.1, Panel f), the effect size of which was equivalent to that of being ten years older.

5.4.1.2 Sub-group sensitivity to air pollution

In our final analysis (Model C), we found that the impact of current exposure to $PM_{2.5}$ differed significantly by gender, age, residence and household consumption (Figure 5.2), but not by smoking status. For males, adults younger than 65 years old, or those living in an urban area, their multimorbidity status was more sensitive to the annual $PM_{2.5}$ exposure in a survey year than females, older adults, and those living in a rural area, respectively. For the growth of $PM_{2.5}$ exposure in a survey year, although its impact on multimorbidity differed significantly by living areas and household consumption status, no practical inferences on the differences can be made due to large uncertainties in the estimated non-linear functions (Figure 5.2).

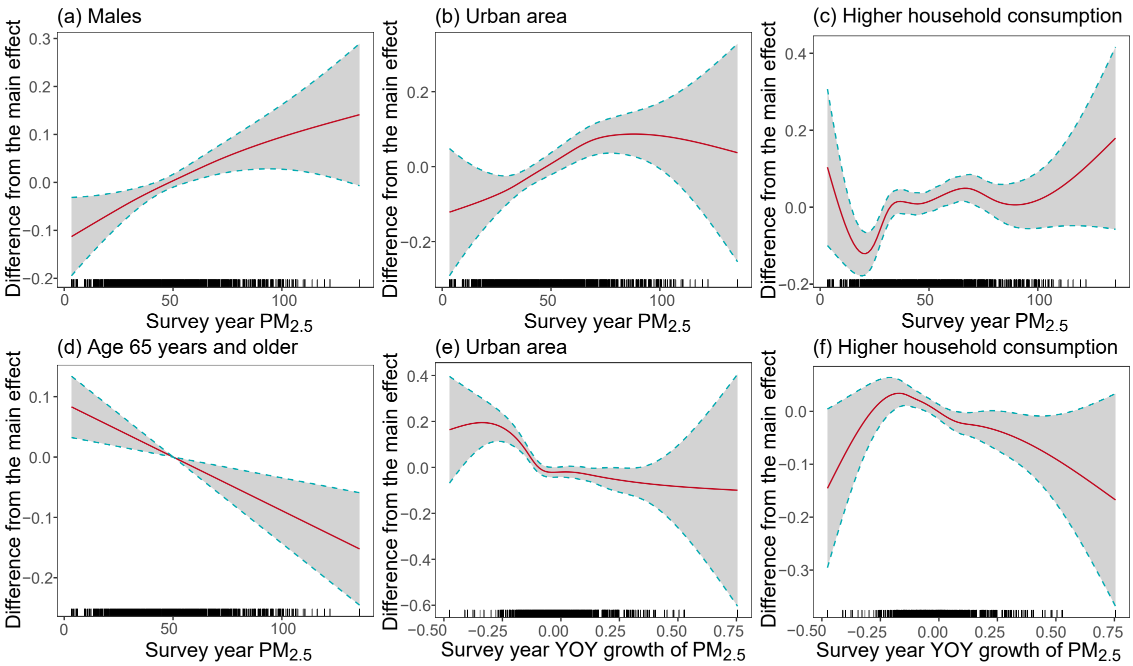


Figure 5.2: Estimated differences from the main effects of $PM_{2.5}$ variables on multimorbidity for different subgroups

Notes: Only statistically significant results are presented. The shaded areas represent the 95% confidence intervals for the smooth functions. Multimorbidity: total number of diseases; $PM_{2.5}$: particles less than 2.5 micrometres in diameter; YOY: year-over-year. Participants experienced past severe $PM_{2.5}$ exposure if their average annual exposure to $PM_{2.5}$ from 2000 to 2010 exceeded 55 µg/m^3.

5.4.1.3 Impact of individual-level covariates

We found robust results for the individual level covariates in Models A, B, and C. Table 5.2, Column 1 shows that age, having basic reading and writing skills, completing elementary school (reference: illiterate), conducting non-agricultural work, having higher household consumption than the median, smoking status, and being overweight were adversely associated with multimorbidity, while being male and consuming alcohol consumption were linked to less severe multimorbidity.[15] We did not find robust results for a significant adverse association between being underweight and multimorbidity. Residence, higher education levels and marital status were not significantly associated with multimorbidity.

5.4.2 Cognition

Figure 5.3 shows the estimated smooth functions from Model A and Model B for the impact of $PM_{2.5}$ exposure on cognition. The results for the linear effects of Model B are summarised in Table 5.2 (Column 2).

5.4.2.1 Impact of air pollution

Model A: Only current exposure to $PM_{2.5}$ considered

Figure 5.3 (at) illustrates a large uncertainty for the association between current exposure to $PM_{2.5}$ and cognition. Figure 5.3 (b) shows that $PM_{2.5}$ exposure reductions in a survey year were linked to better cognition. However, there was no significant effect for $PM_{2.5}$ increases.

Model B: Past and current exposure to $PM_{2.5}$ considered

[15] Estimations of the linear effects from Model A and Model C were similar and are available upon request.

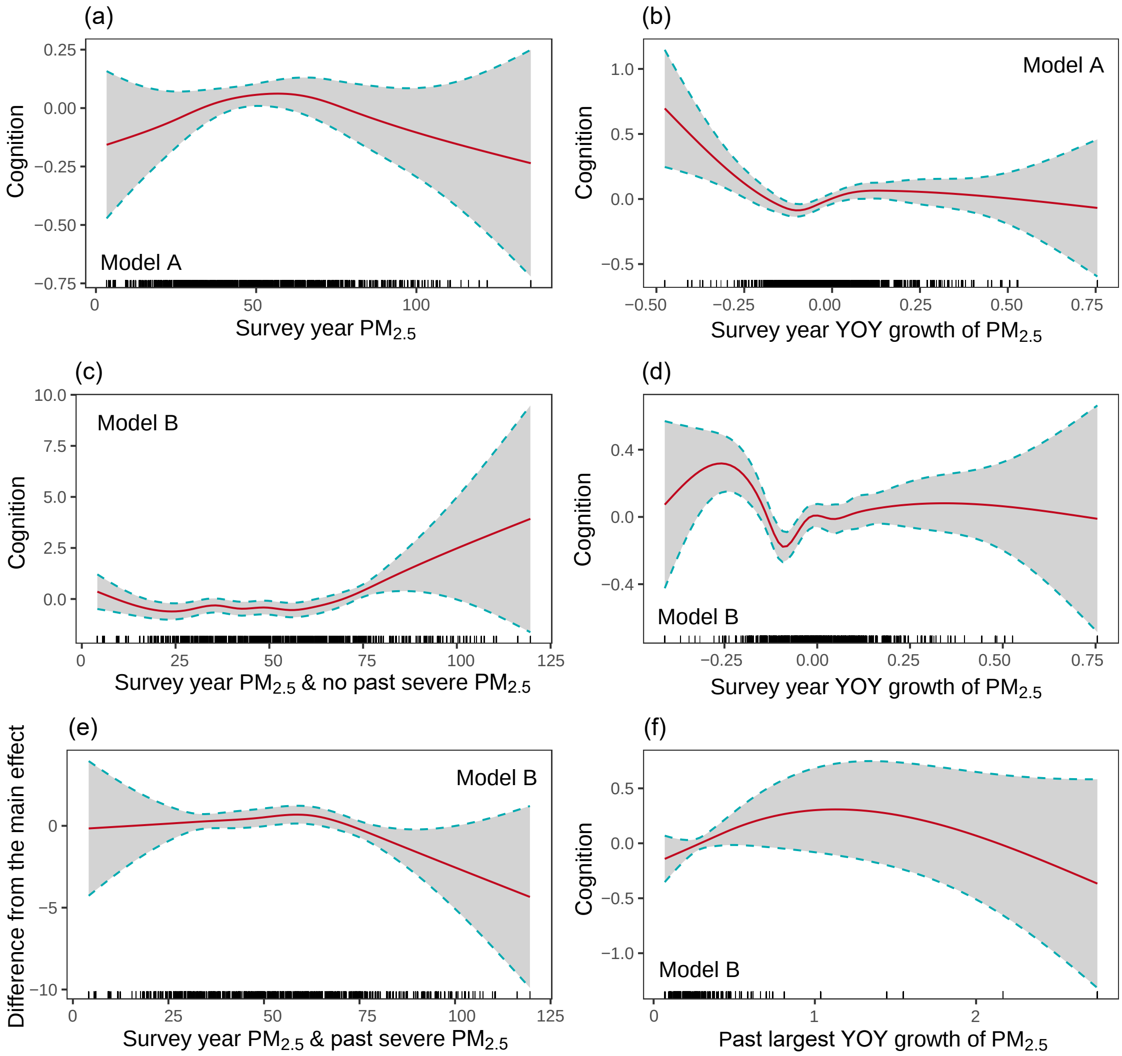


Figure 5.3: Impact of $PM_{2.5}$ exposure on cognition without (Model A) and with (Model B) consideration of past $PM_{2.5}$ exposure

Notes: The shaded areas represent the 95% confidence intervals for the smooth functions. Cognition: total scores for 21 questions on cognitive function; $PM_{2.5}$: particles less than 2.5 micrometres in diameter; YOY: year-over-year. Participants experienced past severe $PM_{2.5}$ exposure if their average annual exposure to $PM_{2.5}$ from 2000 to 2010 exceeded 55 μg/m^3.

As for multimorbidity, Table 5.2, Column 2 demonstrates no significant effect of past severe air pollution exposure on cognition. However, Figure 5.3 (c) and (e) show that exposure to severe air pollution modified the effect of the current exposure to $PM_{2.5}$ on cognition. In the case that exposure to air pollution was not severe in the past, we found a significant non-linear association between the current exposure to $PM_{2.5}$ and cognition (Figure 5.3, Panel c). This association was adverse when the current $PM_{2.5}$ exposure was lower than about 25 µg/m^3. However, there was no significant effect when the $PM_{2.5}$ exposure was between 25 µg/m^3 and 60 µg/m^3. Furthermore, we found a large uncertainty in the association when the $PM_{2.5}$ exposure was larger than about 75 µg/m^3. When the $PM_{2.5}$ exposure was severe in the past (Figure 5.3, Panel e), we found a negative association between the $PM_{2.5}$ exposure and the difference from the main effect on cognition when the $PM_{2.5}$ exposure was larger than about 60 µg/m^3. This result means that the current $PM_{2.5}$ exposure had a stronger adverse effect on cognition for participants who had experienced severe air pollution in the past.

Figure 5.3 (d) shows that the growth of $PM_{2.5}$ in a survey year had a stronger non-linear association than in Model A. However, a reduction higher than 25% no longer had a significant association with cognition. We did not find a significant association between the largest YOY growth of annual $PM_{2.5}$ exposure in the past and cognition (Figure 5.3, Panel f).

Effect of $PM_{2.5}$ exposure compared to that of ageing

Table 5.2, Column 2 shows that being one year older was linked to decreased cognition of 0.073. A 50% reduction of the $PM_{2.5}$ exposure in a survey year was linked to increased cognition of 0.73 (Figure 5.3, Panel b). This effect was equivalent to that of being ten years younger.

5.4.2.2 Sub-group sensitivity to air pollution

The cognitive function of adults younger than 65 years old was more sensitive to current $PM_{2.5}$ exposure (Figure 5.4, Panel a) and its growth (Figure 5.4, Panel d) than adults 65 years and older. Similarly, the cognitive function of those living in an urban area was more sensitive to the current $PM_{2.5}$ exposure (Figure 5.4, Panel c). However, the effect of the growth of $PM_{2.5}$ exposure on cognition did not differ by the living area. Finally, we found no significant results that the association between $PM_{2.5}$ exposure and cognition differ by gender, smoking status, or household consumption.

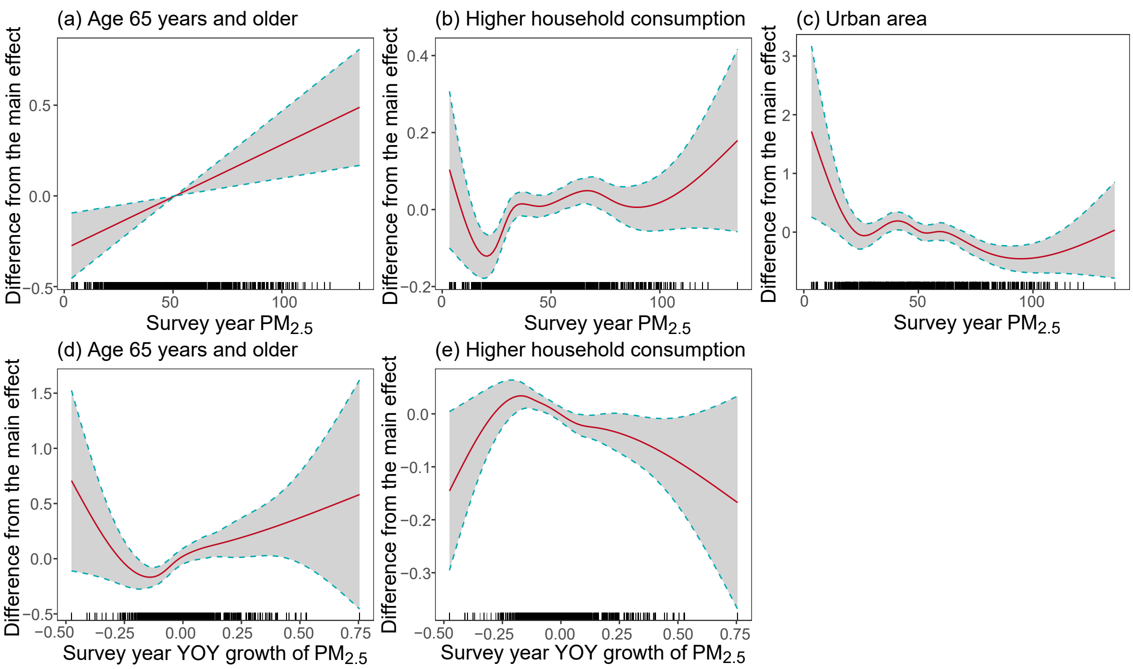


Figure 5.4: Estimated differences from the main effects of $PM_{2.5}$ variables on cognition for different sub-groups

Notes: Only statistically significant results are presented. The shaded areas represent the 95% confidence intervals for the smooth functions. Cognition: total scores for 21 questions on cognitive function; $PM_{2.5}$: particles less than 2.5 micrometres in diameter; YOY: year-over-year. Participants experienced past severe $PM_{2.5}$ exposure if their average annual exposure to $PM_{2.5}$ from 2000 to 2010 exceeded 55 µg/m^3.

5.4.2.3 Impact of individual-level covariates

The results in Table 5.2, Column 2 show that being male, higher education, being married, living in a rural area, residing in a household with a higher-than-median consumption, alcohol consumption, and being overweight were linked to better cognition, while age and being underweight were adversely associated with cognition. These results are consistent with Lei et al. (2014), who studied the effect of demographic and socioeconomic factors on cognition in China using the CHARLS data. Potential explanations include i) non-agricultural work, higher than median household consumption, and higher alcohol consumption were often linked to a higher socioeconomic status, which is associated with superior cognition; ii) males in China on average receive greater education; and iii) being married is associated with living with another person, which helps maintain cognitive skills.

5.4.3 ADL disability

Figure 5.5 shows the estimated smooth functions from Model A and Model B of the impact of $PM_{2.5}$ exposure on ADL disability (hereafter, at the logit scale). The results for the linear effects of Model B are summarised in Table 5.2 (Column 3).

5.4.3.1 Impact of air pollution

Model A: Only current exposure to $PM_{2.5}$ considered

In contrast to our previous findings on multimorbidity and cognition, we found no significant association between the exposure to $PM_{2.5}$ in a survey year and ADL disability (Figure 5.5, Panel a). Instead, we revealed a highly non-linear impact of the survey year YOY growth of $PM_{2.5}$ exposure on ADL disability (Figure 5.5, Panel b).

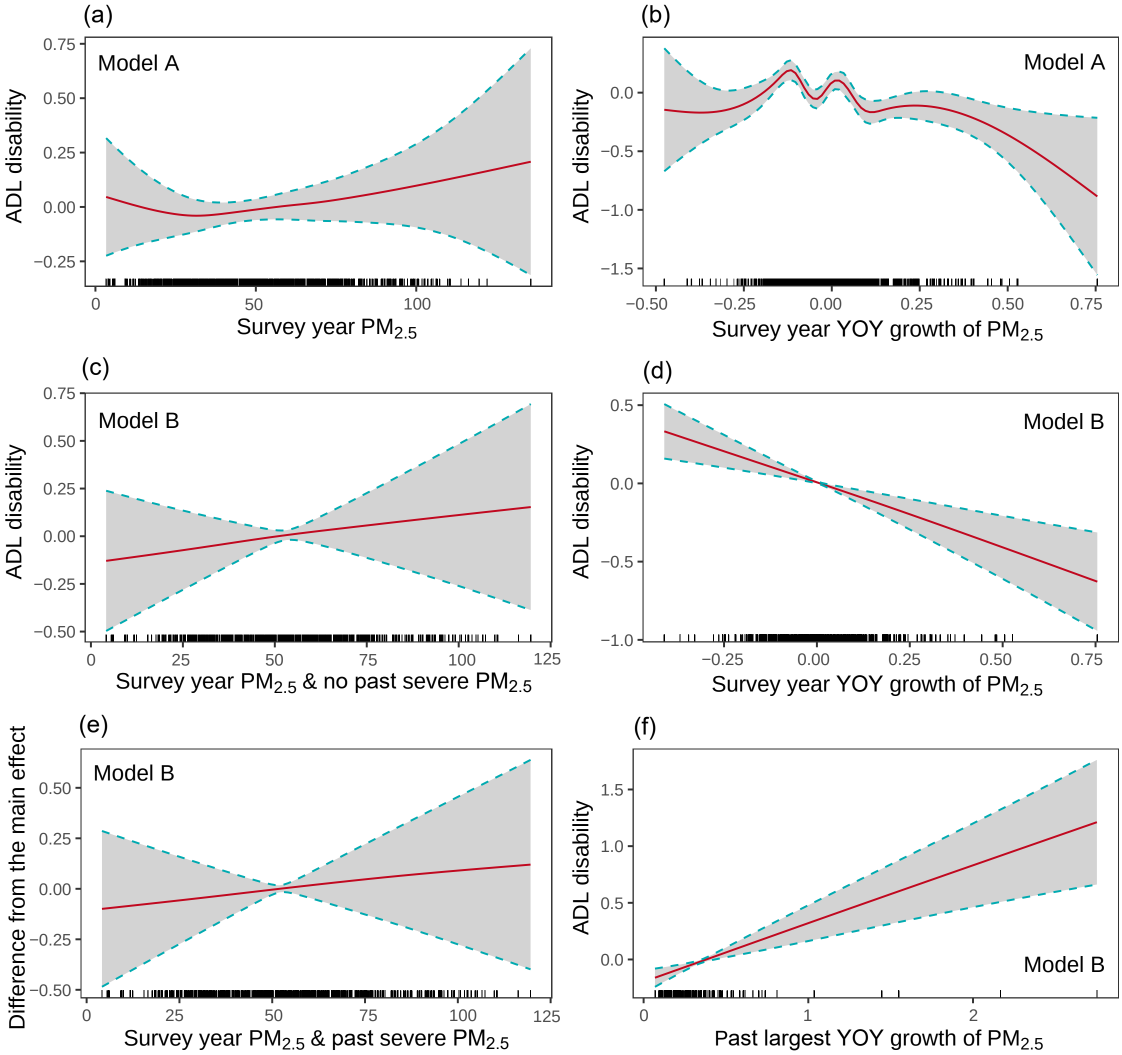


Figure 5.5: Impact of $PM_{2.5}$ exposure on ADL disability without (Model A) and with (Model B) consideration of past $PM_{2.5}$ exposure

Notes: The shaded areas represent the 95% confidence intervals for the smooth functions. ADL disability: participants experienced any difficulty performing the following six activities of daily living: dressing, showering, eating, getting in and out of bed, using the toilet and continence; $PM_{2.5}$: particles less than 2.5 micrometres in diameter; YOY: year-over-year. Participants experienced past severe $PM_{2.5}$ exposure if their average annual exposure to $PM_{2.5}$ from 2000 to 2010 exceeded 55 µg/m^3.

Model B: Past and current exposure to $PM_{2.5}$ considered

As in the cases with multimorbidity and cognition, Table 5.2, Column 3 shows no significant association between past severe air pollution exposure and ADL disability. However, in contrast to the prior cases, Figure 5.5 (c) and (e) also show that the effect of current $PM_{2.5}$ exposure on ADL disability did not differ significantly by experience with past severe air pollution exposure.

After controlling for the effect of past $PM_{2.5}$ exposure, Figure 5.5 (f) shows that the largest growth of past $PM_{2.5}$ exposure was adversely associated with ADL disability. However, the YOY growth of current $PM_{2.5}$ was linked to lower ADL disability (Figure 5.5, Panel d). A potential behavioural explanation is that individuals learnt from experience and took more preventive measures when their local air pollution level increased.

Effect of $PM_{2.5}$ exposure compared to that of ageing

Table 5.2, Column 3 shows that being one year older was linked to an increase of ADL disability by about 0.073. Figure 5.5 (f) shows that a 100% increase of the largest YOY growth of past $PM_{2.5}$ was linked to an increase of ADL disability by about 0.5. This effect is comparable to that of being about seven years older.

5.4.3.2 Sub-group sensitivity to air pollution

Figure 5.6 (a) shows that the adverse effect of current $PM_{2.5}$ exposure on ADL disability for adults living in an urban area was larger than for those living in a rural area. The residence factor modified the effect of the growth of current $PM_{2.5}$ exposure non-linearly, but for the most part, the impact was largely uncertain (Figure 5.6, Panel b). Figure 5.6 (c) shows that the zig-zag behaviour of the current $PM_{2.5}$ exposure on ADL disability in Figure 5.5 was potentially caused by a past or present smoking habit. We did not find that the impact of $PM_{2.5}$ on ADL disability differed significantly by age, gender or household consumption.

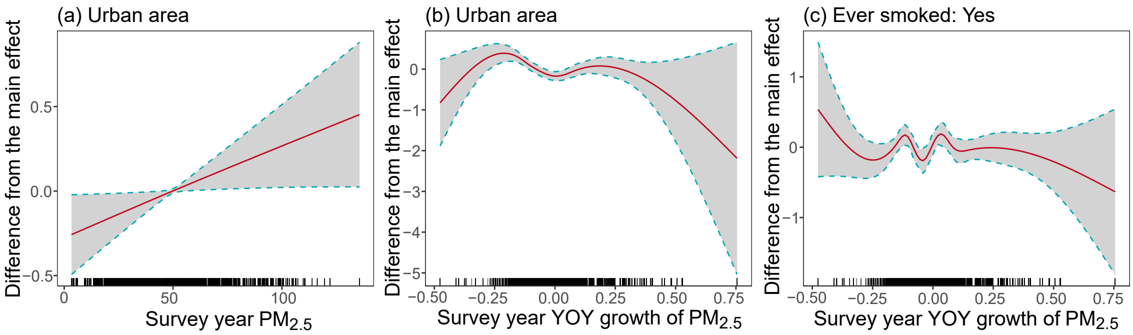


Figure 5.6: Estimated differences from the main effects of $PM_{2.5}$ variables on ADL disability for different subgroups

Notes: Only statistically significant results are presented. The shaded areas represent the 95% confidence intervals for the smooth functions. ADL disability: participants experienced any difficulty performing the following six activities of daily living: dressing, showering, eating, getting in and out of bed, using the toilet and continence; $PM_{2.5}$: particles less than 2.5 micrometres in diameter; YOY: year-over-year. Participants experienced past severe $PM_{2.5}$ exposure if their average annual exposure to $PM_{2.5}$ from 2000 to 2010 exceeded 55 μg/m^3.

5.4.3.3 Impact of individual-level covariates

Table 5.2, Column 3 shows that, as expected, age, non-agricultural work, smoking status, alcohol consumption, and being overweight were linked to a higher probability of ADL disability, while being male and obtaining higher education were linked to a lower probability of ADL disability. We found that marital status, residence, household consumption or being underweight did not significantly affect ADL disability.

5.5 Discussion

Our study utilised a national longitudinal cohort study and satellite-retrieved $PM_{2.5}$ concentrations to investigate the effects of air pollution on health among middle-aged and older adults in China. To our knowledge, we are the first to consider both past (2000–2010, be-

Table 5.2: Associations of past and current exposure to $PM_{2.5}$ with health outcomes in old age, controlling for the individual- and county-level factors and fixed survey period effects

Variables	Multimorbidity	Model B Cognition	ADL disability
Past severe $PM_{2.5}$	-0.072 (0.503)	-0.321 (0.207)	-0.112 (0.098)
Non-parametric estimations of the effects of past and current exposure to $PM_{2.5}$	Figure 5.1	Figure 5.3	Figure 5.5
Individual-level factors			
Age	0.032 (0.002)***	-0.073 (0.004)***	0.073 (0.004)***
Male	-0.193 (0.046)***	0.325 (0.094)***	-0.663 (0.092)***
Education (ref = illiterate)			
Basic reading and writing	0.211 (0.057)***	2.641 (0.1)***	-0.003 (0.087)
Elementary school	0.122 (0.06)*	4.266 (0.105)***	-0.4 (0.095)***
Middle school	0.017 (0.064)	4.99 (0.111)***	-0.67 (0.107)***
High school and above	-0.01 (0.079)	5.934 (0.136)***	-1.054 (0.143)***
Married	0.055 (0.042)	0.325 (0.074)***	0.048 (0.068)
Urban	0.077 (0.056)	0.745 (0.102)***	-0.12 (0.091)
Non-agricultural work	0.122 (0.043)**	0.116 (0.0767)	0.336 (0.07)***
Higher household consumption	0.163 (0.04)***	0.283 (0.07)***	-0.111 (0.066).
Ever smoked	0.07 (0.029)*	-0.136 (0.081).	0.23 (0.082)**
Ever drank	-0.098 (0.015)***	0.209 (0.055)***	0.146 (0.06)*
BMI (ref = normal)			
BMI: overweight	0.466 (0.04)***	0.199 (0.069)**	0.356 (0.066)***
BMI: underweight	0.065 (0.089)	-0.469 (0.159)**	-0.002 (0.14)
Intercept	-0.917 (0.161)***	11.318 (0.316)***	-7.065 (0.275)
City level economic variables	Yes	Yes	Yes
Survey wave dummy	Yes	Yes	Yes
Random effects	Individual, County	Individual, County	Individual, County
Adjusted R^2	0.165	0.4	0.072
Number of observations	24535	20760	24535

Notes: Regression results from generalised additive mixed models (Model B, considering both past and current exposure to $PM_{2.5}$) are summarised with respect to three dependent health outcome variables: multimorbidity (total number of diseases), cognition (total scores for 21 questions on cognitive function), and ADL disability. For multimorbidity and cognition, the model was estimated with a normal distribution, while for ADL disability, the model was estimated with a binomial distribution with a logit link function. The estimated non-parametric functions for each health outcome are summarised by figures in the corresponding sections, respectively. ADL disability: participants experienced any difficulty performing the following six activities of daily living: dressing, showering, eating, getting in and out of bed, using the toilet and continence; $PM_{2.5}$: particles less than 2.5 micrometres in diameter; YOY: year-over-year; Participants experienced past severe $PM_{2.5}$ exposure if their average annual exposure to $PM_{2.5}$ from 2000 to 2010 exceeded 55 µg/m^3. BMI = body mass index. Results for the baseline analysis (Model A) and the sub-group analysis (Model C) are available upon request. The sample size is smaller for cognition because of the missing values in the cognition tests. Standard errors are in parentheses. $.p < 0.1$; $*p < 0.05$; $**p < 0.01$; $***p < 0.001$.

fore the baseline survey year 2011) and current (in a survey year) $PM_{2.5}$ exposure, their interaction and the YOY growth of $PM_{2.5}$ exposure in studying the health effect of $PM_{2.5}$. Our study included three other advantages. First, the analysis of three health outcomes – multimorbidity, cognition and ADL disability – used a consistent modelling strategy. Most previous studies focused on the effect of air pollution on one health indicator, for example ADL disability (e.g., Lv et al., 2020; Zeng et al., 2010), cognition and dementia (e.g., Delgado-Saborit et al., 2021; Wang et al., 2020; Zhang et al., 2018), and diseases such as stroke (e.g., Huang et al., 2019a; Liang et al., 2020), and hypertension (e.g., Liu et al., 2017a). Hence, comparisons across studies are difficult because of different study samples, model designs and air pollution measurements.[16] Our consistent modelling enabled greater result comparability across different health aspects in older individuals. The second advantage of our study design was its flexibility in capturing potential linear and non-linear effects of $PM_{2.5}$ exposure on health. Most previous studies did not study non-linear effects or only allowed for pre-specified degrees of freedom in estimating non-linear functions (e.g., Lv et al., 2020). In our model, the complexity of non-linear associations was automatically decided by the data. Including such flexibility is especially important in developing countries because the level of $PM_{2.5}$ concentrations encompasses a much wider range than those in developed countries, and the assumption of a linear health effect of air pollution is less appropriate. The third advantage of our study design was the matching of $PM_{2.5}$ exposure to an individual and controlling for individual, location, and time confounding factors at both observed and unobserved levels not considered in previous studies (e.g., Zeng et al., 2010; Zhang et al., 2018). Our study identified how air pollution affected each health outcome through different links, and we demonstrated the different non-linear impacts of $PM_{2.5}$ exposure on the three health outcomes.

[16] An exception is (Zeng et al., 2010) which studied the association of a composite air pollution index on ADL disability, cognition, a health deficit index and mortality.

5.5.1 Did the level or growth in $PM_{2.5}$ exposure have a greater impact?

For multimorbidity and cognition, we found that both the level and the YOY growth in annual $PM_{2.5}$ exposure had significant health effects. The finding of a significant adverse health effect of the $PM_{2.5}$ exposure level is consistent with prior studies on the association between air pollution and cognition (Wang et al., 2020; Zeng et al., 2010) and diseases (e.g., Huang et al., 2019a; Liang et al., 2020; Liu et al., 2017a; Seposo et al., 2020; Zeng et al., 2010). However, we found that the YOY growth, rather than the level of annual $PM_{2.5}$ exposure, influenced ADL disability. Although Weuve et al. (2016) also found an insignificant association between self-reported functional limitations and air pollution, our finding contrasts with results from several studies. For example, Zeng et al. (2010) and Lv et al. (2020) reported a significant impact of air pollution on ADL disability for older Chinese people, and other studies in developed and developing countries found that air pollution significantly affected physical functioning and disability (De Zwart et al., 2018; Lin et al., 2017b). Our results suggest that the growth of air pollution exposure is an important factor affecting disability that many past studies failed to consider.

5.5.2 How did past exposure to $PM_{2.5}$ affect health?

We found that past $PM_{2.5}$ exposure affected multimorbidity, cognition, and ADL disability in a survey year differently. First, although past severe air pollution exposure did not significantly affect all three health outcomes, it modified the effect of current annual $PM_{2.5}$ exposure on multimorbidity and cognition, but not ADL disability. Second, the largest YOY growth of annual $PM_{2.5}$ exposure from 2000 to 2010 demonstrated a clear linear and significant adverse effect on ADL disability; its impact was non-linear and had a large uncertainty for multimorbidity and was insignificant for cognition.

5.5.3 Variable effects of current $PM_{2.5}$ exposure on health

We found that the current $PM_{2.5}$ exposure was associated with multimorbidity, cognition and ADL disability differently. First, our findings showed no significant effect of current $PM_{2.5}$ exposure on ADL disability, regardless of consideration of past $PM_{2.5}$ exposure in the model. Second, we found no overall significant effect of current $PM_{2.5}$ exposure on cognition, but this effect differed significantly by past severe air pollution exposure. Third, we identified significant non-linear effects between current $PM_{2.5}$ and multimorbidity, and this effect also differed significantly by past severe air pollution exposure.

The adverse linear association between $PM_{2.5}$ exposure and multimorbidity is consistent with past studies documenting an adverse association between air pollution and diseases (e.g., Huang et al., 2019a; Liang et al., 2020; Liu et al., 2017a; Seposo et al., 2020; Zeng et al., 2010). Our finding of an insignificant effect of current $PM_{2.5}$ on cognition contrasts with studies that identified an adverse impact of air pollution on cognition (e.g., Clifford et al., 2016; Delgado-Saborit et al., 2021; Power et al., 2016; Zhang et al., 2018). However, our result is consistent with Gatto et al. (2014) and Schikowski et al. (2015) , who found no significant effect of $PM_{2.5}$ on cognition. Furthermore, in a UK Biobank cohort study, Cullen et al. (2018) found no significant association between PM_{10}, $PM_{10-2.5}$, or NO_x and cognitive decline.For ADL disability, our findings show that the effect of current $PM_{2.5}$ exposure resembled a J-shaped function as identified by Lv et al. (2020), who focused on an older population (80 years and older) in China. However, our result is statistically insignificant. These statistically insignificant findings are different from many past studies that studied the relationship between air pollution and health, but this could be caused by a potential publication bias within this research area, as revealed by two systematic reviews (Clifford et al., 2016; Peters et al., 2019). Another reason could be that individuals may tend to stay at home or wear masks when the air pollution level is high; therefore, the actual exposure was low when the outdoor exposure is high, which can distort the result.

5.5.4 Different effect modifiers

Our results show that the health effect of $PM_{2.5}$ exposure differed by age (at least 65 years old or younger), gender, residence (urban or rural), socioeconomic status (household consumption higher than the median or not), and smoking status (ever smoked or not). However, the effect modifiers were not necessarily the same for each of the three health outcomes, except that residence modified the effect of $PM_{2.5}$ exposure on all three health outcomes. Furthermore, socioeconomic status modified the effects of $PM_{2.5}$ exposure on multimorbidity. Smoking status only modified the effect of the growth of $PM_{2.5}$ exposure on ADL disability, while gender only modified the effect of $PM_{2.5}$ exposure on multimorbidity.

These findings contrast with Zeng et al. (2010) and Hu et al. (2020), who did not identify any socioeconomic factor that modified the effect of air pollution on ADL cognition, disability, and frailty among older Chinese individuals. Lv et al. (2020) found that gender and smoking status modified the effect of $PM_{2.5}$ on ADL disability, while they did not find a significant difference for residence.

5.5.5 Policy implications

Currently, the air quality standard in China (GB 3095-2012) sets 35 µg/m^3 as the limit of the average annual $PM_{2.5}$ concentrations in urban areas.[17] However, our results showed a significant adverse effect of $PM_{2.5}$ exposure on multimorbidity when the exposure level was higher than 25 µg/m^3, and a significant adverse effect of $PM_{2.5}$ exposure on cognition when the exposure level was lower than 25 µg/m^3 for those without past severe air pollution experience. These findings suggest that an annual exposure of 35 µg/m^3 is not low enough to be considered safe. Furthermore, it does not support the presumption that there is a

[17] See https://www.mee.gov.cn/ywgz/fgbz/bz/bzwb/dqhjbh/dqhjzlbz/201203/t20120302_224165.shtml (in Chinese, accessed on 19 July, 2021).

safe threshold of annual $PM_{2.5}$ exposure, e.g., the threshold of 10 µg/m^3 set by WHO.

Another relevant guideline on setting the air quality targets is to consider percentage reduction, not just level. Our results revealed that, on average, a higher reduction of annual $PM_{2.5}$ exposure was linked to less multimorbidity, better cognition, and lower ADL disability. Compared to setting a target to reach an absolute level of $PM_{2.5}$ concentration, considering a percentage reduction target is more practical due to large regional differences in air pollution and environmental management limitations. Overall, setting the standard for air quality requires assessments of different health burdens due to air pollution and implementation feasibility.

5.5.6 Limitations and further research

Our study has several limitations:

1. Because CHARLS does not publish an individual's exact location, we used grids with different sizes to estimate $PM_{2.5}$ exposure depending on whether an individual lives in an urban or rural area.

2. We could not consider in-house air pollution, such as residential fuel consumption that reportedly accounts for 27% of the primary $PM_{2.5}$ emissions in mainland China (Shen et al., 2019). We do not know to which extent people facing heavily polluted air are taking protective measures.

3. The dataset does not include the exact date of a health event, such as being diagnosed with a disease, or the onset of ADL disability, leading to possible bias in estimating the current impact of $PM_{2.5}$.

4. Our study design only included people that are alive and participated in all four waves of CHARLS. There is potential survival bias and issues of competing risk considering the participants that had died or were missing during follow-ups.

5. Our design did not consider other pollutants such as SO_2 or PM_{10} which are also monitored in major Chinese cities to calculate an air quality index (AQI). However, the $PM_{2.5}$ level usually determines the AQI index most of the time, and therefore $PM_{2.5}$ has often been considered a proxy for air pollution in China.

Future research can explore the relationship between the presence of at least two diseases (comorbidity) and the Charlson Comorbidity Index (Austin et al., 2015; Lee et al., 2020), a widely used measure for multimorbidity. It is also necessary to explore how air pollution affects the sub-domains of general cognition, such as episodic memory and mental intactness, because the influencing factors can be different (Lei et al., 2014). Regarding ADL disability, further research could consider different disability levels. For example, at least two or three ADL disabilities are a key requirement for receiving private long-term care insurance in developed countries and China, respectively. The impact of air pollution on the incidence of long-term care can be important for the pricing and risk management of relevant insurance products.

5.6 Conclusion

We studied the effect of past and current air pollution exposure on cognition, multimorbidity, and ADL disability for middle-aged and older adults in China using a satellite-based $PM_{2.5}$ dataset and a large nationally representative longitudinal survey. We found that $PM_{2.5}$ exposure affected these three health outcomes differently. On average, the current $PM_{2.5}$ exposure was adversely associated with multimorbidity. Furthermore, the YOY growth of annual $PM_{2.5}$ exposure is an important factor that many previous studies failed to consider. This growth influenced all three health indicators, although the range over which the effect was significant was different for each of the health indicators. We found that experience with past severe exposure to $PM_{2.5}$ (average annual exposure of at least 55 $\mu g/m^3$) from 2000 to 2010 did not directly impact the three health outcomes; instead, it modified the effect of current annual $PM_{2.5}$ exposure on multimorbidity and cognition. The largest YOY growth of past $PM_{2.5}$ exposure adversely affected the probability of ADL disability.

Overall, we found that lower exposure to $PM_{2.5}$ was linked to fewer diseases, better cognition status, and a lower chance of disability, even for the population that had experienced past long-term severe air pollution. Urban residents were more sensitive to air pollution for all three health outcomes. However, these findings should be confirmed by future studies and interpreted with caution.

5.7 Appendix to Chapter 6

5.7.1 Estimated $PM_{2.5}$ concentrations in China

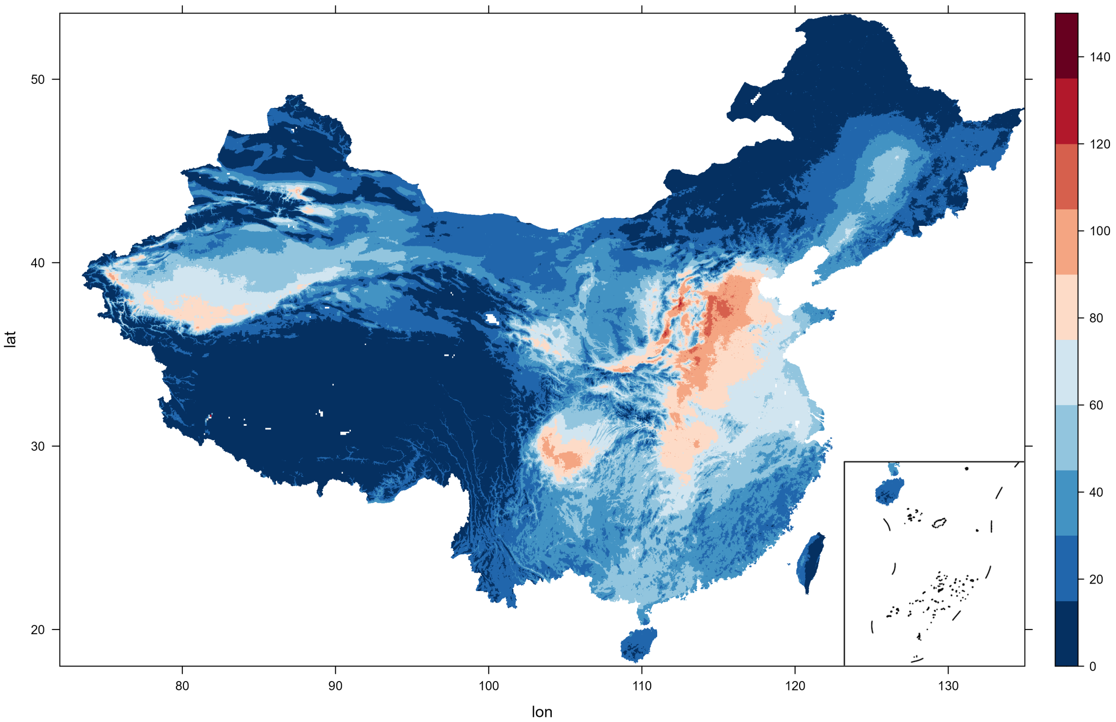
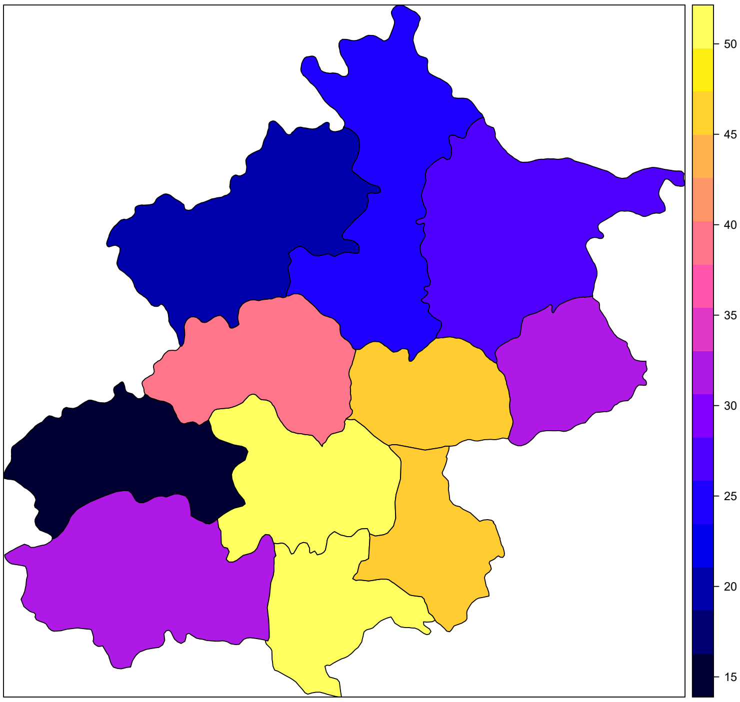
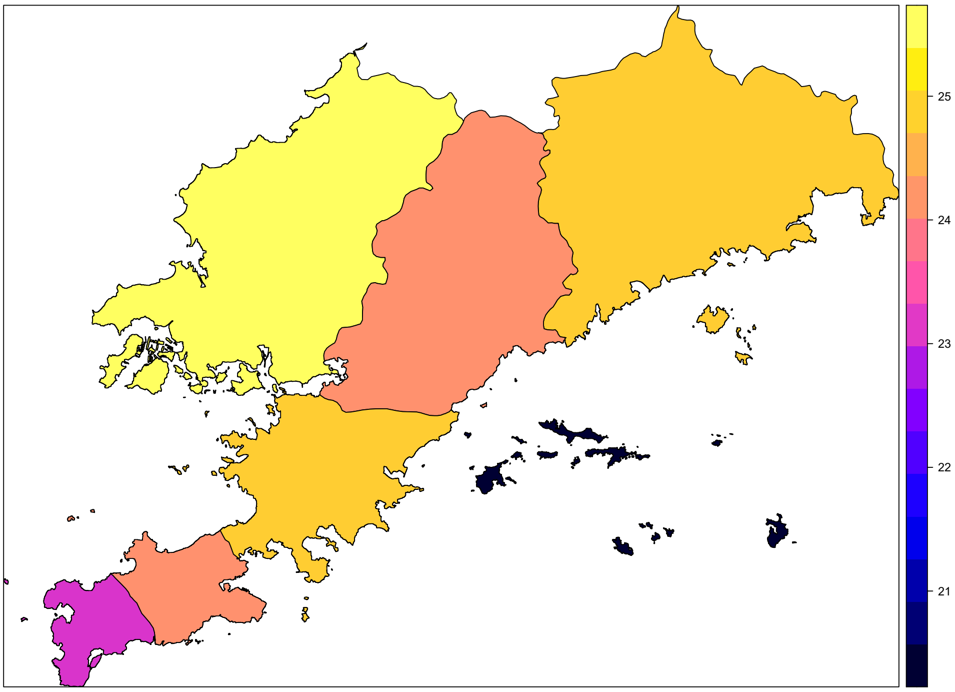


Figure 5.7: Satellite-based $PM_{2.5}$ estimations in China, 2011



(a) Beijing



(b) Dalian

Figure 5.8: Estimated $PM_{2.5}$ concentrations aggregated at the county level in 2018 for two prefecture cities

Notes: Colour scales are different to improve visibility.

(a) Dalian city at the prefecture level. The area highlighted by the green squared represents its urban centre.

(b) The urban centre of Dalian city (zoomed in). The pointer icon and the squares illustrate the average values of $PM_{2.5}$ concentrations used to estimate exposure to $PM_{2.5}$ in an urban area.

Figure 5.9: Satellite images of Dalian city

Chapter 6

Conclusion

China's social insurance systems are facing pressure from rapid population ageing. Outdoor air pollution has become the largest environmental risk factor in many developing countries and has a significant effect on healthcare expenditure. In the wake of the COVID-19 pandemic, the elderly group is most vulnerable, and concerns about health risks have surged. Individuals are increasingly expected to take more responsibility to manage health-related risks such as critical illness, long-term care dependence and longevity risk they face in retirement. Prior studies have identified life annuity as the appropriate product to address longevity risk, yet voluntary annuitisation rates are low in many countries. Health-related risks and the associated uncertain expenditures are key factors affecting the choice of a retirement portfolio.

This thesis analysed the demand for a life annuity, critical illness insurance, and long-term care insurance in urban China from both theoretical and empirical perspectives. It also investigated the health effects of $PM_{2.5}$ (fine particles, particulate matter with a diameter less than 2.5 micrometres) on multimorbidity, cognition, and disability in activities of daily livings (ADL) of middle-aged and older adults in China.

Chapter 2 provided an institutional background on China's public and private retirement insurance. It then discussed the literature on retirement insurance including life annuities, critical illness insurance and long-term care insurance, and afterwards, it summarised the literature on the health effects of air pollution for diseases, cognition and ADL disability.

Chapter 3 conducted an online experimental survey in China to explore the preferences for portfolios of retirement insurance products comprising a life annuity, critical illness insurance, long-term care insurance and a savings account during the COVID-19 pandemic. The survey also collected a comprehensive set of variables measuring the influence of COVID-19 on individuals and covariates related to retirement planning. The study employed best-worst measures to summarise the portfolio preferences and then used regressions to analyse the demand for retirement insurance with respect to personal characteristics and experiences of COVID-19. This chapter also examined whether access to health-contingent insurance (in the form of critical illness insurance and long-term care insurance) could release precautionary savings for the purchase of life annuities.

The results of Chapter 3 showed that: First, the composition of preferred portfolios of retirement insurance products highly depended on individual characteristics. On average, the most preferred retirement portfolio included health-contingent insurance covering 50% of the expected out-of-pocket costs for critical illness and long-term care and a monthly annuity income of about 19.6% of the average disposable income in urban China, with the remaining retirement wealth placed in a savings account. Second, a wide range of factors was associated with annuity demand and preferences for health-contingent insurance. Several factors, such as financial risk tolerance, understanding of retirement insurance products, financial capabilities, and bequest motives, exhibited opposite influences on longevity insurance and health-contingent insurance. For example, risk tolerance in financial matters exhibits a positive association with annuity demand but a negative one for health-contingent insurance. In contrast, understanding retirement insurance products, financial capabilities, and bequest motives are positively associated with demand for health-contingent insurance but negatively associated with annuity demand. Third, access to health-contingent insurance released precautionary savings to enable the purchase of life annuities. Fourth, experiences with and attitudes towards COVID-19 were associated with both annuity demand and preferences for retirement portfolios with different cover levels of health-contingent insurance products. Having purchased COVID-19 insurance is associated with lower annuity demand but a higher preference for portfolios with a full cover for health-related risks. A worse mental health status due to COVID-19 is associated with lower annuity demand and lower preferences for health-contingent insurance. Undertaking more risky behaviour related to COVID-19 is negatively associated with the preference for more cover for health-related OOP costs but is not associated with the demand for annuities. These findings provide insights for policymakers in developing countries for the expansion of social insurance and the development of private insurance markets. For insurers, the results provide a comprehensive array of factors that are important for risk management and financial advice and identify potential issues with selection and product bundling for longevity and health-contingent insurance products.

Chapter 4 developed a life-cycle model of retirement where an individual retiree with basic public insurance chose a portfolio consisting of a life annuity, critical illness insurance, long-term care insurance, and a savings account to maximise their lifetime utility. The model allowed for stochastic transitions between different health states and random critical illness and long-term care expenditures. It also considered different weights on the utility of consumption in different health states. This chapter predicted the optimal insurance for retirees in China with several typical retirement wealth and pension profiles.

The simulation results showed high demand for critical illness insurance for retirees with an average pension, a high demand for annuities for retirees with a low pension, and a small demand for long-term care insurance for retirees across all economic profiles considered in the study. The annuity demand increased for more affluent retirees when considering state-dependent utility, but the optimal insurance allocations were largely determined by the retiree's retirement savings and pension. The results predicted a large welfare gain with optimal insurance. The welfare gain was substantially larger for retirees with lower retirement savings and pensions. The results suggest that policymakers in developing countries to expand social insurance should consider regional economic development and financial budget to decide the direction for further insurance to maximise welfare outcomes. Insurance companies should target population segments with the right insurance products. Furthermore, designing bundled products priced with a joint health transition matrix can release precautionary savings and increase annuity demand by more affluent retirees.

Chapter 5 studied the effects of past and current air pollution exposure on cognition, multimorbidity, and ADL disability for middle-aged and older adults in China. It combined a satellite $PM_{2.5}$ dataset with individual-level data from a nationally representative survey. This chapter employed generalised additive mixed models to model any linear or non-linear associations between $PM_{2.5}$ exposure and each of the three health outcomes, controlling for individual-level, city-level, fixed time effects, and individual and location random effects.

The results showed several important findings on the associations between $PM_{2.5}$ exposure and multimorbidity, cognition and ADL disability. First, there was a non-linear relationship between current $PM_{2.5}$ exposure and multimorbidity but no significant associations for cognition and ADL disability. Second, the year-on-year (YOY) growth of $PM_{2.5}$ is an important factor affecting health that most previous studies have not considered. Annual reductions of $PM_{2.5}$ exposure were linked to less severe multimorbidity, better cognition, and lower rates of disability. Third, past severe exposure to $PM_{2.5}$ modified the effect of current $PM_{2.5}$ exposure on multimorbidity and cognition. Fourth, Urban residents were more sensitive to air pollution for all three health outcomes compared with rural residents. However, these findings should be confirmed by future studies and interpreted with caution.

This PhD research can be extended in several ways. First, from both theoretical and empirical perspectives, future work can explore the role of housing and children on demand for retirement insurance. Second, the life-cycle model in Chapter 4 can be extended to allow for endogenous retirement beyond the official pension eligibility age to account for the possibility that older people without adequate income may choose to continue to work. Third, a future survey could explore why a better understanding of insurance products leads to opposite demand effects for longevity and health-contingent insurance. Fourth, the associations between $PM_{2.5}$ and health outcomes can be investigated in other countries with similar longitudinal studies to validate our findings. Lastly, this thesis focuses on China, and future research could include comparisons with the US and Europe on key dimensions to examine how the findings apply beyond China.

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Supplementary Materials

A.1 Survey screenshots

A.1.1 Survey screenshots translated into English

ARC Centre of Excellence in Population Ageing Research (CEPAR)

UNSW SYDNEY

ONLINE PARTICIPANT INFORMATION STATEMENT

The demand for longevity, health, and long-term care insurance after COVID-19
Professor Hazel Bateman

Participant Information Statement and Consent Form

1.What is the research study about?
You are invited to take part in this research study. The research study aims to learn more about your interest in a new financial product that provides both longevity and health insurance in retirement. You have been invited because you meet the sample criteria, and your contact details were obtained from the research company dataSpring.

2.Who is conducting this research?
The study is being carried out by the following researchers:

Roles in this research	Name	University
Chief investigator	Professor Hazel Bateman	University of New South Wales (Australia)
Partner investigators	Professor Hanming Fang Dr Katja Hanewald	University of Pennsylvania (USA) University of New South Wales (Australia)
Student investigator	Mr Cheng Wan	University of New South Wales (Australia)

Research Funder: This research is being funded by the ARC Centre of Excellence in Population Ageing Research (CEPAR).

3.Inclusion/Exclusion Criteria
Before you decide to participate in this research study, we need to ensure that it is ok for you to take part. The research study is looking to recruit people who meet the following criteria:

- Urban individuals who are between 45-69 years old and not retired.

4.Do I have to take part in this research study?
Participation in any research study is voluntary. If you do not want to take part, you do not have to.

If you decide you want to take part in the research study, you will be asked to:

- Read the information carefully;
- Complete the online questionnaire.

5.What does participation in this research require, and are there any risks involved?
If you decide to take part in the research study, we will ask you to complete an online questionnaire. The questionnaire will ask you questions about financial decisions for retirement, show you information about several retirement financial products, ask you to make several hypothetical retirement wealth allocation tasks and answer some general questions. It should take approximately 30 minutes to complete.

You will be given a fixed payment for a completed questionnaire. You may also be paid a bonus amount depending on the number of correct answers you provide in a quiz in the questionnaire.

If you experience discomfort or feelings of distress while participating in the research and you require support, you can stop participating at any time.

6.What are the possible benefits to participation?
We hope to use information we get from this research study to benefit others who are making financial plans for their retirement.

7.What will happen to information about me?
Submission of the online questionnaire is an indication of your consent. By clicking the 'I agree to participate' button you are providing your permission for the research team to collect and use information about you for the research study. Your data will be kept for a period of 5 years after the publication of the research results. We will store information about you in a non-identifiable format on a server at the University of New South Wales. Your questionnaire responses will only be used for academic research purposes. The information collected for this research project may be made available to other research projects in non-identified form only.

8.How and when will I find out what the results of the research study are?
The research team intend to publish and report the results of the research study in a variety of ways. All information published will be done in a way that will not identify you.

If you would like to receive a copy of the results you can let the research team know by adding your email or postal address at the end of the survey. We will only use these details to send you the results of the research. The results will also be made available via the website of CEPAR:
http://www.cepar.edu.au/publications/working-papers

9.What if I want to withdraw from the research study?
If you do consent to participate, you may withdraw at any time. You can do this by closing the questionnaire. If you withdraw from the research, we will destroy any information that has already been collected. Once you have submitted the questionnaire however, we will not be able to withdraw your responses as the questionnaire is anonymous.

10.What should I do if I have further questions about my involvement in the research study?
The person you may need to contact will depend on the nature of your query. If you require further information regarding this study or if you have any problems which may be related to your involvement in the study, you can contact the following member/s of the research team:

Research Team Contact

Name	Mr. Cheng Wan
Position	PhD Candidate, School of Risk & Actuarial Studies, University of New South Wales
Telephone	••••••••
Email	••••••••

What if I have a complaint or any concerns about the research study?
If you have a complaint regarding any aspect of the study or the way it is being conducted, please contact the UNSW Human Ethics Coordinator:

Complaints Contact

Position	Human Research Ethics Coordinator
Telephone	••••••••
Email	••••••••
HC Reference Number	HC190099

1%

Next >>

Consent Form – Participant providing own consent

You are invited to take part in this research study. The research study aims to learn more about your interest in a new financial product that provides both longevity and health insurance in retirement.

Declaration by the participant

- ☐ I understand I am being asked to provide consent to participate in this research study;
- ☐ I provide my consent for the information collected about me to be used for the purpose of this research study only;
- ☐ I understand that if necessary I can ask questions and the research team will respond to my questions;
- ☐ I freely agree to participate in this research study as described and understand t hat I am free to withdraw at any time during the study and withdrawal will not affect my relationship with any of the named organisations and/or research team members;
- ☐ I understand that I can download a copy of this consent form from www.cepar.edu.au.
- ☐ I agree, tick all the boxes and continue
- ○ I do not wish to participate

2% << Prev Next >>

Welcome

Thank you for agreeing to participate in this survey.

The purpose of this survey is to learn more about your interest in a new financial product that provides both longevity and health insurance in retirement.

The survey begins with a few simple questions about you as we need your answers to ask questions only relevant to you. Your answers are anonymous and cannot be used to identify you personally.

Please DO NOT USE the "back" and "forward" buttons in your browser, please use the buttons at the bottom of each screen.

2% << Prev Next >>

Are you male or female?

- ○ male
- ○ female

3% << Prev Next >>

How old are you? years

4%

<< Prev

Next >>

Have you been diagnosed with a critical illness (for example, cancer, heart attack, stroke, dementia) before?

- Yes
- No

5%

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Next >>

Do you need help with any of the following activities? Please tick all that apply.

- Bathing
- Dressing
- Toileting
- Getting into or out of bed
- Continence
- Feeding
- None of them

5%

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Next >>

Which of the following best describes your current work status? Please choose one.

- Employed by someone else
- Self-employed
- Unemployed including structurally unemployed (Xia Gang)
- Retired
- Not working - Stay-at-home parent or caregiver
- Not working - Other reasons

6% << Prev Next >>

Which city do you live in?

Choose an option

6% << Prev Next >>

What is your current hukou status?

- Urban hukou in the city I live in now (resident)
- Urban hukou in a different city
- Agricultural hukou but live in a city
- Agricultural hukou and live in the countryside

7% << Prev Next >>

What is the highest level of education you have attained?

- No schooling
- Primary school
- Junior middle school
- High School or Specialized Secondary Schools
- Two-Year College degree or Diploma
- Bachelor degree from Four-Year University
- Master or above

8%

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Section 1: Warm-up questions

Does anyone in your household own the following:

	Yes	No	I don't know
Bank account			
Fixed term deposit			
Government bonds			
Stocks			
Shares in an investment fund			
Shares in a money market fund (for example, Yu'eBao from Alipay or Lingqiantong from Wechat)			
Credit card			
Life insurance			
Commercial health insurance			
Commercial long-term care insurance			
Commercial critical illness insurance			
Commercial pension			
Life annuity			
Enterprise annuity			

8%

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Excluding all properties that you own, what is the total value of your household's savings? (including, for example, savings accounts, term deposits, government bonds, stocks, shares in investment fund)

- less than ¥2,000
- between ¥2,000 and ¥9,999
- between ¥10,000 and ¥49,999
- between ¥50,000 and ¥99,999
- between ¥100,000 and ¥249,999
- between ¥250,000 and ¥499,999
- between ¥500,000 and ¥999,999
- ¥1,000,000 or more

9%

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What is the total value of your household's **debt**? (including, for example, mortgages, bank loans, money borrowed from relatives, friends, or using credit cards)

- less than ¥2,000
- between ¥2,000 and ¥9,999
- between ¥10,000 and ¥49,999
- between ¥50,000 and ¥99,999
- between ¥100,000 and ¥249,999
- between ¥250,000 and ¥499,999
- between ¥500,000 and ¥999,999
- ¥1,000,000 or more

10% << Prev Next >>

How many properties do you/your spouse currently own in total? ______ number

10% << Prev Next >>

How much do you think your properties are worth now together? ______ in 10,000 ¥

11% << Prev Next >>

Approximately, how much public pension do you receive or expect to receive per month after retirement?

- Less than ¥800
- Between ¥800 and ¥1,499
- Between ¥1,500 and ¥2,499
- Between ¥2,500 and ¥3,499
- ¥3,500 or more

12%

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Section 2: Introduction to retirement financial products

Retirement planning involves many financial decisions. We would like to know how you think about different strategies to cover your living expenses, and, if required, health-related expenses (such as critical illness expenses and long-term care expenses). In the following four screens, we will provide basic information about these expenses and related hypothetical retirement financial products.

- Some of the products may be similar to products currently available in the market. Please focus on the **hypothetical** products introduced here only.
- Please read the product descriptions carefully. Your understanding may affect the **bonus payment** that you earn from this survey.

13%

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Living expenses

Some of the text is coloured blue - If you hover your mouse over the blue text, an explanation will pop up. For example, try "Lifetime income product" shown below.

Most retirees cover living expenses with money from three sources:

1.Pension

2.Personal savings and investments

3.Transfers provided by their children or other family members

A typical female just retired at age **55** is expected to live until **87** but can live longer or shorter than that. If a retiree lives long, she may not have enough resources to cover the expenses.

Lifetime income product

The **Lifetime income product** is a financial product that helps retirees to cover regular living expenses.

The **Lifetime income product** provides regular income payments every month, **as long as the policyholder is alive**.

- For every **10,000 RMB** paid now (a one-off payment), the policyholder receives a monthly income **of 30 RMB** (inflation- adjusted) for as long as they are alive.
- If the policyholder passes away, the payments stop, and no refund will be paid.

You can click ">>" to continue after 20 seconds.

14%

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Critical illness expenses

The chance of getting **critically ill** (for example, having cancer, a stroke, or heart attack) varies from person to person, depending on their health and medical history. On average, **5 out of 10** female retirees will be critically ill during their retirement. For persons infected with the novel coronavirus, the chance of getting critically ill is much higher.

Public Health Insurance provides basic critical illness coverage. On average, Public Health Insurance will reimburse **half** of the medical expenditures for critical illness. Patients need to use their savings to access more advanced/expensive treatments or drugs which are not covered by Public Health Insurance. The additional cost can range **from tens of thousands to hundreds of thousands RMB**.

Critical illness cash product

The **Critical illness cash product** is a financial product that helps retirees cover critical illness costs.

The **Critical illness cash product** provides a one-off cash payment if the policyholder is **critically ill.** The 25 critical illness conditions (e.g., cancer, stroke, heart attack) are defined by the government. Government-appointed doctors will assess the health condition.

- The policyholder can choose how they want to use the one-off cash payment from the product. For example, the payment can be used to pay for medical treatments or drugs not covered by Public Health Insurance or any other expenses.
- For every **10,000 RMB** paid now (one-off payment), a cash payment of **21,000RMB** (inflation-adjusted) will be provided if the policyholder is critically ill.
- The product offers only one payment at most. If no claim is made or if the policyholder passes away before a diagnosis, no refund will be paid.

The novel coronavirus disease itself is not specifically covered. However, if one of the 25 critical illness conditions is diagnosed after infection, the policyholder can receive the one-off payment from the product .

If you hover your mouse over the blue text an explanation will pop up.

You can click ">>" to continue after 20 seconds.

15%

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Long-term care expenses

The chance of needing long-term care varies from person to person, depending on their health and medical history. However, on average, **5 out of 10** female retirees will need some form of care during their retirement, mostly at older ages.

People need **long-term care** if they need help completing at least three of the following six activities: bathing, dressing, toileting, getting into or out of bed, continence, and feeding. Some people need long-term care for **several months**, while others need it for **many years**.

Currently, **Public Health Insurance** does not provide long-term care insurance in most cities. Where there is no insurance, people pay for long-term care from their savings. The monthly cost of long-term care services can range **from 2,000 to 6,000 RMB**.

Long-term care income product

The **Long-term care income product** is a financial product that helps retirees cover long-term care costs.

The **Long-term care income product** provides regular income every month **as long as the policyholder needs long-term care**. Government-appointed doctors will regularly assess the ability to undertake the six activities.

- The policyholder can choose how they want to use the income from the product. For example, they can use the income to pay for professional care, compensate family members or friends for care provided, or any other expenses.
- For every **10,000 RMB** paid now (a one-off payment), a monthly income of **350 RMB (inflation-adjusted)** will be provided as long as long-term care is needed.
- If the policyholder no longer needs long-term care or passes away, the income stops, and no refund will be paid.
- If the policyholder never needs long-term care, no refund will be paid.

If you hover your mouse over the blue text an explanation will pop up.

You can click ">>" to continue after 20 seconds.

17%

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Savings account

Retirement savings can also be placed in a **savings account** and withdrawn to cover the living expenses, the critical illness, and long-term care expenses mentioned before.

- The money in the savings account may not be enough if the person lives long and/or the expenses are high.
- Any remaining money in the savings account when the account holder dies is passed to their beneficiaries.

17%

<< Prev | Next >>

The three retirement financial products and the savings account are summarised in the table below. Please review the key features for each of them, one row at a time.

	Regular income payments?	Payments only in case of health problems?	Payments for the rest of the policyholder's life?	If the policyholder passes away?
Lifetime income product*	Yes, monthly	No	Yes	Payments stop, no refund
Critical illness cash product*	No, one-off payment if diagnosed	Yes, if critically ill (for any of the 25 conditions)	No, one-off payment if diagnosed	No refund
Long-term care income product*	Yes, monthly income when needing long-term care	Yes, when needing long-term care (needing help with 3 or more activities: bathing, dressing, toileting, getting into or out of bed, continence, and feeding)	No, only when needing long-term care	Payments stop, no refund
Savings account	No, but you can withdraw money any time (provided there is still money in the account)	No, but you can withdraw money any time (provided there is still money in the account)	No, but you can withdraw money any time (provided there is still money in the account)	Beneficiaries inherit any remaining savings

*__PLEASE NOTE__ that all products are priced fairly, and you will receive a **discount** when you buy the lifetime income product, the critical illness cash product and the long-term care income product together. The discount is about **10%** when you buy any **two** products and about **15%** when you buy **three** products.

If you hover your mouse over the blue text an explanation will pop up.

You can click ">>" to continue after 20 seconds.

18%

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Product knowledge quiz

We will now test your knowledge of the financial products we have described. Please answer the following questions about the three retirement financial products and the savings account. Your bonus for this survey depends on the number of correct answers you provide.

19%

<< Prev | Next >>

For each statement below, indicate whether it is true or false?

		True/False	Correct Answer
Lifetime income product	A single payment is exchanged for regular income.	---Choose an option---	
	Income from this product is paid for the life of the policyholder, irrespective of the length of life.	---Choose an option---	
	The policyholder's estate receives a lump-sum payment when he/she passes away.	---Choose an option---	

You can click '>>' to continue after 10 seconds.

19% << Prev Next >>

For each statement below, indicate whether it is true or false?

		True/False	Correct Answer
Critical illness cash product	A single payment is exchanged for a cash payment that can help cover (or reduce) costs in the case of critical illness.	---Choose an option---	
	The payment provided by the product can only be used for medical treatments or drugs.	---Choose an option---	
	A refund will be paid if the policyholder stays healthy.	---Choose an option---	

You can click '>>' to continue after 10 seconds.

20% << Prev Next >>

For each statement below, indicate whether it is true or false?

		True/False	Correct Answer
Long-term care income product	The product will continue to provide an income if the policyholder no longer needs long-term care.	---Choose an option---	
	The product covers the cost of residential care only.	---Choose an option---	
	A single payment is exchanged for regular income that can help cover (or reduce) the cost of long-term care.	---Choose an option---	

You can click '>>' to continue after 10 seconds.

21% << Prev Next >>

For each statement below, indicate whether it is true or false?

		True/False	Correct Answer
Savings account	There will always be money in the savings account as long as the account holder is alive.	---Choose an option---	

You can click '>>' to continue after 10 seconds.

21%

<< Prev Next >>

Section 3: Allocation of retirement savings

Task introduction

Hover your mouse over the blue text for more information.

In the following screens, we will show you nine hypothetical scenarios for the allocation of your retirement savings.

Before you begin completing the nine allocation tasks, please read the following example to understand what we would like you to do:

First, you will be given a hypothetical amount of retirement savings (this example, 150,000 RMB). Suppose you have already used part of it to buy the critical illness cash product (this example, 21%) and the long-term care income product (this example, 19%) .

Next, you will be asked to allocate your remaining retirement savings to the **lifetime income product** and the **savings account** using a slider (example screenshot below).

Use the slider below to show your preferred allocation.

Savings Account: **90%, 80,813RMB**

100% of Savings Account — 100% of Lifetime Income Product

0 RMB — 89792 RMB

Lifetime Income Product: **10%, 8,979RMB**

The output table below summarises the outcome of your allocation to the three retirement financial products and the savings account.

	Product allocation: Task 6	
Critical illness cash product One-off payment if **critically ill**	75,000 RMB	On average, this cash amount can **cover HALF** of the medical expenditures for critical illness not covered by Public Health Insurance
Long-term care income product Monthly income when needing **long-term care**	1500 RMB	On average, this income can **cover HALF** of the cost to pay for professional care
Lifetime income product Monthly income for the rest of your life	**37** RMB	
Savings account Remaining retirement savings	**80,813** RMB	

Your Pension will also provide a monthly income of 1000 RMB, and Public Health Insurance will cover half of the medical expenditures for critical illness.You do not have any insurance for long-term care.

You need to **move the slider at least once** to show your preferred allocation to the **lifetime income product** and to the **savings account**, taking into account the fixed amounts of **critical illness cash product** and **long-term care income product** already purchased.

Remember that you will receive a **discount** when you buy the lifetime income product, the critical illness cash product, and the long-term care income product together. The discount is about **10%** when you buy any **two** products and about **15%** when you buy the **three** products.

You should move the slider and review the outcomes in the table below the slider until you are satisfied with the amounts you have allocated to the lifetime income product and to the savings account.

We will now start the nine allocation tasks.

22%

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Task 1/9

Hover your mouse over the blue text for more information.

Suppose you are aged **55**, you have just retired, and you have retirement savings of **150,000 RMB**. Assume that you will receive a **Pension** of **2000** RMB every month (inflation-adjusted) and that you have **Public Health Insurance** (which will cover half of the cost of critical illness, but none of the cost of long-term care).

In this scenario, assume you **didn't buy** any of the **critical illness cash product** or the **long-term care income product**.

Your remaining savings are **150,000** RMB.

Your task is to decide how you would allocate these remaining savings between the **lifetime income product** and the **savings account**.

Use the slider below to show your preferred allocation.

Savings Account: **100%, 150,000RMB**

100% of Savings Account

100% of Lifetime Income Product

0 RMB

150000 RMB

Lifetime Income Product: **0%, 0RMB**

The output table below summarises the outcome of your allocation to the three retirement financial products and the savings account.

	Product allocation: Task 1	
Critical illness cash product One-off payment if **critically ill**	0 RMB	You need to withdraw from your savings account to cover the cost if critically ill.
Long-term care income product Monthly income when needing **long-term care**	0 RMB	You need to withdraw from your savings account to cover the cost if needing long-term care.
Lifetime income product Monthly income for the rest of your life	**0** RMB	
Savings account Remaining retirement savings	**150,000** RMB	

Your Pension will also provide a monthly income of 2000 RMB, and Public Health Insurance will cover half of the medical expenditures for critical illness. You do not have any insurance for long-term care.

25%

<< Prev

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Task 2/9

Hover your mouse over the blue text for more information.

In this scenario, assume you have already used **24% of the 150,000 RMB** retirement savings to buy the **critical illness cash product**, but you **didn't buy** any of the **long-term care income product**.

Your remaining savings are **114,286** RMB.

Your task is to decide how you would allocate these remaining savings between the **lifetime income product** and the **savings account**.

Use the slider below to show your preferred allocation.

Savings Account: 100%, 114,286RMB	100% of Savings Account 0 RMB	100% of Lifetime Income Product 114286 RMB	Lifetime Income Product: 0%, 0RMB

The output table below summarises the outcome of your allocation to the three retirement financial products and the savings account.

	Product allocation: Task 2	
Critical illness cash product One-off payment if **critically ill**	75,000 RMB	On average, this cash amount can **cover HALF** of the medical expenditures for critical illness not covered by Public Health Insurance
Long-term care income product Monthly income when needing **long-term care**	0 RMB	You need to withdraw from your savings account to cover the cost if needing long-term care.
Lifetime income product Monthly income for the rest of your life	**0** RMB	
Savings account Remaining retirement savings	**114,286** RMB	

Your Pension will also provide a monthly income of 2000 RMB, and Public Health Insurance will cover half of the medical expenditures for critical illness. You do not have any insurance for long-term care.

28%

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Task 3/9

Hover your mouse over the blue text for more information.

In this scenario, assume you have already used **48% of the 150,000 RMB** retirement savings to buy the **critical illness cash product**, but you **didn't buy** any of the **long-term care income product**.

Your remaining savings are **78,571** RMB.

Your task is to decide how you would allocate these remaining savings between the **lifetime income product** and the **savings account**.

Use the slider below to show your preferred allocation.

Savings Account:
100%, 78,571RMB

100% of Savings Account

100% of Lifetime Income Product

0 RMB

78571 RMB

Lifetime Income Product:
0%, 0RMB

The output table below summarises the outcome of your allocation to the three retirement financial products and the savings account.

	Product allocation: Task 3	
Critical illness cash product One-off payment if **critically ill**	150,000 RMB	On average, this cash amount can **cover ALL** the medical expenditures for critical illness not covered by Public Health Insurance
Long-term care income product Monthly income when needing **long-term care**	0 RMB	You need to withdraw from your savings account to cover the cost if needing long-term care.
Lifetime income product Monthly income for the rest of your life	**0** RMB	
Savings account Remaining retirement savings	**78,571** RMB	

Your Pension will also provide a monthly income of 2000 RMB, and Public Health Insurance will cover half of the medical expenditures for critical illness. You do not have any insurance for long-term care.

30%

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Task 4/9

Hover your mouse over the blue text for more information.

In this scenario, assume you **didn't buy** any of the **critical illness cash product**, but you used **29% of the 150,000 RMB** retirement savings to buy the **long-term care income product**.

Your remaining savings are **107,143** RMB.

Your task is to decide how you would allocate these remaining savings between the **lifetime income product** and the **savings account**.

Use the slider below to show your preferred allocation.

Savings Account: **100%, 107,143RMB**

100% of Savings Account | 100% of Lifetime Income Product

0 RMB | 107143 RMB

Lifetime Income Product: **0%, 0RMB**

The output table below summarises the outcome of your allocation to the three retirement financial products and the savings account.

	Product allocation: Task 4	
Critical illness cash product One-off payment if **critically ill**	0 RMB	You need to withdraw from your savings account to cover the cost if critically ill.
Long-term care income product Monthly income when needing **long-term care**	1500 RMB	On average, this income can **cover HALF** of the cost to pay for professional care
Lifetime income product Monthly income for the rest of your life	**0** RMB	
Savings account Remaining retirement savings	**107,143** RMB	

Your Pension will also provide a monthly income of 2000 RMB, and Public Health Insurance will cover half of the medical expenditures for critical illness. You do not have any insurance for long-term care.

33%

<< Prev | Next >>

Task 5/9

Hover your mouse over the blue text for more information.

In this scenario, assume you have **didn't buy** any of the **critical illness cash product**, but you used **57% of the 150,000 RMB retirement savings** to buy the **long-term care income product**.

Your remaining savings are **64,286** RMB.

Your task is to decide how you would allocate these remaining savings between the **lifetime income product** and the **savings account**.

Use the slider below to show your preferred allocation.

Savings Account:
100%, 64,286RMB

100% of Savings Account

100% of Lifetime Income Product

0 RMB

64286 RMB

Lifetime Income Product:
0%, 0RMB

The output table below summarises the outcome of your allocation to the three retirement financial products and the savings account.

	Product allocation: Task 5	
Critical illness cash product One-off payment if **critically ill**	0 RMB	You need to withdraw from your savings account to cover the cost if critically ill.
Long-term care income product Monthly income when needing **long-term care**	3000 RMB	On average, this income can **cover ALL** the cost to pay for professional care
Lifetime income product Monthly income for the rest of your life	**0** RMB	
Savings account Remaining retirement savings	**64,286** RMB	

Your Pension will also provide a monthly income of 2000 RMB, and Public Health Insurance will cover half of the medical expenditures for critical illness.You do not have any insurance for long-term care.

36%

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Next >>

Task 6/9

Hover your mouse over the blue text for more information.

In this scenario, assume you have already used **21% of the 150,000 RMB** retirement savings to buy the **critical illness cash product and 26%** to buy the **long-term care income product**.

Your remaining savings are **79,286** RMB.

Your task is to decide how you would allocate these remaining savings between the **lifetime income product** and the **savings account**.

Use the slider below to show your preferred allocation.

Savings Account: **100%, 79,286RMB**

100% of Savings Account

100% of Lifetime Income Product

0 RMB

79286 RMB

Lifetime Income Product: **0%, 0RMB**

The output table below summarises the outcome of your allocation to the three retirement financial products and the savings account.

	Product allocation: Task 6	
Critical illness cash product One-off payment if **critically ill**	75,000 RMB	On average, this cash amount can **cover HALF** of the medical expenditures for critical illness not covered by Public Health Insurance
Long-term care income product Monthly income when needing **long-term care**	1500 RMB	On average, this income can **cover HALF** of the cost to pay for professional care
Lifetime income product Monthly income for the rest of your life	**0** RMB	
Savings account Remaining retirement savings	**79,286** RMB	

Your Pension will also provide a monthly income of 2000 RMB, and Public Health Insurance will cover half of the medical expenditures for critical illness.You do not have any insurance for long-term care.

38%

<< Prev

Next >>

Task 7/9

Hover your mouse over the blue text for more information.

In this scenario, assume you have already used **43% of the 150,000 RMB** retirement savings to buy the **critical illness cash product and 26%** to buy the **long-term care income product**.

Your remaining savings are **47,143** RMB.

Your task is to decide how you would allocate these remaining savings between the **lifetime income product** and the **savings account**.

Use the slider below to show your preferred allocation.

Savings Account: **100%, 47,143RMB**

100% of Savings Account

100% of Lifetime Income Product

0 RMB

47143 RMB

Lifetime Income Product: **0%, 0RMB**

The output table below summarises the outcome of your allocation to the three retirement financial products and the savings account.

	Product allocation: Task 7	
Critical illness cash product One-off payment if **critically ill**	150,000 RMB	On average, this cash amount can **cover ALL** the medical expenditures for critical illness not covered by Public Health Insurance
Long-term care income product Monthly income when needing **long-term care**	1500 RMB	On average, this income can **cover HALF** of the cost to pay for professional care
Lifetime income product Monthly income for the rest of your life	**0** RMB	
Savings account Remaining retirement savings	**47,143** RMB	

Your Pension will also provide a monthly income of 2000 RMB, and Public Health Insurance will cover half of the medical expenditures for critical illness.You do not have any insurance for long-term care.

41%

<< Prev

Next >>

Task 8/9

Hover your mouse over the blue text for more information.

In this scenario, assume you have already used **21% of the 150,000 RMB** retirement savings to buy the **critical illness cash product and 51%** to buy the **long-term care income product**.

Your remaining savings are **40,714** RMB.

Your task is to decide how you would allocate these remaining savings between the **lifetime income product** and the **savings account**.

Use the slider below to show your preferred allocation.

Savings Account:
100%, 40,714RMB

100% of Savings Account

100% of Lifetime Income Product

0 RMB

40714 RMB

Lifetime Income Product:
0%, 0RMB

The output table below summarises the outcome of your allocation to the three retirement financial products and the savings account.

	Product allocation: Task 8	
Critical illness cash product One-off payment if **critically ill**	75,000 RMB	On average, this cash amount can **cover HALF** of the medical expenditures for critical illness not covered by Public Health Insurance
Long-term care income product Monthly income when needing **long-term care**	3000 RMB	On average, this income can **cover ALL** the cost to pay for professional care
Lifetime income product Monthly income for the rest of your life	**0** RMB	
Savings account Remaining retirement savings	**40,714** RMB	

Your Pension will also provide a monthly income of 2000 RMB, and Public Health Insurance will cover half of the medical expenditures for critical illness.You do not have any insurance for long-term care.

44%

<< Prev

Next >>

Task 9/9

Hover your mouse over the blue text for more information.

In this scenario, assume you have already used **43% of the 150,000 RMB** retirement savings to buy the **critical illness cash product and 51%** to buy the **long-term care income product**.

Your remaining savings are **8,571** RMB.

Your task is to decide how you would allocate these remaining savings between the **lifetime income product** and the **savings account**.

Use the slider below to show your preferred allocation.

Savings Account: 100%, 8,571RMB	100% of Savings Account — 0 RMB	100% of Lifetime Income Product — 8571 RMB	Lifetime Income Product: 0%, 0RMB

The output table below summarises the outcome of your allocation to the three retirement financial products and the savings account.

	Product allocation: Task 9	
Critical illness cash product One-off payment if **critically ill**	150,000 RMB	On average, this cash amount can **cover ALL** the medical expenditures for critical illness not covered by Public Health Insurance
Long-term care income product Monthly income when needing **long-term care**	3000 RMB	On average, this income can **cover ALL** the cost to pay for professional care
Lifetime income product Monthly income for the rest of your life	**0** RMB	
Savings account Remaining retirement savings	**8,571** RMB	

Your Pension will also provide a monthly income of 2000 RMB, and Public Health Insurance will cover half of the medical expenditures for critical illness.You do not have any insurance for long-term care.

46%

<< Prev Next >>

Final task: Preferred portfolio

Hover your mouse over the blue text for more information.

You have just completed nine tasks for how you would allocate your retirement savings of 150,000 RMB between three retirement financial products and a savings account. In the table below, we show you, for each of the nine choices you have made, the payment you would receive from each product, as well as any money remaining in your savings account.

Summary of the nine choices you have just made

Product allocation	Task1	Task2	Task3	Task4	Task5	Task6	Task7	Task8	Task9
Critical illness cash product One-off payment if **critically ill**	0	75,000	150,000	0	0	75,000	150,000	75,000	150,000
Long-term care income product Monthly income when needing **long-term care**	0	0	0	1500	3000	1500	1500	3000	3000
Lifetime income product Monthly income for the rest of your life	90	157	143	223	146	235	93	83	35
Savings account Remaining retirement savings	120,000	70,713	42,859	44,571	29,141	16,646	26,427	23,391	6,571

We would now like to know how you compare the nine retirement product allocations in this table. Therefore, we will show you 12 different combinations of three of the retirement product allocations. For each combination of retirement products, please indicate which product allocation you prefer MOST and which product allocation you prefer LEAST.

47%

<< Prev Next >>

Choice set 1/12

Of the three retirement product allocations below, which one do you prefer MOST, and which one do you prefer LEAST?

Hover your mouse over the blue text for more information.

	Product allocation A	Product allocation B	Product allocation C
Critical illness cash product One-off payment if **critically ill**	0	0	75,000
Long-term care income product Monthly income when needing **long-term care**	1500	3000	3000
Lifetime income product Monthly income for the rest of your life	223	146	83
Savings account Remaining retirement savings	44,571	29,141	23,391

	A	B	C
MOST preferred	○	○	○
LEAST preferred	○	○	○

48%

<< Prev   Next >>

Choice set 2/12

Of the three retirement product allocations below, which one do you prefer MOST, and which one do you prefer LEAST?

Hover your mouse over the blue text for more information.

	Product allocation A	Product allocation B	Product allocation C
Critical illness cash product One-off payment if **critically ill**	150,000	0	75,000
Long-term care income product Monthly income when needing **long-term care**	0	3000	1500
Lifetime income product Monthly income for the rest of your life	143	146	235
Savings account Remaining retirement savings	42,859	29,141	16,646

	A	B	C
MOST preferred	○	○	○
LEAST preferred	○	○	○

49%

<< Prev   Next >>

Choice set 3/12

Of the three retirement product allocations below, which one do you prefer MOST, and which one do you prefer LEAST?

Hover your mouse over the blue text for more information.

	Product allocation A	Product allocation B	Product allocation C
Critical illness cash product One-off payment if **critically ill**	75,000	150,000	0
Long-term care income product Monthly income when needing **long-term care**	0	0	1500
Lifetime income product Monthly income for the rest of your life	157	143	223
Savings account Remaining retirement savings	70,713	42,859	44,571

	A	B	C
MOST preferred	○	○	○
LEAST preferred	○	○	○

50%

<< Prev Next >>

Choice set 4/12

Of the three retirement product allocations below, which one do you prefer MOST, and which one do you prefer LEAST?

Hover your mouse over the blue text for more information.

	Product allocation A	Product allocation B	Product allocation C
Critical illness cash product One-off payment if **critically ill**	75,000	150,000	75,000
Long-term care income product Monthly income when needing **long-term care**	0	1500	3000
Lifetime income product Monthly income for the rest of your life	157	93	83
Savings account Remaining retirement savings	70,713	26,427	23,391

	A	B	C
MOST preferred	○	○	○
LEAST preferred	○	○	○

50%

<< Prev Next >>

Choice set 5/12

Of the three retirement product allocations below, which one do you prefer MOST, and which one do you prefer LEAST?

Hover your mouse over the blue text for more information.

	Product allocation A	Product allocation B	Product allocation C
Critical illness cash product One-off payment if **critically ill**	0	0	150,000
Long-term care income product Monthly income when needing **long-term care**	0	1500	3000
Lifetime income product Monthly income for the rest of your life	90	223	35
Savings account Remaining retirement savings	120,000	44,571	6,571

	A	B	C
MOST preferred			
LEAST preferred			

51%

<< Prev Next >>

Choice set 6/12

Of the three retirement product allocations below, which one do you prefer MOST, and which one do you prefer LEAST?

Hover your mouse over the blue text for more information.

	Product allocation A	Product allocation B	Product allocation C
Critical illness cash product One-off payment if **critically ill**	0	150,000	150,000
Long-term care income product Monthly income when needing **long-term care**	3000	1500	3000
Lifetime income product Monthly income for the rest of your life	146	93	35
Savings account Remaining retirement savings	29,141	26,427	6,571

	A	B	C
MOST preferred			
LEAST preferred			

52%

<< Prev Next >>

Choice set 7/12

Of the three retirement product allocations below, which one do you prefer MOST, and which one do you prefer LEAST?

Hover your mouse over the blue text for more information.

	Product allocation A	Product allocation B	Product allocation C
Critical illness cash product One-off payment if **critically ill**	0	75,000	150,000
Long-term care income product Monthly income when needing **long-term care**	1500	1500	1500
Lifetime income product Monthly income for the rest of your life	223	235	93
Savings account Remaining retirement savings	44,571	16,646	26,427

	A	B	C
MOST preferred	○	○	○
LEAST preferred	○	○	○

52%

<< Prev Next >>

Choice set 8/12

Of the three retirement product allocations below, which one do you prefer MOST, and which one do you prefer LEAST?

Hover your mouse over the blue text for more information.

	Product allocation A	Product allocation B	Product allocation C
Critical illness cash product One-off payment if **critically ill**	0	150,000	150,000
Long-term care income product Monthly income when needing **long-term care**	0	0	1500
Lifetime income product Monthly income for the rest of your life	90	143	93
Savings account Remaining retirement savings	120,000	42,859	26,427

	A	B	C
MOST preferred	○	○	○
LEAST preferred	○	○	○

53%

<< Prev Next >>

Choice set 9/12

Of the three retirement product allocations below, which one do you prefer MOST, and which one do you prefer LEAST?

Hover your mouse over the blue text for more information.

	Product allocation A	Product allocation B	Product allocation C
Critical illness cash product One-off payment if **critically ill**	75,000	75,000	150,000
Long-term care income product Monthly income when needing **long-term care**	0	1500	3000
Lifetime income product Monthly income for the rest of your life	157	235	35
Savings account Remaining retirement savings	70,713	16,646	6,571

	A	B	C
MOST preferred	○	○	○
LEAST preferred	○	○	○

54%

<< Prev Next >>

Choice set 10/12

Of the three retirement product allocations below, which one do you prefer MOST, and which one do you prefer LEAST?

Hover your mouse over the blue text for more information.

	Product allocation A	Product allocation B	Product allocation C
Critical illness cash product One-off payment if **critically ill**	0	75,000	75,000
Long-term care income product Monthly income when needing **long-term care**	0	1500	3000
Lifetime income product Monthly income for the rest of your life	90	235	83
Savings account Remaining retirement savings	120,000	16,646	23,391

	A	B	C
MOST preferred	○	○	○
LEAST preferred	○	○	○

54%

<< Prev Next >>

Choice set 11/12

Of the three retirement product allocations below, which one do you prefer MOST, and which one do you prefer LEAST?

Hover your mouse over the blue text for more information.

	Product allocation A	Product allocation B	Product allocation C
Critical illness cash product One-off payment if **critically ill**	150,000	75,000	150,000
Long-term care income product Monthly income when needing **long-term care**	0	3000	3000
Lifetime income product Monthly income for the rest of your life	143	83	35
Savings account Remaining retirement savings	42,859	23,391	6,571

	A	B	C
MOST preferred	○	○	○
LEAST preferred	○	○	○

55%

<< Prev Next >>

Choice set 12/12

Of the three retirement product allocations below, which one do you prefer MOST, and which one do you prefer LEAST?

Hover your mouse over the blue text for more information.

	Product allocation A	Product allocation B	Product allocation C
Critical illness cash product One-off payment if **critically ill**	0	75,000	0
Long-term care income product Monthly income when needing **long-term care**	0	0	3000
Lifetime income product Monthly income for the rest of your life	90	157	146
Savings account Remaining retirement savings	120,000	70,713	29,141

	A	B	C
MOST preferred	○	○	○
LEAST preferred	○	○	○

56%

<< Prev Next >>

How easy was it for you to complete the tasks on the previous screens?

Very easy				**Very hard**
1	2	3	4	5

56%

<< Prev Next >>

Section 4: Additional product feedback

Please consider the three financial products again.

57%

<< Prev Next >>

Hover your mouse over the blue text for more information.

Please rank the characteristics listed below for each product starting from 1 – most important characteristic to 4 – least important characteristic.
Which other product characteristics would make Lifetime income product more attractive?

- Different income patterns (e.g., payments increase or decrease over time)
- Fixed contract period (e.g., 10 years with guaranteed payments even if the policyholder passes away)
- Price discount of 10%
- Some refund when the policyholder passes away

Please click options to sort

Click the icon on the right to clear the answer

58%

<< Prev Next >>

Hover your mouse over the blue text for more information.

Please rank the characteristics listed below for each product starting from 1 – most important characteristic to 4 – least important characteristic.
Which other product characteristics would make Critical illness cash product more attractive?

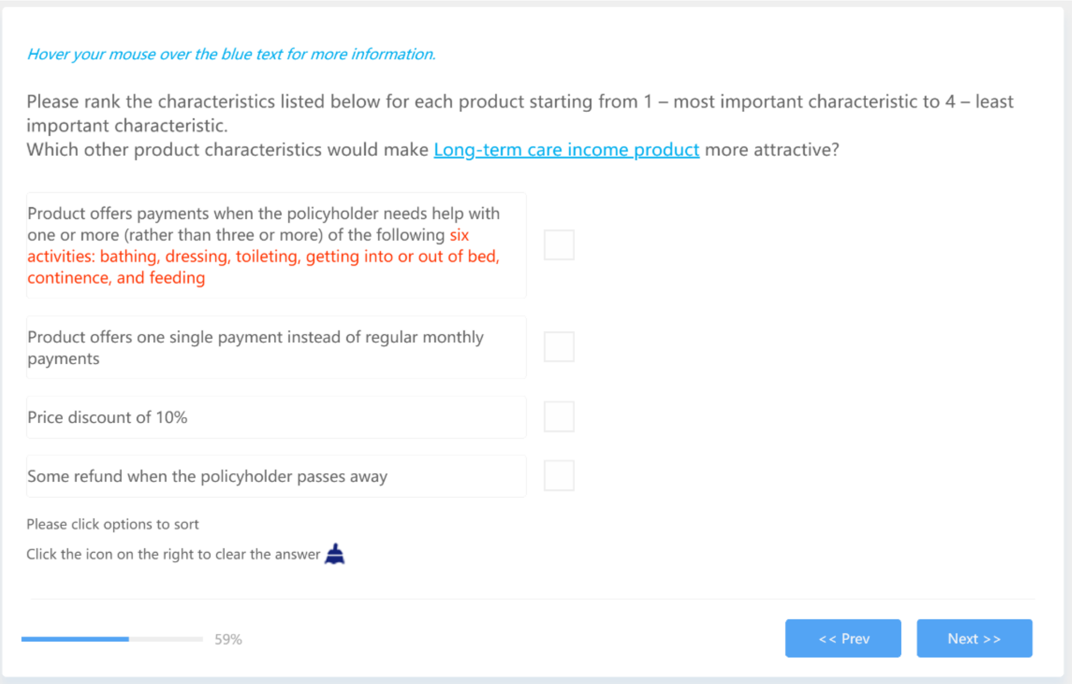
- More diseases covered
- Product can be bought by paying annually rather than a one-off payment
- Price discount of 10%
- Some refund when the policyholder passes away

Please click options to sort

Click the icon on the right to clear the answer

58%

<< Prev Next >>


Hover your mouse over the blue text for more information.

Please rank the characteristics listed below for each product starting from 1 – most important characteristic to 4 – least important characteristic.
Which other product characteristics would make Long-term care income product more attractive?

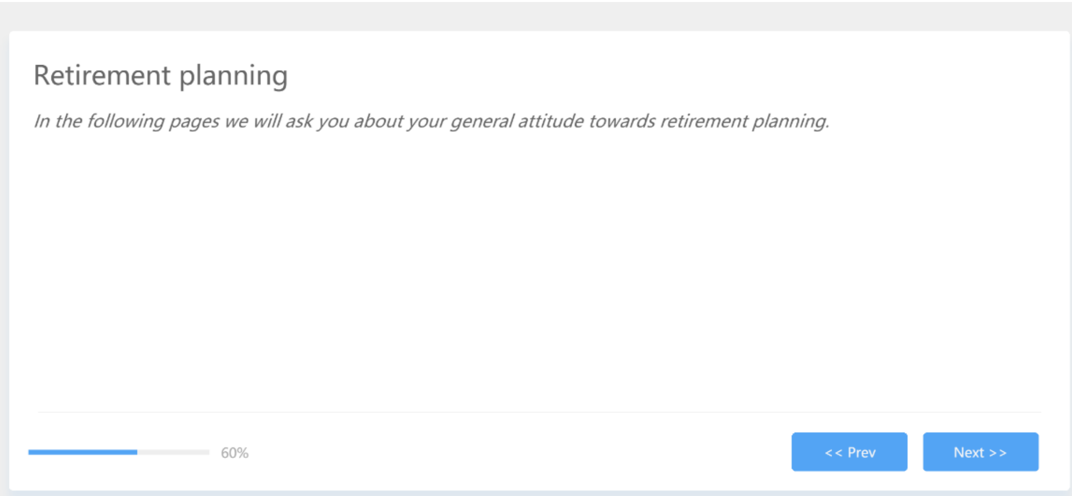
- Product offers payments when the policyholder needs help with one or more (rather than three or more) of the following six activities: bathing, dressing, toileting, getting into or out of bed, continence, and feeding
- Product offers one single payment instead of regular monthly payments
- Price discount of 10%
- Some refund when the policyholder passes away

Please click options to sort

Click the icon on the right to clear the answer

59%

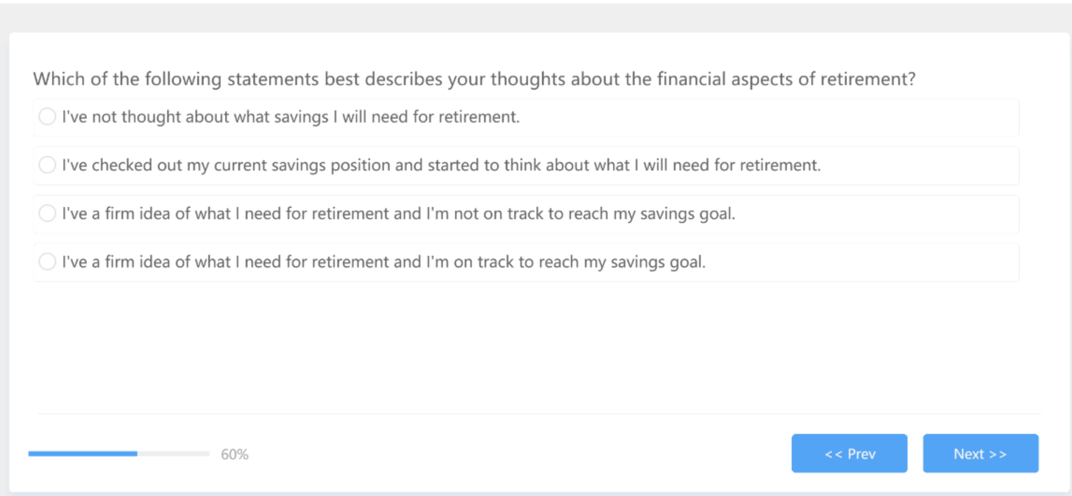
<< Prev | Next >>


Retirement planning

In the following pages we will ask you about your general attitude towards retirement planning.

60%

<< Prev | Next >>


Which of the following statements best describes your thoughts about the financial aspects of retirement?

- I've not thought about what savings I will need for retirement.
- I've checked out my current savings position and started to think about what I will need for retirement.
- I've a firm idea of what I need for retirement and I'm not on track to reach my savings goal.
- I've a firm idea of what I need for retirement and I'm on track to reach my savings goal.

60%

<< Prev | Next >>

For many households, overall spending changes dramatically upon retirement. Please indicate below what your expectations are.

- ◯ My household expects to have no change in spending at retirement.
- ◯ My household will spend more after retirement than before.
- ◯ My household will spend less after retirement than before.

61% << Prev Next >>

People use different time-horizons when they decide how much of their income to spend, and how much to save. Which of the time-horizons mentioned below is in your household most important with regards to planning expenditures and savings?

- ◯ The next couple of months
- ◯ The next year
- ◯ Then next couple of years
- ◯ The next 5 to 10 years
- ◯ More than 10 years from now

62% << Prev Next >>

People's general spending behaviour may be different when they are not healthy. How do you see yourself: Are you generally like person A or person B?

•Person A: Spend as much as possible while being in good health and spend little while being in bad health.
•Person B: Spend as much as possible while being in bad health and spend little while being in good health.

Please tick one box on the scale where 0 means 'Person A' and 10 means 'Person B'.

Person A										**Person B**
0	1	2	3	4	5	6	7	8	9	10

62% << Prev Next >>

How many children do you have that are still alive? *Please count all natural children, fostered, adopted and stepchildren.*

children

63%

<< Prev Next >>

Where do your children live?

- Same household as me
- Same city as me
- Different city but same province as me
- Different province
- Different country

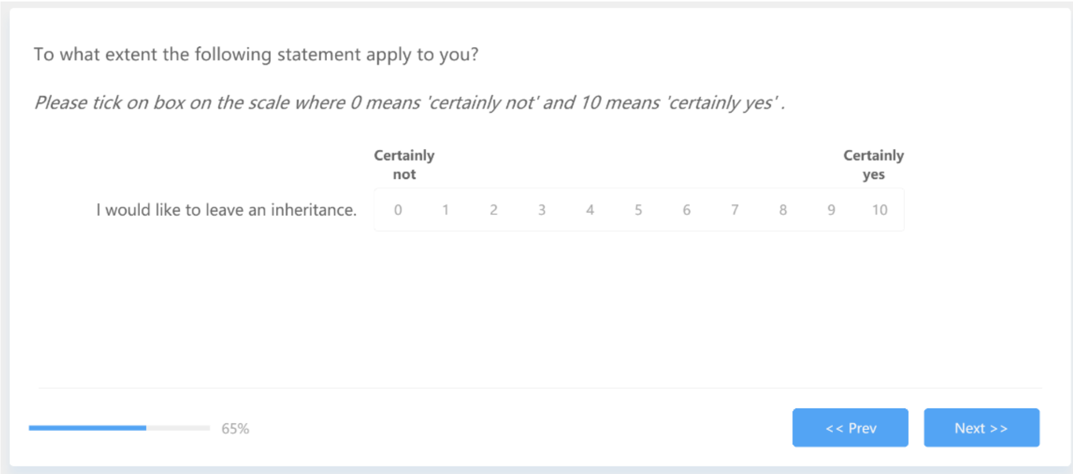
64%

<< Prev Next >>

How many sons do you have? sons

64%

<< Prev Next >>



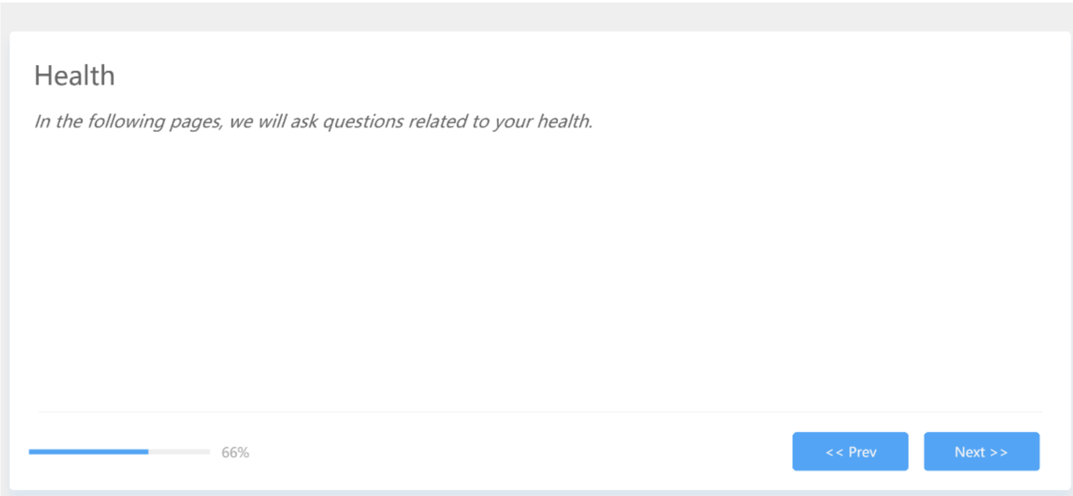
To what extent the following statement apply to you?

Please tick on box on the scale where 0 means 'certainly not' and 10 means 'certainly yes' .

	Certainly not										Certainly yes
I would like to leave an inheritance.	0	1	2	3	4	5	6	7	8	9	10

65%

<< Prev Next >>

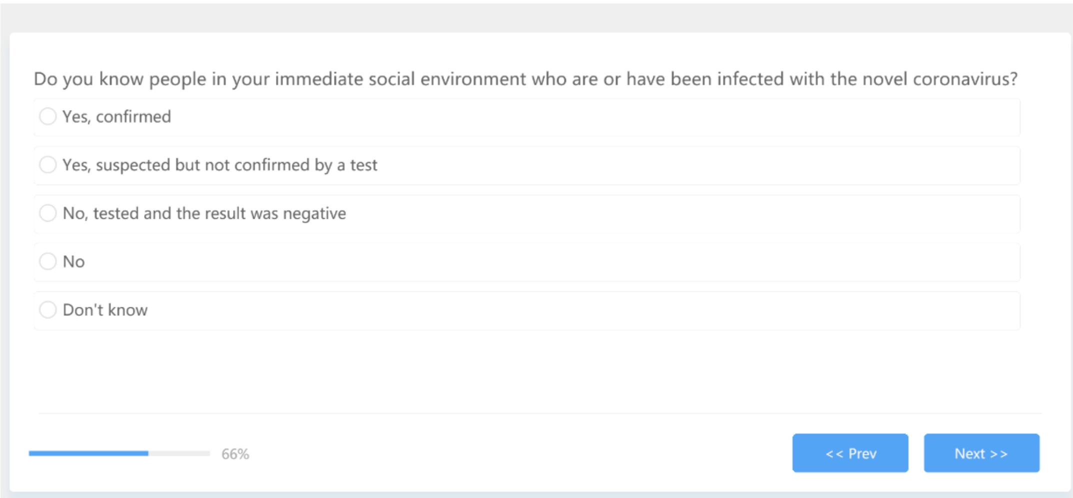


Health

In the following pages, we will ask questions related to your health.

66%

<< Prev Next >>



Do you know people in your immediate social environment who are or have been infected with the novel coronavirus?

- Yes, confirmed
- Yes, suspected but not confirmed by a test
- No, tested and the result was negative
- No
- Don't know

66%

<< Prev Next >>

How does the novel coronavirus make you feel? For each statement below, please indicate how the novel coronavirus makes you feel on a scale from 1 to 7. The novel coronavirus is:

Something that makes me not worry about my health						Something that makes me worry about my health
1	2	3	4	5	6	7

Something I can combat with my own action						Something that makes me feel helpless
1	2	3	4	5	6	7

Not stressful						Stressful
1	2	3	4	5	6	7

Something that does not affect my mood						Something that is making me depressed
1	2	3	4	5	6	7

69%

<< Prev Next >>

Chinese women at your age on average are expected to live to age 87 . To what age do you think you will live?

years

70%

<< Prev Next >>

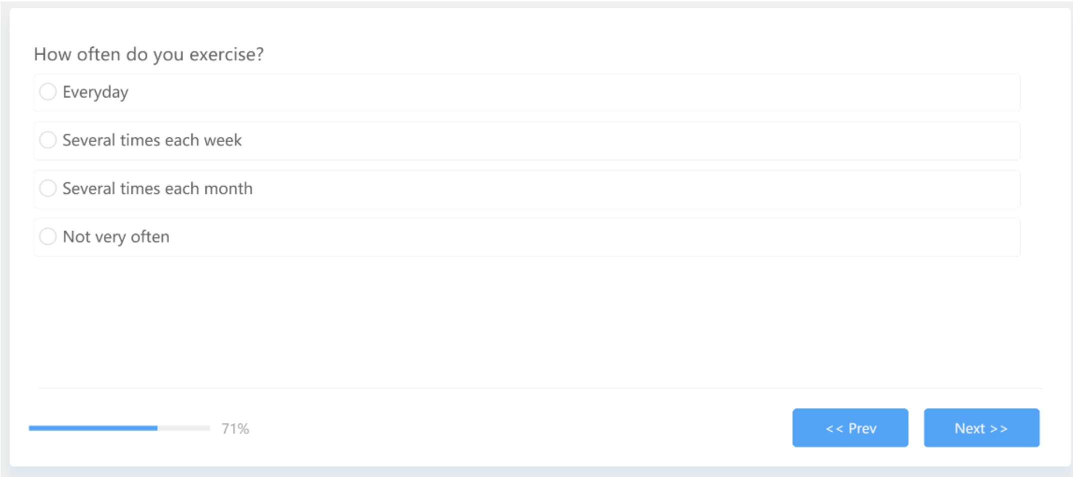
What are your height and weight?

•Height cm

•Weight kg

70%

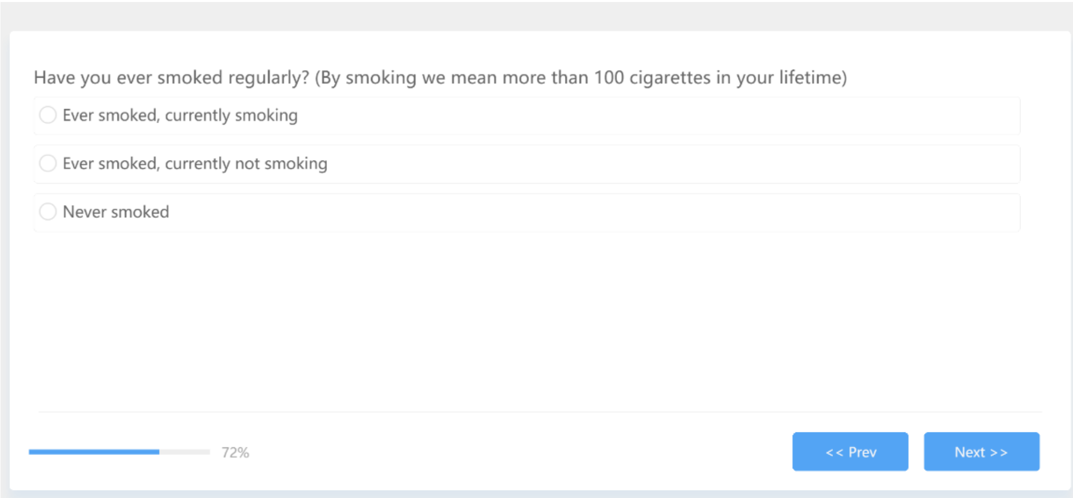
<< Prev Next >>


How often do you exercise?

- Everyday
- Several times each week
- Several times each month
- Not very often

71%

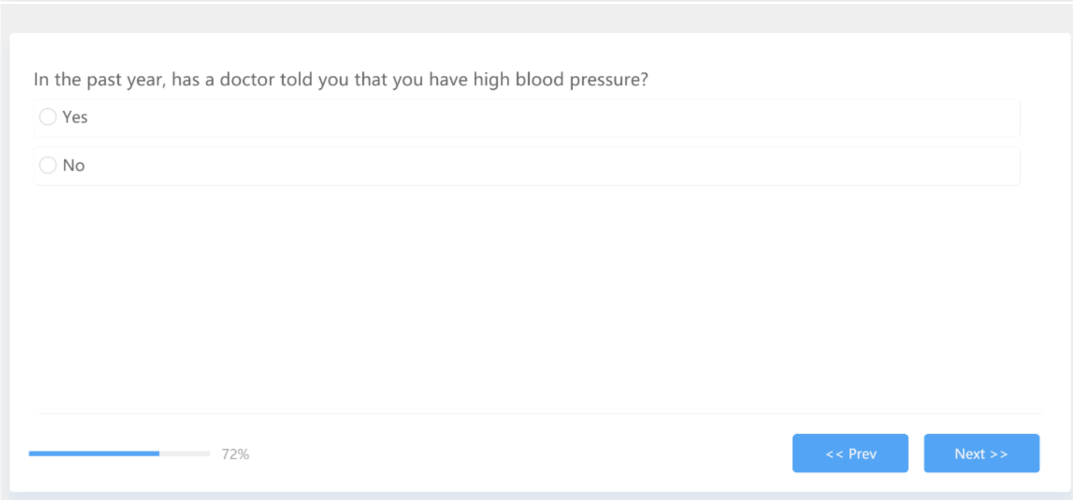
<< Prev | Next >>


Have you ever smoked regularly? (By smoking we mean more than 100 cigarettes in your lifetime)

- Ever smoked, currently smoking
- Ever smoked, currently not smoking
- Never smoked

72%

<< Prev | Next >>


In the past year, has a doctor told you that you have high blood pressure?

- Yes
- No

72%

<< Prev | Next >>

Compared with other people, would you say your health is excellent, very good, good, fair, or poor?

- Excellent
- Very good
- Good
- Fair
- Poor

73% << Prev Next >>

Compared to one year ago, how would you rate your health in general now?

- Much better now than one year ago
- Somewhat better now than one year ago
- About the same as one year ago
- Somewhat worse now than one year ago
- Much worse now than one year ago

74% << Prev Next >>

Excluding all properties that you own, what is the total value of your household's savings? (including, for example, savings accounts, term deposits, government bonds, stocks, shares in investment fund)

- less than ¥2,000
- between ¥2,000 and ¥9,999
- between ¥10,000 and ¥49,999
- between ¥50,000 and ¥99,999
- between ¥100,000 and ¥249,999
- between ¥250,000 and ¥499,999
- between ¥500,000 and ¥999,999
- ¥1,000,000 or more

74% << Prev Next >>

Have you seen the previous question before?

○ Yes

○ No

75%

<< Prev | Next >>

In the last five years, which of the following events happened to you and/or people close to you? Choose all that apply.

	Me	People close to me	None
The person provided active care for elderly members or relatives	☐	☐	○
Medically-trained people provided care at the person's home	☐	☐	○
The person was diagnosed with a critical illness (for example, cancer, heart attack, stroke, dementia)	☑	☐	○
The person could not complete **one** or **two** of the following six activities: Bathing, dressing, toileting, getting into or out of bed, continence, and feeding	☐	☐	○
The person could not complete **three** or more of the following six activities: Bathing, dressing, toileting, getting into or out of bed, continence, and feeding	☑	☐	○

76%

<< Prev | Next >>

Risk attitude and patience

In the following pages, we will ask you about your risk attitude and level of patience.

77%

<< Prev | Next >>

How do you see yourself: Are you generally a person who is fully prepared to take risks in financial matters or do you try to avoid taking risks in financial matters?

Please tick on box on the scale where 0 means 'not prepared to take risks' and 10 means 'fully prepared to take risks'.

Not prepared to take risks										**Fully prepared to take risks**
0	1	2	3	4	5	6	7	8	9	10

77%

<< Prev   Next >>

How do you see yourself: Are you generally an impatient person, or someone who always shows great patience?

Please tick on box on the scale where 0 means 'very impatient' and 10 means 'very patient'.

Very impatient										**Very patient**
0	1	2	3	4	5	6	7	8	9	10

78%

<< Prev   Next >>

How do you rate your overall knowledge of financial matters?

- ○ Very good
- ○ Good
- ○ Moderate
- ○ Poor
- ○ Very poor

79%

<< Prev   Next >>

In the following pages we ask you about your general financial competence. Please answer the questions without a calculator.

79%

<< Prev Next >>

Suppose you had ¥100 in a savings account and the interest rate was 2% per year. After 5 years, how much do you think you would have in the account if you left the money to grow?

- More than ¥102
- Exactly ¥102
- Less than ¥102
- Do not know

80%

<< Prev Next >>

Imagine that the interest rate on your savings account was 1% per year and inflation was 2% per year. After 1 year, how much would you be able to buy with the money in this account?

- More than today
- Exactly the same
- Less than today
- Do not know

81%

<< Prev Next >>

Please evaluate whether this statement is true or false. "Buying shares in a single company usually provides a safer return than buying units in a managed share fund."

- True
- False
- Do not know

81%

<< Prev Next >>

Imagine that we rolled a fair, six-sided die 1000 times. Out of 1000 rolls, how many times do you think the die would come up even? Please enter a number between 0 to 1000 in the box.

_____ times

82%

<< Prev Next >>

In a lottery, the chance of winning a 500 RMB prize is 1%. What is your best guess of how many people would win the prize if 1000 people each buy a single ticket in the lottery? Please enter a number between 0 to 1000 in the box.

_____ people

83%

<< Prev Next >>

In a raffle, the chance of winning a car is 1 in 1000. What percent of tickets in the raffle win a car? Please enter a percentage in the box.

%

83%

<< Prev Next >>

Psychological personality traits

In these questions, we ask you to describe your own personality traits. Please indicate how well each of the following describes you.

	Not at all	a little	Somewhat	a lot
Organized	○	○	○	○
Responsible	○	○	○	○
Hardworking	○	○	○	○
Careless	○	○	○	○
Thorough	○	○	○	○

84%

<< Prev Next >>

Socio-economic information

In the following pages, we will collect some personal information about you.

85%

<< Prev Next >>

What is your marital status?

- Never married
- Married (including living in a long-term partnership)
- Divorced
- Separated
- Widowed

85%

<< Prev | Next >>

Who do you work for? If you are not currently working, please answer according to your most recent previous job.

- Government
- Public institution
- Non-government organisation
- State-owned enterprise
- Private company including foreign firm
- Individual firm and freelancer
- Farmer
- Never worked
- Other

86%

<< Prev | Next >>

Which of following do you have or contribute to? [choose all that apply]

- Urban employee pension
- Urban residential pension
- Urban employee medical insurance
- Urban residential medical insurance
- Other pension provided by your employer
- Other health insurance provided by your employer
- Other commercial pension not mentioned above
- Other commercial health insurance not mentioned above
- None of above

87%

<< Prev | Next >>

Which of the following best describes your current work status? Please choose one.

- ◯ Employed by someone else
- ◯ Self-employed
- ◯ Unemployed including structurally unemployed (Xia Gang)
- ◯ Retired
- ◯ Not working - Stay-at-home parent or caregiver
- ◯ Not working - Other reasons

6% << Prev Next >>

Which city do you live in?

Choose an option

6% << Prev Next >>

What is your current hukou status?

- ◯ Urban hukou in the city I live in now (resident)
- ◯ Urban hukou in a different city
- ◯ Agricultural hukou but live in a city
- ◯ Agricultural hukou and live in the countryside

7% << Prev Next >>

What was your **household income** (including bonuses and pension income) in the last year after paying tax and social security contributions?

- ◯ less than ¥40,000 per year
- ◯ between ¥40,000 and ¥69,999 per year
- ◯ between ¥70,000 and ¥119,999 per year
- ◯ ¥120,000 or more per year

87% << Prev Next >>

Please provide more details about your household income. What was your household income (including bonus, pension income) in the last year after paying tax and social security contributions?

- ◯ Between ¥40,000 and ¥49,999 per year
- ◯ Between ¥50,000 and ¥59,999 per year
- ◯ Between ¥60,000 and ¥69,999 per year

88% << Prev Next >>

Novel coronavirus related questions

The novel coronavirus has a broad impact. We would like to know:
How have your income changed following the spread of the novel coronavirus? My income has:

- ◯ Increased a lot
- ◯ Increased a little
- ◯ More or less the same
- ◯ Decreased a little
- ◯ Decreased a lot

89% << Prev Next >>

The novel coronavirus has a broad impact. We would like to know:
How has your savings changed following the spread of the novel coronavirus? My savings have:

- ○ Increased a lot
- ○ Increased a little
- ○ More or less the same
- ○ Decreased a little
- ○ Decreased a lot

89%

<< Prev | Next >>

Have you bought any insurance since the spread of the novel coronavirus?

- ☐ Novel coronavirus insurance
- ☐ Critical illness insurance
- ☐ Long-term care insurance
- ☐ Commercial medical insurance
- ☐ Other health-related insurance
- ☐ Annuity or commercial pension
- ☐ Other insurance
- ○ None

90%

<< Prev | Next >>

What is the main reason you buy the insurance product(s)?

- ○ Risks of COVID-19
- ○ Awareness of health risks in general
- ○ Price
- ○ Recommendations from others
- ○ People around me bought it
- ○ Other reason

91%

<< Prev | Next >>

The novel coronavirus has widespread economic effects. At the moment, how much do you worry about: (For each statement below, please indicate how the novel coronavirus makes you feel on a scale from 1 to 7.)

	Don't worry at all						Worry a lot
Losing your main source of income	1	2	3	4	5	6	7
Small companies closing down	1	2	3	4	5	6	7
An economic recession in China	1	2	3	4	5	6	7

91% << Prev Next >>

Since the lockdown measures have been loosened, have you done the following?

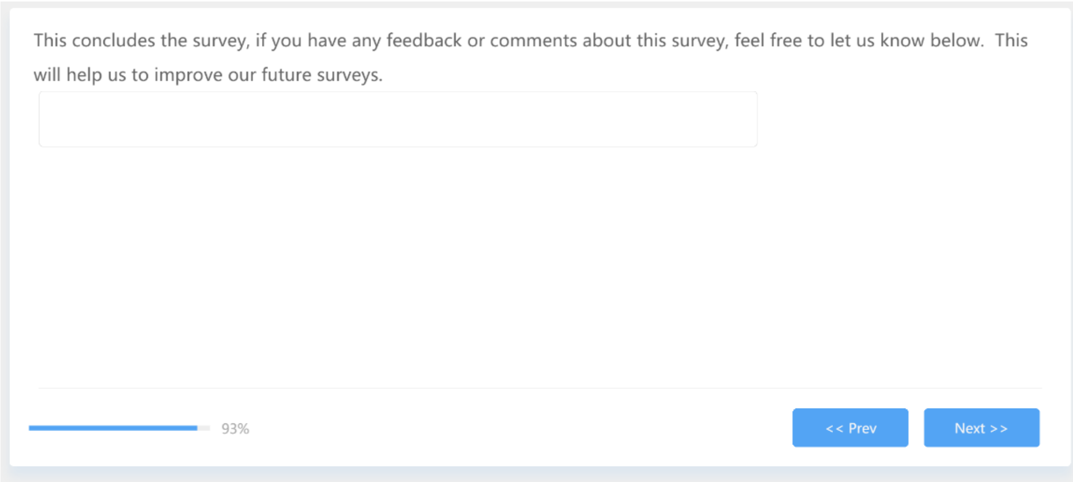
	Always avoided	Often avoided	Sometimes avoided	Never avoided	Does not apply
Avoided seeing relatives outside your home	○	○	○	○	○
Avoided having meals in a restaurant with a friend	○	○	○	○	○
Avoided direct contact with doors or elevator buttons	○	○	○	○	○
Avoided crowded locations like shopping malls	○	○	○	○	○
Avoided travelling	○	○	○	○	○

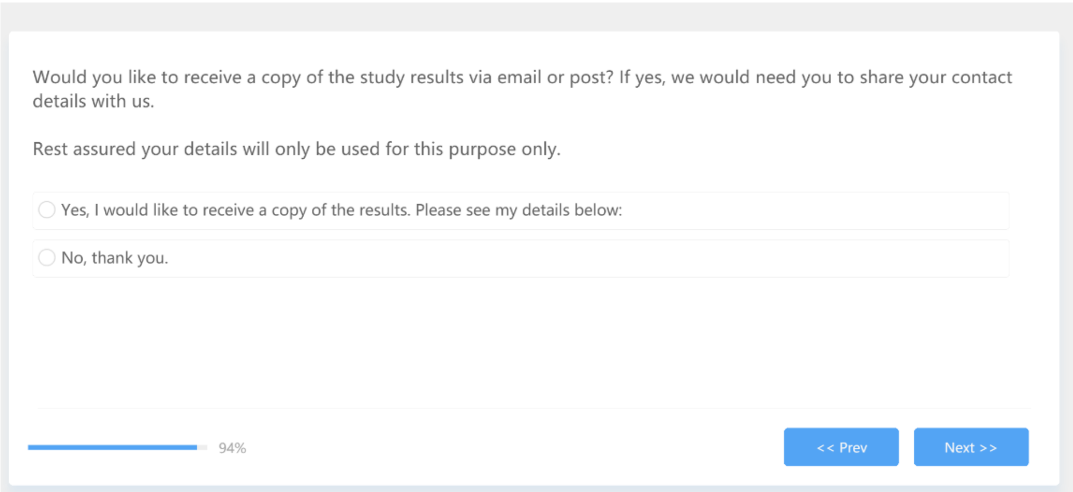
92% << Prev Next >>

How clear do you think the questions in this survey are?

- ○ **Completely clear**
- ○ **Mostly clear**
- ○ **Sometimes clear**
- ○ **Sometimes confusing**
- ○ **Mostly confusing**
- ○ **Completely confusing**

93% << Prev Next >>


This concludes the survey, if you have any feedback or comments about this survey, feel free to let us know below. This will help us to improve our future surveys.
93%
<< Prev
Next >>


Would you like to receive a copy of the study results via email or post? If yes, we would need you to share your contact details with us.
Rest assured your details will only be used for this purpose only.
Yes, I would like to receive a copy of the results. Please see my details below:
No, thank you.
94%
<< Prev
Next >>

A.1.2 Survey screenshots in Chinese

澳大利亚老龄化研究中心 (CEPAR)

网上参与者信息声明

新冠肺炎后养老、健康、长期护理保险产品的需求
黑泽尔·贝特曼教授

参与者知情同意书

1.本次研究的内容是什么?
我们邀请您参与关于新型养老金融产品的研究，这个新产品可以在退休后同时提供养老和健康保险。您收到邀请是因为您符合我们的研究需要，您的联系方式则是通过市场调研公司dataSpring获得的。

2.谁在实施这项研究?
本次研究的团队如下:

本项目任职	姓名	单位
首席研究员	黑泽尔·贝特曼教授	新南威尔士大学（澳大利亚）
研究员	方汉明教授 卡佳·海纳维尔德博士	宾夕法尼亚大学（美国） 新南威尔士大学（澳大利亚）
学生研究员	万程	新南威尔士大学（澳大利亚）

研究资助：本次研究的资金来自澳大利亚老龄化研究中心。

3.筛选条件
研究开始前，我们需要再次确认您是否符合我们的研究需要:
- 45到69岁间尚未退休的城市居民。

4.我必须参与本次研究吗?
参于本研究是完全自愿的，您无需勉强。

如果您决定参与本次研究，您需要:
- 仔细阅读以下信息;
- 完成在线问卷调查。

5.本次研究需要我做什么?可能存在哪些风险?

如果您决定参与本次研究，我们会需要您完成一份在线问卷。该问卷会问您有关退休财务决策的问题，会向您展示几个养老金融产品的信息，请您做一些假想的退休资产分配任务，以及回答一些常规的问题。本问卷大概需要30分钟来完成。

参与此研究将会给您一定奖励。此外，根据您在问卷里的小测验回答问题正确的数量，您将能获得一些额外奖励。

如果您在参与研究时感到不适或烦恼，并且需要帮助，您可以随时停止。

6.参与本研究可能带来哪些好处?
我们希望本次研究获得的信息能够帮助那些有意愿做退休财务规划的人。

7.我的信息会被如何使用?
提交在线问卷表示您同意我们使用您的信息。点击“我同意”按钮即表示您允许研究团队收集和使用您的信息进行研究。在研究结果发表后，您的数据将保留5年。我们将以无法识别您身份的格式在新南威尔士大学的服务器上存储您的相关信息。您的问卷回答将仅用于学术研究，该研究收集的信息可能会以无身份识别的形式提供给其他研究项目。

8.我在什么时候、通过什么方式可以看到研究成果?
研究团队将通过多种方式公布研究成果。所有发布的信息都会经过处理以确保不会泄露您的身份。

如果您希望收到研究成果，请在该问卷最后填上您的电子邮箱或者邮寄地址。您的联系方式将仅被用于给您发送研究成果。本次研究成果也将会通过澳大利亚老龄化研究中心的网站提供:

http://www.cepar.edu.au/publications/working-papers

9.如果我不想参与这项研究了怎么办?
即使您同意参与这项研究，您也可以随时退出，比如通过关闭问卷。如果您退出研究，我们将销毁所有已收集的信息。但是，一旦您提交了调查问卷，因为问卷是匿名的，我们将无法撤回您的信息。

10.如果我对本研究还有其它疑问怎么办?
如果您想了解任何与本研究有关的问题，请联系我们的研究团队:

研究团队联系方式

姓名	万程先生
职位	博士研究生，风险与精算学院，新南威尔士大学
电话	········
电子邮箱	········

如果我想投诉或对本研究有疑虑，该怎么办?
对于本研究的任何方面，如果您想投诉，请联系新南威尔士大学人文伦理协调员:

投诉联系方式

职位	人文研究伦理协调员
电话	········
电子邮箱	········
HC参考编号	HC190099

1%

下一页

知情同意书 – 参与者提供自己的许可

我们邀请您参与一个关于新型养老金融产品的研究，这个新产品可以在退休后同时提供养老和健康保险。

参与者声明

- [x] 我知道自己正在被要求提供自己参与本研究的许可
- [x] 我同意所收集的有关我的信息将仅用于本次研究；
- [x] 我明白如有必要我可以提问，研究团队将回答我的问题；
- [x] 我自愿参与本研究，并且明白我可以随时退出。退出研究不会影响我与前述研究机构或团队的关系；
- [x] 我明白我可以在 www.cepar.edu.au.下载此知情同意书。
- [ ] 我同意，点击上面所有方框，然后继续
- 我不想参与本研究

2%

上一页 下一页

欢迎

感谢您同意参加本次调研。

本次调研的目的是希望了解您对于新型养老金融产品的兴趣，这个新产品可以在退休后同时提供养老和健康保险。

本次调研将首先问您一些简单的问题，我们会用您的回答来问一些仅跟您相关的问题。您的回答是匿名的，不会识别出您的身份。

切勿使用您浏览器自带的“前进”或“后退”按钮，请使用在屏幕下方问卷提供的按键。

2%

上一页 下一页

您是男性还是女性？

- 男性
- 女性

3%

上一页 下一页

您的年龄是? ______ 岁

4%

上一页 下一页

您之前有患过重大疾病吗（比如癌症，心脏病，中风，老年痴呆）？

○ 是

○ 否

5%

上一页 下一页

对下列各项活动，哪些您需要帮助？（请勾选所有适用选项）

☐ 洗澡

☐ 穿衣

☐ 上厕所

☐ 上床与起床

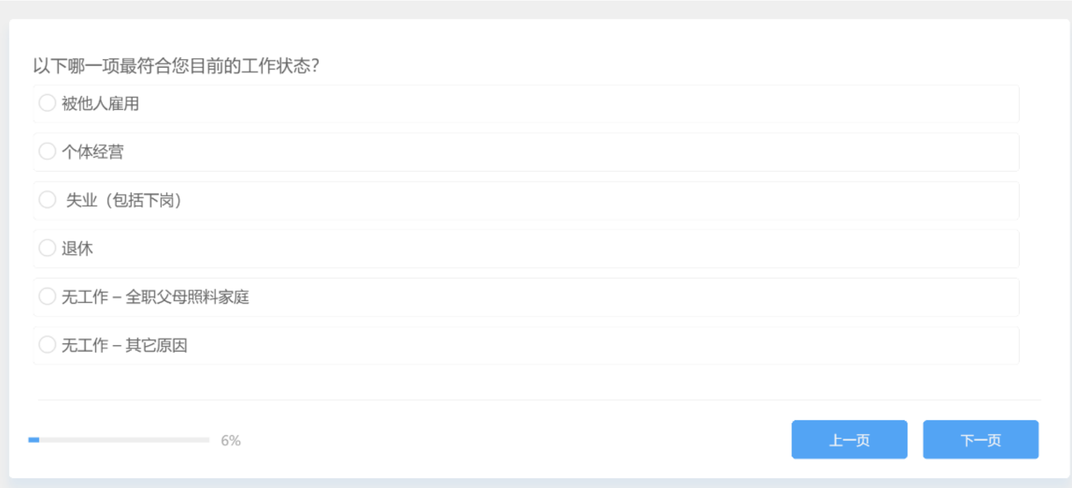
☐ 大小便控制

☐ 吃饭

○ 都不需要

5%

上一页 下一页

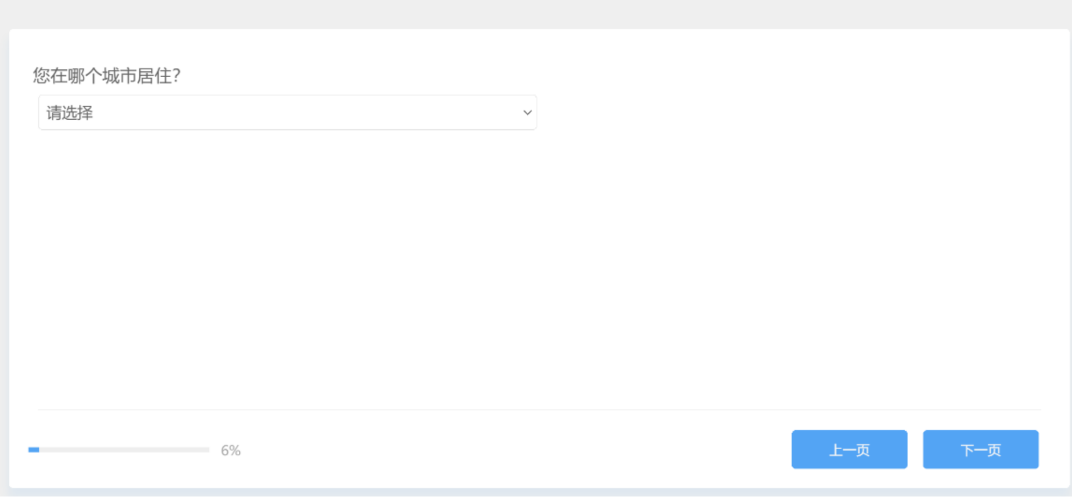


以下哪一项最符合您目前的工作状态?

- 被他人雇用
- 个体经营
- 失业（包括下岗）
- 退休
- 无工作 – 全职父母照料家庭
- 无工作 – 其它原因

6%

上一页 下一页

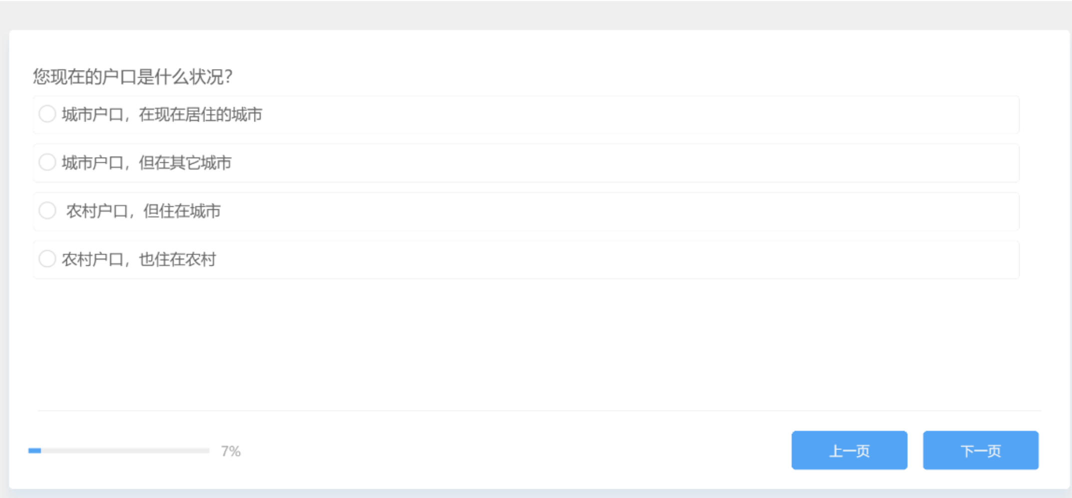


您在哪个城市居住?

请选择

6%

上一页 下一页



您现在的户口是什么状况?

- 城市户口，在现在居住的城市
- 城市户口，但在其它城市
- 农村户口，但住在城市
- 农村户口，也住在农村

7%

上一页 下一页

您获得的最高教育程度是?

- 没上过学
- 小学
- 初中
- 高中或者中专、职业高中、技校
- 大学专科
- 大学本科
- 研究生及以上

8%

上一页 下一页

第1部分：热身问题

您家庭持有以下任何产品吗?

	是	否	不清楚
银行存款			
定期存款			
国库券			
股票			
基金			
货币基金（比如支付宝的余额宝、微信零钱通）			
信用卡			
人寿保险			
商业健康保险			
商业长期护理保险			
商业重大疾病保险			
商业养老金			
生命年金			
企业年金			

8%

上一页 下一页

不算任何房产，您家庭所有资产的价值是多少？（包括比如银行活期存款、定期存款、国库券、股票、基金）

- 小于2000元
- 2000 – 9999元
- 1万 – 4万9999元
- 5万 – 9万9999元
- 10万 – 24万9999元
- 25万 – 49万9999元
- 50万 – 99万9999元
- 100万元以上

9%

上一页 下一页

您家庭所有**负债**的价值是多少？（包括比如房贷、从亲朋好友那借的钱、信用卡欠款、其他银行欠款）

- 小于2000元
- 2000－9999元
- 1万－4万9999元
- 5万－9万9999元
- 10万－24万9999元
- 25万－49万9999元
- 50万－99万9999元
- 100万元以上

10%

上一页 下一页

您和您的配偶（如有）现在总共有几套房产？ ____ 套

10%

上一页 下一页

这些房产现在总共值多少钱？ ____ 万元

11%

上一页 下一页

您现在领到的养老金（或者预计退休以后能领到的）大概每月多少元?

- 不到800元
- 800 - 1499元
- 1500 - 2499元
- 2500 - 3499元
- 3500元以上

12%

上一页 下一页

第2部分：养老金融产品介绍

养老规划涉及许多财务决策。我们想知道您如何考虑不同的策略来支付生活费用、以及健康相关的费用（比如重大疾病以及长期护理的相关费用，如有需要）。在接下来的四页，我们会提供有关这些费用的基本信息、以及相关的假设性养老金融产品。

- 有些产品可能和现在市场上的产品类似，请只考虑这里提供的**假设性**产品。
- 您的理解可能会影响您从本次调查中获得的**奖励**，请仔细阅读这些产品的介绍。

13%

上一页 17

生活费用

有些文字是蓝色的 -- 如果将鼠标放在蓝色文字上，它的解释将会弹出。比如试试下面显示的“终身收入产品”。

大多数退休的人靠以下三种方式来支付生活费用：

1.养老金

2.个人储蓄以及投资

3.子女或其他家庭成员的帮助

一般刚刚退休**55岁**的女性应该会活到**87岁**，但可能更久也可能达不到。如果退休后活得很久，她可能没有足够的资源来支付这些费用。

终身收入产品

终身收入产品是一个帮退休人员支付常规生活费用的金融产品。

只要持有人健在，**终身收入产品**每月都会提供一定的收入。

- 现在每付**1万元**（一次性付款），只要持有人还健在，以后每月提供**30元**（保值）。
- 如果持有人去世，这些收入将会停止，并且不会有退款。

你可以在20秒之后单击“下一页”。

14%

上一页 16

重大疾病花费

患**重大疾病**（比如癌症、中风或者心脏病）的机会因人而异，取决于个人的健康状况和病史。平均来说，**5成**的女性退休人员可能在退休期间患重病。对感染新冠肺炎的人来说，患重大疾病的可能性会高很多。

医保（包括大病保险）提供重大疾病基本保障。平均来说，医保能报销重大疾病医疗费用的**一半**。对那些不在医保报销目录里的更先进或昂贵的药品和治疗手段，病人需要用他们的存款自行支付。扣除医保已报销的花费，病人需要自行支付的费用可能从**数万到数十万**不等。

重大疾病现金产品

重大疾病现金产品是一个帮退休人员支付重大疾病花费的金融产品。

如果持有人**确诊重疾** - 被确诊患有25种重大疾病中任意一种，**重大疾病现金产品**会一次性提供现金。 这些疾病是政府统一定义的，包括癌症、中风、心脏病等。政府指定的医生将会负责疾病的确诊。

- 持有人可以选择如何使用该产品提供的现金，比如，可以用来支付医保不报销的药物和治疗手段，或者花在其它任意地方。
- 现在每付**1万元**（一次性付款），以后如果持有人确诊重疾，他将收到**21,000元**（保值）的现金赔付。
- 该产品最多提供一次现金。如果索赔没有发生或者持有人在确诊前去世，不提供退款。

新冠肺炎本身不在保障范围内。但是，如果25种疾病的任意1种在感染新冠肺炎之后确诊，持有人可以获得该产品提供的一次性现金。

把鼠标移到蓝色文字上会弹出它的解释。

你可以在20秒之后单击“下一页”。

15%　　上一页　17

长期护理花费

需要长期护理的机会因人而异，取决于个人的健康状况和病史。然而，平均来说，**5成**的女性退休人员在退休期间，多数是在年龄较大的时候，可能会需要某种形式的护理。

人们需要**长期护理**是指：他们需要帮助来完成以下六个项目中的至少三项：洗澡，穿衣，上厕所，上床与起床，大小便控制，吃饭。有的人只需要**几个月**的长期护理，而其他的人则需要**许多年**。

目前，在大多数城市，**社保**都不提供长期护理保险。长期护理每月的花费约为**2000至6000元**。

长期护理收入产品

长期护理收入产品是一个帮退休人员支付长期护理费用的金融产品。

只要持有人有长期护理需求，**长期护理收入产品**每月都会提供一定的收入。政府指定的医生将会定期检查这6项能力。

- 持有人可以选择如何使用该产品提供的收入，比如，可以用来请专业护理，补偿照顾他的亲朋好友，或者其他任意花费。
- 现在每付**1万元**（一次性付款），以后只要需要长期护理，该产品每月会提供**350元**（保值）。
- 如果持有人不再需要长期护理或者去世了，该收入会停止，也不会提供退款。
- 如果持有人从来没需要过长期护理，也不提供退款。

把鼠标移到蓝色文字上会弹出它的解释。

你可以在20秒之后单击“下一页”。

17%　　上一页　16

活期存款帐户

退休存款也可以放在一个**活期存款帐户**里，然后取款来支付之前提到的生活花费以及重大疾病和长期护理的花费。

- 如果一个人活得很久或者这些花费很高，他在活期存款帐户里的钱可能不够。
- 如果帐户持有人去世，活期存款帐户里所有剩下的钱都归他的遗产继承人所有。

17%

上一页 下一页

以下表格对这三个养老金融产品和活期存款帐户进行总结：请确认它们的主要特点，每行一个。

	定期收入?	**只有遇到健康问题才有支付吗?**	**只要持有人**健在**就保证支付?**	**如果持有人去世?**
终身收入产品*	是的，每月支付	不是	是的	支付停止，没有退款
重大疾病现金产品*	不是，如果确诊，一次性支付	是，如确诊25种重大疾病任意一种	不是，如果确诊，一次性支付	没有退款
长期护理收入产品*	是的，如需长期护理，每月支付	是，如需长期护理（至少3项需要帮助：洗澡，穿衣，上厕所，上床与起床，大小便控制，吃饭）	不是，只在需要长期护理时才提供	支付停止，没有退款
活期存款帐户	不是，但你可以随时取款（只要帐户里还有钱）	不是，但你可以随时取款（只要帐户里还有钱）	不是，但你可以随时取款（只要帐户里还有钱）	所有剩余存款都归遗产继承人

*请注意，所有产品的定价都是公平的，并且，如果你同时购买终身收入产品、重大疾病现金产品和长期护理收入产品，你会拿到折扣：任意两个一起买打9折，三个全买打85折。

把鼠标移到蓝色文字上会弹出它的解释。

你可以在20秒之后单击“下一页”。

18%

上一页 17

产品知识测验

我们现在来测试您对这些刚介绍的金融产品的理解。请在接下来的几页里回答关于这三个养老金融产品和活期存款帐户的问题，您的奖励将取决于您回答正确的数量。

19%

上一页 下一页

请判断以下每条陈述的真假。

		真/假	正确答案
终身收入产品	用一笔付款换来定期收入。	请选择	
	无论持有人活多久，该产品都为他终身提供收入。	请选择	
	当持有人去世后，他的遗产继承人会得到一笔钱。	请选择	

你可以在10秒之后单击”下一页”

19% 上一页 ?

请判断以下每条陈述的真假。

		真/假	正确答案
重大疾病现金产品	用一笔付款换来在重疾确诊时才提供的一笔钱，这笔钱可以帮忙支付重疾相关的费用。	请选择	
	产品提供的钱只能用于医疗或者药物。	请选择	
	如果持有人一直保持健康，他将收到退款。	请选择	

你可以在10秒之后单击”下一页”

20% 上一页 ?

请判断以下每条陈述的真假。

		真/假	正确答案
长期护理收入产品	如果持有人不再需要长期护理，该产品也可以继续提供收入。	请选择	
	该产品只对住院型的护理费用提供帮助。	请选择	
	用一笔付款换来在需要长期护理时才提供的定期收入，这份收入可以帮助支付长期护理的费用。	请选择	

你可以在10秒之后单击”下一页”

21% 上一页 ?

请判断以下每条陈述的真假。

		真/假	正确答案
活期存款帐户	只要帐户持有人活着，活期存款帐户里就会一直有钱。	请选择	

你可以在10秒之后单击”下一页”

21%

上一页 7

第3部分：退休存款分配

任务介绍

移动鼠标到蓝色文字上方来获得更多信息。

接下来，我们将依次向您展示9种假设的情形来进行退休存款分配。

在您开始进行这9个分配任务之前，请阅读下列例子来了解我们需要您做什么。

首先，我们会给您一笔假设性的退休存款（本例，150,000元），假设您已经用其中的一部分存款购买了重大疾病现金产品（本例，21%）和长期护理收入产品（本例，19%）。

接下来，我们需要您通过移动滑块将剩余的退休存款分配到**终身收入产品**和**活期存款帐户**之中（以下截图为示例）。

使用以下滑块来显示您最满意的分配方案。

活期存款帐户: 60%，53,876元

100% 活期存款帐户

100% 终身收入产品

终身收入产品: 40%，35,916元

0 元

89792 元

以下表格对您的分配方案进行总结（包括三个养老金融产品和活期存款帐户）。

	产品分配方案：任务6	
重大疾病现金产品: **如确诊重大疾病**一次性得到现金	7万5000元	平均来说，这个现金能够**覆盖一半**需要自费治疗重大疾病的费用
长期护理收入产品: 如需**长期护理**的每月收入	1500 元	平均来说，这个收入能够**覆盖一半**请专业护理的费用
终身收入产品: 直到您去世的每月收入	**148** 元	
活期存款帐户: 剩余退休存款	**53,876** 元	

您的养老金也会每月提供3000元，并且医保会报销重大疾病一半的医疗费用。您没有任何长期护理保险。

您需要充分考虑您已购买的**重大疾病现金产品**和**长期护理收入产品**的份量，然后**至少移动滑块一次**来显示您对**终身收入产品**和**活期存款帐户**最满意的分配方案。

请记住，同时购买终身收入产品、重大疾病现金产品和长期护理收入产品时您会拿到**折扣**：任意两个一起买打**9折**，三个全买打**85折**。

您需要持续移动滑块并检查滑块下方表格里的结果，直到您对终身收入产品和活期存款帐户的分配觉得满意。

我们现在将开始9个分配任务。

22%

上一页 下一页


任务1/9
移动鼠标到蓝色文字上方来获得更多信息。
假设您55岁，刚退休，并且有150,000元退休存款。假设您每月的养老金为2000元（保值）然后您有医保（能报销重大疾病花费的一半，但不能报销长期护理费用）。
在本情形中，假设您还没有买任何重大疾病现金产品或者长期护理收入产品。
您的剩余存款是 150,000 元。
您的任务是决定如何在终身收入产品和活期存款帐户之间对这些剩余存款进行分配。
使用以下滑块来显示您最满意的分配方案。
活期存款帐户:
100%，150,000元
100% 活期存款帐户
100% 终身收入产品
0 元
150000 元
终身收入产品:
0%，0元
以下表格对您的分配方案进行总结（包括三个养老金融产品和活期存款帐户）。
产品分配方案：任务1
重大疾病现金产品
如确诊重大疾病一次性得到现金
0 元
如确诊重大疾病，您需要从您的活期存款帐户中取款来支付这些费用
长期护理收入产品
如需长期护理的每月收入
0 元
如需长期护理，您需要从您的活期存款帐户中取款来支付这些费用
终身收入产品
直到您去世的每月收入
0 元
活期存款帐户
剩余退休存款
150,000 元
您的养老金也会每月提供2000元，并且医保会报销重大疾病一半的医疗费用。您没有任何长期护理保险。
25%
上一页
下一页

任务2/9

移动鼠标到蓝色文字上方来获得更多信息

在本情形中，假设您已用了 **150,000 元**退休存款的 **24%** 来买**重大疾病现金产品**，但**没买**任何**长期护理收入产品**。

您的剩余存款是 **114,286** 元。

您的任务是决定如何在**终身收入产品**和**活期存款帐户**之间对这些剩余存款进行分配。

使用以下滑块来显示您最满意的分配方案。

活期存款帐户:
100%，114,286元

100% 活期存款帐户

100% 终身收入产品

0 元

114286 元

终身收入产品:
0%，0元

以下表格对您的分配方案进行总结（包括三个养老金融产品和活期存款帐户）。

	产品分配方案：任务2	
重大疾病现金产品 如**确诊重大疾病**一次性得到现金	7万5000元	平均来说，这笔现金能够**覆盖一半**需要自费治疗重大疾病的费用
长期护理收入产品 如需**长期护理**的每月收入	0元	如需长期护理，您得从您的活期存款帐户中取款来支付这些费用
终身收入产品 直到您去世的每月收入	**0** 元	
活期存款帐户 剩余退休存款	**114,286** 元	

您的养老金也会每月提供2000元，并且医保会报销重大疾病一半的医疗费用。您没有任何长期护理保险。

28%

上一页

下一页

任务3/9

移动鼠标到蓝色文字上方来获得更多信息。

在本情形中，假设您已用了 **150,000 元**退休存款的 **48%** 来买**重大疾病现金产品**，但**没买**任何**长期护理收入产品**。

您的剩余存款是 **78,571** 元。

您的任务是决定如何在**终身收入产品**和**活期存款帐户**之间对这些剩余存款进行分配。

使用以下滑块来显示您最满意的分配方案。

活期存款帐户:
100%，78,571元

100% 活期存款帐户

A

100% 终身收入产品

0 元

78571 元

终身收入产品:
0%，0元

以下表格对您的分配方案进行总结（包括三个养老金融产品和活期存款帐户）。

	产品分配方案：任务3	
重大疾病现金产品 **如确诊重大疾病**一次性得到现金	15万元	平均来说，这笔现金能够**覆盖所有**需要自费治疗重大疾病的费用
长期护理收入产品 如需**长期护理**的每月收入	0元	如需长期护理，您需要从您的活期存款帐户中取款来支付这些费用
终身收入产品 直到您去世的每月收入	**0** 元	
活期存款帐户 剩余退休存款	**78,571** 元	

您的养老金也会每月提供2000元，并且医保会报销重大疾病一半的医疗费用。您没有任何长期护理保险。

30%

上一页　下一页

任务4/9

移动鼠标到蓝色文字上方来获得更多信息。

在本情形中，假设您**没买**任何**重大疾病现金产品**，但用了 **150,000 元**退休存款的 **29%** 来买**长期护理收入产品**。

您的剩余存款是 **107,143** 元。

您的任务是决定如何在**终身收入产品**和**活期存款帐户**之间对这些剩余存款进行分配。

使用以下滑块来显示您最满意的分配方案。

活期存款帐户:
100%，107,143元

100% 活期存款帐户

100% 终身收入产品

0 元

107143 元

终身收入产品:
0%，0元

以下表格对您的分配方案进行总结（包括三个养老金融产品和活期存款帐户）。

	产品分配方案：任务4	
重大疾病现金产品 **如确诊重大疾病**一次性得到现金	0元	如确诊重大疾病，您需要从您的活期存款帐户中取款来支付这些费用
长期护理收入产品 如需**长期护理**的每月收入	1500元	平均来说，该收入能够**覆盖一半**请专业护理的费用
终身收入产品 直到您去世的每月收入	**0** 元	
活期存款帐户 剩余退休存款	**107,143** 元	

您的养老金也会每月提供2000元，并且医保会报销重大疾病一半的医疗费用。您没有任何长期护理保险。

33%

上一页

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任务5/9

移动鼠标到蓝色文字上方来获得更多信息。

在本情形中，假设您**没买**任何**重大疾病现金产品**，但用了 **150,000 元**退休存款**的 57%** 来买**长期护理收入产品**。

您的剩余存款是 **64,286** 元。

您的任务是决定如何在**终身收入产品**和**活期存款帐户**之间对这些剩余存款进行分配。

使用以下滑块来显示您最满意的分配方案。

活期存款帐户:
100%，64,286元

100% 活期存款帐户

A

100% 终身收入产品

0 元

64286 元

终身收入产品:
0%，0元

以下表格对您的分配方案进行总结（包括三个养老金融产品和活期存款帐户）。

	产品分配方案：任务5	
重大疾病现金产品 **如确诊重大疾病**一次性得到现金	0元	如确诊重大疾病，您需要从您的活期存款帐户中取款来支付这些费用
长期护理收入产品 如需**长期护理**的每月收入	3000元	平均来说，该收入能够**覆盖所有**请专业护理的费用
终身收入产品 直到您去世的每月收入	**0** 元	
活期存款帐户 剩余退休存款	**64,286** 元	

您的养老金也会每月提供2000元，并且医保会报销重大疾病一半的医疗费用。您没有任何长期护理保险。

36%

上一页 下一页

任务6/9

移动鼠标到蓝色文字上方来获得更多信息。

在本情形中，假设您已经用了 **150,000 元**退休存款的 **21%** 来买**重大疾病现金产品**、**26%** 来买**长期护理收入产品**。

您的剩余存款是 **79,286** 元。

您的任务是决定如何在**终身收入产品**和**活期存款帐户**之间对这些剩余存款进行分配。

使用以下滑块来显示您最满意的分配方案。

活期存款帐户:
100%，79,286元

100% 活期存款帐户

100% 终身收入产品

0 元

79286 元

终身收入产品:
0%，0元

以下表格对您的分配方案进行总结（包括三个养老金融产品和活期存款帐户）。

	产品分配方案：任务6	
重大疾病现金产品: **如确诊重大疾病**一次性得到现金	7万5000元	平均来说，这个现金能够**覆盖一半**需要自费治疗重大疾病的费用
长期护理收入产品: 如需**长期护理**的每月收入	1500 元	平均来说，这个收入能够**覆盖一半**请专业护理的费用
终身收入产品: 直到您去世的每月收入	**0** 元	
活期存款帐户: 剩余退休存款	**79,286** 元	

您的养老金也会每月提供2000元，并且医保会报销重大疾病一半的医疗费用。您没有任何长期护理保险。

38%

上一页 下一页

任务7/9

移动鼠标到蓝色文字上方来获得更多信息。

在本情形中，假设您已经用了**150,000元**退休存款的 **43%** 来买**重大疾病现金产品**、**26%**来买**长期护理收入产品**。

您的剩余存款是 **47,143** 元。

您的任务是决定如何在**终身收入产品**和**活期存款帐户**之间对这些剩余存款进行分配。

使用以下滑块来显示您最满意的分配方案。

活期存款帐户:
100%，47,143元

100% 活期存款帐户
A
0 元

100% 终身收入产品
47143 元

终身收入产品:
0%，0元

以下表格对您的分配方案进行总结（包括三个养老金融产品和活期存款帐户）。

	产品分配方案：任务7	
重大疾病现金产品: **如确诊重大疾病**一次性得到现金	15万元	平均来说，这个现金能够**覆盖所有**需要自费治疗重大疾病的费用
长期护理收入产品: 如需**长期护理**的每月收入	1500元	平均来说，这个收入能够**覆盖一半**请专业护理的费用
终身收入产品: 直到您去世的每月收入	**0** 元	
活期存款帐户: 剩余退休存款	**47,143** 元	

您的养老金也会每月提供2000元，并且医保会报销重大疾病一半的医疗费用。您没有任何长期护理保险。

41%

上一页 下一页

任务8/9

移动鼠标到蓝色文字上方来获得更多信息。

在本情形中，假设您已经用了 **150,000 元**退休存款的 **21%** 来买**重大疾病现金产品**、**51%** 来买**长期护理收入产品**。

您的剩余存款是 **40,714** 元。

您的任务是决定如何在**终身收入产品**和**活期存款帐户**之间对这些剩余存款进行分配。

使用以下滑块来显示您最满意的分配方案。

活期存款帐户:	100% 活期存款帐户	100% 终身收入产品	终身收入产品:
100%，40,714元	0 元	40714 元	**0%，0元**

以下表格对您的分配方案进行总结（包括三个养老金融产品和活期存款帐户）。

	产品分配方案：任务8	
重大疾病现金产品: 如**确诊重大疾病**一次性得到现金	7万5000元	平均来说，这个现金能够**覆盖一半**需要自费治疗重大疾病的费用
长期护理收入产品: 如需**长期护理**的每月收入	3000元	平均来说，这个收入能够**覆盖所有**请专业护理的费用
终身收入产品: 直到您去世的每月收入	**0** 元	
活期存款帐户: 剩余退休存款	**40,714** 元	

您的养老金也会每月提供2000元，并且医保会报销重大疾病一半的医疗费用。您没有任何长期护理保险。

44%

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任务9/9

移动鼠标到蓝色文字上方来获得更多信息。

在本情形中，假设您已经用了 **150,000 元**退休存款的 **43%** 来买**重大疾病现金产品**、**51%** 来买**长期护理收入产品**。

您的剩余存款是 **8,571** 元。

您的任务是决定如何在**终身收入产品**和**活期存款帐户**之间对这些剩余存款进行分配。

使用以下滑块来显示您最满意的分配方案。

活期存款帐户:
100%，8,571元

100% 活期存款帐户

100% 终身收入产品

0 元

8571 元

终身收入产品:
0%，0元

以下表格对您的分配方案进行总结（包括三个养老金融产品和活期存款帐户）。

	产品分配方案：任务9	
重大疾病现金产品: 如**确诊重大疾病**一次性得到现金	15万元	平均来说，这个现金能够**覆盖所有**需要自费治疗重大疾病的费用
长期护理收入产品: 如需**长期护理**的每月收入	3000元	平均来说，这个收入能够**覆盖所有**请专业护理的费用
终身收入产品: 直到您去世的每月收入	**0** 元	
活期存款帐户: 剩余退休存款	**8,571** 元	

您的养老金也会每月提供2000元，并且医保会报销重大疾病一半的医疗费用。您没有任何长期护理保险。

46%

上一页　下一页

最终任务：产品分配方案偏好

移动鼠标到蓝色文字上方来获得更多信息。

您刚刚对您150,000元的退休存款完成了9次分配任务（在3个养老金融产品和活期存款帐户中）。在下面的表格里，对您这9次选择中的每一次，我们列出了您能够从每个产品中能获得的款项，以及在活期存款帐户中的剩余的钱。

您刚刚所做9个选择的总结

产品分配方案	任务1	任务2	任务3	任务4	任务5	任务6	任务7	任务8	任务9
重大疾病现金产品: **如确诊重大疾病**一次性得到现金	0	7万5000	15万	0	0	7万5000	15万	7万5000	15万
长期护理收入产品: 如需**长期护理**的每月收入	0	0	0	1500	3000	1500	1500	3000	3000
终身收入产品: 直到您去世的每月收入	180	196	143	149	97	117	75	66	23
活期存款帐户: 剩余退休存款	90,000	58,927	42,859	66,857	43,713	49,930	31,713	28,070	9,857

我们现在想知道您如何比较表中的9个养老产品分配方案。因此，我们将向您展示由它们构成的12种不同的组合，其中，每个组合都由3种养老产品分配方案构成，请选择出您最喜欢的一种产品配置方案，以及您最不喜欢的一种产品配置方案。

47%

上一页　下一页

选择组合1/12

以下三种养老产品分配方案，哪一个您最喜欢， 哪一个您最不喜欢?

移动鼠标到蓝色文字上方来获得更多信息。

	产品分配方案A	产品分配方案B	产品分配方案C
重大疾病现金产品: **如确诊重大疾病**一次性得到现金	0	0	15万
长期护理收入产品: 如需**长期护理的**每月收入	0	1500	3000
终身收入产品: 直到您去世的每月收入	180	149	23
活期存款帐户: 剩余退休存款	90,000	66,857	9,857

	A	B	C
最喜欢			
最不喜欢			

48%

上一页 下一页

选择组合2/12

以下三种养老产品分配方案，哪一个您最喜欢， 哪一个您最不喜欢?

移动鼠标到蓝色文字上方来获得更多信息。

	产品分配方案A	产品分配方案B	产品分配方案C
重大疾病现金产品: **如确诊重大疾病**一次性得到现金	0	7万5000	15万
长期护理收入产品: 如需**长期护理的**每月收入	1500	1500	1500
终身收入产品: 直到您去世的每月收入	149	117	75
活期存款帐户: 剩余退休存款	66,857	49,930	31,713

	A	B	C
最喜欢			
最不喜欢			

49%

上一页 1

选择组合3/12

以下三种养老产品分配方案，哪一个您最喜欢， 哪一个您最不喜欢?

移动鼠标到蓝色文字上方来获得更多信息。

	产品分配方案A	产品分配方案B	产品分配方案C
重大疾病现金产品: **如确诊重大疾病**一次性得到现金	0	15万	15万
长期护理收入产品: 如需**长期护理的**每月收入	3000	1500	3000
终身收入产品: 直到您去世的每月收入	97	75	23
活期存款帐户: 剩余退休存款	43,713	31,713	9,857

	A	B	C
最喜欢	○	○	○
最不喜欢	○	○	○

50%

上一页 1

选择组合4/12

以下三种养老产品分配方案，哪一个您最喜欢， 哪一个您最不喜欢?

移动鼠标到蓝色文字上方来获得更多信息。

	产品分配方案A	产品分配方案B	产品分配方案C
重大疾病现金产品: **如确诊重大疾病**一次性得到现金	0	15万	15万
长期护理收入产品: 如需**长期护理的**每月收入	0	0	1500
终身收入产品: 直到您去世的每月收入	180	143	75
活期存款帐户: 剩余退休存款	90,000	42,859	31,713

	A	B	C
最喜欢	○	○	○
最不喜欢	○	○	○

50%

上一页 1

选择组合5/12

以下三种养老产品分配方案，哪一个您最喜欢， 哪一个您最不喜欢?

移动鼠标到蓝色文字上方来获得更多信息。

	产品分配方案A	产品分配方案B	产品分配方案C
重大疾病现金产品: **如确诊重大疾病**一次性得到现金	15万	0	7万5000
长期护理收入产品: 如需**长期护理的**每月收入	0	3000	1500
终身收入产品: 直到您去世的每月收入	143	97	117
活期存款帐户: 剩余退休存款	42,859	43,713	49,930

	A	B	C
最喜欢	○	○	○
最不喜欢	○	○	○

51%

上一页 下一页

选择组合6/12

以下三种养老产品分配方案，哪一个您最喜欢， 哪一个您最不喜欢?

移动鼠标到蓝色文字上方来获得更多信息。

	产品分配方案A	产品分配方案B	产品分配方案C
重大疾病现金产品: **如确诊重大疾病**一次性得到现金	0	7万5000	7万5000
长期护理收入产品: 如需**长期护理的**每月收入	0	1500	3000
终身收入产品: 直到您去世的每月收入	180	117	66
活期存款帐户: 剩余退休存款	90,000	49,930	28,070

	A	B	C
最喜欢	○	○	○
最不喜欢	○	○	○

52%

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选择组合7/12

以下三种养老产品分配方案，哪一个您最喜欢， 哪一个您最不喜欢?

移动鼠标到蓝色文字上方来获得更多信息。

	产品分配方案A	产品分配方案B	产品分配方案C
重大疾病现金产品: **如确诊重大疾病**一次性得到现金	15万	7万5000	15万
长期护理收入产品: 如需**长期护理的**每月收入	0	3000	3000
终身收入产品: 直到您去世的每月收入	143	66	23
活期存款帐户: 剩余退休存款	42,859	28,070	9,857

	A	B	C
最喜欢	○	○	○
最不喜欢	○	○	○

52%

上一页 下一页

选择组合8/12

以下三种养老产品分配方案，哪一个您最喜欢， 哪一个您最不喜欢?

移动鼠标到蓝色文字上方来获得更多信息。

	产品分配方案A	产品分配方案B	产品分配方案C
重大疾病现金产品: **如确诊重大疾病**一次性得到现金	7万5000	15万	0
长期护理收入产品: 如需**长期护理的**每月收入	0	0	1500
终身收入产品: 直到您去世的每月收入	196	143	149
活期存款帐户: 剩余退休存款	58,927	42,859	66,857

	A	B	C
最喜欢	○	○	○
最不喜欢	○	○	○

53%

上一页 1

选择组合9/12

以下三种养老产品分配方案，哪一个您最喜欢，哪一个您最不喜欢?

移动鼠标到蓝色文字上方来获得更多信息。

	产品分配方案A	产品分配方案B	产品分配方案C
重大疾病现金产品: **如确诊重大疾病**一次性得到现金	0	0	7万5000
长期护理收入产品: 如需**长期护理的**每月收入	1500	3000	3000
终身收入产品: 直到您去世的每月收入	149	97	66
活期存款帐户: 剩余退休存款	66,857	43,713	28,070

	A	B	C
最喜欢	○	○	○
最不喜欢	○	○	○

54%

上一页 下一页

选择组合10/12

以下三种养老产品分配方案，哪一个您最喜欢，哪一个您最不喜欢?

移动鼠标到蓝色文字上方来获得更多信息。

	产品分配方案A	产品分配方案B	产品分配方案C
重大疾病现金产品: **如确诊重大疾病**一次性得到现金	7万5000	15万	7万5000
长期护理收入产品: 如需**长期护理的**每月收入	0	1500	3000
终身收入产品: 直到您去世的每月收入	196	75	66
活期存款帐户: 剩余退休存款	58,927	31,713	28,070

	A	B	C
最喜欢	○	○	○
最不喜欢	○	○	○

54%

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选择组合11/12

以下三种养老产品分配方案，哪一个您最喜欢， 哪一个您最不喜欢?

移动鼠标到蓝色文字上方来获得更多信息。

	产品分配方案A	产品分配方案B	产品分配方案C
重大疾病现金产品: **如确诊重大疾病**一次性得到现金	0	7万5000	0
长期护理收入产品: 如需**长期护理的**每月收入	0	0	3000
终身收入产品: 直到您去世的每月收入	180	196	97
活期存款帐户: 剩余退休存款	90,000	58,927	43,713

	A	B	C
最喜欢	◯	◯	◯
最不喜欢	◯	◯	◯

55%

上一页 下一页

选择组合12/12

以下三种养老产品分配方案，哪一个您最喜欢， 哪一个您最不喜欢?

移动鼠标到蓝色文字上方来获得更多信息。

	产品分配方案A	产品分配方案B	产品分配方案C
重大疾病现金产品: **如确诊重大疾病**一次性得到现金	7万5000	7万5000	15万
长期护理收入产品: 如需**长期护理的**每月收入	0	1500	3000
终身收入产品: 直到您去世的每月收入	196	117	23
活期存款帐户: 剩余退休存款	58,927	49,930	9,857

	A	B	C
最喜欢	◯	◯	◯
最不喜欢	◯	◯	◯

56%

上一页 1

你觉得完成前面的这些任务有多容易?

非常容易				非常困难
1	2	3	4	5

56%

上一页 下一页

第4部分：产品反馈

在接下来几页里请再次思考这三个金融产品。

57%

上一页 下一页

移动鼠标到蓝色文字上方来获得更多信息。

请对每个产品按重要性从1（最重要）到4（最不重要）分别排序：

以下产品特点哪些能使终身收入产品更具吸引力？

不同的收入方式（比如收入先多后少，或者先少后多）

固定的合同期（比如保证支付10年，即使持有人去世）

打9折

当持有人去世可获得部分退款

请点击选项进行排序

点击右侧图标，清除答案

58%

上一页 下一页

移动鼠标到蓝色文字上方来获得更多信息。

请对每个产品按重要性从1（最重要）到4（最不重要）分别排序：

以下产品特点哪些能使重大疾病现金产品更具吸引力？

覆盖更多疾病

购买时能分期付款比如每年缴费，而不是一次性付款

打9折

当持有人去世可获得部分退款

请点击选项进行排序

点击右侧图标，清除答案

58%

上一页 下一页

移动鼠标到蓝色文字上方来获得更多信息。

请对每个产品按重要性从1（最重要）到4（最不重要）分别排序：

以下产品特点哪些能使长期护理收入产品更具吸引力？

- 当持有人对以下6项（洗澡，穿衣，上厕所，上床与起床，大小便控制，吃饭）中的1至2项（而非至少3项）需要帮助就可以得到产品付款
- 产品提供一次性付款来代替每月定期付款
- 打9折
- 当持有人去世可获得部分退款

请点击选项进行排序

点击右侧图标，清除答案

59%

上一页 下一页

养老规划

接下来，我们将问您关于退休规划的态度。

60%

上一页 下一页

以下对退休财务方面的描述哪一项最符合您的想法？

- 我还没想过自己退休时需要多少存款。
- 我查过我目前的存款，并且已开始考虑自己退休时需要多少存款。
- 我十分清楚自己退休时需要多少存款，但很难实现我的储蓄目标。
- 我十分清楚自己退休时需要多少存款，并且有望实现我的储蓄目标。

60%

上一页 下一页

对许多家庭来说，退休后的总支出会发生巨大的变化，请在下方指出您的期望。

- ◯ 我的家庭预计退休后的支出不会发生变化。
- ◯ 我的家庭退休后将比以前多花钱。
- ◯ 我的家庭退休后将比以前少花钱。

61%　　上一页　下一页

在对收入考虑花多少和存多少时，人们会通过不同的时间跨度来思考。在您家庭计划消费和储蓄时，以下哪个时间跨度**最为**重要？

- ◯ 接下来几个月
- ◯ 接下来一年
- ◯ 接下来几年
- ◯ 接下来5到10年
- ◯ 接下来10年以上

62%　　上一页　下一页

当人们不再健康的时候，他们的消费习惯可能也会不一样。您如何看待自己：总体来说，您是更像人物A还是人物B？

•人物A：在身体好的时候能花尽量花，在身体不好的时候少花钱。
•人物B：在身体不好的时候能花尽量花，在身体好的时候少花钱。

请在表格里打勾：用0到10来表示更像哪类人的程度，其中0表示“更像人物A”，10表示“更像人物B”，5表示“没有区别”。

人物A										人物B
0	1	2	3	4	5	6	7	8	9	10

62%　　上一页　下一页

您有几个健在的子女？（包括亲生子女、继子女和养子女）＿＿＿ 个

63%

上一页 下一页

他们在哪居住？

- ☐ 和我住在一起
- ☐ 不和我住在一起，但在一个城市
- ☐ 和我住在不同的城市，但省份相同
- ☐ 和我住在不同的省份
- ☐ 住在其它国家

64%

上一页 下一页

他们当中多少个是男性？＿＿＿ 个

64%

上一页 下一页

以下描述多大程度上适用于您?

请在表格里打勾：用0到10来表示想留下遗产的程度，其中0表示“肯定不想”，10表示“肯定想”。

	肯定不想										肯定想
我想留下一笔遗产。	0	1	2	3	4	5	6	7	8	9	10

65%

上一页 下一页

健康状况

接下来，我们将会问您和健康相关的问题。

66%

上一页 下一页

在您经常接触的人里，您知道有人确诊或者感染了新冠肺炎吗?

- 有确诊的
- 有疑似的，但没确诊
- 没有，检测过但没确诊
- 没有，尚未发现
- 不清楚

66%

上一页 下一页

新冠肺炎给您什么样的感受?
对以下每条陈述，请用1-7来表示新冠肺炎给您的感受。
新冠肺炎:

没让我担心自身健康						让我担心自身健康
1	2	3	4	5	6	7

我能靠自身来和它对抗						让我感到无助
1	2	3	4	5	6	7

不使我焦虑						让我焦虑
1	2	3	4	5	6	7

不影响我情绪						让我沮丧
1	2	3	4	5	6	7

69% 上一页 下一页

中国女性在您这个年纪平均寿命预计达到87岁。您认为自己大概会活到多少岁? ______ 岁

70% 上一页 下一页

您的身高和体重是多少?

- 身高 ______ 厘米
- 重量 ______ 斤（注意：单位是斤（500克），不是公斤（1000克））

70% 上一页 下一页

您平时锻炼有多频繁?

- 每天
- 每周几次
- 每月几次
- 不经常锻炼

71%

上一页 下一页

您平时吸烟吗？（吸烟这里指一生中至少抽过100支烟）

- 是的，平时吸烟
- 以前吸烟，现在不吸
- 从不吸烟

72%

上一页 下一页

在过去一年里，有医生说过您有高血压吗?

- 是
- 否

72%

上一页 下一页

与其他人相比，您认为您的健康状况是以下哪种？

- 极好
- 很好
- 好
- 一般
- 较差

73%

上一页 下一页

与一年前相比，您如何评价您现在的健康状况？

- 比一年前好多了
- 比一年前好一点
- 与一年前差不多
- 比一年前差一点
- 比一年前差多了

74%

上一页 下一页

不算任何房产，您家庭所有资产的价值是多少？（包括比如银行活期存款、定期存款、国库券、股票、基金）

- 小于2000元
- 2000－9999元
- 1万－4万9999元
- 5万－9万9999元
- 10万－24万9999元
- 25万－49万9999元
- 50万－99万9999元
- 100万元以上

74%

上一页 下一页

刚才的这个问题您之前见过吗?

- 是
- 否

75% 上一页 下一页

在过去五年中，您或者其它人经历过以下事件吗？选择所有适用的选项。

	我	和我亲近的人	都没有
这个人为长辈或者亲属提供过细心积极的护理			
医生或者护士到这个人的家里进行护理			
这个人被确诊患有重大疾病（比如癌症、心脏病、中风、老年痴呆）			
这个人不能完成以下6项活动中的至少1项：洗澡，穿衣，上厕所，上床与起床，大小便控制，吃饭。			
这个人不能完成以下6项活动中的至少3项：洗澡，穿衣，上厕所，上床与起床，大小便控制，吃饭。			

76% 上一页 下一页

风险态度与耐心

接下来，我们将问您关于风险态度和耐心的问题。

77% 上一页 下一页

您如何看待自己：总体上，您是一个完全准备好承担财务风险的人，还是一个尝试规避财务风险的人？

请在表格里打勾：用0到10来表示承担风险的偏好，其中0表示“没有准备承担风险”，10表示“已完全准备承担风险”。

没有准备承担风险										已完全准备承担风险
0	1	2	3	4	5	6	7	8	9	10

77%

上一页 下一页

您如何看待自己：总体上，您是一个没耐心的人，还是一个一直非常有耐心的人？

请在表格里打勾：用0到10来表示耐心程度，其中0表示“非常没耐心”，10表示“非常有耐心”。

非常没耐心										非常有耐心
0	1	2	3	4	5	6	7	8	9	10

78%

上一页 下一页

您如何评价您对金融知识的了解程度？

- ○ 很好
- ○ 好
- ○ 一般
- ○ 差
- ○ 很差

79%

上一页 下一页

接下来，我们会问您有关普通金融素养的问题。请在不用计算器的情况下回答问题。

79% 上一页 下一页

假设您的储蓄帐户上有100元，利率是每年2%，5年后，您的帐户里会有多少钱？

- 多于102元
- 正好102元
- 少于102元
- 不知道

80% 上一页 下一页

假设您储蓄帐户的利率为每年1%，通货膨胀率为每年2%，1年后，您用这个帐户里的钱能买的东西与今天相比如何？

- 比今天多
- 跟今天一样
- 比今天少
- 不知道

81% 上一页 下一页

请判断下列陈述的真假：“购买单个公司的股票一般比买股票基金提供更安全的回报。”

◯ 真

◯ 假

◯ 不知道

81%

上一页 下一页

假设我们掷一个骰子1000次，这1000次中，您认为偶数应该会被掷出多少次？请在方框内填一个0-1000的数字。

次

82%

上一页 下一页

购买彩票时，中500元的机会为1%，如果现在有1000人，每人购买一张彩票，您认为最有可能多少人中奖？请在方框内填一个0-1000的数字。

人

83%

上一页 下一页

抽奖时，抽中一辆车的机会是千分之一，请问抽中一辆车的百分比是多少？请按百分比填写。

%

83% 上一页 下一页

性格特点

在以下问题中，请您根据自己的性格特点，指出下面的描述对您有多符合。

	一点也不符合	有一点符合	比较符合	非常符合
井井有条的	○	○	○	○
负责的	○	○	○	○
努力的	○	○	○	○
粗心的	○	○	○	○
考虑周全的	○	○	○	○

84% 上一页 下一页

社会经济信息

在以下问题中，我们将收集一些您的个人信息。

85% 上一页 下一页

您的婚姻状况是?

○ 未婚

○ 已婚

○ 离异

○ 分居

○ 丧偶

85%

上一页 下一页

您的工作单位是？请根据您最近的工作来回答。

○ 政府机构

○ 事业单位

○ 非政府组织（社团、协会、学会等）

○ 国有企业

○ 私营企业, 包括外资企业

○ 个体户或自由职业者

○ 农户

○ 从未工作

○ 其它

86%

上一页 下一页

以下哪些您拥有或正在缴费参与？【选择所有适用的选项】

□ 城镇职工养老保险

□ 城镇居民养老保险

□ 城镇职工医疗保险

□ 城镇居民医疗保险

□ 其它雇主提供的养老保险

□ 其它雇主提供的健康保险

□ 其它上述未提的商业养老保险

□ 其它上述未提的商业健康保险

○ 以上都没有

87%

上一页 下一页

扣除税收和五险一金后，您**家庭**去年的收入（包括奖金和津贴等）是多少？

- 低于4万元/年
- 4万－6万9999元/年
- 7万－11万9999元/年
- 12万元以上

87%

上一页 下一页

扣除税收和五险一金后，您家庭去年的收入（包括奖金和津贴等）具体为以下哪个阶段？

- 7万－7万9999元/年
- 8万－8万9999元/年
- 9万－9万9999元/年
- 10万－10万9999元/年
- 11万－11万9999元/年

88%

上一页 下一页

新冠肺炎的相关问题

新冠肺炎有着广泛的影响。我们想知道：
在新冠肺炎扩散之后，您的收入是如何变化的？
我的收入：

- 增加了很多
- 增加了一点
- 基本没变
- 减少了一点
- 减少了很多

89%

上一页 下一页

新冠肺炎有着广泛的影响。我们想知道:
在新冠肺炎扩散之后，您的存款是如何变化的?
我的存款:

- ○ 增加了很多
- ○ 增加了一点
- ○ 基本没变
- ○ 减少了一点
- ○ 减少了很多

89%

上一页 下一页

在新冠肺炎扩散之后，您买了以下任何保险吗?

- □ 新冠肺炎保险
- □ 重大疾病保险
- □ 长期护理保险
- □ 商业医疗保险
- □ 其它健康相关的保险
- □ 年金或者商业养老金
- □ 其他保险
- ○ 无

90%

上一页 下一页

您购买这些保险产品的主要原因是什么?

- ○ 新冠肺炎的风险
- ○ 总体上对健康风险的意识
- ○ 价格
- ○ 其他人的推荐
- ○ 周围有人购买
- ○ 其他原因，请注明

91%

上一页 下一页

新冠肺炎对经济有深远的影响。在这个时刻，您对以下有多担心：
（对以下每条陈述，请用1-7来表示新冠肺炎给您的感受。）

	完全不担心					非常担心
失去我所有的收入	1	2	3	4	5	6	7
小公司倒闭	1	2	3	4	5	6	7
中国经济衰退	1	2	3	4	5	6	7

91%

上一页 下一页

自从封锁隔离的措施变得宽松，您做过以下事情吗？

	一直避免	经常避免	有时避免	从来不避免	不适用
避免和不住一起的亲属见面	○	○	○	○	○
避免和朋友在餐馆吃饭	○	○	○	○	○
避免直接接触门或者电梯按钮	○	○	○	○	○
避免去人多的地方比如购物中心	○	○	○	○	○
避免旅游	○	○	○	○	○

92%

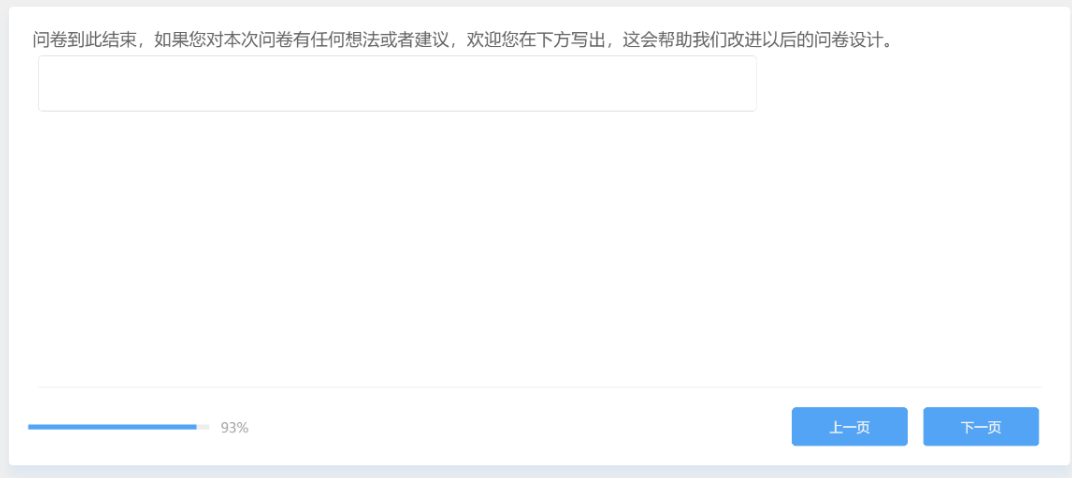
上一页 下一页

您认为此问卷的问题是否清晰易懂？

非常清晰	多数都清晰	有时清晰	有时难懂	多数都难懂	非常难懂
○	○	○	○	○	○

93%

上一页 下一页


问卷到此结束，如果您对本次问卷有任何想法或者建议，欢迎您在下方写出，这会帮助我们改进以后的问卷设计。
93%
上一页
下一页


您想要通过电子邮件或邮寄方式获知本研究的结果吗？如果是，我们可能需要您的联系方式。 请放心，您的信息将仅用于此目的。
是，我想收到研究结果。我的信息如下：
不，谢谢。
94%
上一页
下一页