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The Economic Impact of Non-communicable Diseases on Household Welfare in China

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Abstract

Introduction

The rapidly rising burden of non-communicable diseases (NCDs) in China affects the demand for healthcare services among households and threatens to create an increased financial burden on households, at a time when economic growth has been slowing down and traditional forms of inter-generational support are in decline. However, the design of effective policies to address household impacts of NCDs in China is hindered by a lack of high-quality work on the economic roots of NCDs, the impact of NCDs on households and economic gains that might result from policy action to address NCDs. This thesis aims to fill this gap by investigating the association between socio-economic characteristics and behavioural risk factors and NCD onset, by estimating the economic consequences of NCDs on current and future household welfare associated with coping strategies and by estimating the economic consequences of delayed treatment for NCDs.

Methods

This thesis consists of three quantitative analyses, all of which use longitudinal datasets. Study One uses three waves of longitudinal data from the China Family Panel Studies survey (CFPS, 2010-2014) and a dynamic model conditional on not having an NCD in the initial period to estimate the effects of behavioural and socio-economic risk factors on the onset of NCDs among individuals in China. Study Two uses the same dataset from CFPS over 2010 and 2014 and fixed-effect models to examine whether households in China can maintain consumption expenditures in the face of a new NCD diagnosis and how the households cope with the diseases and the consequences of the coping mechanisms. Study Three draws data from the

China Health and Retirement Longitudinal Study (CHARLS, 2011-2015) and applies difference-in-differences (DID) methods on a matched dataset of individuals to estimate the effects of variation in treatment timing (i.e. early versus late treatment) on healthcare use and health spending among individuals newly diagnosed with hypertension.

Results

Study One shows that being obese, using solid cooking fuels, a history of frequent drinking, and a higher level of household total consumption expenditure during the preceding period were positively associated with NCDs. More importantly, through disaggregating the effects by age subgroups, it shows that some risk behaviours one established decades ago (such as frequent drinking) have long-term and accumulative effects on health, even people have changed behaviour at older ages. Study Two reveals that (non-poor) Chinese households that experienced a substantial increase in out-of-pocket (OOP) health expenditures following an NCD shock can smooth consumption expenditure, through the depletion of housing assets and receipt of public transfers. For poor households, there was no significant increase in health expenditures and no effects on household consumption and assets, suggesting that they might abandon treatment. Both the non-poor and poor were paying the price, the first group in terms of future wealth and the second in terms of health. Study Three suggests that patients who started treatment late spent more on health services and were more likely to incur catastrophic health expenditures (CHE) once they initiated treatment, relative to counterparts who began hypertension treatment earlier. Hypertensive patients having started treatment earlier experienced declines in the probability of incurring health expenditures in the subsequent period.

Implications

In conclusion, NCDs have a long-term impact on household welfare in China. Ignoring the economic cost associated with coping with NCDs and with delayed NCD treatment, can underestimate the costs in the future. Public intervention policies to address the emerging risks of NCDs at an early stage, and insurance policies to protect individuals and households from potentially catastrophic expenses of treating NCDs are needed.

Declaration

This is to certify that:

- the thesis comprises only my original work towards the Doctor of Philosophy except where indicated in the preface;
- due acknowledgement has been made in the text to all other material used; and
- the thesis is fewer than 100,000 words in length, exclusive of tables, figures, the reference list and appendices.

Preface

The thesis was written as "Thesis with Publication". Chapters 1, 2, 3, 4, 8 and 9 were written specifically for the thesis. Chapter 5 includes the text of one published first-author paper, Chapter 6 includes the text of one manuscript submitted for publication and Chapter 7 includes one manuscript prepared for publication which is ready to submit.

In the case of all three papers, I was the initiator and primary author, contributing greater than 50% of the content in the publication. I conducted the data analysis of all three papers and I initiated and wrote the first drafts of all three paper.

The co-authors, including my principal supervisor Professor Peter Annear and co-supervisors Professor Barbara McPake, Professor Ajay Mahal and Dr Michael Palmer, assisted with the interpretation of the results and editing of manuscript drafts. As such, I have provided authorisation forms from each co-author of the published manuscripts as well as manuscripts submitted for publication. In the following instances, text from these publications has been used in this thesis.

- Text on page 73-85 is from Pan and Palmer (2019). This has been published in the China Economic Review by Elsevier on 04 April 2018. I am the first and corresponding author and I contributed more than 65%.
- Text on page 87-116 is from Pan et al (revise and resubmit). This has been submitted for publication to Health Economics by Wiley on 08 Sep 2019 and now is under Revise & Resubmit. I am the first author and I contributed more than 60%.
- Text on page 118-155 is from Pan et al (in preparation). This has not yet submitted for publication but with an intention to submit to Social Science & Medicine. I am the first author and I contributed more than 70%.

All work included in this thesis was carried out after my enrolment as a higher degree research candidate.

I received the Melbourne International Fee Remission Scholarship and Melbourne International Research Scholarship from The University of Melbourne during my candidature. I received Melbourne Abroad Travelling Scholarship, Population Health Investing in Research Students' Training Scholarship from The University of Melbourne, and travelling scholarship from Brocher Foundation to support my presence at several international and domestic research conferences.

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Sincere thanks to my mental health support, my family and friends. This work is dedicated to my parents and grandparents, who wished me to be staying with them but supported me to enter the path of higher learning in Australia. My father was an inspiration, and I believe he would be very delighted if he could see this. Thanks to Jennifer Jiang, Summer Gu and Robin Tan for always being with me, and my friends in Nossal Institute and friends at hometown Nanjing for all the support and encouragement.

I acknowledge The University of Melbourne for providing the Melbourne International Fee Remission Scholarship and Melbourne International Research Scholarship to support my PhD candidature.

Glossary of acronyms

BMI	body-mass index
CFPS	China Family Panel Studies
CHARLS	China Health and Retirement Longitudinal Study
CHE	catastrophic health expenditures
CHNS	China Health and Nutrition Survey
CNKI	China National Knowledge Infrastructure
COPD	chronic obstructive pulmonary disease
CVD	cardiovascular diseases
DALYs	disability-adjusted life years
DBP	diastolic blood pressure
DID	difference-in-differences
FE	fixed-effects
GDP	gross domestic product
GEMIS	Government Employee Medical Insurance Scheme
IHME	Institute for Health Metrics and Evaluation
IPCD	Insurance Program for Critical Diseases
ISSS	Institute of Social Science Survey
LMICs	low-and-middle-income countries
LMIS	Labour Medical Insurance Scheme
MFA	Medical Financial Assistance
NCDs	non-communicable diseases
NHSS	National Health Service Survey
NRCMS	New Rural Cooperative Medical Scheme
OLS	ordinary least squares
OOP	out-of-pocket
PHC	Primary Health Care
PSM	propensity score matching
RCMS	Rural Cooperative Medical Scheme
SBP	systolic blood pressure
SDG	Sustainable Development Goal
SES	socio-economic status
UEMIS	Urban Employee Medical Insurance Scheme
UHC	universal health coverage
URMIS	Urban Residents Medical Insurance Scheme
WHO	World Health Organisation

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Chapter 1 Introduction

1.1 Introduction

Households in China are facing a rising burden of non-communicable diseases (NCDs) and are suffering from its economic impact. An NCD is a medical condition or disease that is non-infectious and non-transmissible among people (Beaglehole et al., 2011; World Health Organization, 2005). As a chronic condition, NCDs require long-term management and control, which can have a long-term economic impact on households. The onset of an NCD in a household can divert scarce household resources to health-related expenditures and can lead to reduced income due to the reduced productive capacity of the household member with the disease. High health expenditures also create barriers for individuals and households to access quality health services when needed, by affecting their health-seeking behaviours through reduced adherence to long-term treatment and abandonment or interruption of treatment (Lexchin & Grootendorst, 2004; Tamblyn et al., 2001).

Currently, NCDs represent the most significant share of the burden of disease in China. As the country develops and undergoes an epidemiological transition, the disease burden shifts from the predominance of infectious diseases to NCDs. Globally, NCDs account for 41 million deaths annually (close to three-quarters of global deaths) (GBD Causes of Death Collaborators, 2018). In China alone, 8.6 million people died from NCDs in 2017 (comprising nearly 90% of total deaths) (Institute for Health Metrics and Evaluation (IHME), 2019a). NCDs are also estimated to be the leading cause of Disability-Adjusted Life Years (DALYs) lost, accounting for 83% of total DALYs in 2017 (Institute for Health Metrics and Evaluation (IHME), 2019a).

The rising burden of NCDs changes the health needs of the population in China. Individuals with NCDs need a combination of preventive, curative and supportive care services while avoiding financial hardship associated with seeking those services. Though China has made

significant progress since the health system reform in 2009, which aims to achieve Universal Health Coverage by 2020 (State Council, 2009), the current health system in China fails to meet such needs. The health delivery system is more hospital-centric and volume-driven, and emphasises treatment over prevention, which leads to high health expenditures. Health insurance schemes are incomplete. Health insurance schemes in China cover 95% of the population, but individuals still need to pay 36% of total health expenditures directly through out-of-pocket (OOP) payment (The World Bank, 2019e; World Health Organization Regional Office for the Western Pacific, 2015). In such settings, households draw more substantially upon their own reserves and upon informal networks (Mitra, Palmer, Mont, & Groce, 2016; Yilma et al., 2014) thereby negatively affecting the future well-being of households as inferred by literature (Genoni, 2012; Mitra et al., 2016; Sparrow et al., 2014a). Alternatively, and more tragically, individuals opt to forego treatment, which has adverse health and economic consequences for the individual and the household.

There is an increasing yet still small literature on the economic impact of NCDs on households, which is a concern considering the distribution of NCDs in China. Most studies are cross-sectional and have focused on the OOP health expenditures associated with NCD care in the current period. These studies have concluded and emphasised the need of targeted financial protection policies for those who have already been impoverished due to NCDs. However, by focusing on OOP health expenditures on current consumption and those who have been impoverished, these studies and resulting policies have ignored the long-term impact related to how the health expenditures are financed and the economic consequences of foregoing and delaying treatment (Wagstaff, 2018). For example, for individuals and households who adopt coping mechanism to maintain current consumption, they may face long-term welfare reduction caused by NCD onsets (Flores, Krishnakumar, O'Donnell, & Van Doorslaer, 2008). Social health safety network has not covered much for households who adopt costly coping

strategies and who delay treatment. If households who cope with NCDs are facing continuous economic burden in the long-term, and individuals who delay NCDs treatment are facing even greater aggregated economic burden in the future, it indicates that the economic burden of NCDs will continue to grow, under current health service delivery and health financing models. Designing new policies to provide long-term financial protection to NCD-affected households is then needed. Investigating the long-term economic impact of NCDs on households can improve the evidence base and provide policy insights on the need for long-term care insurance and other social health insurance policies and new health delivery models.

To understand more fully the long-term economic impact, it is also critical to understand the dynamics of modifiable risk factors and NCDs, which is the starting point and the most important set of considerations in tackling with the NCD disease burden and economic burden. Estimations using typical cross-section data can only capture the association of risk factors and NCDs and economic impact of NCDs at one time point. Panel data would allow one to estimate the dynamics of the association between NCDs and risk factors, and the present value of the household consumption stream in the absence of NCDs and the dynamic effect of NCDs on household welfare.

This thesis aims to provide empirical evidence to fill the gap in estimating the economic impact of NCDs on household welfare in China over time using national-representative longitudinal data.

As a conceptual framework for the thesis, I analyse three key issues to enrich our understanding of the longer-term effects of NCDs on household welfare, which can further provide justification of designing appropriate policies to address the long-term disease burden and economic burden. First, I investigate the risk factors associated with NCD onset and how the association vary at different life stages. The magnitude of the NCD disease burden is rising rapidly, suggesting that public health policies and interventions have not done enough to curb

the disease burden. Traditional epidemiological analysis of NCD risk factors that relies upon cross-sectional data, in effect, compares the effect of risk behaviours (at one time point) among a group who already have an NCD and those who do not. However, risk behaviours may change over time; and to the extent that health status changes with age, it is possible that the effect of risk behaviours on health vary over the life cycle. Cross-sectional analysis cannot observe the generational shift in behaviours and its lifetime impact. I investigate the lifetime influence of risk factors on NCDs through a dynamic model using panel data and by the disaggregation of impacts by age subgroups, particularly the younger sample. It not only informs the impacts of factors on NCD onset at different ages in the life-cycle, but also predicts the future disease burden on the current generation.

Second, I focus on those who have already had NCDs and examine how households financially cope with the NCD onset. We know from the literature that these households face high OOP health expenditures due to NCD treatment and management; however, how they fund these costs and their ability to fund the costs continuously is unknown. New evidence from the coping strategies adopted by NCD-affected households, particularly whether their adopted strategies undermine their future ability to cope with NCD, can inform us the longer-term economic consequence of NCD among who seek NCD treatment.

Third, I focus on those who fail to access to NCD treatment timely. Literature has shown that the increased level of OOP health expenditures due to NCDs can create barriers for individuals and households to access quality health services and affect their health-seeking behaviours through reduced adherence to long-term treatment and delay of treatment. Literature has demonstrated the adverse health consequence of delaying NCD treatment, but the economic impact is not clear. The aggregate health expenditures among those who postpone treatment might exceed aggregate health expenditures among those who seek treatment earlier in the longer term, even if the delayed treatment results in savings early on, and this is the hypothesis

which I seek to test in this thesis.

Thee three panel data analyses add to the literature of the economic consequence of NCDs by providing empirical evidence on the longer-term economic consequence. The results from the analyses will inform how individuals and government prioritise health spending on the prevention and long-term treatment of common NCDs. It may also shed light on the means to reduce health-related poverty and strengthen the health system, which provides various kinds of quality health services to meet population health needs while ensuring that the use of these services does not expose the household to financial hardship.

To have an overall picture of the magnitude of NCD economic burden, I include all types of NCDs in this thesis. More specifically, NCDs include circulation system diseases (such as heart diseases, stroke), cancer, diabetes and other endocrine diseases, chronic lung disease, nervous system diseases, digestive system diseases, genitourinary system disease, eye and ear diseases, skin, muscle and skeleton related disease and congenital anomalies.

In the following sections, I start with the problem statement. Then I introduce the context and state the aims and the scope of the study, and the critical research questions to be addressed. Finally, I present the structure of the thesis.

1.2 Problem Statement

NCDs pose a substantial threat to household welfare and affect labour participation, productivity and national economic growth. The burden of NCDs puts households in danger of reduced economic welfare in the long-term. Chinese households that are facing the burden of NCDs need to mobilise scarce household resources to pay for health-related expenditures because formal financial protection is insufficient. These households are confronted with a choice of opting for treatment or not. When they opt for paying for NCD-related care, they face long-term health expenditures and a potential reduction in non-health consumption

expenditures (Li, Wu, et al., 2012; Sun et al., 2009). Instead, they may choose to avoid the risks of consumption reduction by adopting costly coping strategies (Chetty & Looney, 2006; Xu, 2008), which is similar to households in other low-and-middle-income countries (LMICs) (e.g. Mitra et al., 2016; Sparrow et al., 2014a). Drawing mainly on their reserves may incur a penalty in terms of wealth creation and future capacity to cope with the diseases (Khan, Bedi, & Sparrow, 2015). Alternatively, households who choose to delay or forego treatment arguably pay a more costly price in terms of human capital creation. The economic burden of NCDs can push households into poverty in the future. In turn, the socio-economic disadvantage can increase an individual's risk of NCDs and expose them and their families to an NCD-related poverty trap.

NCDs affect national economic growth in two main ways. First, NCD influence work productivity and labour force participation. Households provide labour and capital to firms who produce goods and services, and households use the income gained through their inputs to consume the outputs of production and to invest in financing future consumption. Also, households contribute to government activities via the payment of direct and indirect taxes (World Health Organization, 2009). The long duration of NCDs leads to the reduction in work productivity and working hours of the diseased household member and potentially caregivers, which leads to an aggregate impact of a further decrease in GDP in the long run. This effect has been evident in China for some time: a 2005 study showed that the estimated losses in national income due to CVD, stroke and diabetes had reached 18 billion USD nationally (World Health Organization, 2005)

Second, NCDs challenge human capital formation. Studies have shown that improved health can increase the returns to investments in education and work experience (Bloom & Canning, 2008; Miguel & Kremer, 2004). The human capital creation is associated with prolonged healthy life span, which can increase work experience and can contribute to delayed retirement.

When the payoff periods are long, people are more willing to invest in improving skills that potentially lead to higher economic growth. However, premature death due to NCDs reduces the payoff periods, thus results in the missing opportunity of labour force participation and economic growth.

1.3 The Context

Health is a fundamental goal of development and a means of achieving it. In 2009, China unveiled its goal of providing affordable and equitable basic health care for all by 2020 (State Council, 2009). That date is approaching, but the economic impact of NCDs on households poses specific challenges for how the goal can be achieved. The extent of the economic impact that NCDs cause to households is influenced by the socio-economic context and health system, in addition to the disease itself (Jan et al., 2018).

Demographic change and economic development fuel the rising burden of NCDs in China. Over the past four decades, China has transitioned from a high-mortality and high-fertility country to a low-mortality and low-fertility country as a result of progress in combating infectious diseases and reducing child mortality and implementation of the one-child policy. These demographic changes are having and will continue to have, dramatic effects on the age distribution in China, which is moving towards an ageing society. A World Bank study in 2011 projected that the number of people with at least one NCD would increase by 40% by 2030 due to rapid population ageing (Langenbrunner, Marquez, & Wang, 2011).

Since the economic reform in 1979, the Chinese economy has been growing rapidly. The annual gross domestic product (GDP) growth rate was more than 10% between 1983 and 1988, 1992 and 1997, 2003 and 2010 (National Bureau of Statistics of China, 2019b). This social and economic transformation has brought rapid urbanisation and changed lifestyles, leading to emerging risk factors of obesity, sedentary lifestyles, stress, smoking, abuse of alcohol and

exposure to pollution and traffic accidents (The World Bank, 2016).

The health system can play a crucial role in mediating the pathways between NCDs and adverse economic impact on households. However, households in China are still facing challenges of cost escalation and health inequities. Beneficiaries of health insurance schemes have to bear more than 50% of their inpatient and outpatient expenditures (Yip et al., 2012). Population coverage of health insurance schemes in rural areas is about 50% lower than in urban areas (Meng & Tang, 2013). China needs to develop new models of health financing and delivery in response to the population needs that relate to the increasing burden, and the economic burden, of NCDs on households. If the system fails to prevent NCDs through reducing risk factors and fails to ensure financial protection to households with members having NCDs, an increasing number of people will die from NCDs, and the welfare loss to households will be substantial.

Creating a health system that protects individuals and their households from the economic impact of NCDs is vital if the UN's Sustainable Development Goal (SDG) of poverty reduction is to be achieved (Jan et al., 2018). China has made massive progress during the past decades in alleviating poverty, but the economic impact of NCDs threatens further progress. Using a poverty headcount ratio at 1.9 dollars per day (2011 PPP), the proportion of the population living below the poverty lines dropped from 66.2% to 0.7% between 1990 and 2015 (The World Bank, 2019h). However, there were still nearly 4 million households that were trapped in poverty or fell into poverty because of diseases in 2017 (People's Daily, 2018). Vulnerable people are at a higher risk of being exposed to risk factors that contribute to the development of NCDs and have higher mortality from NCDs (World Health Organization Regional Office for the Western Pacific, 2007). They have less access to health services with good quality, and fewer resources to cushion NCD shocks. For those who are above the poverty line, studies have suggested that these near-poor households affected by an NCD are more likely to become impoverished due to the high health OOP payments associated with treatment in China (Sun et

al., 2009) as well as in other LMICs (Kankeu, Saksena, Xu, & Evans, 2013; Kien et al., 2016).

The economic growth rate in China has been slowing down in recent years, posing challenges to maintain a healthy and productive population and to sustain efforts in poverty reduction in the long run. China needs reforms in the health sector as the high growth rate of health expenditures due to a volume-driven system would be hard to maintain. To build a health system that meets the needs for quality health services associated with NCDs without financial hardship, now and into the future, it is crucial for policymakers to understand what is lacking in the current health system. While China is facing an increasing burden of NCDs, little is known about the economic impact of NCDs on household welfare in the long term. A better understanding of the long-term economic impact associated with NCDs could be the starting point for health policymakers to confront the increasing burden and the increasing costs of NCDs.

1.4 Aims and Scope

This thesis aims to investigate the economic impact of NCDs on household welfare over time in China to inform the development of appropriate public policies and interventions, improve access to health services associated with NCDs and reduce the financial risks to household welfare. More specifically, this thesis aims:

(1) to understand the association of modifiable risk behaviours and NCD onset in China to provide an evidence base for policy development to protect households from the rising NCD burden.

(2) to estimate the economic consequences of NCDs on current and future household welfare associated with household coping strategies following a diagnosis of an NCD and to understand the potential welfare gain brought by increasing financial protection.

(3) to evaluate the economic consequences at the household level of delayed treatment for

NCDs on individuals' health care utilisation and health expenditures to provide economic justification to design appropriate programs to motivate timely treatment for NCDs.

1.5 Research Questions and Methods

1.5.1 Research Questions

To estimate the economic impact of NCDs on household welfare over time, I pose the following research questions:

(1) What are the risk factors associated with NCDs in China?

(2) To what extent do households in China maintain consumption in the face of an NCD shock?

(3) What coping mechanisms do households use to cope with increased expenses and loss of income associated with NCDs, and what are the consequences on the individual and household well-being?

(4) What are the economic consequences for households of delaying NCD treatment, related to the individual's health utilisation and health expenditures?

1.5.2 Analytical Framework

I follow three analytical frameworks to estimate the economic impact of NCDs on household welfare over time. The first is the intertemporal consumption model with income uncertainty (e.g. Deaton, 1992); second is the welfare cost model of an income shock developed by Chetty and Looney (2006); the third is the health production function proposed by Grossman (1972).

The basic idea of the intertemporal consumption model is that consumption is determined not by current income but by permanent income (Friedman, 1957). The model assumes that consumption does not change over the short term when the household receives new information, such as an onset of NCDs. Under the short-term consumption smoothing assumption,

households can maintain consumption in the presence of unexpected NCD shocks and risky incomes. The extent to which households smooth short-term consumption provides important implications on developing public policies in LMICs.

The welfare cost model by Chetty and Looney (2006) suggests that consumption smoothing is not an adequate indicator for welfare since households may maintain consumption because of risk aversion. The basic idea is that welfare costs (thus need for social safety nets) may be large even where income shocks do not cause large consumption fluctuations if households undertake costly coping strategies to smooth consumption. Therefore, it is essential to investigate how households manage to maintain consumption expenditures.

The health production function (Grossman, 1972) suggests that current health status is a function of current and past health inputs among other things. Individuals demand good health in its own rights and as an investment commodity because health determines the healthy time available for other activities. Households who invest in health (e.g. healthy behaviours, seeking health care services) will enjoy future gains in health. Conversely, those who forego health inputs will experience no change or a relative decline in health status in the future.

These three frameworks guide the investigation of how Chinese individuals and households manage their health (e.g. undertaking healthy or risky behaviours) that contribute to NCDs, how Chinese households cope with an NCD diagnosis (including seeking health services and not seeking care), and what the consequences of NCDs are on individual and household current and future well-being.

1.5.3 Data

I use longitudinal data to estimate the economic impact of NCDs on household welfare over time. Longitudinal data enables a more extended period to observe changes in behaviours and outcomes and allows for controlling several sources of endogeneity. The most complete panel

datasets available in China are the China Family Panel Studies (CFPS) and the China Health and Retirement Longitudinal Study (CHARLS). Both datasets contain health, as well as socio-economic information, and they are used in this study.

1.5.4 Methods

I use quantitative methods to answer the research questions. I use panel data models while addressing the critical sources of endogeneity, including unobserved heterogeneity, simultaneity and measurement error, to provide more robust analysis. These models and methods include the fixed-effect model, dynamic lagged model, propensity score matching and difference-in-differences analysis. I elaborate on them in the Methodology Chapter.

1.5.5 Study Design

This thesis consists of three related studies:

Study one: Risk factors and non-communicable disease diagnosis in China

The rise of non-communicable diseases has placed enormous stress on households and health systems, leading to calls for improved prevention. This study estimates the dynamic effects of risk factors on the diagnosis of NCDs (as a proxy of NCD onset) in China using three waves of the longitudinal data from the China Family Panel Studies survey (2010-2014) and a dynamic model conditional on not having an NCD in the initial period. By focusing on the healthier NCD-free population and identifying risk factors associated with the onset of an NCD for the at-risk population, this study informs the scope of the NCD problem. It provides important information from a prevention point of view. In particular, this study looks at the lifetime impact of risk factors on NCDs through their roles at different stages in the life-cycle.

Study two: Coping and not coping with the non-communicable disease in China

Based on what leads to an NCD onset in China, this study examines whether households can maintain consumption expenditures in the face of a newly acquired NCD and how Chinese

households cope, for example, by selling assets, borrowing money, foregoing treatment, or similar strategies. The second question is important because the welfare costs (and thus the potential national economic gain from expanding social safety nets) may be substantial despite limited fluctuations in consumption levels if households are willing to undertake costly coping strategies to smooth consumption. Also, I examine the future consequences on health outcomes, non-health consumption expenditure and wealth associated with increased health expenditures in the previous period. I use three waves of the longitudinal data from the China Family Panel Studies survey (2010-2014) and fixed-effect models. This study adds to the picture the long-term impact of sacrificing future consumption to accommodate current health spending.

Study three: The economic consequences of delayed treatment: Hypertension in China

Building on study two on the consequences of coping with an NCD, this project investigates the economic consequences for households associated with delayed treatment for NCDs. Literature has established that delaying or no treatment for hypertension can lead to more adverse health outcomes, including increased risk of cardiovascular events such as stroke and myocardial infarction and death (Dahlof et al., 1991; Sandoval et al., 1994; Xu, Goldberg, Shubina, & Turchin, 2015). However, little is known about the economic impact associated with delayed treatment, particularly in LMICs (Kankeu et al., 2013). Delaying hypertension treatment can potentially be economically more problematic if the long-term overall health expenditures among those who postpone treatment exceed expenditures among those who seek treatment earlier. I illustrate the economic impact of delayed NCD treatment on individuals' health care utilisation and health expenditures using the example of hypertension. I use three waves of the China Health and Retirement Longitudinal Study (2011-2015) and conduct a difference-in-differences analysis on a matched set of hypertensive individuals to estimate (1) the effects of variation in treatment timing (i.e. early versus late treatment) on healthcare use and healthcare cost at the time treatment was first initiated; and (2) the dynamic effects on

healthcare use and healthcare cost, depending on the length of treatment. Findings on the economic impact for households associated with delayed treatment imply potential gains are likely where the individual and household can use timely curative health services.

1.6 Structure of the Thesis

The thesis comprises chapters including introduction, literature review on the economic burden of NCDs on households, the context of China and its health system, and a chapter on methodology. It also includes three articles (which are published, submitted or under preparation for publication) on questions related to the subject matter of the thesis, and chapters providing a discussion and conclusion.

Chapter Two, Literature Review, includes existing evidence on risk factors and NCDs, the evidence on the economic impact of NCDs on households and the health shock literature in China and identifies the gap in the literature. Chapter Three, Background, includes the national and health-system context in China. Chapter Four, Method offers a detailed description of the data, and outlines frameworks and empirical methods. Chapters Five to Seven correspond to the three studies. Chapter Eight discusses the implications for the measurement and interpretation of the economic impact of NCDs on household welfare over time, and the policy implication to inform the design of public policies and interventions to address the increasing burden and economic burden of NCDs. Chapter Nine concludes.

Chapter 2 Literature Review

2.1 Introduction

The purpose of the review is to understand the emerging burden of non-communicable diseases (NCDs) in China and the economic impact of NCDs on households and to bring into sharper focus existing gaps in knowledge related to this research. The review contains three sections. Section 2.2 presents the conceptual framework to understand the causes of NCDs and available literature on the burden of NCDs and risk factors in China. Section 2.3 presents a conceptual framework of the economic consequences of diseases and provides insight into analysing the economic burden of NCDs at the household level. Section 2.4 examines the health shock literature to understand the link between health and household welfare in terms of coping strategies. Section 2.5 summarises the existing knowledge gaps in the literature. The first is the lack of a robust estimation of NCDs and risk factors that provides an understanding of the magnitude of the NCD problem and dynamics between risk factors and NCDs. The second gap is the long-term economic impact of NCDs on household welfare.

2.2 The Literature on the Burden of Non-Communicable Diseases and Risk Factors

This section starts with a conceptual framework to guide the literature search on the risk factors and NCDs. There are four categories, the socio-economic, demographic and cultural factors, non-modifiable factors such as age, modifiable behavioural factors and metabolic risk factors. Existing literature showed that key risk factors included unhealthy diet, smoking, high blood pressure, high BMI and outdoor and indoor pollution. Traditional epidemiological analysis of NCD risk factors that relies upon cross-sectional data, in effect, compares the effect of risk behaviours among a group who already have an NCD and those who do not. However, risk behaviours may change over time; and to the extent that health status changes with age, the

effect of risk behaviours on health may vary over the life cycle. A robust estimation between NCD onset and a more extensive set of risk factors, including demographic, socio-economic, lifestyle and environmental factors is needed.

2.2.1 Conceptual Framework to Understand the Causes of NCDs

A non-communicable disease is a medical condition or disease that is non-infectious and non-transmissible among people. An NCD has a prolonged course and requires a long-term and systematic approach to treatment (Beaglehole et al., 2011; World Health Organization, 2005). Currently, NCDs are the leading causes of death and disease burden worldwide, accounting for 40 million deaths annually (close to three-quarters of global deaths) (GBD Causes of Death Collaborators, 2018). The four main types of NCDs include cardiovascular diseases (CVDs), cancer, chronic lung disease and diabetes.

The main risk factors for NCDs among individuals are well known and are similar in all countries. As demonstrated in Figure 2.1, socio-economic, demographic and cultural factors underpin the increasing burden of NCDs. Changes in the social and economic environment have resulted in the rise and spread of behavioural risk factors for NCDs. For example, economic development led to improved food supply towards a high-fat, high-energy-density and low-fibre diet which associated with obesity. Modifiable behavioural risk factors include tobacco use, physical inactivity, unhealthy diet and the harmful use of alcohol. Metabolic risk factors include raised blood pressure, overweight and obesity, high blood glucose and abnormal blood lipids (World Health Organization, 2019).

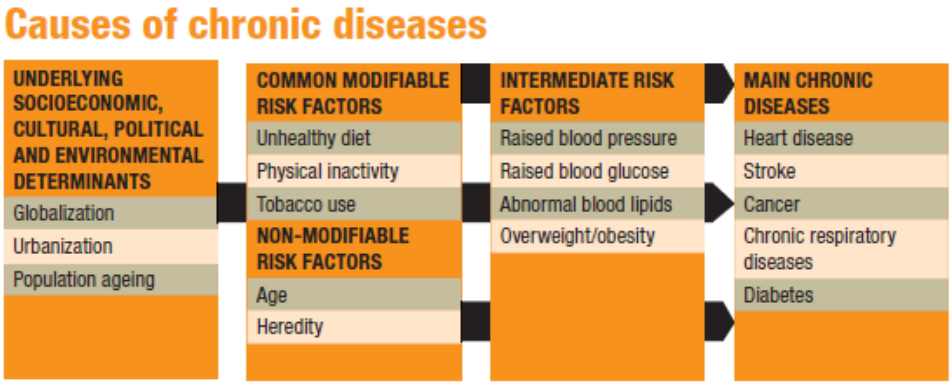

Figure 2.1 Causes of Chronic Diseases (World Health Organization, 2005)

To identify existing literature on the risk factors associated with NCDs in China, I searched PubMed and Web of Science for English-language published articles and the China National Knowledge Infrastructure (CNKI) for Chinese-language articles, both from inception to May 12, 2019. I used combinations of the following keywords: "non-communicable disease", "chronic disease", "chronic illness", "hypertension", "high blood pressure", "cardiovascular", "stroke", "heart disease", "cancer", "diabetes" and "chronic respiratory disease" with "risk factor", "influencing factor", "determinant" and China. There were 771 studies in English and 729 studies in Chinese.

2.2.2 Evidence on the Association between NCD and Risk factors in China

NCDs represent the most significant share of the burden of disease in China, comprising nearly 90 per cent of total deaths) (Institute for Health Metrics and Evaluation (IHME), 2019a). Not surprisingly, there is a rapidly growing literature on the risk factors associated with NCDs in China.

Original studies in the literature differed in the data source. There were three main types of data sources: national and provincial surveillance data, project-based data and household survey data. The surveillance data includes routinely collected data but usually lacks individuals and household socio-economic factors. Examples of data include information gathered from the China Chronic Disease and Risk Factor Surveillance Survey and the Global Burden of Disease

Study. Projects-based data is usually from health screening programs and specific research programs that recruit the general population from communities or patients from hospitals. Examples include the National Stroke Screening and Intervention Program and the China Kadoorie Biobank Study. Household survey data contains more information on socio-economic factors but relies on self-reported data, which is potentially less accurate. Examples include the China Health and Nutrition Survey (CHNS), the China Health and Retirement Longitudinal Study (CHARLS) and the National Health Service Survey (NHSS).

The majority of the studies covered by my review considered NCDs in a very broad sense. For example, the Global Burden of Disease study revealed that the leading risk factors for NCD-related death and disability in China were dietary risks of low fruit and high sodium consumption, tobacco use, high blood pressure, air pollution and high body-mass index (Institute for Health Metrics and Evaluation (IHME), 2019b; Yang et al., 2013). Using data from the 2010 China Chronic Disease and Risk Factor Surveillance Survey, Li, Wang, Jiang, Zhang, and Wang (2013) identified the prevalence of main risk factors for chronic NCDs among Chinese females: low prevalence rates of insufficient intake of fruit and vegetables, overweight and obesity and raised blood pressure, which were 51.7%, 32.3% and 29.7%, respectively. Being more than 35 years old, poorly educated and being a resident of eastern or central China independently increased the likelihood of having multiple risk factors.

Several studies using a cohort study design examined the risk factors and NCDs. They focused on metabolic, behavioural and environmental risks and focused on NCDs. For cardiovascular diseases, increased blood pressure, atrial fibrillation, heavy drinking behaviour and smoking have been documented as the leading risk factors (He et al., 2009; Lao et al., 2009; Li et al., 2016; Wang et al., 2018). Hypertension, diabetes mellitus, overweight, smoking and family history of stroke are the independent risk factor for stroke (Li, Pang, Li, & Zhao, 2019; J. Wang et al., 2017; Xia et al., 2019). For diabetes and related diseases, a high body-mass index (BMI),

dyslipidemia, low intake of whole grains but high intake of refined grains, low physical activity, high blood pressure, waist circumference beyond 85 cm for men and beyond 80 cm for women have been shown to have significantly contributed to the Chinese diabetes burden (Chen et al., 2018; Li & Hu, 2018; Xu et al., 2013; Yang et al., 2010). Smoking, passive smoking, air pollution and solid fuel use have been identified as the leading causes for chronic obstructive pulmonary disease (COPD), lung cancer and chronic respiratory diseases (He et al., 2009; Lin, Murray, Cohen, Colijn, & Ezzati, 2008). Tobacco smoking, chronic infections, low fruit and vegetable intake and drinking alcohol were found to be the main risk factors contributing to cancer in China (Islami et al., 2017; Wang et al., 2012).

Several studies investigated the associations between NCD prevalence or onset and socio-economic factors, mainly using data derived from household surveys. Most of these studies have associated low socio-economic status as indicated low education, unemployment, low income or poverty status, rural residence, or living in a less developed central region of China with an increased probability of NCD onset (Li, Zhang, Jiang, & Wu, 2012; Yang et al., 2013; L. J. Zhang et al., 2014; Zhu et al., 2015). However, not all of these findings are in the same direction. Using data from large scale cross-sectional surveys, several studies found that being a resident in urban settings, living in economically developed regions or belonging to high-income families was associated with a higher probability of diabetes (Xu, He, Wang, & Ware, 2018; Xu et al., 2013). On the other hand, using two waves of data from a longitudinal household survey CHNS and an objective blood pressure measure, Lei, Yin, and Zhao (2012) found no wealth and education gradients in the prevalence of hypertension.

2.2.3 A Summary of the Literature on Risk Factors for NCDs

Several findings from the current literature are noteworthy. First, the majority of the studies examined NCDs in the aggregate, and the risk factors for NCDs identified in the literature were similar, including unhealthy diet, smoking, high blood pressure, high BMI and outdoor and

indoor pollution.

Second, existing studies that used a cohort study design were limited to metabolic, behavioural and environmental risks, most of which did not address much on the socio-economic factors. A robust estimation between NCD onset and a more extensive set of risk factors, including demographic, socio-economic, lifestyle and environmental factors, is thus needed.

Third, studies that have included socio-economic factors drew upon cross-sectional data and essentially provided simple associations between risk factors and NCD onset. These studies did not typically control for unobserved heterogeneity and the two-way causality between risk factors and NCD onset. If unobserved factors are associated with indicators of risk and with the probability of having an NCD, then the resulting estimates of the strength of association will be biased (Greene, 2012). For example, motivation and will power are associated with physical exercise, which is related to the onset of disease. Individuals with unhealthy behaviours are more likely to develop an NCD, but at the same time, the diagnosis of an NCD can change their behaviours. Without mitigating possible bias associated with reverse causation from disease onset to changes on risk behaviours, the estimated effects from risk factors to NCD onset could be biased.

2.3 The Literature on the Economic Impact of Non-Communicable Diseases on Households in China

In this section, I present the key findings on direct costs, including out-of-pocket (OOP) health spending, indirect cost including loss of labour-days and income and household welfare. Overall, the literature shows that NCDs pose huge burden on households as individuals and families incurred high OOP health expenditure and faced reductions in work productivity and income due to the illness. Such a burden often stresses households' capacity to pay, thereby invoking informal coping strategies to cope with NCDs. However, no studies have investigated

the long-term economic impact of NCDs on the household in China.

2.3.1 Existing Evidence on the Economic Impact of Non-Communicable Diseases on Households in the International Context

There is a growing number of studies on the economic impact of NCDs on households in China and other low-and-middle-income countries (LMICs). Globally, six different literature reviews have examined the available evidence on the economic burden on households in LMICs of diseases including NCDs (Alam & Mahal, 2014; Essue et al., 2017; Jan et al., 2018; Jaspers et al., 2015; Kankeu et al., 2013; McIntyre, Thiede, Dahlgren, & Whitehead, 2006). Considering that the emerging burden of NCDs in most LMICs may have similarly significant adverse impact on the livelihoods of populations living in these settings, I start by summarising existing knowledge and gaps on the economic impact of NCD on households in the expended geographical range of LMICs and the estimation methods.

In general, these reviews of literature in the context of LMICs concluded that NCDs pose a heavy financial burden on affected households regardless of income levels, but that low-income families were the most financially affected. They also identified important knowledge gaps in understanding the long-term economic impact of NCDs.

McIntyre et al. (2006) analysed the literature on the economic consequences for households of illness and health care use. The focuses included OOP health spending and labour days loss, and coping strategies and its economic consequences. It included 61 papers, and concluded that health care financing strategies which had placed considerable emphasis on OOP payments could impoverish households in LMICs. However, the studies examined in this review included but not limited to NCDs or chronic diseases. One of the critical contributions is that the authors developed an analytic framework to describe the channels through which diseases can affect the economic welfare of households. This framework has been adopted in several studies

thereafter, such as Kankeu et al. (2013) and Alam and Mahal (2014).

Kankeu et al. (2013) reviewed literature with a specific focus on the financial burden from NCDs in LMICs, which was the first review on this topic. They identified 49 papers between 1990 to 2014. In addition to the substantial variations in study designs and definitions among the studies, they found that most of the studies rely heavily on convenience samples and self-reported data. Without addressing these issues, the results from these papers may be biased. Though with the methodological concerns, their results suggested that NCDs posed a heavy financial burden on many affected households; poor households were the most financially affected when they seek care. These financial costs have deterred many people suffering from NCDs from seeking the care they need.

Alam and Mahal (2014) reviewed more recent empirical literature on measuring the following three economic impacts of health shocks on households, namely OOP health spending, labour supply responses, and non-medical consumption. In particular, they only included studies that sought to correct for the likely endogeneity of health shocks, which helped rest these conclusions on a much stronger empirical foundation. Among all of the 105 papers included, only 8 of them examined the impacts of non-communicable diseases. They generally showed that households containing members with chronic diseases incurred higher levels of OOP healthcare expenditure than those without, and household member labour force participation declined as a consequence. The evidence of consumption smoothing was mixed among three available studies, and there was no robust study examined coping strategies. They suggested additional research on measuring economic implications of non-communicable diseases for households and analyses based on longitudinal data.

Jaspers et al. (2015) conducted a systematic review of the literature evaluating the global economic impact of six NCDs (coronary heart disease, stroke, type 2 diabetes mellitus, cancer, chronic obstructive pulmonary disease and chronic kidney disease) on households and

impoverishment. They identified 64 studies from inception to November 2014, and found that the majority were from the Americas and Western Pacific WHO region. They found that financial catastrophe and impoverishment due to the NCDs existed in all countries and at all income levels. However, the impacts that NCDs on households and impoverishment were likely to be underestimated. Because coping strategies were not considered, and those who do not seek health care due to financial reasons have been overlooked in the literature.

Two more recent reviews synergised evidence on the household economic burden of NCDs and summarised findings on catastrophic health expenditure (CHE): catastrophic health expenditures have incurred in more the 60% of NCD-affected populations (Essue et al., 2017; Jan et al., 2018). These two reviews found that households reported selling assets or calling on family and friends as financing strategies to pay for health care for NCDs, and there may exist challenges of motivation and adherence of treatment due to the long-term cost associated with treatment and management of NCDs. Both suggested several research areas in the future. Longitudinal research is needed to estimate the long-term impact on household NCD burden, and to monitor progress in mitigating CHE and impoverishing health expenditure.

2.3.2 Conceptual Framework to Analyse the Economic Consequences of NCDs on Households

I adopt the framework developed by McIntyre et al. (2006) to guide the search of the literature on the economic impact of NCDs on households in China and to present the key findings on direct costs, including OOP health spending, indirect cost including loss of labour-days and income and household welfare.

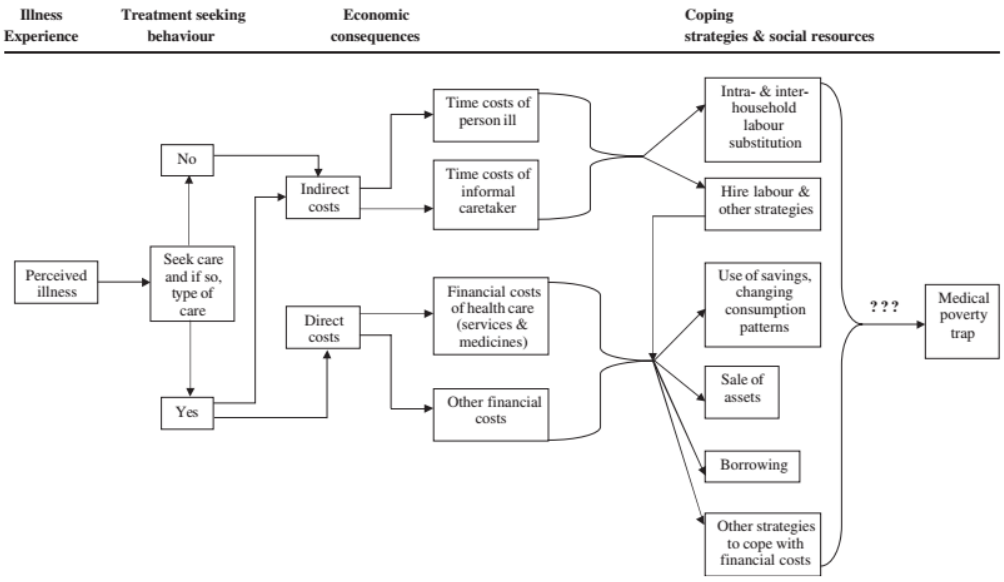

Fig. 1. Simplified flow-chart of key issues relating to the economic consequences of illness.

Figure 2.2 The economic impact of diseases on the household (McIntyre et al., 2006)

I employed a literature search with Web of Knowledge, PubMed, and CNKI, using the combinations of the following keywords: "non-communicable disease", "chronic illness", "chronic disease", "diabetes", "cardiovascular disease", "heart disease", "hypertension", "stroke", "cancer", and "chronic respiratory disease" and "out-of-pocket", "catastroph*", "impoverish", "health expen*", "health spending", "financial burden", "hardship", "absenteeism", "productivity loss", "income", "coping", "consumption", "welfare" and "household*", "famil*", and "China".

The literature in China remains small compared to the enormous burden of NCDs in the country. A total of 472 results were obtained. After excluding studies on the effects of socio-economic status on NCDs, cost-effectiveness analysis and studies that only contained health expenditures acquired from hospitals, 63 potential papers and theses retrieved. Following a review of abstracts, 47 papers were included.

2.3.3 Direct Costs of NCDs on Households

The vast majority of the studies used household survey data to examine the direct costs

associated with NCDs. Outcomes considered in the literature included OOP health spending, the percentage share of OOP in family income or consumption expenditures, and the incidence of CHE.

NCDs in general

Several studies showed that the presence of NCDs or chronic disease was significantly associated with higher OOP health expenditures (Shi et al., 2011; Xie, 2011; You & Kobayashi, 2011). For example, pooling six waves of the longitudinal CHNS data and using two-part model, Xie (2011) found that patients with any of the three NCDs (hypertension, diabetes and stroke) experienced 47% higher health expenditures relative to the general population. Using the CHARLS dataset for 2011, Wang, Li, and Chen (2015) found that the OOP healthcare payments among middle-age and elderly (aged over 45 years old) households with chronic disease patients was nearly two times of that of households without chronic disease patients in 2011 (approximately USD 510 vs USD 262).

It has been documented in the literature that the percentage of households experiencing CHE was higher among NCD-affected households, with differential impacts across NCD-affected households in urban and rural areas and across socio-economic levels. Most of the studies defined CHE as involving OOP health payments exceeding 40% of a household's non-food expenditure. Using data of 55,556 households from the National Health Service Survey (NHSS) in 2008, Li, Wu, et al. (2012) found that across China, the rate of CHE occurrence was ten percentage points higher among households chronic conditions versus those without (13% versus 23%). Using the same survey, Y. Xu et al. (2018) found that in Shaanxi Province, the occurrence rate of CHE among households with members with chronic diseases was 24.3% in rural areas and 19.2% in urban areas, respectively, in 2008. The gap in the occurrence rate of CHE narrowed in 2013: 23.6% of households in rural areas and 24.9% of households in urban areas experienced CHE. Wang et al. (2015) used one wave from the CHARLS data to examine

the incidence and intensity of CHE among elderly households with chronic disease patients. Contrary to the Y. Xu et al. (2018) study, the incidence of CHE was still higher among rural households with chronic disease patients, compared to that in the urban area (30.6% vs 22.0%).

The poor households, who were affected by NCDs, were found to be more likely to incur CHE (Huang, Xiang, Li, & Gu, 2017; Ma, Shang, Chang, & Yin, 2015; Shi et al., 2011; Sun et al., 2009; Wang et al., 2015; Xu et al., 2019). For example, Xu et al. (2019) used a sample of 7,700 households from the NHSS in Jilin province in 2013 and found that the poorest 20% of households had almost half of them with CHEs while the wealthiest 20% of households had the lowest proportion (less than 5%).

Cardiovascular diseases

I identified 15 studies that used household survey data to examine the OOP health spending associated with CVDs and the incidence of CHE. Ten studies looked at hypertension, and the proportion of households experiencing CHE varied from 7% among rural households in inhabited areas in Western China to 20% among rural households in Chongqing (Chen, Qian, & Feng, 2016; Xiao, Zhong, Wang, & Tang, 2016). Five studies examined the health spending associated with stroke. For example, Li, Cai, and Cui (2018) drew data from a multistage stratified random sampling survey, including 3,909 rural households in Yunnan province in 2015 and found that 83 households reported having patients with stroke. There were 47% of these stroke-affected households experienced CHE. Using multivariable logistic regression, they found that the odds ration of experiencing CHE was ten times for stroke-affected households compared to non-affected households. Four studies looked at CVDs as a combination. Using self-reported chronic disease measure from two waves of CHARLS (2011 and 2013), Li, Young, and Jian (2018) found that among 2,568 respondents in 2011 and 3056 respondents in 2013 that reported having CVDs, 44.2% and 48.1% of them experienced CHE in 2011 and 2013 respectively. Huffman et al. (2011) surveyed 290 recently hospitalised CVD

patients in China and found that 70% of patients from the low-income group (the lowest 40%) and 35% from the high-income group (the highest 20%) experienced CHE.

Diabetes

Diabetic patients pay a considerable proportion of medical costs from their pockets. This percentage ranged from 12.8% in Shanghai to 66.9% of annual income for a rural population in Shangdong (Wang et al., 2009; Xu, Feng, Ni, Li, & Wang, 2011). The incidence of CHE varied from 14% in Shandong Province to 22% in Shaanxi Province (Jing et al., 2019; Sun, Yan, Xue, & Gao, 2018)

The presence of complications is usually associated with an increase in the direct medical cost among diabetic patients. For example, Wang et al. (2009) collected individual-level outpatient and inpatient cost information from 20 hospitals in four cities in China and found that the direct medical cost for patients with two complications was nearly double compared to patients without complications. Patients with complications spent a higher proportion as direct OOP payment (44.6% vs 40.4%). For each increase in the number of complications, there was about a 33% increase in annual direct medical cost (Wang, Fu, Zhuo, Luo, & Xu, 2010).

Cancer

Five studies estimated the direct OOP cost associated with cancer. In a cross-sectional survey of 2356 patients diagnosed with colorectal cancer in 37 tertiary hospitals in 13 provinces in China, the one-year OOP health expenditures accounted for 60% of their previous-year household income. It caused 75% of families to perceive an unmanageable financial burden (H. Huang et al., 2017). Mao, Tang, Zhu, Xie, and Chen (2017) used data from Urban Employee's Basic Medical Insurance claim in 2008 and found that among the 2091 insured cancer patients, the average OOP as the proportion of household's capacity to pay was 87.3% in Chongqing, 66.0% in Fuzhou, 33.7% in Beijing and 19.6% in Shanghai. Leng, Jing, Nicholas, and Wang

(2019) revealed that for 792 cancer patients who died between July 2013 and June 2016, about 40% of the health care expenses incurred in the last three months of life, and was mainly driven by hospital costs which accounted for about 70% of end-of-life expenditures.

2.3.4 Indirect Cost of NCDs on Households

The evidence on the effects of NCDs on labour supply and income is much more limited compared to that on health spending. Four studies focusing on CVDs showed that CVDs could lead to a substantial decrease in work time. For example, in a study using household survey in Shandong and Ningxia among 2741 households, Li, Yu, Meng, and Wang (2008) found self-reported lost working days due to heart disease was 5.2 and 4.7 days per week, in two provinces respectively. Using a multistage stratified random sampling in three townships in rural Shangdong, Wang (2007) surveyed 167 patients diagnosed with stroke and found that they reported losing 207 working days on average, and 35.5% of them required attendance from family members, which resulted in an additional loss of 165.4 days on average from family members.

Four studies provided evidence on the loss of working time due to other NCDs using self-reported data from the household survey. Using data from a cross-sectional survey of 2356 colorectal cancer patients in 37 tertiary hospitals in 13 provinces in China between 2012 and 2014, H. Huang et al. (2017) found that the mean reported time loss amounted to 95.9 person-days, including 54.0 person-days for patients and 41.9 person-days for caregivers. In rural Shangdong, COPD patients lost 225 working days on average in 2007 (Yuan et al., 2010). The mean loss of working time reported by diabetic patients varied from 4.6 days in Shandong to 12 days in Shanghai (Li et al., 2008; Zhang, 2009).

Three studies examined the income loss due to NCDs in general or more widely, health shocks. Using panel data and a fixed-effects specification, Lindelow and Wagstaff (2005) found that

health shocks, as measured by a worsening of self-rated health by one rating, led to a reduction in earned income by 6.2%. Two cross-sectional studies examined the effect of CVDs on the loss of income. Huffman et al. (2011) found that the proportion of 290 CVD-affected household in China, 14.3% of the households in the high-income group (top 20%) and 40.9% of the households in the low-income group (the lowest 40%) experienced decreases in household income due to CVDs but the exact amount was not reported. Sun et al. (2003) used data from a household survey in rural Liaoning and reported that individual annual net income among stroke patients was 27% lower compared with those who without.

2.3.5 The Impact of NCDs on Household Welfare

The OOP health spending and household income loss resulting from NCDs can potentially lead to reduced household welfare. Existing studies examined three primary outcomes to understand the effects of NCDs on household welfare: effects on non-health consumption, impoverishment due to NCDs and coping strategies.

Five studies examined the effect of NCDs or chronic diseases on household non-food consumption expenditures. Using data collected from 2,899 households in three cities in Western China and applying a multivariate regression model, Fang, Jiang, Shia, and Ma (2012) found that the presence of chronic disease was negatively associated with the percentage of basic consumption as of the total consumption expenditures. Using six waves of the longitudinal CHNS, Xie (2011) found that patients with any of the three NCDs (hypertension, diabetes and stroke) experienced a 33% decrease in non-health consumption. Using household survey data among 6147 rural households in Ningxia and Shandong provinces, Sun et al. (2009) found that expenditure for chronic diseases accounted for an average of 27% of annual non-food per capita expenditure in Shandong and 35% in Ningxia. There were around 15% of families in both provinces incurring CHE due to chronic diseases. In a household survey among 2741 households, Li et al. (2008) found that direct medical cost on diabetes took up to 42%

and 53% of non-food expenditures in Shandong and Ningxia; and that on heart disease took up to 38% and 33% respectively. Wang, Zhang, and Hsiao (2006) used data from a community-based rural health insurance study in poor rural areas of China in 2002, and they analysed 4,553 households included in this survey. They found that chronic diseases led to a 7% decrease in foods consumption and decreases in non-food consumption, including a 17% decrease in expenditures spent on clothes, 15% in expenses associated with social activities and 10% decrease in durable goods.

Twelve studies measured the likelihood of medical impoverishment using an indicator of the percentage of households that were pushed under the poverty line after incurring OOP health expenditure associated with NCDs. They found that households with chronic diseases were more likely to fell into poverty after paying for health services. For example, Jiang, Ma, Zhang, and Luo (2012) used a sample comprising 39,054 rural households in NHSS in 2008 to investigate medical impoverishment due to chronic diseases. They defined medical impoverishment happened when the total household expenditure is equal to or larger than the food-based poverty line (USD 355.1 in 2008), but household expenditure minus out-of-pocket health payment is smaller than the food-based poverty line. Before paying for health care, 14.3% of households with chronic patients were under the poverty line, and the proportion increased to 24.8% after medical payment. The percentages of households without members having chronic diseases pre- and post-payment was 15.6% and 20.8%. Among the non-poor families, those in the lowest family income quintile with a chronically ill patient were 30 times more likely than those in the highest family income quintile to be impoverished because of health spending. Similarly, using a poverty line USD 1.08 per day and household survey data from 2006 linked to claims records of health expenditures, Yip and Hsiao (2009) found that medical spending increased the poverty headcount by 40.7% (or 9.1 percentage points) for chronic disease patients, compared to 22.9% (7.0 percentage points) for patients without chronic

conditions.

Coping mechanisms that households engage in following an NCD onset have important implications for understanding household welfare. However, there were only four studies that examined the strategies families adopted to cope with NCDs. The most commonly used strategies were dissaving and receiving remittance from relatives and friends. Only one study used longitudinal data to examine the effects of NCDs on receiving remittance and found that NCDs increased the probability of receiving remittance by 2.4% and increased income from private transfer by 18.7% (Xie, 2011). The remaining three studies relied upon cross-sectional data and used self-reported information on the financial sources used to pay for OOP health expenditures. Among households with hypertension patients in Western China, 42.5% reported financing medical costs with their income or savings, 40.6% through support from their children, and 13.5% from borrowing (Cui et al., 2011). Among households with members diagnosed with diabetes in rural Shandong, the share of those using income, receiving remittances from relatives or friends, and using savings to finance medical expenditure was 63.8%, 31.7%, and 20.2% respectively (Wang, Sun, Liu, & Meng, 2013). By contrast, a study of 5,097 households in three cities (Lan Zhou, Gui Lin and Xi An) in China showed that households containing individuals with chronic diseases could cover OOP expenditures with their regular income, without adopting other strategies (Fang, Shia, & Ma, 2012).

2.3.6 A Summary of the Literature on the Economic Impact of NCDs on Households in China

The number of studies examining the economic impact of NCDs on households in China is still relatively limited. Overall, existing evidence showed that households with NCD members bore a high burden of OOP health expenditure and faced reductions in working time and income due to the illness. The high OOP health expenditure often stressed households' capacity to pay, thereby invoking informal coping strategies to cope with NCDs.

There are several noteworthy findings. First, most studies looked at chronic diseases or NCDs in combination, but the definitions used varied across studies. For example, Shi et al. (2010) defined a chronic ailment as an ailment that lasted for at least 12 months, resulting in functional limitations or the need for ongoing medical services and includes disability. Sun et al. (2009) defined chronic disease as an illness or symptom with at least three months of continuous duration or intermittent presentation within the last 12 months. For studies that draw data from the NHSS, their chronic diseases also included chronic infectious diseases such as malaria (e.g. Sun et al., 2018; Xiao et al., 2016). These studies included a wide range of conditions rather than just NCDs. For studies that focused on specific NCDs, cardiovascular diseases and diabetes were the most investigated disease. The number of studies on the effect of cancer and chronic respiratory diseases was small.

Second, with regards to the type of economic impact investigated in the study, a great number of studies investigated the direct health expenditures associated with NCDs; much fewer studies provided evidence on indirect cost and the effects of NCDs on household welfare. NCDs require long-term care; however, no studies investigated the long-term economic impact of NCDs on the household.

Third, the existing studies relied heavily on convenience samples in cross-sectional settings, and most of the analyses did not address potential endogeneity biases. When the information was acquired from household surveys, there can be potential measurement bias related to self-reports of diseases and household income and expenditures.

2.4 Health Shocks Literature

The review in the previous section suggests that the evidence on the effects of NCDs on household welfare was limited, and they usually took a partial approach, analysing the drop in household consumption caused by NCDs and ignoring the coping mechanisms adopted by

NCD-affected households (e.g.Sun et al., 2009; Wang et al., 2006). In this section, I review the evidence on the effects of health shock on household welfare and the coping strategies adopted by households in LMICs, and the effects of chronic infectious diseases (such as tuberculosis, malaria and hepatitis) on household welfare and the coping strategies in China, which may be relevant for analysing how health payments are financed among households in China.

2.4.1 Health Shocks Literature in LMICs

In LMICs, the shocks literature has focused on natural, economic and environmental shocks which affect households in a certain geographical area (e.g. Frankenberg, Smith, & Thomas, 2003; Kochar, 1999). Recently, more attention has been given to the idiosyncratic health shocks faced by households (Alam & Mahal, 2014). Health shocks are among the major and most harmful shocks to household welfare in LMICs, leading to the most considerable income losses and triggering more coping strategies than non-health-related shocks (Wagstaff & Lindelow, 2014; Yilma et al., 2014).

The early health shocks literature concentrated on the question of whether households can smooth consumption in the face of a health shock (e.g. Gertler & Gruber, 2002; Wagstaff, 2007). The welfare cost of shocks, and hence, the potential value of formal insurance programs, has been analysed through consumption-smoothing regressions (Wagstaff & Lindelow, 2014). In the context of Indonesia, Gertler and Gruber (2002) found that households were unable to fully insure the economic costs of illness that affected physical functioning. In Ethiopia, Abay and Joachim von (2004) found that households could maintain food consumption but could not maintain non-food consumption against illness. In Vietnam, Wagstaff (2007) revealed that households spent less on food consumption following a health shock.

Following Chetty and Looney (2006), who showed that consumption was not an adequate indicator for welfare since households may maintain consumption because of risk aversion,

recent papers have investigated the risk-coping strategies employed by households in the event of a health shock (Islam & Maitra, 2012; Khan et al., 2015; Mitra et al., 2016; Sparrow et al., 2014a; Wagstaff & Lindelow, 2014). The basic idea is that welfare costs (thus need for social safety nets) may be large despite income shocks not causing large consumption fluctuations if households are highly risk-averse and undertake costly coping strategies to smooth consumption. For instance, households maintain consumption expenditures against health shocks through borrowing and drawing upon family networks in Indonesia (Sparrow et al., 2014a); through increased borrowing, sale of productive assets, and decreased education expenses in Vietnam (Mitra et al., 2016); through the sale of productive assets in Bangladesh (Islam & Maitra, 2012; Khan et al., 2015); and through dissaving in Laos (Wagstaff & Lindelow, 2014).

The current literature used a range of health shock measures with limited focus on NCDs. These include self-reported symptoms or illness (Sparrow, Suryahadi, & Widyanti, 2013; Yilma et al., 2014), functional limitation such as days unable to carry out activities of daily living (Genoni, 2012; Gertler & Gruber, 2002; Liu, 2016; Mitra et al., 2016) and hospitalisation (Mitra et al., 2016; Wagstaff, 2007). The general problem is that these measures may capture both unexpected changes in health that are temporary as well as persistent (Genoni, 2012; Sparrow et al., 2014b). NCDs have a prolonged course and require a long-term and systematic approach to treatment. The financial risks and behaviours of households may likely differ between persistent and short-lived health shocks. The extent to which households can smooth consumption due to anticipated and unanticipated variation in the health of a family member is also of interest (Strauss & Thomas, 2008).

Four studies provide robust estimations on the effects of NCDs or chronic diseases on household consumption and the channel through which they maintain consumption in LMICs settings. In the context of Sri Lanka, Kumara and Samaratunge (2017) investigated the impact

of NCD onset on household consumption and found households sacrificed food consumption. However, they did not identify NCD as an unexpected shock to households and did not examine the associated coping strategy. Mirelman (2014) found that households used financial coping strategies, mainly through reducing expenditure on food and utilities, to cope with an adult NCD death in Matlab, Bangladesh. Although the measure in this study, NCD death, was an objective measure, mortality was a short shock rather than persistent. Abegunde and Stanciole (2008) provided evidence on the economic impact of chronic disease in Russia. They found households were able to insure non-health consumption against chronic diseases, through informal coping mechanisms irrespective of insurance cover. Gertler and Gruber (2002) used a measure of chronic symptoms and found no effect on household consumption. Chronic symptoms were defined as self-reported symptoms that lasted more than one month, which by the authors own admission may or may not be chronic or long-lasting.

There were a few cross-sectional studies that examined coping strategies through convenience sampled interview and surveys without addressing endogeneity issues; thus, their results are not discussed here (e.g. Azzani, Yahya, Roslani, & Su, 2017; Okediji et al., 2017).

2.4.2 Evidence on Health Shocks and Household Welfare in China

Three studies looked at the impact of health shocks on household welfare in China using longitudinal data and assessed the extent of risk protection afforded by health insurance. The evidence on the effect of health insurance on mitigating health shocks on households is mixed.

Using four rounds of the CHNS data over the period 1991-2000 and fixed effects regressions, Lindelow and Wagstaff (2005) examined the impact of a health shock, as measured by the worsening of self-rated health of the household head, on medical spending, income and labour supply. The authors found a health shock leads to a 5-6 per cent reduction in income and labour supply and a 9 per cent increase in medical spending. The poor benefited from in-kind transfers

from family and friends in the event of a health shock. However, the transfers comprised only a small portion of total income and were insufficient to insure the negative effects of the health shock on income. Using the same dataset from CHNS over seven waves between 1993 and 2011 and a first-difference regression, Liu (2016) examined the impact of a different health shock, as measured by changes in the number of days unable to carry out daily activities of the household head and spouse, on household income, food consumption and medical spending. The author found that households can fully insure household income and food consumption in the face of a health shock and associated increase in out-of-pocket medical expenditures. However, there was a negative impact on individual earnings which was consistent with the earlier study finding of reduced labour supply. A health shock on the household head or spouse leads to a decrease in school enrollment and productive investments and an increase in child labour. These effects were mitigated by access to health insurance. Zhang, Gan, Xu, and Yao (2014) used a sample of households in 48 Chinese villages for the period 1986-2002 and studied the dynamic effects of major health shocks, defined as medical expense accounted for more than 25% of household net income. Their results showed that health shock caused the reductions in household income per capita and productive assets by 16.2% and 75% respectively, and an increase in borrowings by more than 100%. They further found that having access to health insurance at the village level helped alleviate the average negative impacts of health shocks on income by almost half.

2.4.3 Evidence on Chronic Infectious diseases and Household Welfare in China

There were three studies investigated the impact of chronic infectious diseases on household welfare and the coping strategies in China. Using a cross-sectional study design among 435 patients with tuberculosis (TB), Liu et al. (2020) found that TB-related health care caused 26% of TB-affected households to fall below the poverty line. Patients in the poorest households had the highest poverty headcount ratio (70%). Nearly half of TB patients adopted coping

strategies to finance their health expenses, and half of them borrowed money. In addition, one-third of TB patients experienced food insecurity and social exclusion. Another study investigated the economic effects of TB cases on poverty in rural China. Using a case-control study design on patient-reported data, the authors found that there was statistically significant association between poverty and TB. There were 66% of the TB-affected households borrowed from relatives and friends, 45% sold productive assets (e.g. tractors, draft animals) and 8% borrowed from banks (Jackson, Sleigh, Wang, & Liu, 2006). Using a qualitative study design, Hutchison, Khan, Yoong, Lin, and Coker (2017) conducted five focus group discussions and 47 in-depth interviews with patients with TB or multidrug-resistant tuberculosis (MDR-TB). Most of the interviewed patients reported impoverishment due to TB treatment and care, and they relied on multiple resources of funding, including selling their crops and household assets, taking out loans and relying on family members.

2.4.4 A summary of the Health Shock Literature

To accurately determine the welfare costs associated with health shocks, and therefore, the consequences of insurance policies, it is necessary to learn why and how households smooth consumption (Chetty & Looney, 2006). The existing literature suggested that households in China as well as in other LMICs may be highly risk-averse in the event of a health shock, implying that social insurance could have a substantial role to play in the management of ex-ante and ex-post financial risk.

However, few studies provided insights into the coping mechanisms associated with NCDs and among those that did they either relied upon cross-sectional data and did not address unobserved heterogeneity or include a limited number of coping strategies (Jaspers et al., 2015). Besides, the contemporaneous effects of health shocks on household economic outcomes and coping mechanisms as reported in previous papers were inferred to impact negatively on the future well-being of households. The question has been little empirically tested.

2.5 Gaps in the Literature

This chapter analysed the literature on NCDs and risk factors in China, the economic impact of NCDs on households in China and health shock literature in LMICs to explore the current understanding of the emerging disease burden and economic burden of NCDs. Through reviewing the literature, I find that there are few robust analyses of the association between risk factors and NCDs, and little is known on the long-term economic impact of NCDs on households in China. The gaps in literature have been summarised as follows.

To begin with, most studies on risk factors for NCDs drew upon cross-sectional data and did not control for the unobserved heterogeneity and the two-way association between risk factors and NCD onset thus the results can be biased. In addition, risk behaviours may change over time; and to the extent that health status changes with age, it is possible that the effect of risk behaviours on health vary over the life cycle. Little is understood on the dynamic effects of risk factors and NCDs. Most previous studies in China were limited either to demographic and behavioural risk factors or to demographic and socioeconomic factors. Restricting these studies to a focus on only limited risk factors provides too little evidence for a full understanding of how risk factors contributed to NCDs in China.

More importantly, this literature review identified a significant gap in understanding the long-term economic impacts of NCDs on households. The long-term nature of NCDs and the OOP costs associated with ongoing treatment can create a long-term financial burden on households. Little is known about how direct costs and indirect costs of the management of NCDs evolve over time and how these costs affect household welfare in the long-run. Estimations using typical cross-section data can only capture economic impact of NCDs at one time point. Panel data would allow one to estimate the present value of the household consumption stream in the absence of NCDs and the dynamic effect of NCDs on household welfare. However, the availability of such panel data – with both information on individual NCD status and household

economic outcomes over a long period – is limited in China. When long-term panel data is unavailable, our understanding of the long-term consequences of NCDs on household welfare can be enriched through analysing how health payments are financed and the consequences of the coping mechanisms (Flores et al., 2008; Wagstaff, 2018).

Lastly, all the available studies focused on the economic consequences among those who sought medical treatment. However, the costs, both direct and indirect, associated with lack of timely treatment and foregoing treatment can be substantial, particularly in the long run. Little is known about the health and economic consequence for those who do not seek care, particularly among those who forego treatment due to financial reasons.

2.6 Summary

Current studies on risk factors and NCDs showed that unhealthy diet, smoking, high blood pressure, high BMI and outdoor and indoor pollution contributed to NCDs in China. The existing literature looking at the short-term economic impact of NCDs on households suggested that NCDs posed a heavy financial burden on affected households, and can eventually lead to loss of human capital and poverty.

This review identifies two main gaps in the literature to understand the economic impact of NCDs on household welfare over time in China. The first is the lack of a robust estimation of NCDs and risk factors that provides an understanding of the magnitude of the NCD problem. Improved understanding of the factors associated with NCD onset can help to ensure that risks are delayed to the oldest possible age and are not preceded by long and costly periods of morbidity.

The second gap is the long-term economic impact of NCDs on household welfare. More specifically, how households cope with NCDs and the subsequent consequences of the coping strategies, and the economic consequences of delayed treatment for NCDs. Ignoring the cost

associated with coping strategies can underestimate the long-run burden of health payments. Ignoring the impact of delayed treatment can affect how individuals and government prioritise health spending on the prevention and long-term treatment of common NCDs.

This thesis aims to fill the gaps in current literature to enrich our understanding of the economic impact of NCDs on household welfare over time in China to inform the development of appropriate public policies and interventions, improve access to health services associated with NCDs and reduce the financial risks to household welfare.

Chapter 3 Background

3.1 Introduction

This background chapter describes the context of China and the health system in China. I start with a brief introduction of the international context of the rising burden of NCDs in section 3.2. In section 3.3, I summarise the demographic change and economic development over the past four decades. In section 3.4, I describe how economic development fuels the rising burden of NCDs, thereby leading to changes in the health needs of the population. Then in section 3.5, I describe how the health system in China has developed over the years alongside economic reform and the key challenges the health system is currently facing to meet population needs. Section 3.6 concludes that demographic and economic changes lead to the emerging burden of NCDs. With the moderating economic growth rate, this NCD burden poses challenges to maintaining a healthy and productive population in the long run.

3.2 The International Context

Globally, NCDs are the leading cause of global disease burden, contributing to approximately three-quarters of total deaths in 2017 (GBD Causes of Death Collaborators, 2018), with over 85% of premature mortality occurring in LMICs (World Health Organization, 2019). The socio-economic, demographic and cultural factors underpin the increasing burden of NCDs. Changes in the social and economic environment have resulted in the rise and spread of behavioural risk factors for NCDs.

The growing burden of NCDs along with technological innovation in health care and the increasing demand for health care service have posed challenges to the affordability of health care for households and governments. The extent to which households can afford vary by disease, health system and the socio-economic context across countries (Jan et al., 2018).

Health systems, including both the service delivery system and social health insurance schemes can play an important role in mediating the pathway between NCDs and economic welfare. Many LMICs have reformed their health systems to provide financial risk protection, ensure access to quality essential health care services and affordable essential medicines. For example, through expanding financial protection through social health insurance (e.g. Thailand, China), tax-financed health care (e.g. Thailand, Costa Rica), and innovative, small-scale funding mechanisms such as health equity funds (e.g. Cambodia, Laos) (Jan et al., 2018; McIntyre, Ranson, Aulakh, & Honda, 2013).

3.3 The Demographic and Economic Context of China

China is moving towards an ageing society. China is the most populous country in the world, with nearly 1.4 billion people (The World Bank, 2019i). In the past 70 years, China has undergone a significant demographic change, including decreasing population growth and an ageing population. The annual population growth rate has been decreasing from 1.3% in 1980 to 0.6% in 2017 (The World Bank, 2019g). The decline in population growth is due primarily to the one-child policy, which was introduced in 1979. Before the policy, the fertility rate was 5.9 births per woman in 1970; then it fell dramatically to 2.9 births per woman in 1979, and 1.5 in the late 1990s and remained stable (Zeng & Hesketh, 2016). As the people born before 1970 are reaching old age, the percentage of the population aged over 65 years grew from 4.7% in 1980 to 10.6% in 2017 (The World Bank, 2019f).

Over the past 40 years, China experienced rapid growth in its economy, leading to rapid urbanisation and massive but uneven progress in poverty reduction. China has transformed from a highly planned and centralised economy to a dynamic market economy. Since the economic reform in 1979, the Chinese economy has been growing strongly. The annual gross domestic product (GDP) growth rate was more than 10% between 1983 and 1988, 1992 and 1997, 2003 and 2010 (National Bureau of Statistics of China, 2019b). In 2010, China became

the second-largest global economy after the USA in terms of GDP and joined the upper-middle-income country group.

During the same period between 1979 and 2019, China experienced rapid urbanisation, with the urban population rising from 19% of the national population in 1980 to 29% in 1994 and progressed even faster since, escalating to 50% in 2010 (Chen, Liu, & Tao, 2013). However, rapid urbanisation also enlarged urban-rural disparities. In 2018, the disposable income per capita in urban areas was almost three times that in rural areas, and the consumption expenditures per capita in urban areas were more than twice that in rural areas (National Bureau of Statistics of China, 2019b). The Hukou system, an institution controlling population movement for most of China's rural population, contributes further to the rural-urban inequality (Chan & Buckingham, 2008). The hukou system influences access to a range of resources, services and opportunities, such as education, urban employment, housing and health care (Liu, 2005).

The rapid economic growth and urbanisation fuelled tremendous but uneven progress in poverty reduction in China. Using a poverty headcount ratio at 1.9 dollars per day (2011 PPP), the proportion of the population living below the poverty lines dropped from 66.2% to 0.7% during 1990 and 2015 (The World Bank, 2019h). However, the progress is uneven across provinces (Montalvo & Ravallion, 2010). A report delivered by the United Nations Development Programme showed that the lowest 25% of National Poor Counties in terms of living standard, were mainly distributed in Western China such as Tibet, Qinghai and Gansu (United Nations Development Programme China, 2016).

3.4 The Rising Burden of NCDs

Demographic change and economic development fuel a rising burden of NCDs, which changes the health needs of the population. With economic development, China has transitioned from a

high mortality and high fertility country to a low mortality and low fertility country. The infant mortality rate dropped from 47.2 per 1000 live births in 1980 to 8.0 in 2017 (The World Bank, 2019c), and the under-five mortality rate dropped from 62.3 per 1000 live births in 1980 to 9.3 in 2017 (The World Bank, 2019d). During the same period, China has experienced an improved food supply towards a high-fat, high-energy-density and low-fibre diet (Du, Lu, Zhai, & Popkin, 2002; Wang, Mi, Shan, Wang, & Ge, 2007), which leads to a significant reduction in malnutrition and improved health status. Life expectancy at birth has increased substantially, from 35 years in 1949 to 67 years in 1980 and 76 years in 2017 (The World Bank, 2019b). Meanwhile, the social and economic transformation brought urbanisation and changed lifestyles, leading to emerging risk factors of obesity, sedentary lifestyles, smoking, abuse of alcohol, stress and exposure to pollution and traffic accidents (The World Bank, 2016).

NCDs have become the most significant disease burden in China. The percentage of death caused by NCDs has increased from 70% in 1990 to nearly 90% in 2017 (Institute for Health Metrics and Evaluation (IHME), 2019a). Cardiovascular and cerebrovascular diseases, cancer and chronic respiratory diseases were the leading causes of death, together accounting for 79.4% of total deaths in 2012 (National Health and Family Planning Commission, 2015). The morbidities associated with NCDs increased significantly. According to cancer registration data from the National Cancer Center in 2013, there were 3.09 million new cases. The morbidity was 235 per 100,000 population (National Health and Family Planning Commission, 2015). Since 1989, cancer morbidity has increased at a rate of 2.4% per year (male at 2.0% and female at 3.0%, respectively) (National Health and Family Planning Commission, 2015). Incidence from atherosclerotic cardiovascular disease increased from less than 250 per 100,000 population in 1990 to nearly 500 per 100,000 population in 2016 (Zhao, Liu, Wang, Zhang, & Zhou, 2019). The prevalence of diabetes was reported to be less than 1% in 1980, 5.5% in 2001, 9.7% in 2008, and 10.9% in 2013 (Hu & Jia, 2018).

Economic reform has led to increased income inequality, which also has an impact on health inequality across provinces, between and within rural and urban areas (Zhang & Kanbur, 2005). Lower-income groups in China have a higher prevalence of NCDs compared to the rest of population; at the same time, they are also less likely to seek health care, suggesting that they are more vulnerable to the burden of NCDs (Cai, He, Song, Zhao, & Cui, 2013; Langenbrunner et al., 2011).

The rising burden of NCDs changes the health needs of the population. Individuals and households with NCDs need a combination of preventive, curative and supportive care services, and need to be able to access these without financial hardship. In the meanwhile, rising incomes and levels of education contribute to population demands for more and better health services. China needs a health system that can effectively meet such needs.

3.5 Health System in China

China has made progress in improving the health outcomes of its citizens through building a stronger primary care health system to address the infectious disease, and more recently in moving towards universal health coverage. However, the rapidly rising burden of NCDs affects the health needs of individuals and families, which poses new challenges. In the following sections, I describe the development of China's health system over the past seven decades and summarise the challenges the current system is facing in the context of a rising burden of NCDs and decreasing economic growth.

3.5.1 Health System Development

The development of China's health system since 1949 can be summarised into four stages: highly centralised planned system before 1979, decentralisation and adapting to the establishment of the market economy between 1979 and 2002, development of the public health system and basic social health insurance schemes since 2003, and the new round of

health care reform since 2009.

During its early years, China established a highly centralised planned economic system. The health system in China was also subject to a highly centralised unified plan, management and development. Faced with the high infant and child mortality and massive prevalence of infectious diseases, China managed to build a basic health service delivery system in the rural and urban areas. It emphasised primary health care and focused on disease prevention. According to the financial policies during this period, public hospitals, public clinics and anti-epidemic institutions were all government-owned and received government funds for infrastructure and personnel. During the same time, China started to build its medical insurance schemes at a low level but with broad coverage. The schemes consisted of a rural cooperative medical scheme (RCMS), government employee medical insurance scheme (GEMIS), and labour medical insurance scheme (LMIS). China made great achievement with limited available health resources.

With the economic reform and opening-up policy in 1979, the health system focused on adapting to the establishment of the market economy. The core of the reform included "decentralisation of power and benefits" and increasing financial autonomy of public hospitals, meaning that hospitals need to increase user charges and drug mark-ups to generate revenue. Government budget funds were mainly used to subside public health facilities and support rural areas. In cities, the government aimed to improve the efficiency of health facilities and rebuilt the community medical system, but it provided insufficient political and economic support. For health insurance, the coverage of RCMS in rural areas dropped dramatically from 90% in 1976 to 5% in 1985, primarily due to the transformation from the collective economy to the household responsibility system (Song, 2002). In urban areas, GEMIS and LMIS both experienced difficulties. The government needed to pay premiums for civil servants and private sectors needed to pay for their employees. These two schemes relied on a single fundraising

channel and lacked effective control of health costs, therefore the government and private sectors faced heavy burden. In 1994, an Urban Employee Medical Insurance Scheme (UEMIS) was initiated to provide financial protection for urban employees. However, the profit-seeking behaviour of public hospitals and lack of sufficient financial protection for patients made it difficult and costly for employees and residents to access medical services. OOP health expenditure accounted for over 60% of total health expenditures in 2001.

Following the severe acute respiratory syndrome (SARS) outbreak in 2003, the government developed a new public health system and disease surveillance system. Between 2003 and 2008, there was a rapid development of the Basic Medical Insurance Scheme; the New Rural Cooperative Medical Scheme (NRCMS) was founded in 2003 and Urban Residents Medical Insurance Scheme (URMIS) in 2007 to provide health insurance for rural residents and urban residents who were not employed or not in the labour market. In 2007, the government established the Medical Financial Assistance (MFA) scheme to provide financial protection for the poor by providing a subsidy for premium costs and a potential further subsidy for OOP payments.

In March 2009, the government issued a guiding policy document, “Deepening the Health System Reform”, aiming to achieve universal health coverage by 2020. The main tasks included expanding health insurance coverage, strengthening the capacity of the delivery system, establishing an essential drug system, expanding public health services and reforming public hospitals.

Currently, China has established a multi-level social health insurance scheme covering over 95% of its residents. The scheme consists of three components, UEMIS, URMIS and NRCMS, covering both urban and rural residents. Since 2009, China has extended the health service package of the social health scheme. Per capita fund for resident-based health insurance increased from 100 Chinese Yuan in 2008 to 700 Chinese Yuan in 2018, and 70% were from

government subsidies (Meng, Mills, Wang, & Han, 2019). The multi-level scheme is supported by MFA and with supplements from the Insurance Program for Critical Diseases (IPCD), Civil Servant Medical Insurance and private insurance. In 2017, 56.2 million people (4% of the population) received subsidies to pay for their social health insurance premiums through MFA, and received on average ¥757 (about 12% of average inpatient spending per admission in 2017) to cover OOP expenses (Fang, Eggleston, Hanson, & WU, 2019). The IPCD was established in 2012, aiming to provide further financial protection for the high medical expenditures of patients with a critical illness. A certain percentage (decided by the local governments) of the fund of each scheme is reserved for the IPCD. Thus beneficiaries can get reimbursement for medical expenses over the set ceiling. By 2017, more than a billion people in China were covered by IPCD and 11 million people received extra benefits (Fang et al., 2019). More recently, at the end of 2015, the Chinese government has announced the decision of integration of basic health insurance systems of rural and urban residents (Xinhuanet, 2015), with an aim to achieve UHC and narrow the disparities in access to healthcare service and in healthcare costs existed between different insurance schemes.

China has improved the health delivery system. The centre for disease prevention and control, health supervision institutes, maternal and childcare institutes and grassroots level healthcare centres now provide public health services. Government primary healthcare facilities provide basic medical services, and general hospitals and specialised hospitals provide outpatient and inpatient services.

3.5.2 Current Challenges

Though China has made an effort to build primary healthcare services and expand health insurance schemes, the current health system is still treatment-focused and volume-driven, leading to high health expenditures while not maximising health outcomes for the whole population. This model is hard to maintain because firstly, a treatment rather than control and

prevention focused approach to the rising burden of NCDs, will continue to lead to cost escalation; and secondly, the lower-pace of economic growth in recent years makes it difficult to support high health expenditures in the long run.

There are shortcomings in both service delivery and health financing models. Service delivery has a strong bias toward treatment rather than prevention, which is not sustainable, especially for NCDs. Both urban and rural patients can freely choose primary care or hospital providers for service, but people tend to visit secondary and tertiary hospitals rather than at primary care level. A WHO report showed that outpatient visits at secondary and tertiary levels were 12 times higher than at primary level in 2012 and the inpatient service use were 17 times at the higher level of health facilities compared to at primary level (World Health Organization Regional Office for the Western Pacific, 2015).

The volume-driven delivery system leads to devastatingly high health expenditure. The higher the level of the medical provider patients choose, the higher the medical cost and the OOP cost to patients. Total health expenditure as a proportion of GDP increased from 4.5% to 5.0% between 2000 and 2016. Health expenditures increase continuously at a rate higher than GDP growth (The World Bank, 2016). Since 2002, the growth rate of health expenditures per capita remained at 13% and rose to 36% in 2008 and 19% in 2012 (The World Bank, 2019a). At the system level, the direct health expenditures associated with NCDs was USD210 billion in 2005 and was projected to grow to over USD500 billion by 2015 (Bloom et al., 2013). The total economic impact of the five major NCDs was projected to be over USD27 trillion for the period between 2012 and 2030 (Bloom et al., 2013).

These rapidly increasing health expenditures challenge the health insurance schemes in providing financial protection to households. China has achieved close to universal population coverage, but the health service benefit package and patient financial reimbursements of these schemes are incomplete and unequal. Consequently, households and individuals have to bear a

certain share of high health costs. Table 3.1 shows the benefit coverage, collection and pooling mechanisms for the insurance schemes. The beneficiaries of health insurance schemes need to pay OOP health expenditures for outpatient health services and pay partially for inpatient expenses (deductibles, co-payments and over-the-ceiling payments).

Table 3.1 Overview of the statutory financing system

		Coverage			Collection		Pooling of funds	
		Breadth	Scope	Depth	Government health expenditure	Social insurance contribution	Financial transfer payment	Insurance funds
Basic medical insurance	UEBMI	Employees and retirees in urban areas	Inpatient/ outpatient/ pharmacy services in designated institutions	Deductible, copayment and ceiling settings for eligible fees listed on the insurance drug/ diagnostic and therapeutic items/ medical services list		Individual and employer. At least 2% and 6% respectively of annual income		Personal accounts and pooling of funds
	URBMI	Unemployed residents (students included) in urban areas	Inpatient services as a priority, cover outpatient services if possible		√	Individual and government subsidy	√	Pooling of funds
	NRCMS	Residents in rural areas			√		√	
MFA		Poor			√		√	
IPCD						√		Pooling of funds

Source: World Health Organization Regional Office for the Western Pacific (2015)

As shown in Table 3.1, the scope, depth and pooling of funds vary across different schemes and between different regions, impacting on health service utilisation pattern and health expenditures on different population segments. The level of per capital fund, individual contribution and reimbursement level varies across the three basic medical insurance schemes. In 2013, NRCMS funds were pooled at the county level (2489 rural counties). The per capita fund was 370 Chinese Yuan, and rural residents contributed 18% of it; URBMI funds were pooled at the municipal level (333 municipalities). The per capita fund was 360 Chinese Yuan, and urban residents contributed 22% of it. For UEBMI, individual and employer contributed

at least 2% and 6% respectively of annual income (Wang et al., 2020). As of 2018, the per capita fund was approximately 4190 Chinese Yuan per person of UEBMI, compared to 780 for URBMI and 660 for NRCMS (Yip et al., 2019). The reimbursement level of the NRCMS is far below that of UEBMI and URBMI. The reimbursement rate for inpatient care was 68%, 48% and 44% for UEBMI, URBMI and NRCMS, respectively, in 2011 (Fu et al., 2014). It is worth mentioning that the annual reimbursement ceiling was also much lower for NRCMS. This is because the population average income determines the reimbursement ceiling. More specifically, for UEBMI, URBMI and NRCMS, it was six-times average wage of employees in the city, six-times disposable income of local residents in the city and six-times income of local farmers (Yu, 2015). Though each city has different policies, the actual reimbursement for outpatient care was always much less compared to inpatient care because of the relatively high deductible and low ceiling, and the low reimbursement rate.

Compared with urban residents, the disparity of funds and reimbursement has had a significant impact on individuals in rural communities accessing and using health care and receiving financial protection. For example, a study showed that the incidence of health impoverishment decreased from 7% to 5% between 2010 and 2016. However, the decrease was smaller in rural areas (from 8.5% to 7.8%) than in urban areas (from 6.2% down to 3.0%) (Zhao et al., 2020).

Even within urban areas, different urban medical insurance schemes (UEBMI and URBMI) have different impacts on health service utilisation and health expenditures. Out-of-pocket health expenditures for URBMI participants were much higher and more likely to lead to catastrophic health expenses than the UEBMI (Center for Health Statistics and Information, 2015). In a socioeconomically underdeveloped city, Xian et al. (2019) found that urban employees (those who with UEBMI) had significantly higher outpatient visit rates in all hospital types than urban residents (those who with URBMI), and the explanation is that URBMI enrollees were unable to get compensation from the insurance scheme for outpatient

visits and can only pay through OOP expenditures. Hospitalisation expenses and hospitalisation compensation ratios of urban employees were also significantly higher than rural residents in all hospital types.

In addition, the reimbursement levels and benefit packages are inconsistent between districts. For example, the reimbursement level of inpatient service for residents under 60 years in Shanghai is 80% at primary hospitals, 75% at secondary hospitals and 60% at tertiary hospitals in 2020 (The Paper, 2019). In Chengdu, a key municipal city in Western China, the reimbursement level of inpatient service for low-risk residents is 85%, 75% and 53% respectively at the three hospital levels in 2020 (Renmingwang, 2019). In Ningxia, a less developed area in Western China, the reimbursement level for all residents is 90%, 83% and between 55% to 75% at the three hospital levels respectively in 2020 (Ningxia News, 2019).

Many studies have shown that health insurance provides limited financial protection to households (e.g.Wang et al., 2015; Yip & Hsiao, 2009). The main reason is that outpatient service is generally not covered in the insurance schemes. Patients with NCDs are less protected and have a higher probability of incurring catastrophic health expenditures (Jing, Yin, Shi, & Liu, 2013; Li et al., 2014; Sun et al., 2009; Yip & Hsiao, 2009). The poor found to be less protected from the financial risks of NCDs (Sun et al., 2009; Xu et al., 2019). National economic growth is slowing, but health spending is not likely to follow suit if nothing is done to develop new models of service delivery and health financing. GDP growth in China was 6.4% in 2018, the slowest pace over the last four decades of double-digit growth (National Bureau of Statistics of China, 2019a). The decline in economic growth poses challenges to maintaining a healthy and productive population and to sustaining efforts in poverty reduction, especially when China is facing an ageing population and increasing NCD burden.

3.6 Summary

During the past four decades, China has experienced demographic and epidemiological changes and rapid economic growth. China has made tremendous progress in improving health outcomes and reducing poverty. However, the ageing population and the increasing burden of NCDs pose challenges to the health system in meeting population health needs. The service delivery system is severely hospital-centric and volume-driven, leading to high health spending. The health financial protection system is incomplete in China, posing a substantial financial burden on households. There exist health inequalities both in service use and in health financial protection between urban and rural areas, different regions and among different income levels. With the economy slowing down, China needs to develop new models of health financing, delivery and interventions in response to the population needs that are associated with the increasing burden of NCDs and its economic burden on households.

Chapter 4 Method

4.1 Introduction

This chapter outlines the methods employed to estimate the economic impact of NCDs on households in China. Section 4.2 presents the analytical framework that informs the study design, and Section 4.3 describes the study design and the hypotheses for each of the study. In section 4.4, I introduce the two nationally representative longitudinal datasets used in this thesis: China Family Panel Studies and China Health and Retirement Longitudinal Study, and the attrition and measurement issue of each dataset. Sections 4.5 covers general empirical methods and models applied in health economics to address the endogeneity between health and economic outcomes

4.2 Analytical Frameworks

I followed three analytical frameworks for the quantitative analyses to estimate the economic impact of NCDs on household welfare over time. The first is the intertemporal consumption model with income uncertainty (e.g. Deaton, 1992); secondly, the welfare cost model of an income shock developed by Chetty and Looney (2006); and thirdly, the health production function proposed by Grossman (1972).

The intertemporal consumption model provides the theoretical ground to examine whether households can maintain consumption in the presence of an unexpected NCD onset. It is based on the theory of intertemporal choice, which formalises the trade-offs between present and future consumption. In this study, I followed the permanent income hypothesis by Friedman (1957), that individuals and their households plan their consumption level according to long-term and permanent income rather than temporary income. Affected by many unforeseen factors, temporary income varies, but people's expectations about their long-term income

would not change. Thus their consumption level remains the same over a short-term. Under the short-term consumption smoothing assumption, households can maintain consumption in the presence of unexpected shocks, such as an NCD, and risks to income. The extent to which households smooth short-term consumption is vital for public policies in LMICs (Deaton, 1992). In the case of an illness shock, a disease (NCD) onset may lead to the increase of health expenditures and the loss of income due to reduced productive capacity, especially if it affects a prime, working-age member. If households are incapable of proper intertemporal allocation, then there is a need for the government to allocate on their behalf. This study examines the relationship between an NCD onset and household welfare by first estimating the impact of an NCD on household non-health consumption.

The second conceptual framework is the welfare cost model by Chetty and Looney (2006), which considers how households maintain consumption to determine the welfare costs associated with health shocks. The basic idea is that welfare costs are determined by the product of the proportionate change in consumption induced by the income shock and a coefficient of relative risk aversion. The welfare costs may be substantial despite income shocks not causing large consumption fluctuations if households are highly risk-averse and undertake costly coping strategies to smooth consumption. In this case, households are willing to take whatever means are necessary to maintain consumption even though the costs of doing so may be high (e.g. the reduction of human capital or productive assets); in this case, the extension of social safety nets could provide substantial welfare gains. Followed by estimating the impact of NCDs on household consumption, I examined the behavioural response of households to an NCD onset through a wide range of coping strategies as a proxy for the level of relative risk aversion of households.

The health production function (Grossman, 1972) proposes that current health status is a function of current and past health inputs, among other things, which supports the analysis of

how investment in health (such as healthy behaviours and health-seeking behaviour) contributed to health status in the future. A person inherits an initial stock of health that depreciates over time and can be increased by investment. Direct inputs into the production of investments in the stock of health include own time, medical care, diet, exercise, housing and other market goods. The health production function theory views health as a durable good that is demanded by consumers. Individuals demand good health for itself as a consumption commodity and also as an investment commodity because health determines the healthy time available for market and non-market activities. In this way, individuals and households who invest in health (e.g. healthy behaviours, seeking health care services) will enjoy future gains in health status. Conversely, those who defer or forego health inputs will experience no change or a relative decline in health status in the future. Following this framework, I estimated the association between modifiable risk behaviours and NCD diagnosis, as well as the effect of health expenditures in the previous period on future health.

4.3 Study Design

This quantitative research consists of three studies.

Study one: Risk factors and Non-communicable Disease Diagnosis in China

This study estimates the dynamic effects of risk factors on the diagnosis of NCDs in China using three waves of the longitudinal data from China Family Panel Studies survey (2010-2014), conditional on not having an NCD in the initial period. The hypothesis is that modifiable behaviour risk factors (such as being obese, using solid fuel to cook, drinking and smoking), as well as socioeconomic factors, contribute to the diagnosis of NCDs. There will be different effects of behavioural risk factors on the population at different life-cycle and between males and females. Individuals with a higher socioeconomic level are hypothesised to have a higher level of probability to be diagnosed with NCDs.

Study two: Coping and Not Coping with the Non-communicable Disease in China

Grounded in what leads to an NCD diagnosis in China, this study examines whether households in China can maintain consumption expenditures in the face of an NCD onset and how Chinese households cope with the diagnosis of an NCD. Also, this study examines the consequences of health, non-health consumption expenditure and wealth associated with increased health expenditures in the previous period. I use three waves of the longitudinal data from the China Family Panel Studies survey (2010-2014) and fixed-effect models. The hypothesis is that households in China can maintain non-health consumption in the face with an NCD onset. The households are hypothesised to adopt costly strategies to cope with the diseases, such as selling assets and borrowing. These coping strategies are expected to have negative impacts on the future consumption and wealth of the households.

Study three: The Economic Consequences of Delayed treatment: Hypertension in China

Building on study two on the consequences of coping with an NCD, this study analyses the economic consequences of delayed treatment on individuals' health care utilisation and health expenditures using the example of hypertension. I use three waves of the China Health and Retirement Longitudinal Study (2011-2015) and conduct difference-in-differences analysis on a matched set of hypertensive individuals. The hypothesis is that individuals with delayed treatment have higher levels of health expenditures than their early treatment counterparts.

4.4 Data and Measurement Issues

Ideally, to evaluate the economic impact of NCDs on household over time or throughout the life-cycle, long-term panel data over decades is required. Longitudinal data gives repeated observations on the units of interest, whether they be individuals, households or organisations, and allows for controlling of several sources of endogeneity. While there is only limited availability of such a longitudinal dataset in China, investigating the longer-term economic

impact of NCDs on households using the currently available data can be the starting point. The most complete panel datasets available are the China Family Panel Studies (CFPS) and China Health and Retirement Longitudinal Study (CHARLS). Both contain health and socioeconomic information, and these two datasets were used in this thesis. In the following sections, I introduce the two datasets, including how each was collected, what information was covered, and quality of the dataset, including non-response and attrition issues and measurement issues.

4.4.1 China Family Panel Studies

The Dataset

The CFPS is a nationally representative longitudinal survey designed and conducted by the Institute of Social Science Survey (ISSS) of Peking University, China. There have so far been five waves of the national-wide survey, a baseline study in 2010 and four follow-up surveys in 2012, 2014, 2016 and 2018. The study unit of CFPS is household. The 2010 CFPS baseline survey interviewed 14,798 households and all their inhabitants (Xie & Jin, 2015). I used the first three waves in this study.

CFPS draws a sample from 25 provincial regions in China (excluding Hong Kong, Macao, Taiwan, Xinjiang, Qinghai, Inner Mongolia, Ningxia, and Hainan), which cover 95% of the Chinese population. By design, half of the sample was generated by oversampling with five independent sampling frames (Shanghai, Liaoning, Henan, Gansu, and Guangdong) to enable cross-region comparisons. The rest half of the sample was from an independent sampling frame composed of 20 provinces (Xie, Qiu, & Lv, 2012; Yu Xie et al., 2017). The primary sampling unit consisted of administrative districts or counties, the second-stage sampling unit consisted of administrative villages or neighborhood communities, and the third-stage sampling unit consisted of households.

The CFPS collects information at individual, family, and community levels through face-to-

face interview or phone interview and collects self-reported data. The individual- and household-level surveys focus on the respondents' socioeconomic, educational and health-related characteristics along with family economic activities, family dynamics and relationships. The community-level surveys collect information on infrastructure, demographic profiles, social services, economic conditions, administration and politics of the rural villages and urban communities where the respondents live (Qin, Wang, & Chee-Ruey, 2018; Xie, 2012).

Non-response and attrition are a common feature of longitudinal survey data (Jones, 2007). In CFPS, there were 33600 individuals and 14798 households at the baseline. There were more than 1000 households who refused to be interviewed in the 2010 CFPS baseline survey, and the response rate mainly depended on the type of community and the willingness to cooperate of the community committee. Several solutions proposed to deal with refusals and other factors that lead to sample loss have been described elsewhere (Yu Xie et al., 2017). The CFPS has conducted four follow-up waves and adopts several follow-up strategies. In the follow-up survey conducted in 2012, about 85 per cent of the originally surveyed households were successfully interviewed. There were 22791 individuals and 11329 households retained in the three waves of 2010, 2012 and 2014, suggesting a drop out rate was approximately 30%. Three main reasons have contributed to the attrition in follow-up surveys of CFPS: demographic events such as the death of members; family splitting for reasons such as divorce leading to the change of sampling frame, and refusal to respond at subsequent waves (Jones, 2007; Yu Xie et al., 2017). It is noteworthy that CFPS tracked the migrant samples that even moved out of initially sampled areas and interviewed migrants with a shorter version of the questionnaire.

CFPS conducted an internal evaluation of the representativeness of the sample to the population. The results showed that shapes of the age-structure using CFPS baseline data and the Census 2010 data were identical (Xie & Hu, 2014).

To address the oversampling of the five key provinces in the sampling design, non-response rate and attrition issues in follow-ups and post-stratification, CFPS provides both cross-sectional weights for individuals and households, and panel weights for individuals and households in each wave. It is suggested to employ appropriate weight adjustment to achieve sample representativeness and more efficient statistical inference (Xie et al., 2012).

Measuring health outcomes (NCDs)

CFPS has several types of health measures for adult respondents through self-reported symptoms such as fever, pain, palpitation, and self-reported diseases diagnosed by doctors. Specifically, I identified NCD-affected individuals based on the question set: “During the past six months, have you had any doctor-diagnosed chronic disease”; and, the doctor’s diagnosis of the disease. Each respondent who answered “Yes” to the first question was asked to select the type of disease from the Disease Codebook, and the two most serious diseases were recorded if there were more than one. I adopted the definition of NCDs determined by the National Health and Family Planning Commission, which followed the classification of "Group II Diseases" as per the ICD-10 code (World Health Organization, 2016). Specifically, NCDs include circulation system diseases (such as heart diseases, stroke), cancer, diabetes and other endocrine diseases, chronic lung disease, nervous system diseases, digestive system diseases, genitourinary system disease, eye and ear diseases, skin, muscle and skeleton releated disease and congenital anomalies. Table 4.1 provides a list of NCD included in this thesis and in the CFPS dataset.

The baseline survey in 2010 covered 33600 individuals, among which, 4236 individuals had at least one NCD. The follow-up survey in 2012 covered 35719 individuals, 3465 individuals had at least one NCD. In 2014, among 37147 individuals, 4698 individuals had at least one NCD.

Table 4.1 List of NCDs included in this thesis

Code in CFPS	Name	Group II Disease	Code in CFPS	Name	Group II Disease
1	**A. Infectious diseases**	**N**	**5**	**E. Endocrine, nutritional, metabolic and autoimmune diseases**	**Y**
1.1	Typhoid and paratyphoid fever	N	5.36	Hyperthyroidism	Y
1.2	Bacterial food poisoning	N	5.37	Diabetes	Y
1.3	Septicemia	N	5.38	Nutrition deficiency or malnutrition	N
1.4	Hepatitis A	N	5.39	Rachiotis	Y
1.5	Other intestinal infectious diseases	N	5.40	obesity and other hypernutrition	Y
1.6	Tuberculosis	N	5.41	Other endocrine, nutritional, metabolic and autoimmune diseases	Y
1.7	Tetanus	N	**6**	**F. Blood and blood-forming organs diseases**	**Y**
1.8	Septicemia	N	6.42	Anemia	Y
1.9	Rubeola	N	6.43	Other diseases of blood and blood-forming organs	Y
1.10	Japanese B encephalitis	N	**7**	**G. Mental disorder**	**N**
1.11	Epidemic hemorrhagic fever	N	7.44	Senile,presenile organic psychosis	N
1.12	Hepatitis B	N	7.45	Schizophrenia	N
1.13	Leptospira	N	7.46	Depression	N
1.14	SARS	N	7.47	Other mental disorders	N
1.15	Other non-intestinal infectious diseases	N	**8**	**H. Nervous system diseases**	**Y**
2	**B. Parasitic disease**	N	8.48	Cephalomeningitis	N
2.16	Malaria	N	8.49	Epilepsy	Y
2.17	Schistosomiasis	N	8.50	Acute infectious polyneuritis	Y
2.18	Other parasitosis	N	8.51	Parkinson's disease	Y
3	**C. Malignant tumors**	Y	8.52	Other nervous system diseases	Y
3.19	Malignant tumor of nasopharynx	Y	**9**	**I. Eye and adnexa diseases**	**Y**
3.20	Malignant tumor of esophagus	Y	9.53	Glaucoma	Y
3.21	Malignant tumor of stomach	Y	9.54	Cataract	Y
3.22	Malignant tumor of colon	Y	9.55	Disease of cornea(total)	Y
3.23	Malignant tumor of rectum and anus	Y	9.56	Other diseases of the eye and adnexa	Y
3.24	Malignant tumor of liver	Y	**10**	**J. Ear and mastoid process diseases**	**Y**
3.25	Malignant tumor of pancreas	Y	10.57	Otitis media and mastoiditis	N
3.26	Malignant tumor of trachea, bronchus and lung	Y	10.58	Other diseases of ear and mastoid process	Y
3.27	Malignant neoplasm of breast	Y	**11**	**K. Circulation system diseases**	**Y**
3.28	Cervical malignant tumor	Y	11.59	Acute rheumatic fever	Y
3.29	Leukemia	Y	11.60	Chronic rheumatic heart disease	Y
3.30	Other malignant tumor	Y	11.61	Angina pectoris	Y
4	**D. Benign/in situ/uncertain behavior tumors**	Y	11.62	Acute myocardial infarction	Y
4.31	Benign tumors of uterus	Y	11.63	Other ischemic heart disease	Y
4.32	Benign neoplasm of brain	Y	11.64	Cor pulmonale	Y
4.33	Other benign tumors	Y	11.65	Other types of heart disease	Y
4.34	Tumor in situ	Y	11.66	Hypertension	Y
4.35	Neoplasms of uncertain or unknown behavior (total)	Y	11.67	Cerebrovascular disease	Y
			11.68	Varix of lower limb	Y
			11.69	Other circulation system disease	Y

Code in CFPS	Name	Group II Disease	Code in CFPS	Name	Group II Disease
12	**L. Respiratory system diseases**	**Y**	**16**	**P. Skin and subcutaneous tissue diseases**	**Y**
12.70	Acute nasopharyngitis (common cold)	N	16.106	Carbuncle and furuncle	Y
12.71	Acute upper respiratory tract infection like pharynx, larynx, trachea and tonsil infection	N	16.107	Cutitis	Y
12.72	Influenza	N	16.108	Other diseases of skin and subcutaneous tissue	Y
12.73	Pneumonia	N	**17**	**Q. Muscle,skeleton and connective tissue diseases**	**Y**
12.74	Chronic pharyngitis and laryngitis	Y	17.109	Rheumatoid arthritis	Y
12.75	Pneumonectasis	N	17.110	Lumbar disc disease	Y
12.76	Other chronic obstructive pulmonary diseases(including chronic bronchitis)	Y	17.111	Osteomyelitis	Y
12.77	Asthma	Y	17.112	Other motor system diseases	Y
12.78	Other diseases of the respiratory system (including acute lower respiratory tract infection)	N	**18**	**R.Congenital anomalies**	**Y**
13	**M. Digestive system diseases**	**Y**	18.113	Congenital heart disease	Y
13.79	Dental diseases & other oral/ salivary gland and submandibular diseases	Y	18.114	Other congenital anomalies	Y
13.80	Acute or chronic gastroenteritis	Y	**19**	**S. Certain conditions originating in the perinatal period**	**N**
13.81	Peptic ulcer	Y	19.115	Premature delivery	N
13.82	Appendix disease	Y	19.116	Birth injury	N
13.83	Hernia of abdominal cavity	Y	19.117	Birth asphyxia	N
13.84	Intestinal obstruction	Y	19.118	Tetanus neonatorum	N
13.85	Chronic liver disease and cirrhosis	Y	19.119	Other neonatal disease	N
13.86	Cholelithiasis and cholecystitis	Y	**20**	**T. Injury and poisoning**	**N**
13.87	Other digestive system disease	Y	20.120	Fracture	N
14	**N. Genitourinary system diseases**	**Y**	20.121	Dislocations, sprains and strains	N
14.88	Nephritis and nephrosis	Y	20.122	Intracranial and internal damage (including neural)	N
14.89	Endonephritis	Y	20.123	Open wounds and vascular injuries	N
14.90	Urinary system calculi	Y	20.124	Burns	N
14.91	Other disease of the genitourinary system(subtotal)	Y	20.125	Poisoning and toxic effect	N
14.92	Prostate hyperplasia or inflammation	Y	20.126	Other injury and poisoning	N
14.93	Other diseases of male reproductive organs	Y	**21**	**V. Others**	**N**
14.94	Breast disease	Y	21.127	Pregnancy surveillance	N
14.95	Salpingitis and oophoritis	N	21.128	Sterilization	N
14.96	Uterovaginal prolapse	Y	21.129	Hospitalization for special treatment	N
14.97	Other diseases of female reproductive organs	N	21.130	Physical examination	N
15	**O. Pregnancy, childbirth and postpartum complications**	**N**	21.131	Other causes	N
15.98	Spontaneous abortion	N	**999**	**Signs, symptoms and unclear situations**	**N**
15.99	Induced abortion	N			
15.100	Cyophoria and delivery haemorrhage	N			
15.101	pregnancy-induced hypertension	N			
15.102	Eutocia	N			
15.103	Obstructed labour	N			
15.104	Postpartum complications	N			
15.105	Other pregnancy/childbirth diseases or postpartum complications	N			

Measuring household economic outcomes

CFPS collects self-reported data on household income and expenditures, and the questionnaire is answered by the person who has a comprehensive, detailed knowledge of family's financial situation. In the following paragraphs, I give a brief introduction to the two outcome measures collected and constructed in CFPS. Detailed information on the construction of the household economic outcomes has been described elsewhere (Wu et al., 2015; Yu Xie et al., 2017). Details on the construction of the economic measures used in my thesis have been described in the following two chapters.

In CFPS 2010, household income segments include savings, financial products, pensions or social security, salaries, rewards or bonuses, agricultural income, value of gifts. There were changes in the follow-up waves since 2012, that CFPS classified five income categories: wage income, business income, transfer income, property income and other income. To ensure the comparability between the baseline and the follow-up waves, CFPS generated a set of income variables in the follow-up waves that were comparable to those in 2010 (Yu Xie et al., 2017). It is worth noting that in many LMICs, rural households would consume a considerable portion of agricultural products themselves. CFPS considered the value of the products that were consumed by the rural families themselves and counted into household income.

CFPS contains four types of expenditures: (1) consumption expenditures, such as expenditure on food, clothing, housing, household appliance and daily used commodities, transportation and communication, entertainment and education, health care; (2) transfer expenditure, such as financial support to family members or friends, social donations for major family events; (3) insurance expenditure; and (4) housing expenditure, including mortgage payment. CFPS has generated a composite variable of household expenditures (Yu Xie et al., 2017).

4.4.2 China Health and Retirement Longitudinal Study

The Dataset

CHARLS is a longitudinal study of Chinese residents aged over 45 years. It is designed and collected by Peking University, aiming to gather data on the socio-economic determinants and consequences of ageing. CHARLS has three waves so far, in 2011, 2013 and 2015. The survey includes a rich set of questions regarding economic standing, physical and psychological health, demographics and social networks of aged persons. Specifically, it provides objective health measures by collecting blood samples (in 2011 and 2015) and recording blood pressure (in all three waves).

Samples were chosen through multistage probability sampling with a probability-proportional-to-size sampling technique. CHARLS selected 150 counties from 28 provinces. The administrative villages (cun) in rural areas and neighbourhoods (shequ or juweihui) in urban areas were the primary sampling units (PSUs).

CHARLS was developed based on the best international practices and was harmonized with Health and Retirement Study (HRS) type surveys, to ensure international comparisons of the findings in CHARLS with those in other studies (Chien, Lin, Phillps, Wilkens, & Lee, 2018). CHARLS includes the following modules: demographics, family structure and changes, health status and functioning, physician-diagnosed chronic illnesses, lifestyle and health-related behaviours, physical function, cognition testing, health care and insurance, work, retirement and pension, income and consumption and assets (individual and household). Details of the sampling, interview and measurement procedures and quality control measures within the CHARLS are described in (Zhao, Hu, Smith, Strauss, & Yang, 2014a).

The national baseline survey for CHARLS included 17708 individual participants. Among them, 13702 individuals with blood pressure measurement at the baseline in 2011, but only

7367 remained in all three waves and with blood pressure measurement, with a drop-out rate of around 45%. To deal with nonresponse and sampling-frame bias, CHARLS team provides sample weights for households, individuals, and biomarkers.

Health outcomes (Hypertension)

In CHARLS, blood pressure was measured through a physical examination accompanying the survey. The Systolic Blood Pressure (sbp) and Diastolic Blood Pressure (dbp) were measured and recorded three times using an electronic sphygmomanometer. The time span between each measure was at 45 seconds. Following the guideline by the National Health and Family Planning Commission (2015), I used an average of the three blood pressure readings.

Actual Hypertension. I defined individuals with the real condition as those who had sbp >=140 mmHg or dbp >=90 mmHg or taking anti-hypertension medicines.

Diagnosed Hypertension. The respondent was considered to be aware of the condition if the answer to "Have you been diagnosed with hypertension by a doctor" or "Do you know if you have hypertension" is Yes. Since Wave 2, re-interviewed respondents were asked to confirm whether they have had or not had hypertension based on their previous report. If the respondent disputed the previous release, the re-interviewed respondent was then asked whether they have been diagnosed with the condition since the last interview. The diagnosis status in previous waves is adjusted accordingly.

Among the 13702 individuals who had blood pressure measured at baseline, 5262 had real hypertension, 3367 were aware or diagnosed with hypertension. In 2013, there were 12897 individuals have blood pressure measurement. 5442 had real hypertension, 3755 were aware or diagnosed with hypertension. In 2015, there were 16144 individuals have blood pressure measurement, 6186 had real hypertension, 4963 were aware or diagnosed with hypertension.

Health service use and health expenditure outcomes

CHALRS collects information on health service utilisation, including inpatient service, outpatient service, dental care at different levels: general hospital, specialised hospital, community healthcare center, township hospital, village clinic. CHALRS collects self-reported health expenditures, including healthcare costs (inclusive of OOP payments and insurance reimbursement) and OOP expenditures at different levels of health facilities.

4.5 Empirical Methods

In section 4.5.1, I introduce the endogenous issues relevant to this study and associated with the datasets I use. Then I describe general models for panel data and approaches on evaluating the treatment effects, which can potentially address the endogeneity issues. This section does not cover detailed methods for each study, which have been described in the subsequent three chapters

4.5.1 Endogeneity between Health and Economic Outcomes

Quantitative research is concerned with model building and data analysis, mainly by using a regression model to study the relationship between a dependent variable and one or more independent variables. In a simple version of a multiple linear regression model (4-1), a critical assumption is that the regressors (x_i) and error term (ε_i) are uncorrelated. Without the premise, the estimator obtained would not be consistent.

$$y_i = x_i' \beta + \varepsilon_i, \quad (4\text{-}1)$$

When we partition x_i in (4-1) into two sets of variables, x_1 and x_2, with the assumption that x_1 is not correlated with ε and x_2 is correlated, it is assumed that x_1 is exogenous in the model and that x_2 is endogenous (Greene, 2012).

There are several settings where endogeneity may arise.

Omitted variables bias. The bias arises when critical independent variables, either observed or

unobserved, are omitted in the specification. For example, one wants to estimate the effects of individual income on health. In an extreme case, the equation only contains an independent variable (income) and an error term. As we know, some observable health behaviours such as smoking and unobservable variables such as personal will may also determine health. When these variables are not included in the equation, the effect of them would be absorbed in the error term. Smoking behaviour and a person's will are also associated with income, and therefore, in this equation, income is correlated with the error term thereby causing inconsistent and biased estimation of the regressor of income.

Measurement Error. This bias arises when one cannot collect direct data on the variable, or some variables are inherently unmeasurable, such as health. Take the measure of NCD as an example. The measured NCD status consists of actual NCD status and a measurement error. Existing studies use clinical data or self-reported NCD as a proxy measure of true NCD. When using clinical data, the measurement error may come from the ability of doctor, medical technology to detect diseases as well as the capacity of patients to communicate symptoms. When using self-reported NCD, the measurement error may come from recall bias and access to health service. In both cases, measurement error will lead to inconsistent estimation.

Attrition bias. In panel data, the individuals remain in the sample in all the follow-up waves are likely to be a subset of those who are healthier. The less healthy individuals may die during the longitudinal survey. In this case, the health outcome, for example, for those "survivors", is systematically better than that for the population as a whole.

Simultaneity bias or reverse causation bias. Arises when one or more of the explanatory variables are jointly determined with the dependent variable. A characteristic example is the association between health and income. The causal pathway from health to income is that health can affect productivity and hourly wages. Potential pathways from income to health include access to health care and health knowledge. Similarly, such two-way effects exist

between disease and modifiable behavioural risk factors. Individuals with unhealthy behaviour are more likely to develop an NCD, and at the same time, the diagnosis of an NCD can change their behaviours. Similar to omitted variable error, the explanatory variable is correlated with the regression error term.

Dynamic effects. It happens when including a lagged term of the dependent variable on the right-hand side of the equation and is commonly seen in panel data analysis. In panel data models, the error term contains the time-invariant unobserved features of individual i. In this case, the lagged term regressor is correlated with the error term, because the unobserved heterogeneity is persistent in every period (Cameron & Trivedi, 2009; Nickell, 1981). It is also a form of omitted variable bias specific to analysis using panel data and fixed-effects estimation. An example is that current health is affected by previous health expenditures as well as previous health (Au & Johnston, 2014).

Endogenous treatment effects. Arise when estimating the treatment effect among those who are in treatment and those who are not. As a form of omitted variable bias, there might be some unobserved fundamental determinants that affect whether an individual has an opportunity to be treated or be included in an intervention. This is the main challenge in estimating the effect of delayed treatment on health service use and health expenditures in study three. Some unobserved variables such as the perceived value of care can affect whether and when a person gets medical treatment for NCDs and changes the outcomes. In this situation, the estimated effects of treatment are not accurate.

4.5.2 Models for Panel Data

I used the fixed-effects (FE) model in study two to control for the time-invariant variables when estimating the effect of an NCD onset on household welfare. A panel dataset contains information on the same individual or household at several subsequent points in time. By

utilising this repeated information, one can control for the time-invariant omitted variable bias.

A simple model for FE estimation, for each individual *i*, writes as:

$$y_{it} = \beta_1 x_{it} + a_i + u_{it}, \qquad t = 1,2, \dots, T \quad (4\text{-}2)$$

where a_i referred to time-invariant heterogeneity; the error u_{it} is the time-varying error, representing unobserved factors that change over time and affect y_{it}.

Now, for each *i*, average this equation over time, one can get

$$\overline{y_i} = \beta_1 \overline{x_i} + a_i + \overline{u_i}, \quad (4\text{-}3)$$

where $\overline{y_i} = T^{-1} \sum_{t=1}^{T} y_{it}$. Because a_i is fixed overtime, when subtracting (4-3) from (4-2), for each *t*, one can get:

$$y_{it} - \overline{y_i} = \beta_1 (x_{it} - \overline{x_i}) + (u_{it} - \overline{u_i}), \quad t = 1,2, \dots, T \ (4\text{-}4)$$

where $y_{it} - \overline{y_i}$ is the time-demeaned data on y. After the FE transformation, the unobserved heterogeneity a_i has disappeared. Then the equation (4-4) is estimated by pooled OLS (Wooldridge, 2013).

An important assumption for the FE estimator to be consistent is that the idiosyncratic error u_{it} should be uncorrelated with any explanatory variable across all periods. It allows for correlation between a_i and the explanatory variables in any period. It is worth noticing that any explanatory variable that is time-invariant for all *i* would be swept away by FE transformation. Therefore, the effects of such variables cannot be estimated in the FE model.

An alternative model is the random-effects (RE) model. The RE specification carries all of the FE assumptions plus an additional requirement that a_i and the explanatory variables are uncorrelated in all periods. If one cannot rule out that the additional assumption, one should use the FE model (Cameron & Trivedi, 2009).

4.5.3 Evaluation on Treatment Effects

Difference-in-differences

The difference-in-differences (DID) approach to evaluate nonexperimental data has been applied extensively in the health economics literature. The approach is based on a before and after (pre-post) design with a control group (Jones, 2007). DID assumes that unobserved heterogeneity in participation is present, but that such factors are time-invariant. With data on project and control observations before and after the program intervention, therefore, this fixed component can be differenced out. DID can be estimated with cross-sectional data and panel data with two or multiple periods (Duflo, 2001).

The DID estimator relies on a comparison of participants and nonparticipants before and after the intervention. DID estimation starts with calculating the average difference in outcomes separately for treatment and control groups both before and after the treatment and then calculating the difference in the average changes in outcomes for these two groups over time. The additional difference gives the DID estimators (Angrist & Pischke, 2009). I used the DID approach to design analysis in study three.

Matching Methods

Matching provides a general approach to deal with selection on observables. It addresses the problem that in the observed data, confounding factors may be non-randomly distributed over the treated and controls (Jones, 2007). Propensity score matching (PSM) constructs a statistical comparison group that is based on a model of the probability of individuals in treatment, using observed characteristics. Individuals are then matched on the basis of this probability (the propensity score) to non-treatment individuals (Shahidur, Gayatri, & Hussain, 2010). Individuals for which no match is found are dropped because no basis exists for comparison. By careful selection of the "treated" individuals (e.g. individuals in hypertension treatment)

and “untreated” (e.g. non-treated hypertensive individuals), and through matching each treated individual with one or more untreated counterparts (nearest neighbours matching), the treatment endogeneity due to observable factors can be eliminated. In this study, I applied PSM in study three to address the treatment effect bias.

Chapter 5 Risk factors and non-communicable disease diagnosis in China

5.1 Introduction

This chapter analyses the dynamic effects of risk factors on the onset of non-communicable disease (NCDs) in China, with the results presented in a published paper (below). Using longitudinal data from three waves of the China Family Panel Studies survey (2010-2014) and a dynamic model conditional on not having an NCD in the initial period, this chapter aims to identify risk factors associated with the onset of an NCD for the at-risk population and to informs the scope of the NCD problem and what contributes to NCD diagnosis. The hypothesis is that modifiable behavioural risk factors (such as being obese, using solid fuel to cook, drinking and smoking), as well as socioeconomic factors, contribute to the self-reported diagnosis of NCDs. There will be different effects of behavioural risk factors on the population at different stages of the life-cycle and between males and females.

The following study was published in the China Economic Review in August 2018 and is reproduced in the published version.

5.2 Published paper

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Risk factors and non-communicable disease diagnosis in China

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ABSTRACT

The rise of non-communicable diseases has placed enormous stress on health systems leading to calls for improved prevention. This article examines the association of risk factors and non-communicable disease diagnosis in China using longitudinal data which enables us to control for important simultaneity bias. Using three waves of the China Family Panel Studies (CFPS) survey (2010–2014) and a dynamic model conditional on not having an NCD in the first period, we find positive association of being obese, using solid cooking fuels, history of frequent drinking, and household consumption expenditure during the preceding period on non-communicable disease onset. We find significant heterogeneity in risks across the population suggesting that a targeted policy response is required to reduce the burden of non-communicable disease in China.

1. Introduction

Non-communicable diseases (NCDs) currently account for close to three-quarters of total deaths worldwide, or approximately 40 million deaths annually (GBD 2016 Causes of Death Collaborators, 2017). Of these deaths, the vast majority stem from low- and middle-income countries (LMICs) where the death rate associated with NCDs is increasing at the fastest rate (Checkley et al., 2014; GBD 2016 Causes of Death Collaborators, 2017). This particularly concerns the emerging economies where accelerated economic and epidemiological transitions have sped the shift in the disease burden from communicable to non-communicable disease. Worldwide, the magnitude of the NCD disease burden is rising faster than improvements in prevention and treatment, which suggests that public health policies and interventions have not done enough to curb the global burden of disease attributable to NCDs (Behrman, Behrman, & Perez, 2009; Institute for Health Metrics and Evaluation, 2016b). One explanation, for which this article contributes, relates to the evidence on the risk factors associated with NCD onset (Behrman et al., 2009). Improved understanding on the factors associated with NCD onset can help to ensure that risks are delayed to the oldest possible age and are not preceded by long and costly periods of morbidity. This is of particular import to LMICs where public resources allocated to health and social health protections are most limited.

In this paper we estimate associations of a comprehensive set of risk factors and NCD onset in China - the world's largest transitional economy and population. The paper contributes to the building literature on the risk factors associated with NCDs in LMICs (e.g. Aryal et al., 2015; Miranda, Kinra, Casas, Davey Smith, & Ebrahim, 2008; Wu et al., 2015). The vast majority of these studies rely upon cross-sectional data which does not address the dynamic nature of health behaviours (Kerkhofs & Lindeboom, 1997). It is probable that people diagnosed with NCDs in one period change their risky behaviours in the current or future period. In the case of two-way feedback between risk factors and the probability of having an NCD estimations will be biased. Cross-sectional studies cannot address reverse causality which represents an important source of endogeneity in the literature on risk factors and

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health. The literature that does address this form of unobserved heterogeneity is contained mostly to industrialised country settings and adopts a range of health measures (not exclusively NCDs) (Bell & Britton, 2014; Bell, Orford, & Britton, 2015).

Using three waves of the China Family Panel Studies (CFPS) survey (2010–2014) and a dynamic model conditional on not having an NCD in the first period, we examine the association of risk factors on the diagnosis of NCDs for the Chinese population. We find positive associations of being obese, using solid fuels to cook, having a history of frequent alcohol consumption, and household consumption expenditures during the preceding period on the current onset of NCD. We find significant heterogeneity across the population. Being obese, using solid cooking fuels and higher household consumption expenditures are associated with the onset of NCDs for people under age 60 while history of frequent drinking is associated with NCD onset for the elderly. The effect of obesity is contained to the non-poor and past drinking is contained to males.

The dramatic demographic and economic change experienced in China over the past four decades is well documented (Banister, Bloom, & Rosenberg, 2012; Golley & Wei, 2015). Life expectancy at birth in China has risen from 44 in the 1960's to 76 in 2015 (World Bank, 2017). The elderly population is expected to increase from under 10% of the total population in 2000 to 30% in 2050 (Kinsella & He, 2009). The country has experienced high yet unequal levels of economic growth which have led to changes in living and nutrition standards including a change in diet towards fatty foods and rise in adult body mass index (Du, Lu, Zhai, & Popkin, 2002). These changes have coincided with a pronounced shift in the burden of disease with NCDs currently comprising close to 90% of total deaths in China (Institute for Health Metrics and Evaluation, 2017). The three main killers are cardiovascular diseases (CVDs), cancer and chronic respiratory diseases; accounting for 79% of total deaths (Institute for Health Metrics and Evaluation, 2017; National Health and Family Planning Commission, 2015).[1] The epidemiological transition has placed enormous stress on a health system which traditionally has focused on infectious, as opposed to chronic, disease (World Bank, 2016).

The risk factors associated with NCDs in China are the subject of increasing attention. The recent Global Burden of Disease study estimates dietary risks, associated particularly with low consumption of fruit and vegetables and high sodium, to account for approximately one-fifth of DALY's and one-third of deaths in China (Institute for Health Metrics and Evaluation, 2016a). Other important risk factors include high blood pressure, tobacco use, air pollution and alcohol use. The analysis focuses on behavioural, environmental and metabolic risks; socioeconomic factors are not quantified. Several studies have identified indicators of low socio-economic status as triggers of chronic diseases in China, including low education, low income or poverty status, living in a rural location or lesser developed central region (Li, Wang, Jiang, Zhang, & Wang, 2013; Tang, Jian, & Guo, 2014; Yang & Gao, 2014). However, inconsistencies appear in these findings with one study reporting higher subjective social status and higher education as positively associated with chronic diseases (Tang & Jian, 2013). These studies all draw upon cross-sectional data. The exception is the study by Lei, Yin, and Zhao (2012) who use longitudinal data to estimate the risk factors associated with hypertension. In contrast to cross-sectional findings, they find no wealth or education gradient in disease prevalence. However, as pointed out by the authors, their models cannot rule out reverse causality and other endogeneity bias.

Our paper makes several noteworthy contributions to the literature. First, we apply a dynamic model which investigates the lagged effect of risk factors on the diagnosis of NCDs conditional on not having an NCD in the initial period. By restricting the sample to people without an NCD in the initial period and looking at how the variation in lagged determinants is associated with the variation in NCD diagnosis, we mitigate possible bias associated with reverse causation from disease onset to changes on risk behaviours. Second, unlike most other papers that examine a collection of disease and health states we focus specifically upon NCDs.[2] We provide estimates of a rich set of risk factors, including demographic, socio-economic, lifestyle and environmental factors, whereas most previous studies in China are limited either to demographic and behavioural risk factors or to demographic and socioeconomic factors. Third, to the extent that health status changes with age it is possible that the effect of risk behaviours on health also vary over the life cycle (Jaacks, Gordon-Larsen, Mayer-Davis, Adair, & Popkin, 2013; Kerkhofs & Lindeboom, 1997). We investigate differential effects of risk factors on NCDs across age groups as well as across selected sub-populations to provide a comprehensive analysis of NCDs risk factors across the Chinese population. Due to the sheer size of the population at risk, improved estimations on the risk factors associated with NCDs in China provides health authorities with the opportunity to predict the future growth of NCDs in China and potentially slow the growing burden of NCDs, not only in China but worldwide.

The paper is structured as follows. Section 2 describes the data and the measures. Section 3 presents the empirical strategy. Results are presented in Section 4, and Section 5 provides a discussion of results. Section 6 concludes.

2. Data, study sample, and description of key variables

The CFPS survey is a nationally representative biennial longitudinal survey designed and conducted by the Institute of Social Science Survey (ISSS) of Peking University. The survey is drawn from 25 provinces, which cover 95% of the national population, and follows a three-stage cluster probability sampling design (Xie et al., 2017). So far, the CFPS has been collected over four waves, including a baseline survey in 2010 and three follow-up surveys in 2012, 2014 and 2016. We use the first three waves of the data which are currently available. We use the nationally representative sample for our study which forms a panel of 14,861 individuals

[1] One-in-four Chinese adults are estimated to have hypertension and one-in-ten are diabetics; the rate of cancer is approximately one-in-400 (National Health and Family Planning Commission, 2015). Another survey estimates one in five adults is living with cardiovascular disease (National Center for Cardiovascular Diseases, 2014).

[2] Studies typically use a measure of chronic disease which encompasses a collection of infectious diseases, parasitic diseases, injuries, pregnancy and postpartum complications (Center for Health Statistics and Information, 2015). The misclassification of NCDs may lead to estimation bias and thus mislead policy and intervention response.

over the three waves.[3] We restrict our sample to persons who are without an NCD in the baseline and remain as respondents in all three waves, which comprises a sample of 13,022 individuals. We use information from wave 2 and wave 3 to construct the outcome variables and information from wave 1 and wave 2 to construct the lagged independent variables.

The CFPS contains a rich collection of information collected at individual, household and community levels.[4] Of particular import to this study is information on disease types, which we use to identify NCDs. Specifically, we identify NCD-affected individuals based on the question set: "During the past six months, have you had any doctor-diagnosed chronic disease"; and, the doctor's diagnosis of the disease. Each respondent who answered "Yes" to the first question was asked to select the type of disease from the Disease Codebook, and the two most serious diseases were recorded if there was more than one. We adopt the definition of NCDs determined by the National Health and Family Planning Commission, which follows the classification of "Group II Diseases" as per the ICD-10 code (World Health Organization, 2016).[5] Individuals living with NCDs (coded as 1) are defined as persons having either of their two diagnosed diseases as classified within the "Group II Diseases." Respondents who answered "No" to chronic diseases, or for whom neither of the two diagnosed chronic diseases was classified as an NCD, are defined as not living with NCDs (coded as 0). In our restricted sample of individuals who did not report an NCD in the first period, 9.3% report an NCD in 2012, and 14.1% report NCD onset in 2014.

The CFPS collects information on several behavioural risk factors commonly identified in the literature as associated with NCDs, such as smoking status, obesity, and environmental factors. Environmental factors include type of household cooking fuels and level of pollution in the local community. Households that use firewood, straw or coal for cooking are classified as using *solid* fuels (Zhang & Smith, 2007). An indicator for ambient pollution is derived from the question: "Is there any highly polluting enterprise, such as a chemical plant, a metallurgical refinery or a papermill within a 5-kilometer radius centred at your village/residential committee office." Obesity is derived from self-reported height and weight and is classified according to the calculated body mass index (BMI). Following the recommendation of the Working Group on Obesity in China (Chen, Lu, & Department of Disease Control Ministry of Health, 2004), an individual with a BMI $\geq$ 28 is classified as obese; and an individual with a BMI $<$ 18.5 is classified as underweight. Information collected on smoking status includes two binary-indicator questions about whether respondents currently smoke or have smoked in the past. Drinking status includes whether the volume of pure alcohol consumed by the respondent exceeds the national criteria of heavy drinking behaviour,[6] and whether the respondent used to drink frequently (at least three times per week) in the past. In addition to NCD and behavioural risk factors, the CFPS provides information on other health measures and access to health services. Past health may have an impact on current health and other covariates, which can be controlled by the inclusion of a lagged health variable in the regression (Bockerman & Ilmakunnas, 2009). We include a lagged measure of self-rated health (SRH) in our model as an indicator for the individual's health status in the preceding period.[7] We rescale the SRH variable into three categories of healthy, fair and unhealthy.[8] An indicator for having access to health service is derived from the question: "How long does it take from your house to the nearest health facility by the fastest means of transportation? (in minutes)." We consider within 15 min as having (physical) access to health service which is a target of the Chinese government to achieve by 2030 (Xinhuanet, 2016).

The CFPS includes a rich collection of demographic and socio-economic factors. Notably, the survey collects information on household consumption expenditure and income. We elect to use total household consumption expenditure rather than income as it is commonly deemed a better measure of permanent income in the context of China and particularly in the rural context (Deaton, 1997). Consistent with other studies, we also include explanatory variables for the years of schooling as well as age, gender, ethnicity, and geographic residency as standard demographic variables.

Classification of urban residency in this study is based on the Hukou registration system. The Hukou registration system in China divides the population into agricultural (rural) and non-agricultural (urban) sectors, which influences access to a range of resources, services and opportunities, such as jobs, education, housing, and health care. We include a set of province dummies to control for variation in disease profiles and other differences across the 25 provinces. Definitions of the dependent and independent variables are provided in Appendix A.

Table 1 displays weighted means and robust standard errors for the lagged variables used in the regressions. The mean age of our sample is 48 years in 2010 which increases to 50 years in 2012. There is a slightly higher proportion of females (54%) relative to males and the vast majority of respondents are of Han ethnicity, married, and with rural Hukou registration. The mean year of

[3] The survey collected two samples including a sample of oversampled five "large" provinces and twenty other "small" provinces, and a second resampled national sample which includes a second-stage sampling of the five "large provinces" and the twenty "small" provinces (Xie et al., 2017). Our sample is the latter, which is representative of the national population. We tested our results against the oversampled sample and the results were qualitatively very similar (results are available upon request).

[4] The survey contains three modules: an individual- and household-level survey collect demographic, socioeconomic and health-related information, while the community-level survey collects information on infrastructure, demographic profiles, social services and economic conditions.

[5] We consulted with Bureau of Disease Control and Prevention, National Health and Family Planning Commission on the complete list.

[6] The binary variable of heavy drinking behaviour derives from the questions: "Have you often drunk alcohol (at least 3 times a week) in the past one month"; if yes, "What types of alcohol have you drunk, strong spirits, wine or beer" and the level of consumption for each type of alcohol. The amount of pure alcohol consumed was calculated according to proportions of 4% for beer, 52% for strong spirits and 10% for wine (Li et al., 2011). Heavy drinking was defined as whether the daily quantity of pure alcohol consumed exceeded 61 g for a male and 41 g for a female as per national guidelines (National Health and Family Planning Commission, 2015).

[7] SRH is commonly used as a general health measure in household surveys and has been consistently found to be a strong predictor of morbidity and physical Functioning (Xu & Xie, 2016). We are aware of the potential reporting heterogeneity bias of SRH and methods to adjust for the bias such as anchoring vignettes. However, the lack of anchoring vignette data in the 2010 baseline and inconsistent measures of SRH between the baseline and the 2012 follow-up survey prevents us from using such techniques to adjust in both years.

[8] The original scale included five categories but there was inconsistency across the waves. The scale in 2010 was "1. Healthy; 2. Fair; 3. Relatively unhealthy; 4. Unhealthy; and 5. Very unhealthy" and in 2012 was "1. Excellent; 2. Very good; 3. Good; 4. Fair; 5. Poor."

Table 1
Descriptive statistics of the lagged covariates.

	2010		2012	
	Mean	S.E.	Mean	S.E.
Behaviours				
Obese	0.057	(0.004)	0.066	(0.004)
Underweight	0.096	(0.007)	0.099	(0.007)
Heavy drinker	0.061	(0.005)	0.043	(0.004)
Past frequent drinker	0.041	(0.003)	0.098	(0.006)
Smoker	0.289	(0.007)	0.282	(0.007)
Past smoker	0.062	(0.004)	0.092	(0.005)
Solid cooking fuels	0.468	(0.030)	0.362	(0.029)
Polluting enterprises within 5 km radius	0.267	(0.027)	0.216	(0.027)
Self-rated health: healthy	0.497	(0.013)	0.624	(0.012)
Self-rated health: fair	0.370	(0.011)	0.205	(0.010)
Self-rated health: unhealthy	0.133	(0.007)	0.171	(0.008)
Health care facility within 15 min	0.843	(0.017)	0.855	(0.014)
SES				
Year of schooling	6.686	(0.189)	6.415	(0.195)
Logarithm of household consumption expenditures	9.786	(0.034)	10.207	(0.035)
Demographic				
Age	47.856	(0.494)	49.837	(0.493)
Female	0.535	(0.004)	0.535	(0.004)
Married	0.855	(0.005)	0.851	(0.006)
Household size	4.093	(0.088)	4.088	(0.089)
Urban Hukou	0.277	(0.030)	0.294	(0.032)
Han ethnicity	0.894	(0.027)	0.894	(0.027)
Observations	13,022		13,022	

Source: China Family Panel Studies 2010–2012.
Notes: Provincial dummy variables are not displayed. Robust standard errors clustered at the household level are in parenthesis. Estimates are appropriately weighted to reflect the complex survey design.

schooling of the sample is approximately 6 years. Obesity prevalence increases slightly from 6% to 7% and the prevalence of being underweight remains at 10%. The proportion of the sample using solid cooking fuels falls from 47% to 36%. Smoking prevalence remains high at 29–28% and an additional 6–9% of the sample has smoked at some time in the past. The prevalence of heavy drinking behaviour decreases from 6% in 2010 to 4% in 2012 and higher proportion of people no longer drink frequently (10% versus 4%). The proportion of the sample exposed to ambient pollution falls from 27% to 22% over the two waves.

3. Empirical strategy

In order to investigate associations between risk factors and NCD diagnosis, for those alive and NCD free in China, we apply a dynamic pooled linear probability model for the sample reporting no NCD in the baseline period according to the following specification:

$$N_{it} = \alpha + \beta X_{it-1} + \gamma_t + \gamma_p + \varepsilon_{it} \quad (1)$$

where N is a binary indicator of NCD status for individual i in year t; X denotes a set of individual characteristics including demographic, socioeconomic and risk factors associated with NCDs. These variables are lagged by one period, $t - 1$. In addition, we include a set of year and provincial fixed effects, γ_t and γ_p, respectively; and ε_{it} is an individual error term. The model estimated coefficients, β, represent the partial effects of risk factors on NCD diagnosis for the at-risk population. Robust standard errors are computed and adjusted for clustering at the household level.

There exist several challenges in the consistent estimation of β. First, there may be two-way effects between onset of NCDs and risk factors. For example, people diagnosed with NCD in the one period may change behaviour (smoking, drinking) in that or future periods. Our strategy is to apply a dynamic model of health where NCD onset is a function of lagged risk factors. The lagged model presents coefficients as average effects of change in NCD status but we are primarily interested in the development of new NCD cases (i.e. from no NCD to being diagnosed with an NCD). This requires us to restrict our sample to those who are free of NCDs in the initial period. As such we do not consider those who already have an NCD.

The traditional approach to address sample selection issues is to introduce a sample selection correction which, in effect, derives theoretical population estimates for the group who already have an NCD and those that do not. The factors which trigger disease among persons who already have an NCD (pretending that they did not) is arguably of less practical importance or relevance than those associated with being diagnosed with an NCD conditional on not having an NCD to start with. There remains the problem that

some covariates may have already caused an individual to develop an NCD by the time we first observe them which cannot be addressed by the traditional selection correction.[9] We address this issue relating to the lifetime influence of the covariate on NCD status through the disaggregation of impacts by age subgroups, particularly the younger sample which has much less initial-year prevalence. This further allows us to better understand the lifetime impacts of the factors on NCD onset as their roles at different ages in the life-cycle may be different.

Second, there is potential measurement error in the self-reported NCDs variable. Though our measure of NCD is more objective, as determined by doctor diagnosis, it remains open to potential bias relating to factors such as those associated with education level and access to health service (Strauss & Thomas, 2008). To reduce this potential bias, we include a rich set of controls including years of schooling, and a binary variable indicating whether the individual resides within a household within 15 min of the nearest health facility. However, there may remain unobserved factors which influence both the measurement of NCDs and risk factors of interest. One potential such factor is the scale-up of the National Public Health Service Program after 2012 which offered free blood pressure and glucose check-ups for the high-risk population (State Council, 2012). This program likely explains the jump in reported cardiovascular disease (and overall NCD prevalence) in the 2014 wave of the data. If this is the case and that unobserved characteristics which determined program participation are related to our set of risk factors then the estimates may be biased. Whilst we cannot rule out measurement bias, estimates for the 2012 period before the scale-up of the program are qualitatively very similar to the main results for the pooled 2012–2014 sample presented in the following section which suggests that unobserved factors related to the jump in reported NCD prevalence are not driving our results. These estimates are presented in Appendix B (column 2). We also present estimates using contemporaneous controls (column 1) for the 2012 outcome and observe several changes in the lagged specification (column 2) which suggests the presence of feedback effects. Notably, the negative impact of heavy drinking on NCD onset becomes insignificant and the magnitude and significance level of the positive impact of past frequent drinking effects become greater in the lagged specification.

Third, the presence of unobserved determinants of both NCDs and risk factors of interest can bias our estimation. The availability of panel data can normally help attenuate the effects of unobserved heterogeneity at the individual level by applying a fixed-effects specification. However, given the persistence of most NCDs (individual's simply manage their NCDs after onset rather than becoming NCD free again) a fixed effects specification adds little in this context. In addition, a fixed-effects model cannot identify the impact of important factors that lack of variation over time, such as gender and education. Given our short four-year panel we elect the dynamic pooled OLS model as our preferred specification and acknowledge that our results remain subject to bias in terms of being casual estimates.[10] So while we cannot infer causality from these estimates our panel data and use of lagged risk factors does help reduce the endogeneity associated with reverse causation which represents a first in the literature on the determinants of NCDs in LMICs.

4. Results

Table 2 presents results from the pooled OLS specifications for the full sample and by age groups. For the full sample (column 1), conditional on not having an NCD to start with, there is a significant positive association between obesity and NCD onset. People who are obese in the preceding period experience a 4% higher probability of reporting an NCD in the following period. We also find a strong positive effect of frequent drinking history on NCD onset of 3.4%. The use of solid cooking fuels increases the probability of reporting an NCD by 1.1% (significant at the 10% level). Other factors positively associated with NCDs include age, poor or unhealthy self-rated health, education level, household consumption expenditures, being female, and living in an urban location. The coefficient on the age-squared term is positive and highly significant indicating that the likelihood of NCD onset increases at a higher rate with age. We find a mildly significant negative effect of being underweight and no significant associations for smoking and current drinking status, living within 5 km of a polluting enterprise within 15 min from a health facility.

Table 2 also presents the effects of risk factors by age group. The obesity effect is highest among the middle age group of 45–60 years at 6.6% followed by the age group < 45 years at 3.7% with no significant association among the elderly age group above 60 years of age. Conversely, the effects of past heavy drinking are highest among the elderly at 7.7% followed by 2.2% among the young (the latter is significant at the 10% level only) with no association among the middle-aged. The negative population effect associated with being underweight increases in size (and significance level) to 4.6% among the elderly population and becomes insignificant for the non-elderly population. The positive effect of using solid cooking fuels is contained to the non-elderly population with similar sized effects among the young and middle-aged populations though the effect is significant for the former only. The effects of poor self-rated health and female gender increase across the life-cycle whereas effects associated with schooling and urban location remain relatively consistent with age.

Table 3 presents the effects of risk factors across subpopulations as determined by gender, urban/rural and poverty[11] status. The effect of obesity is higher among the female, urban and non-poor populations and is insignificant among the poor. The effect of solid cooking fuels use is significantly higher among the female, urban and poor populations and is insignificant among the male and rural

[9] By extension there are also those people already deceased who we do not observe at all where their risk factors and NCDs onset may have contributed to an early death.

[10] We also ran random effects specifications and the results were qualitatively very similar. Our results are also robust to the inclusion of community fixed effects. These results are available from the authors upon request.

[11] Poor and non-poor households are classified based on the self-report of whether the household received any poverty subsidy or a low living allowance from the government.

Table 2
Pooled OLS estimated effects of risk factors on NCD diagnosis for the full sample, and by age group.

	Full sample	< 45 years	45–60 years	> 60 years
Obese	0.040***	0.037***	0.066***	−0.024
	(0.011)	(0.013)	(0.020)	(0.035)
Underweight	−0.015*	0.004	−0.013	−0.046**
	(0.009)	(0.009)	(0.019)	(0.021)
Heavy drinker	−0.015	−0.014	−0.019	0.014
	(0.01)	(0.012)	(0.017)	(0.025)
Past frequent drinker	0.034***	0.022*	0.031	0.077***
	(0.011)	(0.013)	(0.020)	(0.029)
Smoker	−0.011	−0.003	−0.009	−0.022
	(0.007)	(0.007)	(0.015)	(0.020)
Past smoker	−0.001	0.000	0.022	−0.031
	(0.011)	(0.012)	(0.022)	(0.025)
Solid cooking fuels	0.011*	0.011*	0.012	0.002
	(0.006)	(0.006)	(0.011)	(0.018)
Polluting enterprises within 5 km radius	0.000	−0.003	0.004	−0.002
	(0.006)	(0.006)	(0.012)	(0.018)
Self-rated health (reference category: healthy)				
Fair	0.041***	0.031***	0.052***	0.045***
	(0.005)	(0.006)	(0.010)	(0.016)
Unhealthy	0.154***	0.144***	0.151***	0.178***
	(0.009)	(0.015)	(0.015)	(0.021)
Health care facility within 15 min	0.004	0.007	0.003	0.011
	(0.007)	(0.007)	(0.014)	(0.019)
Years of schooling	0.002**	0.001	0.002*	0.007***
	(0.001)	(0.001)	(0.001)	(0.002)
Natural logarithm of household consumption expenditure	0.012***	0.008**	0.018***	0.004
	(0.003)	(0.004)	(0.006)	(0.009)
Age	0.000	−0.008***	−0.015	0.072***
	(0.001)	(0.003)	(0.027)	(0.025)
Age squared	0.000***	0.000***	0.000	−0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Female	0.026***	0.013*	0.034**	0.087***
	(0.006)	(0.007)	(0.014)	(0.020)
Married	0.010	0.016*	0.028	0.022
	(0.008)	(0.008)	(0.019)	(0.020)
Household size	0.001	−0.001	0.002	0.002
	(0.002)	(0.002)	(0.003)	(0.005)
Urban hukou registration	0.017**	0.013*	0.020	0.020
	(0.007)	(0.007)	(0.014)	(0.020)
Han ethnicity	−0.005	−0.005	0.001	0.010
	(0.009)	(0.009)	(0.020)	(0.035)
Year	0.038***	0.018***	0.043***	0.085***
	(0.005)	(0.005)	(0.010)	(0.016)
Province dummies	Yes	Yes	Yes	Yes
Observations	26,044	14,028	7962	4054
R-squared	0.081	0.047	0.064	0.088

Source: China Family Panel Studies 2010–2014.
Notes: Provincial dummy coefficients are not displayed. Robust standard errors clustered at the household level are in parenthesis.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

populations. The positive association of past frequent drinking is contained to the male, urban and non-poor populations. The negative effect associated with being underweight is contained among the urban population whereas positive consumption expenditure effects are highest among the poor. Effects associated with poor self-rated health are higher among the female, urban and non-poor populations. The positive effect associated with living in an urban area is higher among the non-poor population and is insignificant among the poor. We observe small, yet statistically significant, negative effects of current smoking behaviour among males and heavy drinking among the rural and non-poor populations.

In Table 4, we dig further to examine the associations of selected risk factors by age and subpopulation. The obesity effect among females is contained to the population below the age of 60 years of age and in fact reverses direction for the middle age group where the effect for males is higher and more significant than females. The higher effects associated with obesity among urban and non-poor populations derive mostly from the middle-aged population. The effect of solid cooking fuel among females and among the poor

Table 3
Pooled OLS estimated effects of risk factors on NCD diagnosis by subpopulation.

	Full	Female	Male	Urban	Rural	Poor	Non-poor
Obese	0.040***	0.039**	0.036***	0.040**	0.039***	0.040	0.040***
	(0.011)	(0.017)	(0.013)	(0.019)	(0.013)	(0.040)	(0.011)
Underweight	−0.015*	−0.008	−0.023*	−0.036**	−0.007	0.006	−0.016*
	(0.009)	(0.011)	(0.012)	(0.017)	(0.010)	(0.023)	(0.009)
Heavy drinker	−0.015	−0.001	−0.012	0.016	−0.022**	0.037	−0.021**
	(0.010)	(0.058)	(0.010)	(0.023)	(0.010)	(0.033)	(0.010)
Past frequent drinker	0.034***	−0.022	0.050***	0.058***	0.025*	0.046	0.034***
	(0.011)	(0.025)	(0.012)	(0.022)	(0.013)	(0.035)	(0.012)
Smoker	−0.011	0.023	−0.014**	−0.014	−0.010	−0.008	−0.012
	(0.007)	(0.024)	(0.007)	(0.014)	(0.008)	(0.021)	(0.007)
Past smoker	−0.001	−0.027	0.002	−0.016	0.004	−0.031	0.000
	(0.011)	(0.030)	(0.012)	(0.023)	(0.012)	(0.033)	(0.012)
Solid cooking fuels	0.011*	0.014*	0.008	0.035**	0.007	0.033*	0.010
	(0.006)	(0.008)	(0.007)	(0.015)	(0.006)	(0.019)	(0.006)
Polluting enterprises within 5 km radius	0.000	0.002	−0.003	−0.028**	0.009	0.018	−0.002
	(0.006)	(0.008)	(0.007)	(0.011)	(0.007)	(0.021)	(0.006)
Self-rated health (reference category: healthy)							
Fair	0.041***	0.052***	0.029***	0.038***	0.040***	0.036**	0.041***
	(0.005)	(0.007)	(0.007)	(0.011)	(0.006)	(0.018)	(0.005)
Unhealthy	0.154***	0.166***	0.135***	0.189***	0.146***	0.133***	0.159***
	(0.009)	(0.012)	(0.014)	(0.023)	(0.010)	(0.024)	(0.010)
Health care facility within 15 min	0.004	0.008	−0.001	−0.018	0.006	−0.031	0.008
	(0.007)	(0.010)	(0.009)	(0.020)	(0.007)	(0.020)	(0.007)
Years of schooling	0.002**	0.002*	0.002**	0.004**	0.001	0.004*	0.001*
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)
Natural logarithm of household consumption expenditure	0.012***	0.009**	0.014***	0.014*	0.009***	0.027***	0.009***
	(0.003)	(0.005)	(0.004)	(0.007)	(0.004)	(0.010)	(0.003)
Age	0.000	−0.001	0.000	0.000	0.000	0.004	−0.001
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.003)	(0.001)
Age squared	0.000***	0.000***	0.000***	0.000***	0.000***	0.000	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Female	0.026***			0.028**	0.025***	0.059***	0.022***
	(0.006)			(0.013)	(0.007)	(0.019)	(0.007)
Married	0.010	0.016	0.015	0.010	0.004	0.018	0.009
	(0.008)	(0.012)	(0.010)	(0.016)	(0.009)	(0.020)	(0.008)
Household size	0.001	0.005**	−0.004*	0.000	0.001	−0.002	0.001
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.004)	(0.002)
Urban hukou registration	0.017**	0.018*	0.015*			0.013	0.018***
	(0.007)	(0.010)	(0.009)			(0.022)	(0.007)
Han ethnicity	−0.005	−0.006	−0.004	0.020	−0.009	−0.007	−0.005
	(0.009)	(0.014)	(0.011)	(0.027)	(0.010)	(0.022)	(0.010)
Year	0.038***	0.049***	0.026***	0.037***	0.038***	0.049***	0.038***
	(0.005)	(0.007)	(0.006)	(0.010)	(0.006)	(0.016)	(0.005)
Province dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	26,044	13,485	12,559	6612	19,325	2602	23,395
R-squared	0.081	0.092	0.071	0.108	0.075	0.103	0.082

Source: China Family Panel Studies 2010–2014.
Notes: Provincial dummy coefficients are not displayed. Robust standard errors clustered at the household level are in parenthesis.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

doubles for the middle-aged population to 2.9% and 7.0%, respectively. We observe a large significant effect of 20.5% for heavy drinking among the elderly poor population. The effects of past frequent drinking are contained to the elderly male, urban, non-poor population.

5. Discussion

Our results add new weight to the literature on the risk factors of NCDs in China. Our contribution lies in attempting to address simultaneity bias and in the analysis of heterogeneous effects across the population. Several of the key findings warrant further discussion and analysis.

The positive association between obesity and the probability of reporting NCDs is a common finding in the literature (Wang et al.,

Table 4
Pooled OLS estimated effects of selected risk factors by age group and subpopulation.

	Full sample	Female	Male	Urban	Rural	Poor	Non-poor
Obese							
< 45	0.037***	0.046**	0.027*	0.030	0.038**	0.063	0.034***
	(0.013)	(0.023)	(0.015)	(0.023)	(0.015)	(0.051)	(0.013)
45–60	0.066***	0.051*	0.081***	0.082**	0.057**	0.101	0.065***
	(0.020)	(0.028)	(0.029)	(0.035)	(0.025)	(0.077)	(0.021)
> 60	−0.024	−0.033	−0.031	−0.035	−0.027	−0.141	−0.014
	(0.035)	(0.051)	(0.050)	(0.061)	(0.045)	(0.097)	(0.038)
Heavy drinker							
< 45	−0.014	0.062	−0.014	−0.003	−0.016	−0.011	−0.014
	(0.012)	(0.116)	(0.012)	(0.030)	(0.012)	(0.033)	(0.013)
45–60	−0.019	0.089	−0.021	0.023	−0.030*	0.005	−0.019
	(0.017)	(0.110)	(0.017)	(0.042)	(0.018)	(0.052)	(0.018)
> 60	0.014	−0.121	0.025	0.032	0.005	0.205**	−0.011
	(0.025)	(0.077)	(0.026)	(0.053)	(0.028)	(0.083)	(0.025)
Past frequent drinker							
< 45	0.022*	−0.006	0.031**	0.006	0.028*	0.107*	0.016
	(0.013)	(0.031)	(0.015)	(0.023)	(0.016)	(0.060)	(0.014)
45–60	0.031	0.009	0.042*	0.071*	0.016	−0.012	0.037*
	(0.020)	(0.043)	(0.022)	(0.042)	(0.023)	(0.057)	(0.022)
> 60	0.077***	−0.066	0.106***	0.149**	0.051	0.054	0.084***
	(0.029)	(0.072)	(0.031)	(0.061)	(0.032)	(0.067)	(0.032)
Solid cooking fuels							
< 45	0.011*	0.007	0.017**	0.036*	0.009	0.030	0.010
	(0.006)	(0.009)	(0.008)	(0.020)	(0.006)	(0.020)	(0.007)
45–60	0.012	0.029*	−0.005	0.041	0.005	0.070*	0.009
	(0.011)	(0.016)	(0.015)	(0.031)	(0.012)	(0.039)	(0.012)
> 60	0.002	−0.005	0.003	0.055	−0.006	−0.032	0.006
	(0.018)	(0.028)	(0.022)	(0.039)	(0.020)	(0.056)	(0.019)

Source: China Family Panel Studies 2010–2014.
Notes: Each coefficient is from a separate regression model. Provincial dummy coefficients are not displayed. Robust standard errors clustered at the household level are in parenthesis.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

2015; Wang, Mi, Shan, Wang, & Ge, 2007; Zhou et al., 2002). The effect is confined to the non-poor and this pattern is consistent across all age groups. Studies show that Chinese residents with a higher socioeconomic status (SES) are more likely to be overweight or obese (Jaacks et al., 2013; Zhang, Dagevos, He, van der Lans, & Zhai, 2008), although there is a shift in the burden of obesity towards the poor (Du, Mroz, Zhai, & Popkin, 2004). In our sample, the prevalence of obesity at baseline is higher among the non-poor than the poor (6% vs. 4%), which suggests that it is still more of a problem among the non-poor. There exists the caveat that the poor may have less access to quality health care from which to report diagnosed disease.

We find significantly higher effects of obesity among the non-elderly population, particularly the middle-aged population, which is in line with the international literature (Cameron et al., 2003; Flegal, Carroll, Ogden, & Curtin, 2010; Mokdad et al., 1999). The effect of obesity on the onset of disease disappears among the elderly population. The intuition is that NCDs are age-related and that there are a host of other factors that determine disease among the elderly (Suzuki et al., 2009; Wang & Yang, 2014). There are also issues relating to sample selection and the death of older obese people prior to survey. In our sample, we may have removed elderly obese people already diagnosed with NCDs. The finding of a protective effect of being underweight among the elderly suggests that those who remain in our sample are more likely to be the healthier.

We find interesting gender differences in the effects of obesity by age. For people under 45 years of age, the effect is higher and more significant for females which is in line with our main results and the literature (Strauss & Thomas, 2008). However, we find that for an older population (aged between 45 and 60 years) obese males have a higher probability of reporting NCD than females. One explanation is a period shift towards a high-fat, high-energy-density and low-fibre diet experienced since the economic reform in 1980s (Du et al., 2002; Wang et al., 2007), and that a large body is considered as a sign of prowess, prosperity and wealth among Chinese males (Xiao et al., 2013). We add interactions between household consumption expenditures and obesity and indeed find a positive effect on the intervening variables for the male (p-value < 0.001) but not the female sample (p-value $= 0.200$). Our results of a positive association among middle-aged males and younger females are consistent with Jaacks et al. (2013) who conclude that period effects in China have a stronger influence on obesity among males while younger female cohorts are at an increased risk compared with their older counterparts.

Our results add to the evidence on the harmful effects of household solid fuel use on health. Several studies identify the harmful impact of household air pollution on health in China and other low- and middle-income country contexts (Lin, Murray, Cohen, Colijn,

& Ezzati, 2008; Mestl, Aunan, & Seip, 2007; Nie, Sousa-Poza, & Xue, 2016; Rehfuess, Mehta, & Pruss-Ustun, 2006; Zhang & Smith, 2007). To identify the effect of solid fuel use accurately it is necessary to take a multitude of confounding factors into account, such as exposure time, indoor activity, room layout, smoking and ambient pollution. Our study controlled for an array of factors including smoking status, area pollution and fixed effects.[12] When controlling for individual and community level exposure to pollution, we identify solid cooking fuel use as a key risk factor associated with NCD onset, particularly in urban areas. Most studies on the impact of solid fuel use on health have focused on the rural population and have found significant association between solid fuels and increased risk of diseases including cardiovascular diseases, respiratory diseases (Liao, Tang, & Wei, 2016; Lin et al., 2008; Qu, Yan, Qu, & Ikram, 2015). In our sample, usage of solid fuels is significantly higher in rural than urban areas (58% vs 19% at baseline). However, there is evidence that with incomplete switch to clean fuels in urban area, urban residents still face an increased associated health risks (Kim et al., 2015; Mestl et al., 2007). Our estimation suggests that, conditional on not having an NCD to start with, solid fuel use in urban areas is associated with higher risk of NCD onset than in rural areas. We find further that females are at greatest risk and particularly those between 45 and 60 years of age. When we disaggregate further we find that the effect is largely among rural women. We add interactions between solid fuel use and female gender into the models and find positive significant effects on the intervening variable for the rural sample (0.015, p-value = 0.088) and in particular for rural sampled aged 45–60 years (0.041, p- value = 0.040)[13] This is in line with several previous studies which likely reflects gender differences in cooking and domestic duties in China (Liao et al., 2016; Lin et al., 2008; Nie et al., 2016). It is at odds with one study which finds no significant gender difference in the health of members of households which use coal for cooking (Mestl, Aunan, & Seip, 2006).

We find no significant effect of smoking behaviour and past smoking behaviour on the risk of NCD onset at the population level. This is at odds with existing knowledge that tobacco use is a key risk factor of NCDs (Wolf, Dagostino, Kannel, Bonita, & Belanger, 1988). Surprisingly, we find a negative effect of smoking on NCD onset among the male sample. One possibility is that smoking or drinking may play a part in professional career development of males in China (Hao, Chen, & Su, 2005). To examine such potential pathways, we add interactions between expenditure and smoking in the models and find no conclusive evidence of intervening variables at standard levels of significance (p-value = 0.358). In addition, we find a negative effect of heavy drinking behaviour among the rural and non-poor subpopulations. These effects are counter-intuitive and may be related to omitted variable bias. When we run the fixed effects specification the negative effects disappear which suggests that this may be the case.[14]

Whilst we do not find significant effects associated with current heavy drinking behaviour we find strong positive effects of past drinking behaviour on NCD onset. The effects associated with a history of frequent drinking are concentrated largely among the elderly male population. In addition, we find a very large positive effect of current heavy drinking behaviour (21%) on NCD onset among the elderly poor which upon further analysis is found also to be contained to the male population. In China, heavy drinking behaviour is more common among males so our results are not surprising (Hao et al., 2005). However, the age-related effects are novel and may imply a life-time or chronic effect of drinking on health which has been reported in the literature (Fillmore & Midanik, 1984).

We find that household consumption expenditure is positively associated with the onset – or at least the reporting – of NCDs. Though counter-intuitive, this is not an uncommon finding in LMIC settings (Cai, He, Song, Zhao, & Cui, 2013; Subramanian, Corsi, Subramanyam, & Smith, 2013; Zimmer & Kwong, 2004). Such countries are characterized by inadequacies in public investment and social protection mechanisms that are manifested in unequal access to health services; disadvantaged segments of the community are less likely to seek health care and therefore be diagnosed with disease (Gao, Qian, Tang, Eriksson, & Blas, 2002; Strauss et al., 2012; Wang et al., 2012). We in fact find positive effects for both the poor and non-poor populations, and the effect is larger among the poor individuals (0.027 versus 0.009) which suggests that the consumption gradient associated with health care use is steeper among the poor (Table 3).

Our results take us a step forward in the literature on risk factors and NCDs in China however there remain several noteworthy caveats. Our dynamic model conditional on being free of NCDs in the initial period helps to reduce potential two-way bias between disease onset and risk factors yet introduces a selection bias. Our estimates on the probability of acquiring an NCD relate only to the population free of NCDs and not for the population as a whole. Another source of selection bias is the *survivor* effect. By restricting our sample to those who remain in all three waves it could be that only respondents in good health remain. Our results furthermore do not address endogeneity bias associated with omitted variables and measurement error. Our four-year panel data provides limited analysis on the long-term influence of the risk factors, and with pooled OLS specifications we cannot distinguish age from birth cohort effect, thus further research is needed to distangle these effects.

Nonetheless by focusing on the healthier NCD-free population and identifying risk factors associated with diagnosis of an NCD for the at-risk population our results provide important information from a prevention point of view. Our results shed light on the lifetime impacts of risk factors on NCD diagnosis as their roles are found to differ at different stages in the life-cycle. Meanwhile, some risk behaviours such as frequent drinking may have long-term and accumulative effects on health. Looking at general population effects or focusing on certain population groups such as the working aged population may mask these important differences. Our results also reveal important differential effects determined by other personal and geographic characteristics.

[12] Our results are robust to both provincial and community level fixed effects.

[13] The analogous results for the urban sample were insignificant at 0.027 (p-value = 0.329) and 0.038 (p-value = 0.496), respectively. The complete model results are available from the authors upon request.

[14] Results are available from the authors upon request.

6. Conclusion

In this paper, we estimate the dynamic effects of risk factors on the diagnosis of NCDs in China, the world's most populated country. Our specification enables us to control for important simultaneity bias. We find positive impacts of being obese, using solid fuels to cook, having a history of frequent drinking, and household consumption expenditures during the preceding period on the current diagnosis of NCDs. Our results are broadly in line with earlier findings in China and other country settings. However, our results across age groups add new weight to the literature on China. Obesity, solid fuel use and consumption effects are confined to people under age 60 whereas effects associated with drinking history are confined to the elderly population. Obesity effects are contained to the non-poor population and frequent drinking history effects are contained to the male population.

Whilst our results must be interpreted with a certain degree of caution they offer several considerations for policy makers. First, public health promotion and interventions relating to eating, drinking and activity behaviours should be gender and age sensitive e.g. to address elevated risks associated with obesity among young females. Second, interventions and public health messages should be delivered at an early stage since some risk factors may take a long time to take effect, such as frequent drinking. Third, interventions should be geographically targeted to address elevated risks associated with obesity, past drinking habits and solid cooking fuel use in urban areas and the use of solid cooking fuels among middle-aged women in rural areas. Better-informed public health policy can help to ensure that NCD risks in China are delayed to the oldest possible age and are not preceded by long and costly periods of morbidity.

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Appendix A. Definition of variables

Variable	Definition
NCD	= 1 if respondent reports at least one NCD; = 0 if otherwise.
Behaviours	
Obese	= 1 if BMI of respondent is equal to or > 28 kg/m^2; = 0 if otherwise.
Underweight	= 1 if BMI of respondent is < 18.5 kg/m^2; = 0 if otherwise.
Heavy drinker	= 1 if the daily quantity of pure alcohol consumed by a male respondent is in excess of 61 g or that by a female respondent is in excess of 41 g; = 0 if otherwise.
Past frequent drinker	= 1 if respondent used to drink alcohol at least 3 times a week in the past; = 0 if otherwise.
Smoker	= 1 if respondent currently smokes; = 0 if otherwise.
Past smoker	= 1 if respondent used to smoke in the past; = 0 if otherwise.
Solid cooking fuels	= 1 if household uses open firewood, straw and coal to cook; = 0 if otherwise.
Polluting enterprises within 5 km radius	= 1 if household is located in a community which is within 5 km from a polluting enterprise; = 0 if otherwise.
Self-rated health (SRH)	= 1 if self-rated as healthy; = 2 if self-rated as fair; = 3 if self-rated as unhealthy.
Health care facility within 15 min	= 1 if household could access to the nearest health facility within 15 min; = 0 if otherwise.
SES	
Years of schooling	Years of schooling.
Logarithm of household consumption expenditure	Natural log of total household consumption expenditure.
Demographic	
Age	Age in years.
Female	= 1 if respondent is female; = 0 if otherwise.
Married	= 1 if respondent is married or cohabitation; = 0 if otherwise.
Household size	Number of household members.
Urban hukou registration	= 1 if Hukou is non-agricultural; = 0 if otherwise.
Han ethnicity	= 1 if respondent is Han ethnicity; = 0 if otherwise.
Province of residence	25 provincial dummies.
Year of interview	= 1 if 2010; = 2 if 2012.

Appendix B. OLS estimated effects of risk factors on NCD onset in 2012

	Contemporaneous controls	Lagged controls
Obese	0.019	0.019
	(0.012)	(0.014)
Underweight	−0.013	−0.020**
	(0.011)	(0.010)
Heavy drinker	−0.032**	−0.017
	(0.014)	(0.011)
Past frequent drinker	0.020*	0.037**
	(0.011)	(0.019)
Smoker	−0.012	−0.012
	(0.010)	(0.008)
Past smoker	0.003	−0.004
	(0.013)	(0.015)
Solid cooking fuels	0.015**	0.014**
	(0.007)	(0.007)
Polluting enterprises within 5 km radius	−0.001	−0.009
	(0.008)	(0.007)
Self-rated health (reference category: healthy)		
Fair	0.052***	0.036***
	(0.008)	(0.006)
Unhealthy	0.173***	0.110***
	(0.012)	(0.012)
Health care facility within 15 min	0.009	0.000
	(0.009)	(0.008)
Years of schooling	0.002***	0.001
	(0.001)	(0.001)
Natural logarithm of household consumption expenditure	0.020***	0.015***
	(0.004)	(0.004)
Age	−0.001	0.000
	(0.001)	(0.001)
Age squared	0.000***	0.000***
	0.000	0.000
Female	0.009	0.017**
	(0.009)	(0.008)
Married	0.010	0.006
	(0.010)	(0.009)
Household size	0.000	0.002
	(0.002)	(0.002)
Urban hukou registration	0.017**	0.017**
	(0.008)	(0.008)
Han ethnicity	0.007	0.001
	(0.011)	(0.010)
Province dummies	Yes	Yes
Observations	13,022	13,022
R-squared	0.085	0.060

Source: China Family Panel Studies 2010–2012.
Notes: Provincial dummy coefficients are not displayed. Robust standard errors clustered at the household level are in parenthesis.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

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Chapter 6 Coping and not coping with non-communicable disease in China

6.1 Introduction

This chapter analyses how Chinese households cope with the diagnosis of a non-communicable disease (NCD) and the consequences of the coping mechanisms. The chapter aims to examine whether households in China can maintain consumption expenditures in the face of a new NCD diagnosis and how Chinese households cope with the diagnosis of an NCD. The chapter also examines the future consequences for health, non-health consumption expenditure and wealth associated with increased health expenditures in the previous period.

The hypothesis is that households in China can maintain non-health consumption in the face with an NCD onset. The households are hypothesised to adopt costly strategies to cope with the diseases, such as selling assets and borrowing. These coping strategies are expected to have negative impacts on the future consumption and wealth of the households.

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6.2 Manuscript submitted to publication

Health Economics

Coping and not coping with non-communicable disease in China

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Keywords:	Non-communicable diseases, Health shocks, Household welfare, China

Coping and not coping with non-communicable disease in China

September 7, 2019

Abstract

The welfare implications of coping mechanisms undertaken in the face of a health shock are little known. Using longitudinal data from China, this paper examines how households cope with the diagnosis of a non-communicable disease and the consequences on their future well-being. We find that households cope with the main financial risk of disease-related health expenditures through the depletion of housing assets and receipt of public transfers. Poor households forego medical expenditure in the event of a disease shock. We find further among the diseased population that spending more on health in the preceding period leads to improved health and reduced assets in the future period. Taken together our results suggest that Chinese households struck by disease maintain current consumption at the expense of future wealth (for the rich) and future health (for the poor).

Keywords: Non-communicable diseases, health shocks, coping mechanisms, household welfare, China

JEL codes: I12, I14, I15, I3, C23

1 Introduction

The World Bank's *Voices of the Poor* study identified health shocks as among the most burdensome for households, which has also found empirical support (Narayan, Patel, Schafft, Rademacher & Koch-Schulte 2000, Wagstaff & Lindelow 2014). The onset of a chronic health condition in a household can divert scarce household resources to health-related expenditures and can also lead to reduced income due to the reduced productive capacity of the household member with disease (and their primary caregiver), especially if it is a prime working-age member. How households cope with these income risks and moreover what is the consequence of risk-coping mechanisms on their welfare over time is not well understood. This has clear implications for policy. If households are less equipped to cope with the income risks associated with health shocks and undertake costly coping mechanisms, such as selling productive assets or avoiding treatment, then the future welfare costs and thus welfare gain from increasing social insurance may be large (Chetty & Looney 2006, Chetty 2006). Conversely, if households can cope relatively easily with the financial risks of health shocks, such as through accessing informal networks or cheap credit, then public insurance may crowd out private efforts with limited gain to society.

To accurately determine the welfare costs associated with health shocks, and therefore the need for insurance policies, it is necessary to determine (i) the financial risks associated with health shocks and how households cope with these risks, and (ii) the consequence of these coping mechanisms on their welfare. The existing health shocks literature has concentrated on the former questions. The early literature concentrated on the question of whether households can smooth consumption in the face of a health shock (Gertler & Gruber 2002). Following Chetty and Looney (2006) who show that consumption is not an adequate indicator for welfare since households may maintain consumption because of risk aversion, recent papers have investigated the risk-coping strategies employed by households in the event of a health shock (Liu 2016, Islam & Maitra 2012, Sparrow, de Poel, Hadiwidjaja, Yumna, Warda & Suryahadi 2014, Khan, Bedi & Sparrow 2015, Mitra, Palmer, Mont & Groce 2016). Contemporaneous effects of health shocks on household economic outcomes and coping mechanisms as reported in the existing literature are inferred to impact on the future well-being of households. However, the empirical evidence is weak and is where we seek to make a contribution.

In this paper, we examine how Chinese households cope with a non-communicable disease (NCD) shock and the future consequences of coping mechanisms on well-being. Using three waves of the China Family Panel Studies survey (2010-2014) and fixed effects specifications, we find that Chinese households that experience a significant increase in out-of-pocket health expenditures following a NCD shock are able to smooth consumption expenditure through the depletion of housing assets and receipt of public transfers. We do not find a significant increase in health expenditures among poor households (even after controlling for insurance), suggesting that they forego treatment. We find further that spending more on health in the preceding period leads to improved health and reduced assets in the future period among NCD patients. This suggests that the non-poor and poor are each paying a price in terms of future wealth and health, respectively, by risk-coping mechanisms undertaken today. The poor arguably pay a higher price in terms of human capital creation which suggests that increased insurance could yield large welfare gains.

Our paper makes several noteworthy contributions to the literature. We simultaneously study coping mechanisms and their consequences on future well-being, whereas the existing literature is limited to contemporaneous effects of health shocks on economic welfare and coping mechanisms. An exception is the study by Khan et al. (2015) who examine the consequences of household

coping mechanisms of borrowing and depleting productive assets to morbidity and mortality on future consumption. Our paper examines several future economic and health outcomes, and focuses on the question of whether households choose to seek treatment (proxied by the level of health expenditures) as an overall measure for coping mechanisms. This approach is justified since in our study, as in the majority of other studies, health expenditures (rather than loss of income) is the primary financial risk through which our health shocks measure impacts on household welfare. Our results are nationally representative whereas the Khan et al. (2015) study is based on data from urban communities in just one municipality in Bangladesh.

The health shocks literature is small and focuses on a limited set of health measures and coping mechanisms. We adopt a NCD measure as our health shock measure in the context of China. This is important because empirical studies have shown that risk-aversion can vary depending upon the scale of the shock and the context (Chetty, 2006). The current literature uses a range of health measures but with limited focus on NCDs.[1] The general problem is that these measures may capture both changes in health that are temporary as well as persistent. NCDs have a prolonged course and require a long-term and systematic approach to treatment (World Health Organization 2005, Beaglehole, Bonita, Horton, Adams, Alleyne, Asaria, Baugh, Bekedam, Billo, Casswell, Cecchini, Colagiuri, Colagiuri, Collins, Ebrahim, Engelgau, Galea, Gaziano, Geneau & Haines 2011). It is likely that the financial risks and behaviours of households may differ between persistent and short-lived health shocks. The extent to which households can smooth consumption due to anticipated and unanticipated variation in the health of a family member is also of interest. Kumara and Samaratunge (2017) investigate the impact of NCD incidence on household consumption, without identifying NCDs as an unexpected shock to households. Our measure of a NCD shock is the new diagnosis of NCDs among households who are free of NCD members in the initial period. We consider the onset of NCDs as unanticipated shocks providing new information to individuals and households. People thus cannot fully predict the exact timing of the occurrence of such a disease which enables us to better isolate the effect of the shock on well-being (Smith 1999, Lindeboom, Llena-Nozal & van der Klaauw 2016).

Several studies have shown that certain subpopulations, especially the poor, are less equipped to cope with the income risks associated with health shocks due to less access to savings, wealth, credit markets and informal risk-sharing networks (Sparrow et al. 2014, Khan et al. 2015). At the same time, poor households may be more risk-averse in that they are close to a subsistence level of consumption and reluctant to reduce consumption further when their income drops (Chetty & Looney 2006). As a consequence, they may be willing to undertake costly coping strategies to smooth their consumption in the face of health shock. We add to this literature by examining a wide array of coping mechanisms associated with a NCD shock and their future consequences for well-being of the poor (and non-poor) in China. Like several other papers (Mitra et al. 2016, Khan et al. 2015), we find the poor can insure consumption in the face of a health shock but do so through treatment avoidance and at a cost to future health which represents a new and important finding in the literature.

The remainder of the paper is structured as follows. The following section 2 provides a background of NCDs in China. Section 3 discusses the data and definition of key variables. Section 4 outlines the conceptual framework and empirical strategy. Section 5 presents the results followed by a discussion of results in section 6. Section 7 concludes.

[1] These include self-reported symptoms or illness (Sparrow et al. 2014, Yilma, Mebratie, Sparrow, Abebaw, Dekker, Alemu & Bedi 2014), functional limitation such as days unable to carry out activities of daily living (Mitra et al. 2016, Genoni 2012, Gertler & Gruber 2002, Liu 2016) and hospitalization (Mitra et al. 2016).

2 Non-communicable disease in China

NCDs represent the greatest share of the global burden of disease, accounting for close to three-quarters of global deaths (GBD Causes of Death Collaborators 2017).[2] Of these deaths, the vast majority stem from large transitional economies, such as China. In 2017, 8.6 million people died from NCDs in China, comprising nearly 90 per cent of total deaths (Institute for Health Metrics and Evaluation 2017). The rapid rise of NCDs in China has been fuelled by unprecedented demographic change and economic development (World Health Organization 2015, Yang, Wang, Zeng, Gao, Liang, Zhou, Wan, Yu, Jiang, Naghavi, Vos, Wang, Lopez & Murray 2013). Over the last four decades, China has achieved remarkable progress in combating infectious disease and reducing child mortality, transitioning from a high mortality and high fertility country to a low mortality and low fertility country. This has contributed to changing population age structures and an increase in the incidence of age-related NCDs. Alongside demographic change, social and economic development has brought urbanisation and changed lifestyles which have resulted in the behavioural risk factors for NCDs becoming widespread. According to the Global Burden of Disease study, the leading risk factors for death and disability in China are dietary risks of low fruit and high sodium consumption, tobacco use, high blood pressure, air pollution and high body-mass index (Institute for Health Metrics and Evaluation 2017).

The literature on the economic impact of health shocks, and NCDs in particular, in China is small given the scale of the issue. Studies typically rely upon cross-sectional data, limited outcome variables and include a wide range of health measures rather than just NCDs.[3] With a few exceptions the majority of papers do not address unobserved heterogeneity. Using four rounds of the China Health and Nutrition Survey over the period 1991-2000 and fixed effects regressions, Lindelow and Wagstaff (2005) examine the impact of a health shock, as measured by the worsening of self-rated health of the household head, on medical spending, income and labour supply. The authors find a health shock leads to an 5-6 percent reduction in income and labour supply and a 9 percent increase in medical spending. They find further evidence that the poor benefit from in-kind transfers from family and friends in the event of a health shock. However, the transfers comprise only a small portion of total income and is insufficient to insure the negative effects of the health shock on income. They also find that health shocks have a smaller impact on medical spending of the poor which may suggest that the poor are less likely to obtain health care when they experience shock.

Using the same dataset over seven waves from 1993-2011 and first-differenced regressions, Liu (2016) examines the impact of a different health shock, as measured by changes in the number of days unable to carry out daily activities of the household head and spouse, on household income, food consumption and medical spending. Contrary to the Lindelow and Wagstaff (2005) study, households can fully insure household income and food consumption in the face of a health shock and associated increase in out-of-pocket medical expenditures. However, there is a negative impact on individual earnings which is consistent with the earlier study finding of reduced labour supply. The paper investigates several coping mechanisms through which households insure consumption and income, including child schooling and child labour, investment in agriculture-related activities, and health insurance. A health shock on the household head or spouse leads to a decrease in school

[2] According to the World Health Organization, a NCD is a medical condition or disease that is non-infectious and non-transmissable among people (World Health Organization 2005, Beaglehole et al. 2011). The four main types of NCDs include cardiovascular disease, cancer, chronic lung disease and diabetes.

[3] For a detailed review refer Pan (2019).

enrollment and productive investments and an increase in child labour. The human capital effects were muted by access to health insurance leading the author to conclude that health insurance has an important role to play in crowding out potentially costly coping mechanisms.

Our paper builds on this earlier work in several important aspects. First, the China Health and Nutrition Survey used in previous studies has limited geographical coverage and economic variables. The data is representative for only 9 of 33 provinces and includes only information on food consumption and thus has only a partial measure of household welfare and has limited information on coping mechanisms. For instance, investment in productive activities is used as a proxy variable for accessibility to credit. Furthermore, the adopted health shocks variables in previous papers are transitory in nature (Liu, 2016).[4] We draw upon nationally representative longitudinal data, NCD measures as a more persistent measure of health shock, and a rich collection of economic welfare and coping mechanism variables. Second, we provide heterogeneous effects for the poor (and non-poor) samples across all outcomes to sytematically examine how health shocks impact differentially upon the most vulnerable households. Third and most importantly, we investigate an additional empirical question. Existing papers estimate contemporaneous effects of health shocks on economic outcomes and coping mechanisms. For instance, Liu (2016) is primarily concerned with the question of how health insurance mitigates the economic impact of health shocks. In addition to the estimation of contemporaneous effects, we estimate the effects of coping mechanisms on future well-being which is particularly important from a policy point of view.

3 Data and descriptive statistics

This analysis uses data from the China Family Panel Studies (CFPS) survey. The CFPS is a nationally representative, biennial longitudinal survey implemented by the Institute of Social Science Survey (ISSS) of Peking University, China. So far, the CFPS has conducted four waves of data collection, including a baseline survey in 2010 and three follow-up surveys in 2012, 2014 and 2016. We use the available first three waves of data and restrict the sample to households without a member with a diagnosed NCD in the first wave. The three waves form a balanced panel of 11,329 households and among them, 8,508 households do not have any members diagnosed with a NCD in 2010.[5] The CFPS contains a rich collection of information collected at individual, household and community levels (for a detailed description of the survey refer Xie et al., 2017).[6]

We identify NCD-affected individuals based on the question: 'During the past six months, have you had any doctor-diagnosed chronic disease'; and, the self-reported doctor diagnosis of the disease. Specifically, we identify individuals as living with NCDs if their diagnosed diseases are classified within the 'Group II Diseases' as per the ICD-10 code (World Health Organization, 2016).[7] NCDs-affected households are defined as those with one working-age member (16 to 60 years old) diagnosed with at least one NCD; households with no member with NCDs are non-affected households.[8] We

[4] As reported by Liu (2016), the correlation between the current health shock and the first- and second-lagged health shocks are -0.66 and -0.31, respectively. This implies that the health shocks measure is mean-reverting and transitory.

[5] The baseline sample comprised 14,798 households and 33,600 adults.

[6] The survey contains three modules: an individual- and household-level survey collect demographic, socioeconomic and health-related information, and the community-level survey collects information on infrastructure, demographic profiles, social services and economic conditions.

[7] Detailed description of the NCD classification has been described in Pan and Palmer (2018).

[8] We focus on the working-age population with a disease on the premise that disease onset in this group is more likely to affect household welfare (Mitra et al. 2016). In 2010, approximately 15% of the households had one

remove from the balanced panel of households with no NCDs in the first wave households with more than one working aged member with NCD and households with non-working aged members with NCDs in either of the two consecutive waves to form a balanced panel of 7853 households which constitutes our final sample.

For the outcome variables, we focus on a range of economic and coping mechanism variables. We adopt total household (non-health) consumption expenditures as our primary measure of economic welfare. In addition, we examine the impacts of NCDs on out-of-pocket health expenditures and earned income to identify the main source of financial risk. Health expenditures include total household expenditures on medical care and other health care in the past year (excluding that which was reimbursed or reimbursable but including paid by or borrowed from relatives). Earned income includes all wage income, operating income including net agriculture income and non-agriculture self-employed income of the household earned over the past one year. For the coping mechanisms, we include transfer income (public and private) over the past one year; assets (housing and land, financial, productive assets and durable goods), and non-housing debts at the time of interview.[9]

The descriptive statistics of the outcome and control variables for NCD households and non-NCD households in 2012 (among NCD-free households in 2010) are presented in Table 1.[10] Compared with non-NCD households which constitute approximately 88% of the full sample, NCD households on average have a similar level of (non-health) consumption expenditure yet significantly higher health expenditures and higher earned income. In terms of unearned income, they have higher public transfer income and a similar level of private transfer income. NCD households have lower holdings of house and land assets and higher financial and productive assets, and non-housing debt. In terms of household demographic and other characteristics, NCD households on average are younger (lower proportion of members aged over 60) and more likely to reside in urban areas with a lower level of poverty and higher education of the household head compared to non-NCD households.[11]

4 Empirical strategy

This section puts forward an econometric approach for estimating the longer-run impacts on well-being of coping with health shocks. First, we estimate the impact of a NCD shock on contemporaneous economic outcomes (to identify the main source of financial risk) and coping mechanisms. Second, we estimate the impact of past health inputs on the future well-being of diseased households. The approach enables us to estimate the future well-being implications of whether households choose to outlay current resources towards the treatment of the disease or not; that is, whether they 'cope' or do 'not cope' with the onset of disease.[12]

working-aged member with NCDs; the prevalence rates for 2012 and 2014 are 13% and 17%, respectively

[9] Detailed information on the construction of unearned income variables has been described elsewhere whereas asset and debt variables were constructed by the CFPS group (Wu, Dai, Cui, Zhang, Zhang, Chen, Xu & Xie 2015, Xie, Zhang, Tu, Ren, Sun, Lv, Ding, Hu & Wu 2017).

[10] The definitions of these variables are provided in Appendix Table 1.

[11] The Hukou registration system in China divides the population into agricultural (rural) and non-agricultural (urban) sectors, which influences access to a range of resources, services and opportunities, such as jobs, education, housing, and health care. We use information on Hukou registration to construct an indicator variable for whether the household lives in an urban or rural area. Poor and non-poor households are classified based on the self-report of whether the household received any poverty subsidy or a low living allowance from the government in baseline.

[12] Note that foregoing treatment is also a coping mechanism but whether it is an informed decision taking into account the future consequences is unknown.

To estimate the impact of NCD onset on contemporaneous economic outcomes we start from an OLS model and employ a fixed effects (FE) model as our preferred specification, as follows:[13]

$$lnY_{hct} = \delta NCD_{hct} + \beta X'_{hct} + \tau_t + \tau_c + \alpha_h + \varepsilon_{hct} \qquad (1)$$

where Y_{hct} is a measure of the natural log of economic outcomes and coping mechanisms for the hth household living in county c in time t; NCD_{hct} is a binary indicator for a household with a working-age member with a newly-diagnosed NCD; X_{hct} denotes a vector of characteristics of the household and the household head; τ_t and τ_c represent time and community fixed effects, respectively; α_h are household-specific effects; and ε_{hct} is an idiosyncratic error term. The selection of household control variables are those that are thought to be exogenous and not caused by NCD onset (Angrist & Pischke 2009). These include household size; share of female members; share of members under 16 years; share of members over 60 years; gender, age, age-squared and highest education level of the household head; urban residence; province of residence; and month of interview (refer Appendix Table 1. for details of outcome and control variables). For all estimations, robust standard errors are clustered at the county level to capture any shocks to the outcome variable across households within the county and over time.[14]

The coefficient of interest δ is an estimate of the impact of NCD onset on economic welfare and coping mechanisms. We identify households that experience a NCD shock as those with one newly-diagnosed working-aged NCD member in 2012 from NCD free households in the baseline. To the individual and the household, NCD onset is considered as an event in which the exact timing cannot be anticipated. The challenge in consistently estimating δ may arise from three aspects: measurement error, unobserved heterogeneity, and simultaneous bias. Whilst our measure of NCD is more objective, as diagnosed by a doctor, it remains open to potential measurement error relating to unobservable factors associated with education level, access of health service, and economic outcomes (Strauss and Thomas, 2008). To the extent that the bias is systematic or consistent across time it will be mitigated by our empirical strategy. The presence of time-invariant and time-varying unobserved heterogeneity may be a determinant of both health and the outcome of interest. The FE model enables us to eliminate the time-invariant component. A final estimation problem relates to simultaneity bias, which is dealt with partly through our identification of unanticipated NCD shocks. Furthermore, it is suggested that simultaneity bias may be less of a problem with a more objective measure like an onset of specific conditions (Smith 1999). We investigate the effects of a group of serious NCDs on household welfare as a robust check and our results are qualitatively unchanged.[15]

To estimate the future consequences of a NCD shock on health and economic well-being, we start from pooled OLS models and estimate as our preferred specification the following dynamic FE models of health and economic outcomes for a pooled sample of NCD patients from a household containing one working-aged NCD member in 2010 and or 2012:

[13] We conducted Hausman tests that strongly rejected the null hypothesis that random effects provide consistent estimates and thus adopt the household FE specification as our main specification.

[14] Both the random and fixed effects estimators assume that the idiosyncratic error term is independently and identically distributed which is often not suitable in panel data applications. For short panels, as in our case, it is possible to obtain cluster robust-standard errors.

[15] We identify serious NCDs based on the China country profile from the GBD study including those diseases that cause the most death and disability combined (cerebrovascular disease; cardiovascular disease excluding hypertension, acute rheumatic fever, angina; cancer; nervous system disease; diabetes; COPD; lumbar disc disease) (Institute for Health Metrics and Evaluation 2017). We consider more severe NCDs (such as heart attack) as more likely to represent exogenous shocks. Results are available upon request.

$$Y_{iht} = \theta HE_{h,t-1} + \beta X'_{i,t-1} + \lambda H_{i,t-1} + \alpha_{ih} + \varepsilon_{iht} \quad (2)$$

where Y_{iht} is a measure of health or economic welfare in the current period for individual i or household h, $HE_{h,t-1}$ is household-level out-of-pocket health expenditures[16] in the proceeding period, $X_{i,t-1}$ is a vector of observed individual characteristics in the preceding period, $H_{i,t-1}$ is self-assessed health in the preceding period, α_{ih} is the individual-level or household-level fixed-effect, and ε_{iht} is an error term. For the outcome variables, we adopt two health measures including enumerator rated health (ERH), and hospitalisation, and three economic variables including (non-health) consumption, income and assets.[17] We control for a range of lagged characteristics broadly in line with the literature (van Doorslaer & Jones 2003, Au & Johnston 2014). These include age, age-squared, gender, marriage status, employment status, smoking status, log of household income, urban residence, province of residence, and month of interview. We control further for lagged SAH since current SAH can be affected by past health shocks (Au & Johnston 2014).[18] Standard errors are clustered at the county level.

5 Results

5.1 Impact of NCDs on economic outcomes

Table 2 reports FE specifications of the effect of having one working-aged household member newly diagnosed with a NCD on different economic outcomes among households who are initially free of disease. The coefficient of interest in both OLS and FE specifications are similar in direction and level of significance for each outcome (OLS results are presented in Appendix Table 2). The results indicate that NCD onset at the household level is associated with reduced consumption expenditure and increased health expenditure and earnings. However, the coefficients on consumption and earnings are small in magnitude and statistically insignificant, suggesting that Chinese households can insure consumption and that there is no direct shock to earned income associated with the diagnosis of a NCD. The main financial risk is through increased health expenditures. NCD-affected households experience 55% higher health spending compared with non-affected households. In terms of coping mechanisms, having a newly diagnosed member with a NCD is associated with a 30% increase in the receipt of public transfers (significant at the 10 per cent level), defined as government subsidies and social donations. The coefficient is also positive for the private transfer income outcome, however is not significant at standard levels of significance. Conversely, there is a negative effect on the value of housing and land assets (significant at the 10 per cent level) and positive statistically insignificant effects on financial and other assets. The coefficient for the debt

[16] We use household-level health expenditure controlling for household size. Individual-level health expenditures are only consistently available for individual hospitalization costs and few NCD respondents reported be admitted to hospital.

[17] ERH is rated by trained enumerators. It is a seven-scale indicator ranging from 1 to 7 as from very poor to very good. Hospitalization is a binary outcome generated from the question: "Were you hospitalized last year". The definitions of the health measures and economic variables are provided in Appendix Table 1.

[18] We rescale the SAH variable into three categories of unhealthy, fair and healthy. Since estimation of an equation which contains a lagged dependent variable and individual effects can lead to inconsistent estimation (Arellano & Bond 1991), we do not include SAH models in our baseline results. For GMM estimation, values of outcomes lagged two periods or more are valid instruments in an equation in first differences. However, our sample is a pooled sample of NCD patients in 2010 and or 2012. We note that the SAH lagged dependent variable ordered logit fixed effects model results are consistent with those from the analagous ER H specification with lagged SAH (results are available upon request).

outcome is also insignificant at standard levels of significance. Family size remains a significant positive predictor of economic outcomes whereas other controls are absorbed into the household fixed effect with a few exceptions. For instance, living in a household with a higher share of females and having a household head with upper secondary education is positively associated with household earnings.

5.2 Heterogeneous effects for the poor

To the extent that household risk aversion varies by level of income, we examine how the impact on household economic welfare and risk-coping mechanisms of having a newly diagnosed member with a NCD differs by poverty status. To do so, we re-estimate the specifications reported above for the poor and non-poor sub-samples separately. Since nearly 90% of our sample are non-poor, results are similar to those reported for the full sample above and are presented in Appendix Tables 4 & 5. We present results for the poor household sample classified based on the self-report of whether the household received a low living allowance from the government in 2010.[19] In total, there are 690 households identified as poor in our sample. Once again we report on results for the FE specifications.[20] As shown in Table 3, there are siginificant differences for the poor sub-sample compared with the full (and non-poor) sample. The size of the coefficient for the health expenditures outcome is greatly reduced and is no longer significant at conventional levels of significance. The negative coefficient on the NCD variable of interest in the consumption model is increased in magnitude yet remains statistically insignificant which may reflect imprecision in estimation due to the reduced sample size. The significant positive effect on public transfers for the full sample is now negative and no longer statistically significant. The significant negative effect on housing and land assets is now positive and statistically insignificant. Effects on earnings, private transfers, financial and productive assets, and non-housing debt are reversed in direction and remain statistically insignificant. We also observe some differences in the effects of other covariates on outcomes compared with the full (and non-poor) sample. For instance, education effects of the household head are no longer significant for the earnings outcome and are significant for the consumption and health expenditures outcome. The positive effect of share of females in the household is larger in magnitude and now significant for the health expenditures plus the earnings outcome.

5.3 Future consequences on health and welfare

To estimate the future effects of NCD diagnosis on household well-being, we estimate a series of dynamic OLS and FE models of health and economic outcomes amongst a pooled sample of NCD patients from a household containing one working-aged NCD member in 2010 and or 2012. As specified in Equation (2), the preferred FE specification estimates the effect of health expenditures in the previous period on outcomes in the current period controlling for past observed, and unobserved, heterogeneity. Summary statistics of the outcome and control variables are presented in Appendix Table 6. In Table 4 we present reduced-form results for two health outcome variables including

[19] In China, the official poverty line is determined only for rural areas. Local government identifies poor households based on either the official poverty line or a local poverty line adjusted for the cost of living. In addition to the poverty cash transfer, the low living allowance (Di Bao) program has been implemented in urban and rural areas to provide additional social protection to poor households. The poverty eligibility criteria for Di Bao varies across in regions.

[20] Results for the OLS specifications are presented in Appendix Table 3.

an ordinal scale variable of enumerator assessed health, and a binary variable of hospitalisation. In order to control for time-invariant heterogeneity, particularly the response heterogeneity, we apply a linear FE model for all three health measures. Because the linear FE model disregards the ordinal nature of ERH, we present results from ordered-logit FE models for these two measures, as described in Baetschmann et al. (2015). For the hospitalization binary outcome, we apply an appropriate logit FE model.

As shown in Table 4, for the OLS specification, health expenditures in the previous period are associated with improved ERH, and increased probability of hospitalisation in the following period. For the linear FE specifications, the coefficient of interest for the hospitalisation outcome changes sign and is no longer significant at standard levels of significance whereas the positive effect on ERH increases in magnitude and remains significant. For the ordered logit FE and logit FE specifications, the effects on hospitalisation are significantly increased in size and are now statistically significant at the 5 per cent level whereas the effect on ERH is also increased in magnitude but is no longer statistically significant which may relate to computational inefficiencies of the ordered FE model for small samples with little variation in ERH overtime (Nickell 1981).

Table 5 reports on FE specifications of the effect of past health expenditures on current outcomes of economic well-being over the pooled 2010-2012 NCD patient sample. The OLS results suggest that patients that spend more on past health expenditures experience an increase in non-health consumption, income, and assets (in particular, productive and durable assets) in the future period (Appendix Table 7). Coefficients of interest on housing/land and financial asset category outcomes are also positive yet statistically insignificant. When controlling for unobserved heterogeneity, the FE results tell a different story of health expenditures leading to a reduction in productive and durable assets in the future period. Specifically, a 10% increase in health expenditures in the previous period leads to a 0.69% reduction in the value of productive and durable assets in the following period (significant at the 10 per cent level). Analogous coefficients on consumption, income, and financial assets are also negative but statistically insignificant whereas that on housing/land assets remains positive and statistically insignificant. Whilst most coefficients behave in the expected manner or are absorbed into the individual fixed effect, we observe mixed results on certain covariates. Notably, the coefficient on past income and urban Hukou status is negative for consumption expenditure and assorted asset category outcomes. The negative coefficient on income is small in magnitude and mildly significant e.g. a 10% increase in income leads to a 0.2% decrease in non-health consumption. Due to the little variation of Hukou status overtime (only 13 individuals changed) in our sample, the urban Hukou result is likely noise.

6 Discussion

NCDs account for an increasingly large share of the global burden of disease due to the rapid rise in LMICs over the past decade, and in emerging economies including China in particular. Despite this, little is currently known about the impact of NCDs on the well-being of households and the capacity of households to cope with the onset of NCDs or health shocks in general. Most notably, little is known about the consequences of risk-coping and risk-management strategies on the future welfare of households. This carries important implications for the design of public insurance policy and programs. If households can self-insure the financial risks of health shocks relatively easily and inexpensively, through access to formal credit markets or through social networks for example, without significant impact on welfare then social insurance may crowd out private mechanisms with little welfare gain (Chetty, 2006, Chetty and Looney, 2006). On the other hand, if households are

highly risk-averse and adopt whatever means are necessary to insure current consumption which are detrimental to future welfare then public insurance may bring large welfare gains.

In this paper we estimate the impact of NCD diagnosis among persons of working-age on the well-being of households in China using three waves of the China Family Panel Studies survey (2010-2014). Our key findings can be summarised as follows. First, the main financial risk associated with the onset of a NCD is through the channel of sharply increased health expenditures (an average increase of 55%) with no apparent direct shock to income. Second, households in China can insure non-health consumption expenditure in the face of a NCD shock and health-expenditure related risk. This is achieved ex-post through the depletion of housing and land assets, and the receipt of public transfers. For the poor population, the primary coping mechanism is to forego treatment and eliminate associated health expenditure risk.[21] Third, and most novel, we find that increase in health expenditures among the NCD patient population in the past period leads to an improvement in health status and a deterioration on productive and durable assets in the future period. Results suggest that households which choose to undertake treatment and associated coping mechanisms incur a penalty in terms of wealth creation. Poor households which choose not to seek treatment pay a price in terms of human capital creation.

Our results are in line in several respects with the health shocks literature in other LMIC settings. The majority of studies find health expenditures to be the predominant source of financial risk associated with health shocks (Sparrow et al., 2014, Mitra et al., 2016).[22] The absence of direct shocks to earnings may be due to the relative flexibility of intra-household labour substitution in informal sector jobs which dominate labour markets in LMICs (Sauerborn, Adams & Hien 1996). In China, labour supply is an important mechanism in which to insure consumption against health shocks (Liu, 2016). Unfortunately, the recall periods of our health shock measure and labour supply variables do not marry up so we are unable to test this accurately. Consistent with our findings, the majority of recent studies find that households including the poor can generally insure consumption in the face of a health shock. Early studies in the context of Indonesia and Vietnam find that households were less able to insure consumption in the event of a health shock potentially due to the limited coverage of public health insurance which has expanded rapidly in recent times (Gertler & Gruber 2002, Wagstaff 2007). Approximately one decade later, Vietnamese households including the poor could maintain consumption in the face of several health shock measures (Mitra et al., 2016).[23]

However, the question is less about whether households can insure consumption but at what cost (Chetty and Looney, 2006). Our findings regarding the receipt of public transfers and depletion of assets are broadly consistent with other findings in the literature (Mitra et al., 2016, Liu, 2016). Similar to the Vietnam context, the effect of public transfers in our sample is contained to rural households, particularly among the rural non-poor.[24] It may indicate that the baseline non-poor households (more likely the near poor) benefit from the government subsidies. In 2011, the Chinese

[21] Note we do not anticipate ex-ante risk-management to be dominant due to our estimation strategy which aims to identify unanticipated NCD shocks. Furthermore, we also tested our results against a potentially more exogenous health shock measure of severe NCDs and the results are qualitatively unchanged.

[22] A few studies also revealed that for the poor and the informal sector, health shocks also impact negatively on income, however, the magnitude of the negative effects on income is much smaller than that of the positive effects on health expenditure (Sparrow et al., 2014, Khan et al., 2015).

[23] The urban poor in Bangladesh are also able to insure consumption in the face of a health shock (Khan et al., 2015).

[24] For the FE specification, the NCD coefficient on public transfers for the rural sample is 0.448 (p-value = 0.036) versus 0.345 (p-value=0.318) for the urban sample. The coefficient for the rural poor sample is -0.180 (p-value = 0.797) versus 0.385 (p-value = 0.081) for the rural non-poor sample.

government introduced a revised poverty line for rural households and as such more rural near-poor households became eligible for poverty subsidies (Xian, Wang & Wu 2016). Our result on the depletion of household assets is consistent with several other studies (Genoni 2012, Khan et al. 2015, Mitra et al. 2016, Liu 2016). However, the particular class of housing and land assets represents a new finding in the literature. In the China context, the price of housing has been growing rapidly over recent years. However, the market value of housing fell by 28% among households with a newly diagnosed NCD member implying that these households might deplete housing assets to raise cash to pay for medical treatment or other costs associated with their illness. The effect applied only to non-poor households, suggesting that the better off have more opportunity to draw on such assets as a coping strategy (Dercon 2002). Unlike studies in other contexts, we do not find any association between our health shocks measure and increased borrowing which may reflect formal credit constraints in China. In our sample, among those who incur non-housing debts, the majority (75%) borrow money from friends and private money lender rather than banks or formal credit institutions.

Our finding relating to the foregoing of treatment among the poor population in China as a mechanism in which to maintain consumption represents a new finding in the health shocks literature. The majority of papers observe a strong positive relationship between health shocks and health-related expenditures among the poor (Sparrow et al., 2014, Mitra et al., 2016, Kumara and Samaratunge, 2017). Our finding is consistent with the theory that risk aversion differs by income level and context, and the empirical literature on the use of risk-coping strategies among poor households (Dercon, 2002, Chetty and Looney, 2006). A review of the literature by Dercon (2002) identifies constraints which limit the use of assets, formal credit and income diversification among the poor, whereas informal risk-sharing and public safety nets provide only limited protection against financial risk. In our case, we do not find any association between the new diagnosis of a NCD and the depletion of assets, receipt of public and private transfers, or accumulation of debt among poor households in China. We examine further the possibility that health insurance may be driving our result through the inclusion of an insurance control variable in the health expenditure model for the poor sample and the results remain qualitatively unchanged.[25] This finding is also consistent with other studies in China which show that health insurance has only very limited protection against health shocks (Wagstaff & Lindelow 2008, Yip & Hsiao 2009, Meng, Xu, Zhang, Qian, Cai, Xin, Gao, Xu, Boerma & Barber 2012, Liu 2016). The 2010 round of our survey asked respondents the reasons for foregoing medical treatment. As shown in Appendix Table 8, the poor are much more likely to report expensive costs as the reason for foregoing treatment compared to the non-poor (39% versus 29%).

Our main contribution relates to our findings on the consequences of household coping mechanisms for future well-being. Previous studies have focused on the contemporaneous effects on consumption and financial coping strategies; the future consequences on household well-being have largely been ignored. Using an array of health and economic outcomes, we find that coping with the onset of a NCD through the outlay of resources to medical treatment is associated with an improvement in health and depletion of assets in the future period. Since we control for past income, the result implies that foregoing medical expenditures leads to a steady state of poor health or perhaps a deterioration in health for households of any given level of income including the poor. Contrary to Khan et al. (2015), we do not find any future consumption (or income) effects of coping with

[25] For the preferred FE specification, the coefficient on the NCD variable of interest is unchanged and the coefficient on insurance is positive but statistically insignificant. We furthermore do not find any significant effect of insurance on other economic outcomes. These results are available upon request.

health shocks which suggests that Chinese households can smooth consumption over the short to medium term at least. There exists a large literature on both the benefits of wealth and human capital creation for human well-being. This particularly relates to human capital creation which suggests that the welfare gains associated with increased social protections for households in China could be significant, especially for the poor. A caveat of our analysis relates to the two-year window under which we estimate future welfare effects. Future work would benefit from longer panels to estimate the longer term impact of NCDs on household well-being.

7 Conclusion

This paper investigates the economic consequences for the household of having a working-aged member diagnosed with a NCD in China. The results are timely in view of the rapid rise in the prevalence of NCDs in the country over the past two decades. In spite of recent efforts to expand public health insurance and targeted poverty alleviation programs, our results suggest that households, especially those that are classified as poor, are ill-protected from the financial risk of increased medical expenditures associated with more persistent idiosyncratic health shocks such as the onset of a NCD. As such, they are resorting to selling off housing and land assets and or in the case for which they are bereft of assets of significant value, electing to forego medical treatment. The consequences in the short-run are the depletion of household assets and human capital which are likely to carry longer-term consequences for household welfare. Our results support the expansion of public transfers and deepening of insurance coverage, especially to the poor, as well as measures to improve accessibility to affordable formal credit markets in China. We offer these considerations with the cautionary note that further long-term analysis is required to better inform effective policy response.

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Table 1: Descriptive statistics by household non-communicable disease status in 2012

	Full		NCD Household		Non-NCD Household	
	Mean	S.E.	Mean	S.E.	Mean	S.E.
Log of consumption expenditures	10.055	(0.032)	10.126	(0.050)	10.046	(0.032)
Log of health expenditures	6.375	(0.079)	7.270	(0.101)	6.259	(0.084)
Log of earned income	8.233	(0.106)	8.687	(0.221)	8.173	(0.107)
Log of public transfers	4.155	(0.131)	4.332	(0.199)	4.132	(0.131)
Log of private transfers	1.381	(0.076)	1.402	(0.139)	1.379	(0.078)
Log of housing assets	11.215	(0.080)	11.010	(0.144)	11.241	(0.088)
Log of financial assets	8.313	(0.088)	8.511	(0.148)	8.287	(0.091)
Log of productive assets	8.668	(0.069)	8.904	(0.098)	8.637	(0.070)
Log of debt	2.441	(0.107)	2.652	(0.185)	2.414	(0.112)
Household size	3.895	(0.067)	3.989	(0.084)	3.883	(0.071)
Share of female members	0.422	(0.004)	0.438	(0.008)	0.420	(0.005)
Share of members under 16	0.143	(0.006)	0.128	(0.008)	0.145	(0.006)
Share of members over 60	0.133	(0.006)	0.043	(0.006)	0.144	(0.007)
Urban residence	0.286	(0.027)	0.339	(0.034)	0.279	(0.028)
Poor household	0.092	(0.010)	0.069	(0.011)	0.095	(0.011)
HH age	49.925	(0.296)	49.572	(0.485)	49.971	(0.311)
HH female	0.320	(0.015)	0.334	(0.024)	0.318	(0.015)
HH less than primary school	0.282	(0.016)	0.258	(0.023)	0.285	(0.017)
HH primary school	0.236	(0.009)	0.227	(0.019)	0.237	(0.009)
HH lower secondary school	0.290	(0.009)	0.300	(0.022)	0.289	(0.009)
HH upper secondary school	0.135	(0.009)	0.155	(0.017)	0.132	(0.010)
HH college above	0.057	(0.007)	0.060	(0.011)	0.057	(0.007)
Number of households	7853		690		7163	

NOTE: Sample is restricted to households without NCDs in 2010.

Table 2: FE estimates of having a newly diagnosed NCD on economic outcomes

	Consumption expenditures (1)	Health expenditures (2)	Earned income (3)	Public transfer (4)	Private transfer (5)	Housing assets (6)	Financial assets (7)	Productive assets (8)	Debt (9)
NCD	-0.059	0.546***	0.066	0.301*	0.200	-0.281*	0.021	0.140	-0.126
	(0.043)	(0.192)	(0.208)	(0.178)	(0.208)	(0.146)	(0.222)	(0.159)	(0.242)
Family size	0.139***	0.176***	0.313***	-0.019	-0.099	0.101**	0.085	0.132**	0.239***
	(0.021)	(0.059)	(0.073)	(0.071)	(0.072)	(0.040)	(0.089)	(0.064)	(0.078)
Share of female members	-0.004	0.167	1.464***	0.935**	0.118	0.239	0.402	-0.664*	0.564
	(0.103)	(0.340)	(0.383)	(0.389)	(0.400)	(0.311)	(0.507)	(0.379)	(0.408)
Share of members under 16 years	-0.235	0.565	-0.287	-0.074	-0.375	-0.302	-0.609	-0.223	-0.705
	(0.143)	(0.654)	(0.609)	(0.533)	(0.630)	(0.463)	(0.658)	(0.431)	(0.612)
Share of members over 60 years	-0.368***	-0.306	-0.560	0.287	0.988*	-0.400	0.882	-0.458	-1.004**
	(0.133)	(0.427)	(0.493)	(0.483)	(0.597)	(0.331)	(0.574)	(0.351)	(0.443)
HH female	0.029	-0.060	-1.112***	0.115	-0.042	0.069	-0.422	-0.417	-0.202
	(0.086)	(0.278)	(0.311)	(0.314)	(0.380)	(0.284)	(0.408)	(0.295)	(0.423)
HH age	-0.018	-0.080	0.099	-0.118	-0.396***	0.230***	-0.131	0.082	-0.088
	(0.018)	(0.065)	(0.101)	(0.109)	(0.102)	(0.071)	(0.100)	(0.095)	(0.097)
HH age squared	0.000	0.001	-0.001	0.002	0.004***	-0.002***	0.001	-0.001	0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
HH highest education level (Ref: none)									
HH primary school	-0.004	-0.026	-0.131	-0.099	-0.310	-0.172	-0.031	0.206	0.479
	(0.069)	(0.236)	(0.300)	(0.266)	(0.286)	(0.217)	(0.301)	(0.274)	(0.357)
HH lower secondary school	-0.037	0.038	0.327	-0.217	-0.042	-0.012	0.648	-0.105	0.522
	(0.081)	(0.335)	(0.358)	(0.395)	(0.393)	(0.328)	(0.473)	(0.353)	(0.516)
HH upper secondary school	0.093	-0.102	1.432**	0.096	1.103	-1.114*	0.161	0.332	0.572
	(0.155)	(0.621)	(0.582)	(0.694)	(0.804)	(0.662)	(0.865)	(0.626)	(0.853)
HH college above	0.096	-0.203	2.036*	0.083	-0.269	-0.967	0.835	-0.694	1.810*
	(0.197)	(0.848)	(1.148)	(2.017)	(1.783)	(1.353)	(1.651)	(1.027)	(1.004)
Urban residence	0.060	-0.046	-0.740***	-0.441	0.510	-0.597	-0.003	0.601	-0.360
	(0.076)	(0.270)	(0.273)	(0.365)	(0.430)	(0.426)	(0.318)	(0.572)	(0.375)
Constant	9.588***	6.499***	4.308*	4.441	11.430***	3.814*	7.078**	5.246**	1.873
	(0.479)	(1.788)	(2.342)	(3.104)	(2.773)	(2.036)	(2.879)	(2.537)	(2.511)
Number of households	7853	7853	7853	7853	7853	7853	7853	7853	7853
R-squared	0.263	0.027	0.093	0.330	0.076	0.031	0.450	0.281	0.015

NOTE: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Outcome variables are transformed into natural logarithm form. All models include indicators of month of interview, year of interview and province dummies. The FE sample includes the balanced sample of 7853 households in 2010 and 2012. Robust standard errors clustered at the county level are in parenthesis. All estimates are appropriately weighted to reflect the complex survey design.

Table 3: FE estimates of having a newly diagnosed NCD on economic outcomes among poor households

	Consumption expenditures (1)	Health expenditures (2)	Earned income (3)	Public transfer (4)	Private transfer (5)	Housing assets (6)	Financial assets (7)	Productive assets (8)	Debt (9)
NCD	-0.298	0.224	-0.169	-0.170	-0.584	0.410	-0.296	-0.516	0.739
	(0.244)	(0.498)	(0.759)	(0.613)	(0.543)	(0.705)	(0.745)	(0.547)	(1.381)
Family size	0.151***	0.450**	0.288*	-0.024	-0.085	0.098	0.257	0.108	0.290
	(0.035)	(0.206)	(0.158)	(0.258)	(0.197)	(0.089)	(0.172)	(0.163)	(0.247)
Share of female members	0.410	2.643**	2.811**	0.096	0.444	1.716**	1.929	-0.603	1.460
	(0.311)	(1.240)	(1.121)	(1.071)	(1.232)	(0.853)	(1.333)	(1.544)	(1.655)
Share of members under 16 years	-0.297	-3.697*	0.027	1.099	-3.570*	-0.355	-2.325	-1.245	0.003
	(0.283)	(1.913)	(1.641)	(1.655)	(1.997)	(0.927)	(1.574)	(1.649)	(1.848)
Share of members over 60 years	-0.075	-0.799	-0.994	0.207	-0.346	-0.897	1.227	-1.310	-0.438
	(0.437)	(1.328)	(1.499)	(1.141)	(1.584)	(0.858)	(1.405)	(1.215)	(1.575)
HH female	0.580**	0.722	-1.682	0.311	0.769	0.957	-0.003	0.340	0.989
	(0.277)	(1.361)	(1.252)	(1.445)	(1.086)	(1.240)	(1.538)	(1.228)	(1.631)
HH age	0.002	-0.217	-0.122	-0.099	-0.144	-0.016	0.067	0.015	-0.193
	(0.053)	(0.176)	(0.210)	(0.135)	(0.209)	(0.165)	(0.179)	(0.167)	(0.157)
HH age squared	0.000	0.003*	0.002	0.001	0.001	0.000	0.000	-0.001	0.002
	(0.000)	(0.002)	(0.003)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
HH highest education level (Ref: none)									
HH primary school	0.685***	0.180	0.098	-0.327	-0.224	-0.615	0.276	0.764	2.139
	(0.239)	(0.765)	(1.615)	(0.964)	(0.827)	(0.586)	(0.765)	(0.846)	(1.296)
HH lower secondary school	0.422	0.393	-0.579	-0.488	-0.521	-1.365	2.031	0.565	2.555
	(0.276)	(1.039)	(1.522)	(1.155)	(1.025)	(1.307)	(1.382)	(1.341)	(1.977)
HH upper secondary school	0.868*	1.628	-1.034	-0.930	-2.306*	-2.733	2.103	0.482	2.117
	(0.440)	(1.768)	(2.316)	(1.106)	(1.333)	(2.902)	(1.944)	(2.056)	(2.439)
HH college above	1.915**	7.074**	-4.653	-0.552	-6.068*	-1.059	9.437	1.267	2.451
	(0.752)	(2.805)	(3.131)	(2.341)	(3.313)	(2.939)	(7.254)	(2.578)	(3.157)
Urban residence	-0.254	0.542	-1.450*	0.164	0.686	1.963*	-0.804	0.728	-1.066
	(0.269)	(0.674)	(0.851)	(0.935)	(0.556)	(1.095)	(0.738)	(0.930)	(0.690)
Constant	7.232***	5.306	6.968	7.599*	7.064	8.658*	-4.686	0.167	-0.383
	(1.685)	(4.506)	(5.066)	(3.926)	(5.555)	(4.493)	(5.765)	(4.626)	(6.511)
Number of households	690	690	690	690	690	690	690	690	690
R-squared	0.288	0.103	0.110	0.055	0.048	0.107	0.646	0.347	0.050

NOTE: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Outcome variables are transformed into natural logarithm form. All models include indicators of month of interview, year of interview and province dummies. The FE sample includes the balanced sample of 690 households in 2010 and 2012. Robust standard errors clustered at the county level are in parenthesis. All estimates are appropriately weighted to reflect the complex survey design.

Table 4: Estimated effects of past health expenditures on future health

	Enumerator rated health			Hospitalization		
	Pooled OLS	Linear FE	Ordered Logit FE	Pooled OLS	Linear FE	Logit FE
	(1)	(2)	(3)	(4)	(5)	(6)
Log of health expenditures	0.025*	0.0757*	0.131	0.015***	-0.005	-0.375**
	(0.015)	(0.043)	(0.094)	(0.005)	(0.012)	(0.176)
Log of household income	0.026**	0.057	0.111	0.006*	0.013	0.055
	(0.013)	(0.042)	(0.074)	(0.003)	(0.012)	(0.077)
SAH (Ref: unhealthy)						
Fair	0.410***	0.161	0.507	-0.105***	0.061	0.979
	(0.081)	(0.262)	(0.629)	(0.022)	(0.059)	(0.775)
Healthy	0.490***	-0.093	-0.010	-0.079***	-0.007	-0.860
	(0.077)	(0.267)	(0.657)	(0.022)	(0.094)	(0.760)
Family size	-0.027	-0.089	-0.178	0.003	0.033	1.224*
	(0.031)	(0.118)	(0.283)	(0.007)	(0.035)	(0.660)
Age	0.000	0.344	0.625	-0.006	0.047	-0.443
	(0.033)	(0.436)	(0.969)	(0.007)	(0.148)	(0.930)
Age squared	0.000	-0.001	-0.001	0.000	0.000	0.005
	(0.000)	(0.004)	(0.010)	(0.000)	(0.002)	(0.010)
Female	-0.022			-0.060**		
	(0.076)			(0.027)		
Urban Hukou	0.360***	0.273	2.057	0.008	-0.527**	-3.092
	(0.117)	(0.771)	(1.474)	(0.027)	(0.262)	(1.967)
Married	-0.210			-0.039		
	(0.149)			(0.037)		
Employed	0.013	-0.041	-0.269	-0.022	0.068	1.810**
	(0.081)	(0.187)	(0.556)	(0.023)	(0.071)	(0.803)
Smoking	0.076	-0.315	-1.381	-0.082***	-0.134	-0.552
	(0.097)	(0.311)	(1.061)	(0.027)	(0.167)	(0.925)
Constant	5.335***	-9.174		0.184	-1.106	
	(0.747)	(10.530)		(0.168)	(3.581)	
Observations	2801	2801	488	2801	2801	54
R-squared	0.088	0.109		0.043	0.063	

NOTE: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All the independent variables are in the previous period. The sample includes the unbalanced sample of 2801 individuals in 2010 and 2012. Robust standard errors clustered at the county level are in parenthesis. All estimates are appropriately weighted to reflect the complex survey design.

Table 5: FE estimates of past health expenditures on future economic well-being

	Consumption expenditure (1)	Earned income (2)	Housing assets (3)	Financial assets (4)	Productive assets (5)
Log of health expenditures	-0.040	-0.051	0.016	-0.085	-0.069*
	(0.027)	(0.124)	(0.110)	(0.187)	(0.041)
Log of earned income	-0.028*		-0.079*	0.213*	0.011
	(0.015)		(0.044)	(0.114)	(0.020)
SAH (Ref: unhealthy)					
Fair	-0.098	-0.158	-0.276	-0.015	-0.131
	(0.100)	(0.455)	(0.248)	(0.728)	(0.144)
Healthy	-0.114	-0.354	0.030	0.452	0.069
	(0.142)	(0.368)	(0.333)	(0.808)	(0.154)
Family size	-0.110*	0.929*	-0.099	-0.085	-0.007
	(0.061)	(0.498)	(0.128)	(0.421)	(0.145)
Age	0.333	-0.335	0.735	1.371	0.137
	(0.219)	(0.914)	(0.975)	(1.082)	(0.328)
Age squared	-0.003	0.005	-0.011	-0.022*	0.001
	(0.002)	(0.010)	(0.011)	(0.011)	(0.003)
Urban Hukou	-0.303**	4.438	-0.239	-2.957	-2.111*
	(0.152)	(2.857)	(0.573)	(3.311)	(1.104)
Employed	0.110	0.248	0.476	-1.376	-0.118
	(0.095)	(0.387)	(0.316)	(0.921)	(0.178)
Smoking	0.226*	-1.625**	0.015	0.134	0.058
	(0.127)	(0.778)	(0.189)	(1.345)	(0.142)
Constant	1.728	8.385	2.445	-6.390	0.992
	(5.200)	(20.740)	(21.930)	(27.190)	(8.200)
Observations	2801	2801	2801	2801	2801
R-squared	0.134	0.128	0.043	0.242	0.208

NOTE: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All the independent variables are in the previous period. Outcome variables are transformed into natural logarithm form. The sample includes the unbalanced sample of 2801 individuals in 2010 and 2012. Robust standard errors clustered at the county level are in parenthesis. All estimates are appropriately weighted to reflect the complex survey design.

Table A1: Definition of variables

Variable	Definition
Log of consumption expenditures	Natural logarithm of total household non-health consumption expenditure over the past one year.
Log of health expenditures	Natural logarithm of total household health expenditure over the past one year.
Log of earned income	Natural logarithm of total household earned income over the past one year.
Log of public transfers	Natural logarthim of transfers received from governments over the past one year.
Log of private transfers	Natural logarthim of transfers received from relatives and friends over the past one year.
Log of housing assets	Natural logarthim of total household value of house and land assets.
Log of financial assets	Natural logarthim of total household value of financial assets.
Log of productive assets	Natural logarthim of total household value of productive assets and durable goods.
Log of debt	Natural logarthim of household non-housing debts.
Household size	Number of family members.
Share of female members	Proportion of household members who are female.
Share of members under 16	Proportion of household members who are under 16 years old.
Share of members over 60	Proportion of household members who are over 60 years old.
Urban residence	= 1 if household's Hukou is non-agricultural; =0 if otherwise.
Poor household	= 1 if household received any allowance from the government; =0 if otherwise.
HH age	Age of the head of household in years.
HH age squared	Age of the head of household squared
HH female	= 1 if the head of household is female; =0 if otherwise.
HH less than primary school	= 1 if highest education of the household head is less than primary schoool; =0 if otherwise
HH primary school	= 1 if higest education of the housheold head is primary schoool; =0 if otherwise.
HH lower secondary school	= 1 if higest education level of the household head is lower secondary schoool; =0 if otherwise.
HH upper secondary school	= 1 if the higest education level of the household head is upper secondary schoool; =0 if otherwise.
HH college above	= 1 if higest education level of the housheold head is college or above; =0 if otherwise.
SAH	Self-assessed health: = 1 if unhealthy; = 2 if fair; = 3 if healthy.
ERH	Enumerator rated health: = 1 if very unhealthy; = 2 if unhealthy; =3 if relatively unhealthy; =4 if fair; = 5 if relatively healthy; = 6 if healthy; = 7 if very healthy.
Hospitalization	= 1 if admitted to hospital in last year; =0 if otherwise.
Age	Age of the household member with NCDs in years.
Age squared	Age of the household member with NCDs squared
Female	= 1 if the NCD member is female; =0 if otherwise.
Urban Hukou	= 1 if the Hukou of the NCD member is non-agricultural; =0 if otherwise.
Married	= 1 if NCD member is married; =0 if otherwise.
Employed	= 1 if NCD member is employed; =0 if otherwise.
Smoking	= 1 if NCD member is smoking; =0 if otherwise.
Han ethnicity	= 1 if NCD member is Han ethnicity; =0 if otherwise.

Table A2: OLS estimates of having a newly diagnosed NCD on economic outcomes in 2012

	Consumption	Health	Earned income	Public transfer	Private transfer	Housing assets	Financial assets	Productive assets	Debt
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
NCD	-0.023	0.974***	0.065	0.330**	0.223*	-0.319**	0.124	0.014	0.112
	(0.032)	(0.097)	(0.182)	(0.148)	(0.134)	(0.153)	(0.144)	(0.078)	(0.197)
Family size	0.148***	0.182***	0.511***	0.219***	-0.114***	0.177***	0.070**	0.212***	-0.744***
	(0.011)	(0.029)	(0.035)	(0.035)	(0.032)	(0.023)	(0.031)	(0.025)	(0.177)
Share of female members	0.042	-0.085	0.685**	-0.375	-0.057	-0.129	0.285	0.147	0.226***
	(0.072)	(0.207)	(0.274)	(0.303)	(0.218)	(0.221)	(0.214)	(0.172)	(0.055)
Share of members under 16 years	-0.113	0.035	-2.129***	-0.655*	0.374	-0.663**	-0.286	-0.298	0.248
	(0.093)	(0.233)	(0.374)	(0.356)	(0.328)	(0.276)	(0.288)	(0.243)	(0.305)
Share of members over 60 years	-0.335***	0.420**	-3.033***	2.120***	1.159***	-0.446**	-0.240	-1.088***	-0.838*
	(0.059)	(0.198)	(0.301)	(0.376)	(0.298)	(0.220)	(0.204)	(0.162)	(0.436)
HH female	-0.018	0.210**	-0.603***	0.169	0.098	-0.004	-0.264***	-0.146*	-0.471*
	(0.030)	(0.091)	(0.148)	(0.147)	(0.098)	(0.118)	(0.085)	(0.076)	(0.262)
HH age	0.007	0.049**	0.115***	0.144***	-0.033	0.067**	-0.040**	0.019	0.002
	(0.007)	(0.023)	(0.027)	(0.032)	(0.027)	(0.031)	(0.020)	(0.022)	(0.173)
HH age squared	-0.000***	-0.000***	-0.002***	-0.001**	0.001**	-0.001**	0.000	-0.000*	0.037
	0.000	0.000	0.000	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.030)
HH highest education level (Ref: none)									
HH primary school	0.125***	0.151	0.166	0.348***	0.062	0.374***	0.671***	0.513***	-0.001***
	(0.037)	(0.126)	(0.166)	(0.133)	(0.124)	(0.101)	(0.106)	(0.144)	(0.000)
HH lower secondary school	0.189***	0.134	0.134	0.796***	-0.038	0.341***	0.771***	0.728***	-0.306*
	(0.035)	(0.119)	(0.162)	(0.159)	(0.129)	(0.102)	(0.106)	(0.153)	(0.167)
HH upper secondary school	0.286***	0.173	0.425**	0.796***	0.151	0.529***	0.981***	0.863***	-0.226
	(0.055)	(0.138)	(0.189)	(0.206)	(0.174)	(0.157)	(0.144)	(0.149)	(0.216)
HH college above	0.558***	0.563***	1.856***	-0.491	0.556**	1.695***	1.799***	1.472***	-0.281
	(0.066)	(0.206)	(0.272)	(0.313)	(0.230)	(0.200)	(0.203)	(0.181)	(0.249)
Urban residence	0.479***	0.153	-1.553***	-0.457**	-0.426***	-0.733***	0.792***	0.464***	-0.299
	(0.037)	(0.120)	(0.216)	(0.218)	(0.125)	(0.197)	(0.120)	(0.103)	(0.332)
Constant	7.419***	4.357**	-0.278	0.699	3.270*	3.105	11.600***	8.633***	-0.383
	(0.685)	(2.174)	(2.796)	(1.602)	(1.881)	(2.811)	(0.896)	(0.777)	(1.241)
Number of households	7853	7853	7853	7853	7853	7853	7853	7853	7853
R-squared	0.326	0.051	0.245	0.176	0.062	0.086	0.110	0.263	0.048

NOTE: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Outcome variables are transformed into natural logarithm form. All models include indicators of month of interview, year of interview and province dummies. The sample includes a sample of 7853 households in 2012. Robust standard errors clustered at the county level are in parenthesis. All estimates are appropriately weighted to reflect the complex survey design.

Table A3: OLS estimates of having a newly diagnosed NCD on economic outcomes among poor households in 2012

	Consumption	Health	Earned income	Public transfer	Private transfer	Housing assets	Financial assets	Productive assets	Debt
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
NCD	-0.055	1.429***	-0.680	0.577	-0.297	-0.136	0.289	-0.408	0.777
	(0.111)	(0.364)	(0.679)	(0.470)	(0.504)	(0.604)	(0.379)	(0.251)	(0.828)
Family size	0.156***	0.286***	0.513***	0.082	-0.025	0.280***	0.209***	0.272***	0.380**
	(0.031)	(0.067)	(0.086)	(0.081)	(0.075)	(0.068)	(0.072)	(0.049)	(0.182)
Share of female members	0.386*	-0.099	1.420*	-0.460	-1.183**	0.301	-0.021	1.095*	1.032
	(0.202)	(0.572)	(0.783)	(0.554)	(0.532)	(0.595)	(0.659)	(0.583)	(0.800)
Share of members under 16 years	-0.465*	0.131	-1.499	1.601*	-0.052	-1.890**	0.026	-0.710	-4.028**
	(0.264)	(0.702)	(1.228)	(0.838)	(0.877)	(0.870)	(0.733)	(0.442)	(1.878)
Share of members over 60 years	-0.434**	0.906	-3.348***	0.431	0.511	-0.762	-0.391	-1.944***	-1.203
	(0.176)	(0.579)	(0.782)	(0.539)	(0.624)	(0.642)	(0.437)	(0.588)	(1.135)
HH female	-0.135	0.525*	-0.555	-0.039	0.227	-0.285	-0.441	-0.049	-0.022
	(0.091)	(0.294)	(0.480)	(0.339)	(0.337)	(0.416)	(0.315)	(0.207)	(0.579)
HH age	0.024	0.124**	0.229**	0.110*	0.020	-0.039	-0.033	0.038	-0.073
	(0.022)	(0.057)	(0.091)	(0.065)	(0.072)	(0.057)	(0.046)	(0.051)	(0.095)
HH age squared	0.000	-0.001**	-0.002***	-0.001	0.000	0.000	0.000	-0.001	0.000
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)
HH highest education level (Ref: none)									
HH primary school	0.097	-0.058	0.528	0.306	-0.403	0.046	0.555*	0.799***	-0.068
	(0.100)	(0.271)	(0.417)	(0.338)	(0.380)	(0.303)	(0.329)	(0.244)	(0.547)
HH lower secondary school	0.080	-0.378	-0.035	0.473	-0.407	-0.401	0.427	0.931***	0.153
	(0.102)	(0.333)	(0.442)	(0.352)	(0.377)	(0.354)	(0.309)	(0.240)	(0.547)
HH upper secondary school	0.237*	-0.666	-1.163	0.853	0.654	-1.298	0.083	0.553	-0.049
	(0.138)	(0.605)	(0.964)	(0.877)	(0.639)	(0.991)	(0.542)	(0.359)	(0.734)
HH college above	0.023	1.568***	-0.267	1.803	-1.260**	-2.839	1.209	1.545	-3.030**
	(0.530)	(0.521)	(1.839)	(2.303)	(0.597)	(4.068)	(1.122)	(1.422)	(1.170)
Urban residence	0.313***	0.169	-0.970	-0.171	-0.284	-1.650**	0.467	0.016	-0.381
	(0.102)	(0.307)	(0.623)	(0.416)	(0.416)	(0.694)	(0.361)	(0.322)	(0.573)
Constant	9.291***	2.277	5.461**	5.886***	7.381***	5.184**	5.690***	6.406***	9.674***
	(0.664)	(1.666)	(2.629)	(2.173)	(2.068)	(2.154)	(1.425)	(1.568)	(2.908)
Number of households	690	690	690	690	690	690	690	690	690
R-squared	0.319	0.195	0.377	0.147	0.161	0.223	0.195	0.360	0.155

NOTE: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Outcome variables are transformed into natural logarithm form. All models include indicators of month of interview, year of interview and province dummies. The sample includes a sample of 690 households in 2012. Robust standard errors clustered at the county level are in parenthesis. All estimates are appropriately weighted to reflect the complex survey design.

Table A4: OLS estimates of having a newly diagnosed NCD on economic outcomes among non-poor households in 2012

	Consumption expenditure (1)	Health expenditure (2)	Earned income (3)	Public transfer (4)	Private transfer (5)	Housing assets (6)	Financial assets (7)	Productive assets (8)	Debt (9)
NCD	-0.020	0.960***	0.143	0.329**	0.267**	-0.332**	0.137	0.047	0.020
	(0.033)	(0.103)	(0.186)	(0.153)	(0.131)	(0.158)	(0.145)	(0.078)	(0.203)
Family size	0.149***	0.168***	0.514***	0.234***	-0.125***	0.165***	0.048	0.200***	0.186***
	(0.012)	(0.034)	(0.039)	(0.035)	(0.035)	(0.025)	(0.033)	(0.026)	(0.051)
Share of female members	-0.013	-0.172	0.488*	-0.259	0.077	-0.214	0.300	-0.063	0.158
	(0.077)	(0.221)	(0.291)	(0.320)	(0.222)	(0.230)	(0.215)	(0.166)	(0.336)
Share of members under 16 years	-0.089	0.016	-2.314***	-0.902**	0.387	-0.493*	-0.299	-0.248	-0.540
	(0.095)	(0.284)	(0.378)	(0.356)	(0.364)	(0.287)	(0.322)	(0.252)	(0.435)
Share of members over 60 years	-0.314***	0.390*	-2.978***	2.176***	1.151***	-0.345	-0.215	-0.898***	-0.414*
	(0.062)	(0.224)	(0.317)	(0.414)	(0.338)	(0.234)	(0.230)	(0.163)	(0.250)
HH female	-0.011	0.176*	-0.613***	0.185	0.107	0.019	-0.232**	-0.156*	0.047
	(0.030)	(0.091)	(0.153)	(0.156)	(0.105)	(0.115)	(0.097)	(0.082)	(0.166)
HH age	0.007	0.037	0.103***	0.128***	-0.050	0.0830**	-0.0549**	0.013	0.053
	(0.007)	(0.025)	(0.029)	(0.034)	(0.031)	(0.034)	(0.022)	(0.022)	(0.033)
HH age squared	-0.000***	0.000	-0.001***	-0.001***	0.001**	-0.001**	0.000*	0.000	-0.001**
	0.000	0.000	0.000	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
HH highest education level (Ref: none)									
HH primary school	0.114***	0.164	0.161	0.460***	0.123	0.383***	0.662***	0.434***	-0.203
	(0.037)	(0.132)	(0.172)	(0.142)	(0.133)	(0.106)	(0.123)	(0.146)	(0.177)
HH lower secondary school	0.173***	0.197	0.130	0.971***	0.028	0.368***	0.783***	0.649***	-0.084
	(0.034)	(0.120)	(0.168)	(0.171)	(0.138)	(0.108)	(0.119)	(0.155)	(0.209)
HH upper secondary school	0.266***	0.227	0.485**	0.985***	0.146	0.601***	1.006***	0.801***	-0.067
	(0.054)	(0.144)	(0.198)	(0.209)	(0.179)	(0.147)	(0.155)	(0.151)	(0.248)
HH college above	0.506***	0.575***	1.794***	-0.184	0.654***	1.653***	1.731***	1.332***	-0.035
	(0.062)	(0.215)	(0.278)	(0.306)	(0.230)	(0.202)	(0.206)	(0.181)	(0.321)
Urban residence	0.504***	0.152	-1.574***	-0.549**	-0.485***	-0.620***	0.837***	0.508***	-0.777***
	(0.038)	(0.127)	(0.224)	(0.226)	(0.128)	(0.203)	(0.126)	(0.100)	(0.184)
Constant	10.698***	4.794**	0.617	0.822	3.549*	4.869*	11.46***	8.858***	-0.516
	(0.747)	(2.210)	(2.193)	(1.651)	(1.912)	(2.594)	(0.892)	(0.789)	(1.253)
Number of households	7163	7163	7163	7163	7163	7163	7163	7163	7163
R-squared	0.329	0.048	0.241	0.180	0.066	0.083	0.110	0.244	0.065

NOTE: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Outcome variables are transformed into natural logarithm form. All models include indicators of month of interview, year of interview and province dummies. The sample includes a sample of 7153 households in 2012. Robust standard errors clustered at the county level are in parenthesis. All estimates are appropriately weighted to reflect the complex survey design.

Table A5: FE estimates of having a newly diagnosed NCD on economic outcomes among non-poor households in 2012

	Consumption expenditure (1)	Health expenditure (2)	Earned income (3)	Public transfer (4)	Private transfer (5)	Housing assets (6)	Financial assets (7)	Productive assets (8)	Debt (9)
NCD	-0.035	0.598***	0.104	0.272	0.234	-0.303**	0.075	0.202	-0.205
	(0.040)	(0.190)	(0.207)	(0.183)	(0.215)	(0.144)	(0.232)	(0.160)	(0.252)
Family size	0.140***	0.127*	0.321***	-0.036	-0.100	0.095**	0.059	0.138*	0.222***
	(0.023)	(0.068)	(0.076)	(0.075)	(0.080)	(0.046)	(0.105)	(0.073)	(0.076)
Share of female members	-0.061	-0.114	1.339***	1.026**	0.043	0.086	0.190	-0.682*	0.443
	(0.109)	(0.354)	(0.408)	(0.394)	(0.410)	(0.331)	(0.523)	(0.373)	(0.434)
Share of members under 16 years	-0.224	0.978	-0.298	-0.304	-0.120	-0.256	-0.410	-0.141	-0.717
	(0.156)	(0.700)	(0.649)	(0.564)	(0.640)	(0.499)	(0.719)	(0.466)	(0.668)
Share of members over 60 years	-0.367**	-0.246	-0.476	0.077	1.181*	-0.341	0.976	-0.348	-1.016**
	(0.142)	(0.474)	(0.524)	(0.491)	(0.639)	(0.359)	(0.604)	(0.364)	(0.450)
HH female	0.001	-0.092	-1.106***	0.115	-0.064	0.007	-0.406	-0.452	-0.256
	(0.088)	(0.281)	(0.324)	(0.336)	(0.399)	(0.280)	(0.412)	(0.311)	(0.445)
HH age	-0.018	-0.029	0.131	-0.189	-0.442***	0.271***	-0.104	0.095	-0.085
	(0.017)	(0.071)	(0.102)	(0.122)	(0.109)	(0.078)	(0.111)	(0.110)	(0.112)
HH age squared	0.000	0.000	-0.001	0.002**	0.005***	-0.003***	0.001	-0.001	0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
HH highest education level (Ref: none)									
HH primary school	-0.083	-0.025	-0.179	-0.142	-0.304	-0.074	-0.029	0.142	0.276
	(0.068)	(0.239)	(0.255)	(0.267)	(0.299)	(0.219)	(0.315)	(0.279)	(0.348)
HH lower secondary school	-0.086	0.018	0.374	-0.252	0.003	0.144	0.570	-0.172	0.302
	(0.082)	(0.355)	(0.359)	(0.399)	(0.404)	(0.314)	(0.460)	(0.357)	(0.508)
HH upper secondary school	0.023	-0.244	1.524**	0.083	1.285	-1.005	0.102	0.265	0.421
	(0.158)	(0.642)	(0.615)	(0.727)	(0.825)	(0.678)	(0.887)	(0.651)	(0.885)
HH college above	0.026	-0.346	2.171*	-0.077	0.031	-0.893	0.703	-0.758	1.674
	(0.200)	(0.869)	(1.174)	(2.083)	(1.810)	(1.379)	(1.694)	(1.038)	(1.027)
Urban residence	0.094	-0.113	-0.685**	-0.476	0.547	-0.861**	0.117	0.577	-0.307
	(0.082)	(0.255)	(0.282)	(0.365)	(0.460)	(0.435)	(0.301)	(0.536)	(0.405)
Constant	9.730***	6.634***	3.588	5.430	12.200***	2.977	7.005**	5.150*	2.194
	(0.465)	(1.926)	(2.485)	(3.314)	(2.753)	(2.214)	(3.111)	(2.728)	(2.885)
Number of households	7163	7163	7163	7163	7163	7163	7163	7163	7163
R-squared	0.267	0.027	0.095	0.373	0.084	0.033	0.431	0.275	0.016

NOTE: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Outcome variables are transformed into natural logarithm form. All models include indicators of month of interview, year of interview and province dummies. The sample includes the balanced sample of 7163 households in 2010 and 2012. Robust standard errors clustered at the county level are in parenthesis. All estimates are appropriately weighted to reflect the complex survey design.

Table A6: Descriptive statistics of dynamic model among NCD patients

	2010/2012		2012/2014	
	Mean	S.E.	Mean	S.E.
Outcome variables				
ERH_very unhealthy	0.005	(0.002)	0.003	(0.002)
ERH_unhealthy	0.022	(0.007)	0.015	(0.008)
ERH_relatively unhealthy	0.081	(0.013)	0.046	(0.011)
ERH_fair	0.164	(0.018)	0.135	(0.018)
ERH_relatively healthy	0.330	(0.022)	0.292	(0.019)
ERH_healthy	0.262	(0.025)	0.317	(0.024)
ERH_very healthy	0.136	(0.019)	0.192	(0.022)
Hospitalization	0.148	(0.013)	0.158	(0.016)
SAH_unhealthy	0.386	(0.019)	0.300	(0.021)
SAH_fair	0.214	(0.018)	0.214	(0.018)
SAH_unhealthy	0.400	(0.020)	0.486	(0.022)
Log of consumption expenditures	10.078	(0.051)	10.311	(0.055)
Log of earned income	8.235	(0.175)	9.075	(0.154)
Log of housing assets	11.397	(0.129)	11.162	(0.150)
Log of financial assets	8.492	(0.146)	5.862	(0.209)
Log of productive assets	8.887	(0.095)	9.194	(0.093)
Control variables				
Log of health expenditures	7.055	(0.088)	7.320	(0.083)
Log of earned income	9.240	(0.113)	8.526	(0.211)
Family size	3.929	(0.085)	3.865	(0.076)
Age	47.982	(0.345)	48.786	(0.372)
Age squared	2,383.408	(31.256)	2,453.157	(34.788)
Female	0.581	(0.017)	0.621	(0.022)
Urban Hukou	0.316	(0.035)	0.358	(0.038)
Married	0.918	(0.011)	0.928	(0.011)
Employed	0.493	(0.028)	0.718	(0.028)
Smoking	0.268	(0.015)	0.216	(0.017)
Han ethnicity	0.945	(0.013)	0.948	(0.014)
Observations	1438		1363	

NOTE: Outcome variables are in one period ahead of the same individual. All estimates are appropriately weighted to reflect the complex survey design.

Table A7: OLS estimates of past health expenditures on future economic well-being

	Consumption expenditure (1)	Earned income (2)	Housing assets (3)	Financial assets (4)	Productive assets (5)
Log of health expenditures	0.053***	0.019	0.017	0.027	0.062***
	(0.012)	(0.064)	(0.048)	(0.054)	(0.021)
Log of household income	0.008		0.077*	0.254***	0.025
	(0.008)		(0.042)	(0.048)	(0.021)
SAH (Ref: unhealthy)					
Fair	0.210***	0.239	0.754***	0.986***	0.503***
	(0.060)	(0.251)	(0.246)	(0.268)	(0.114)
Healthy	0.298***	0.706***	0.615**	0.049	0.535***
	(0.068)	(0.264)	(0.277)	(0.318)	(0.131)
Family size	0.126***	0.470***	0.120*	-0.072	0.180***
	(0.019)	(0.076)	(0.066)	(0.086)	(0.040)
Age	0.041*	0.190**	-0.037	-0.029	0.047
	(0.024)	(0.081)	(0.075)	(0.094)	(0.039)
Age squared	-0.001**	-0.003**	0.001	0.000	-0.001*
	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)
Female	0.042	0.301	-0.238	-1.027***	-0.253*
	(0.071)	(0.313)	(0.205)	(0.286)	(0.134)
Urban Hukou	0.571***	-0.259	-0.140	1.162***	0.478***
	(0.070)	(0.264)	(0.248)	(0.326)	(0.150)
Married	0.089	-0.361	0.964**	-0.038	0.460***
	(0.121)	(0.446)	(0.429)	(0.429)	(0.170)
Employed	0.136**	1.656***	0.459**	-0.633**	0.323***
	(0.055)	(0.238)	(0.198)	(0.306)	(0.094)
Smoking	0.047	0.243	-0.575***	-0.446	-0.409***
	(0.078)	(0.341)	(0.219)	(0.286)	(0.134)
Constant	8.262***	2.455	8.884***	6.873***	6.399***
	(0.557)	(1.775)	(1.422)	(2.047)	(0.899)
Observations	2801	2801	2801	2801	2801
R-squared	0.201	0.131	0.054	0.074	0.123

NOTE: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All the independent variables are in the previous period. Outcome variables are transformed into natural logarithm form. The sample includes the unbalanced sample of 2801 individuals in 2010 and 2012. Robust standard errors clustered at the county level are in parenthesis. All estimates are appropriately weighted to reflect the complex survey design.

Table A8: Reasons for foregoing treatment by poverty status

	Poor (%)	Non-poor (%)
Expensive medical costs	38.8	28.9
Long distance to health facilities	6.9	2.7
Do not trust doctors	1.0	0.7
No need to see a doctor	45.3	59.8
Too much procedures in hospital	2.9	3.7
Other	5.1	4.2

NOTE: The sample includes 12088 individuals from 7853 households in 2010. All estimates are appropriately weighted to reflect the complex survey design.

Chapter 7 The economic consequences of delayed treatment: Hypertension in China

7.1 Introduction

This chapter analyses the economic consequences of delayed hypertension treatment in China. Using three waves of the China Health and Retirement Longitudinal Study (CHARLS) and a difference-in-differences analysis on a matched set of hypertensive individuals, this study aims to estimate: (1) the effects of variation in treatment timing (i.e. early versus late treatment) on healthcare use and health spending at the time treatment was first initiated; and (2) the dynamic effects on healthcare use and healthcare costs, depending on the length of treatment. The hypothesis is that individuals who delay treatment for hypertension would use more health services and spend more on health at the time when they initiate treatment, relative to counterparts who begin treatment earlier. Hypertensive patients who start treatment more prior is expected to experience declines in service use and healthcare costs in a longer period.

This chapter presents the manuscript prepared for publication.

7.2 Manuscript prepared for publication

The economic consequences of delayed treatment: Hypertension in China

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The economic consequences of delayed treatment: Hypertension in China

Abstract

Considerable recent attention has been directed to the economic consequences of hypertension and other non-communicable diseases (NCDs) for households who seek medical care. However, not everyone gets treated in a timely fashion. Nearly 50% of Chinese adults have hypertension, but fewer than one-third of the hypertensive population are currently being treated. The difference between disease prevalence and treatment rates suggests that many individuals with hypertension are effectively failing to access treatment timely. Although there exist stylised model-based estimates of health system impacts of improved hypertension control in high-income countries, little is known about the household economic consequences of not accessing hypertension treatment in real-world settings, especially in low- and middle-income countries (LMICs). We used three waves (2011, 2013 and 2015) of the China Health and Retirement Longitudinal Study and "difference-in-difference" methods on a matched set of newly-diagnosed hypertensive individuals to assess the impact of not accessing hypertension treatment timely on health service use and healthcare costs. Among hypertensive patients diagnosed in 2013, we compared the healthcare utilisation and costs of an early treatment group who began treatment in 2013 with a late treatment group comprising hypertensive patients that began treatment in 2015. A control group of hypertensive patients who did not seek care in both 2013 and 2015 was used throughout. Among newly diagnosed hypertensive patients, initiating treatment (whether early or late) was, unsurprisingly, associated with greater healthcare use and higher healthcare costs than those who did not seek care in the corresponding time period. Hypertensive patients who started treatment early experienced declines in the probabilities of incurring healthcare costs (inclusive of insurance reimbursements) and out-of-pocket (OOP) health expenditures in the following period. Among those who were diagnosed with moderate

to severe hypertension in 2013, starting treatment late was associated with higher healthcare costs and a higher probability of incurring catastrophic health expenditures at the time patients initiated treatment, relative to the costs incurred by counterparts who began treatment earlier, at the time they started treatment. Our results highlight the potential reduction in household healthcare costs and the short-run health system implications associated with early intervention for hypertension in a real-world setting in China.

Key words: delaying treatment; hypertension; economic consequences; health expenditures; China;

1. Introduction

Non-communicable diseases (NCDs) are a major source of ill-health and economic burden among Chinese households (The World Bank, 2016). In 2017, NCDs accounted for nearly 8.6 million deaths, or about 90% of all-cause deaths in China (Institute for Health Metrics and Evaluation (IHME), 2019a), of which high systolic blood pressure alone contributed to nearly one-third. A 2017 study of 1.7 million Chinese adults showed that nearly 50% had hypertension, but less than one-half of hypertensive patients were aware of their condition; fewer than one-third of patients with hypertension reported being treated, and less than one-in-twelve individuals had their blood pressure under control (J. Lu et al., 2017). The large gaps between hypertension prevalence and the awareness rate, and between awareness and treatment rates suggest that many individuals in China do not obtain treatment for hypertension in a timely manner, whether they are aware of their condition or not.

Delaying or otherwise not accessing treatment for hypertension can worsen health outcomes, including increasing the risk of cardiovascular events such as stroke and myocardial infarction and death (Dahlof et al., 1991; Sandoval et al., 1994; Xu et al., 2015). However, little is known

about the economic impact of delayed treatment, particularly in low- and middle-income countries (LMICs) (Kankeu et al., 2013). Studies on the economic consequences of NCDs on households mainly focus on people who seek treatment, suggesting that paying for care can adversely affect household well-being (Jan et al., 2018). However, lack of timely hypertension treatment can potentially be economically more problematic if the long-term overall health expenditures among those who postpone treatment exceed expenditures among those who seek treatment earlier. In this sense, postponing treatment can be thought of as a coping mechanism (e.g. Wagstaff, 2018) which reduces health expenditures, or household consumption expenditures, in the short run but may negatively influence household well-being in the longer term. We are unaware of any work that examines the economic consequences to households from not obtaining hypertension (or any type of NCD) treatment in a timely fashion. In this paper we aim to address this gap using longitudinal household survey data from China.

The theoretical underpinnings of our argument rests on the prognosis of untreated versus treated hypertension (e.g. Dahlof et al., 1991; Sandoval et al., 1994; Smirk, 1972). Without treatment, health among hypertensive patients is expected to depreciate faster and the probability of death likely to increase over time. Hypertensive patients who receive treatment for their condition are typically expected to have both a flatter survival curve and a higher probability of survival compared with those untreated (Figure 1).

Viewed from the perspective of the Grossman (1972) model of demand for healthcare, hypertension treatment can be considered an investment in health, a form of human capital. Faster equilibrium declines in health stock are the likely outcome of a combination of higher rates of health depreciation with diminishing returns to higher levels of health expenditures. To the extent that delayed treatment increases the rate of depreciation of health stock, the

Grossman model predicts faster future declines in health stock and higher medical expenditures.

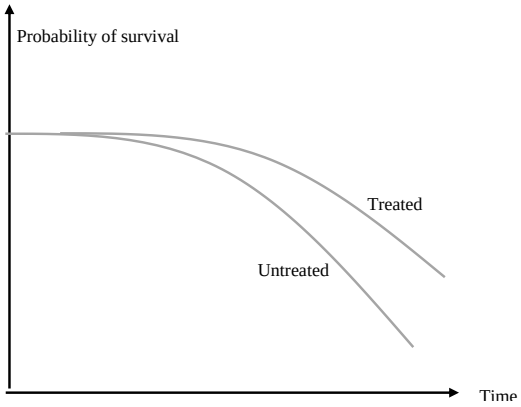

Figure.1 Probability of survival to time "t" with and without hypertension treatment

One implication of the above argument is that over a length of time, aggregate (discounted) health expenditures among those who postpone treatment will exceed aggregate health expenditures among those who seek treatment earlier, even if the delayed treatment results in savings early on. The time period over which the superiority of early treatment can be demonstrated need not be particularly long, especially if there are high fixed costs at the early stages of treatment (e.g., diagnostics, consultations with specialists, etc.) before a course of treatment is determined. Indeed, these perceived initial fixed costs of treatment might carry greater salience than large health losses for untreated individuals, which may have led to delayed treatment in the first place.

Testing the hypothesis that individuals who delay hypertension treatment have higher levels of health expenditures than their early treatment counterparts requires a comparison of the (discounted) health costs for (hypertension-related) health conditions for early and late treatment groups over time. This, however, was not possible in our survey data that gathered information on healthcare and expenditures for an individual, but without specifying a condition. Detailed administrative data on healthcare use and linked to survey data could have helped to separate hypertension treatment related costs from other healthcare costs associated with an individual. However, the administrative data available in China cannot be linked to the

survey data we use.

Instead, using the healthcare use and expenditure data in the survey, we test two theoretical implications of our model: all else the same, (1) the healthcare costs for individuals at the time hypertension treatment is first sought, would be lower for people who start treatment early compared to those start treatment late; and (2) healthcare costs will decline with the length of time of being in hypertension treatment.

We assess the effects of delayed treatment for hypertension on individuals' health care utilisation and healthcare costs (including all healthcare costs, out-of-pocket (OOP) health payments and the incidence of catastrophic health expenditure)[1], using three waves of the China Health and Retirement Longitudinal Study (CHARLS). Applying difference-in-difference (DID) methods on a matched dataset of hypertensive individuals, we estimated (1) the effects on healthcare use and healthcare costs among those who started hypertension treatment early, by length of treatment; and (2) the effects of variation in treatment timing (i.e. early versus late treatment) on healthcare use and healthcare costs at the time hypertension treatment was first initiated (Callaway & Sant'Annaz, 2018).

We find that hypertensive patients who started treatment earlier had a lower probability of incurring healthcare costs in the following period. Among those who were newly diagnosed with moderate to severe hypertension, patients who started treatment later spent more on health services and were more likely to incur catastrophic health expenditures (CHE) at the time they initiated treatment, compared to counterparts who began hypertension treatment earlier. We also found a positive association between household income and outpatient health service utilisation, suggesting that financial obstacles to utilising health services continue to have an effect despite the extensive coverage of social health insurance schemes in China. Thus, poor

[1] In the remining of the text, healthcare costs includes all health costs whether financed by OOP payments or insurance reimbursement. OOP payments or OOP health expenditures refers healthcare cost that paid through out-of-pocket and are not covered or reimbursed by any health insurance.

households who end up delaying hypertension treatment will face a higher financial burden of illness in the future, and their healthcare costs will be larger, compared to if they had obtained treatment earlier.

Our study advances the literature on household-level economic impacts associated with hypertension in China and other LMICs by providing evidence of the consequences of delayed hypertension treatment. Existing literature on China highlights OOP health expenditures and the incidence of CHE due to hypertension among those who seek health care. Le, Zhankun, Jun, and Keying (2012) found that the incidence of CHE due to hypertension was 8.9% in a sample of 3,052 households in Yunnan Province in 2010; a second study, using a sample of 8,310 households in Chongqing in 2013, concluded that 28.4% of the households containing hypertensive patients who sought treatment experienced CHE (Xiao et al., 2016). Similar findings have been reported in other LMICs where NCDs have imposed a substantial financial burden on households, especially the poor (Essue et al., 2017; Jan et al., 2018; Jaspers et al., 2015). However, these studies did not account for the costs associated with postponed hypertension treatment and can therefore bias our understanding of the true magnitude of the economic impact of hypertension over the longer term.

We also contribute to the methodological literature on the measurement of NCD treatment effects when the timing of treatment initiation varies across individuals, taking account of recent econometric developments in DID methods (e.g. Abraham & Sun, 2018; Callaway & Sant'Annaz, 2018; Goodman-Bacon, 2018). Our analysis uses three waves of nationally representative panel data, which enabled us to identify groups with different timing of initiating treatment for hypertension and to assess the consequences of variation in treatment timing (i.e. early and delayed hypertension treatment) among Chinese households.

2. The Chinese Context

With a population of nearly 1.4 billion, China is the most populous country in the world (The World Bank, 2019g). Over the last four decades, China has undergone significant demographic change, including declining population growth rates accompanied by a rapidly ageing population (The World Bank, 2019f). The Chinese economy has also grown rapidly over this period and is now the second-largest global economy in terms of GDP.

Rapid demographic changes and economic development have fuelled the rise of NCDs in China. Apart from an ageing population, social and economic development in China has brought about faster urbanisation and changed lifestyles, resulting in behaviours contributing to increased risk of acquiring NCDs. Currently, the leading risk factors for death and disability in China are high blood pressure, dietary risks due to low fruit and high sodium consumption, tobacco use, air pollution and high body-mass index (Institute for Health Metrics and Evaluation (IHME), 2019b; Yang et al., 2013).

The growing prevalence of NCDs underlines the need for access to a combination of preventive, curative and supportive care services. However, the healthcare delivery system in China is hospital-centric, volume-driven, and emphasises treatment over prevention, potentially leading to higher health expenditures than would otherwise be needed (The World Bank, 2016). Health insurance schemes are available but incomplete:[2] Almost 95% of China's population is covered by some form of health insurance, but individuals still pay nearly 36% of total health expenditures in the form of out of pocket expenditure, particularly for outpatient care (The World Bank, 2019e; Yip et al., 2012). This OOP expenditure can lead to lower non-medical consumption expenditures for NCD-affected households who seek treatment (K. Fang et al., 2012; Xie, 2011). High household OOP costs can also influence health-seeking behaviours, resulting in many individuals with NCDs postponing necessary treatment or abandoning

[2] The scheme consists of three components, Urban Employee Medical Insurance Scheme (UEMIS), Urban Resident Medical Insurance Scheme (URMIS) and New Rural Cooperative Medical Scheme (NRCMS), supported with Medical Financial Assistance (MFA) and with supplements of Insurance Program for Critical Diseases (IPCD).

treatment midway (Meng et al., 2012).

Delays in treatment for hypertension can lead to serious health consequences, including stroke and coronary artery disease (Gu et al., 2008; Liu et al., 2007), potentially resulting in a large economic and disease burden on households in the future. In the interim, as hypertension may take years to develop into a severe health condition, there are opportunities for prevention and management. Any sufficiently large adverse economic impact of delaying hypertension treatment would imply welfare gains from early intervention, and a justification for appropriate financial protection interventions and policies to address the economic burden on patients with hypertension, and more broadly, NCDs.

3. Data and Methodology

3.1 Data

As noted previously, the ideal dataset for our analysis would be a combination of a household panel survey and corresponding administrative data on health service use, over a long enough period, but administrative datasets that are matched to panel data are not readily accessible in China. Instead, relying on a panel survey we: (1) estimated the effects on healthcare use and healthcare costs across time among those who started treatment early; and (2) compared the effects of early treatment and late treatment on healthcare use and healthcare costs at the time treatment was first sought by a person with hypertension. We describe how we identify the early and late treatment groups in Section 3.2.2. We used data from the China Health and Retirement Longitudinal Study (CHARLS), that gathered information from individuals aged 45 or over in China on measures of physical and psychological health (including recorded blood pressure based on a physical examination), demographics and socioeconomic status. Details of the blood pressure measurement procedure and data quality safeguards used in CHARLS are described in a protocol paper (Zhao, Hu, Smith, Strauss, & Yang, 2014b).

Our analysis used all three waves (2011, 2013 and 2015) of CHARLS data that are publicly available. The baseline sample comprised 17,708 individuals, among which 13,702 had blood pressure information. Of these, 9,157 individuals remained in the follow-up wave in 2013 and had their blood pressure measured. Finally, 7,367 individuals remained in the 2015 wave and had blood pressure measurement data available. Our analysis is based on the balanced panel of 7,367 individuals with blood pressure measurement in all three waves.[3]

3.2 Variables

We used a difference-in-difference (DID) model on a matched set of hypertensive individuals. This required identifying hypertensive individuals, the construction of treatment and control groups, and the matching of the groups based on a set of common variables.

3.2.1 Hypertension-related variables

An individual was defined as hypertensive if they had either a systolic blood pressure (sbp) ≥140 mmHg, or diastolic blood pressure (dbp) ≥90 mmHg,[4] or if they were taking anti-hypertension medicines at the time of the survey.

3.2.2 Indicators of the Timing of Treatment

For purposes of comparison, there were two treatment (early and late treatment) groups and one control group in our analysis. All individuals in the treatment and control groups were free of hypertension in 2011 but were identified as having hypertension in the 2013 wave of

[3] Compared with the baseline sample with blood pressure data (13,702 individuals), the balanced sample had similar estimated mean age and proportions of gender, highest educational level attained and proportion of respondents with physical chronic conditions. However, the balanced sample had a slightly larger proportion of individuals holding the agricultural Hukou, and of health insurance, and were less likely to have hypertension at baseline.

[4] In CHARLS, blood pressure is measured through a physical examination accompanying the survey. The systolic blood pressure and diastolic blood pressure are measured and recorded three times using an electronic sphygmomanometer. The time span between each measure is at 45 seconds. We used an average of the three blood pressure readings reported in the CHARLS dataset.

CHARLS.[5] We restricted the sample to individuals who were hypertension-free in 2011 (baseline) to avoid a situation whereby individuals who reported being treated at baseline (and thus classified as early users under our approach) may themselves have been significant treatment delayers (in the past), compared to the individuals diagnosed as being hypertensive for the first time in the CHARLS baseline survey (and thus untreated). Because CHARLS data do not contain information about the time when individuals began hypertension treatment in the baseline survey, we could not adjust for past delays.

We identified individuals in *early treatment* as those who were hypertension-free in 2011 (first wave) and then identified as having hypertension and reported being treated in 2013 (the second wave of CHARLS). Individuals were categorised as having *delayed treatment* if they were hypertension free in 2011, identified as having hypertension in 2013 and 2015, but reporting treatment only in the 2015 wave of CHARLS. As noted above, there were 7,367 individuals with blood pressure measurement in all three waves. Among them, 4,718 individuals were hypertension free in 2011 and 959 were newly diagnosed with hypertension in 2013. Among the 959 hypertensive individuals, 464 were also classified as hypertensive in 2015. Of these 464 individuals, 141 individuals started treatment in 2013 and remained in treatment in 2015 (early treatment), and 67 individuals started treatment in 2015 (late treatment) and 229 were untreated in both the 2013 and 2015 waves.[6]

We designated the untreated (or more precisely, those not treated as of 2015) hypertensive individuals as our control group. These 229 individuals developed hypertension in 2013 but were not in treatment in either 2013 or 2015. We chose untreated hypertensive patients over healthy non-hypertensive individuals as our control set because these are the individuals whose

[5] We excluded individuals who were identified as having hypertension through directly blood pressure measurement and patients who reported taking medicine in 2011.
[6] Among the 464 individuals categorized as consistently having hypertension between 2013 and 2015, there were 27 individuals who reported being treated in 2013 but were not under treatment in 2015. As we assumed the irreversibility of treatment in our analysis, we did not include them in any of the treatment or control groups.

health service needs (or health expenditures) will most likely parallel those in the treatment group, if they decided not to pursue treatment, adjusting for other factors that might influence treatment choice and timing. In section 3.3 we describe our approach to assess the parallel path assumption that is critical for the validity of DID approaches. Separately, we ran a robustness check by using the set of healthy (non-hypertensive) individuals as the control group. The results we obtained in this latter case (reported in Appendices) were qualitatively similar to the main results.

3.2.3 Matching groups of treatment and control

A potential source of bias in DID analysis is selection in treatment, for example, if more serious hypertensive cases or individuals with multi-morbidity choose to get treated early. Alternatively, people in urban settings or with higher incomes or those with access to more generous health insurance choose to get treated earlier. Not adequately accounting for unobserved heterogeneity may result in a violation of the parallel paths condition. Combining matching methods with DID analysis can help to limit this problem by controlling for pre-program characteristics (Shahidur et al., 2010). We matched three groups – early treatment, delayed treatment and no treatment – using propensity scores constructed from information on a set of baseline individual characteristics. The choice of matching variables was guided by factors that might influence individuals' health-seeking behaviour.[7] Our matching variables included age, gender, urban or rural residence, and baseline (2011) indicators of health insurance status, systolic blood pressure, number of diagnosed NCDs, individual healthcare costs in the last month, educational attainment and household per capita income (we used household non-medical consumption as a proxy of permanent income), as reported (variables defined in Appendix Table 2). Table 1 summarises the number of matched treatment and control individuals in each group resulting

[7] We accounted for took into account of the reasons for delaying seeking health care reported by respondents who felt ill in the month preceding the survey but did not seek health care (as shown in Appendix Table 1)

from this exercise. Post-matching, we did not find any statistically significant differences in the estimated means of the matching variables (Appendix Table 3).

Table 1. Number of matched cases in each group among newly diagnosed hypertensive patients

Group name	No of cases	Matched cases	Unmatched cases
Early Treatment	141	103	38
Late Treatment	67	48	19
Control	229	170	59

3.2.4 Outcome variables

We investigated two sets of outcomes: health service use and health expenditures. Health service use was captured by two indicators: a binary variable for whether an individual made an outpatient visit in the month preceding the survey, and a binary variable for an inpatient stay in the 12 months preceding the corresponding survey round. Health expenditure outcomes included (1) the probability of incurring any healthcare costs, (whether paid through OOP or paid by insurance provider) in the month preceding the survey; (2) the magnitude of healthcare costs in the month preceding the survey, including both OOP health expenditures and insurer reimbursement; [8] (3) the probability of incurring any OOP health expenditures in the month preceding the survey; (4) the level of OOP health expenditures in the month preceding the survey; (5) the incidence of catastrophic health expenditures. [9] Descriptive statistics for outcomes among matched treatment and control groups across the three waves are reported in Appendix Table 4.

3.3 Empirical strategy

We conducted a DID analysis with two treatment groups and a control group of untreated hypertensive patients to estimate the consequences of delayed hypertension treatment on health

[8] We transformed health expenditure in the natural logarithm form in the specification.
[9] We measured catastrophic health expenditure at the individual level, using hypertensive patients' monthly OOP health expenditure as the numerator and monthly non-food household expenditure per capita as denominator. We considered the following catastrophic thresholds: 20%, 30% and 40%

service use and OOP health expenditures. Our specification accounts for treatment heterogeneity characterised by (1) treatment timing, i.e., when treated for the first time, and (2) variation in effects over time (treatment dynamics) (Callaway & Sant'Annaz, 2018).

Our analysis used three comparison groups: two treatment groups (early treatment, late treatment) and one control group (hypertensive but no treatment) across, three-time periods (2011, 2013 and 2015), labelled t_1, t_2, t_3. We estimated the parameters of the following regression model:

$$Y_{ict} = a + \beta_1 \text{Early} + \beta_2 \text{Late} + \delta_1 t_2 + \delta_2 t_3 + \gamma_1 \text{Early} * t_2 + \gamma_2 \text{Early} * t_3 + \gamma_3 \text{Late} * t_2 + \gamma_4 \text{Late} * t_3 + \theta X_{ict} + \tau_c + \varepsilon_{ict}$$

where Y_{ict} refers to the outcome variable for individual 'i' living in county c in time t; Early and Late are two dummy variables indicating early and late treatment groups; and t_2 and t_3 are time dummies indicating 2013 and 2015, respectively. X_{ict} refers to individual and household characteristics, including age, gender, household-level income per capita (we used household non-health consumption as a proxy of permanent income), educational attainment and average time required to reach the nearest health facility. τ_c represents county fixed effects; and $\varepsilon_{ict}$is the usual error term. Errors were clustered at the household level.

As indicated in Table 2, the coefficient γ_1 denotes the short-term (or immediate) effect of treatment for the early treatment group compared to the control group between 2011 and 2013, whereas γ_2 can be interpreted as the longer-term effect for the same group between 2011 and 2015. The difference in γ_1 and γ_2 indicates the variation in effects over time. The coefficient γ_3 that compares outcomes for the *late* treatment group (that reported hypertension treatment only in 2015) to the control group between 2011 and 2013 can be thought of as the *pre-treatment effect* for the late treatment group. Finally, γ_4 denotes the short-term effects of hypertension treatment between 2011 and 2015, for the late treatment group, relative to the control group. The difference between γ_4 and $\gamma_1$indicates the effects of variation in treatment

timing on healthcare use and health expenditure at the time treatment was first initiated.

Table 2. Coefficients for interaction terms

Interaction terms	t2 (2013)	t3 (2015)
Early treatment (ref: No treatment)	γ_1	γ_2
Late treatment (ref: No treatment)	γ_3	γ_4

Two assumptions are required for the coefficients to be interpreted in the manner described in Table 2. The first is that the parallel trend assumption holds, conditional on baseline covariates. In the context of the analysis of this paper, the assumption requires that in the absence of treatment, the change in outcomes for the treated group is the same as the untreated group. Although we cannot directly test for this assumption for either treatment group, we can test whether parallel paths hold for the pre-treatment period for the late treatment group (Karan, Yip, & Mahal, 2017), that is, between 2011 and 2013, conditional on covariates. Specifically, our null hypothesis for this purpose was H_0: $\gamma_3 = 0$. As shown below, this was not rejected in our results. The second assumption is the irreversibility of treatment. In this paper, if an individual is treated, that individual will be assumed to remain treated in the following period as well.[10] This is in line with the Guidelines for hypertension prevention and management in China (Committee on Guidelines for hypertension prevention and management in China, 2018), that most hypertensive patients require long-term sustained treatment (including lifestyle intervention and anti-hypertensive therapy). Moreover, this assumption is consistent with most DID setups that exploit the enacting of an intervention (continuously) on some subjects while not implementing it on another subject.

We should expect treatment to increase contemporaneous healthcare use and to result in higher healthcare costs and OOP health expenditure in any given period, compared to no treatment. Thus, the expected signs for all coefficients excepting γ_3, are positive. Because initiating

[10]As mentioned in section 3.2.2, there were 168 individuals started treatment in 2013, among which, 141 (84%) remained in treatment in 2015, the rest 27 individuals did not reported being in treatment and were not included in the analysis.

treatment early might influence later expenditures, we also tested for $H_0: \gamma_1 = \gamma_2$ against the alternative $\gamma_1 \neq \gamma_2$. Finally, because of our interest in assessing the implications of early versus late treatment, we also tested for $H_0: \gamma_1 = \gamma_4$ against the alternative $\gamma_1 \neq \gamma_4$. One might also expect that, with longer-term management, patients experience declines in health service use and in OOP health expenditures, that is $\gamma_1 > \gamma_2$; and that expenditures associated with early treatment will be less than with late treatment: that is $\gamma_4 > \gamma_1$. We calculated the observed z score for the difference of two coefficients (e.g. γ_1 and γ_2) and compared it with one-sided test statistics to test the hypothesis. The results are reported in Appendix Table 5.

4. Results

4.1 Main results

The estimated effects of hypertension treatment on outpatient and inpatient service utilisation are reported in Table 3. The probability of using outpatient care was 18% higher for the early treatment group compared to the control group between 2011 and 2013 (Column 1, γ_1), and 6% higher between 2011 and 2015, compared to the control group (Column 1, γ_2). The probability of using outpatient service decreased in the following period ($\gamma_2 < \gamma_1$) although the change was not statistically significant (as shown in Appendix Table 5). For those who started treatment late, the probability of seeking outpatient care between 2011 and 2015 was 17% higher compared to the control group (Column 1, γ_4). The magnitudes of the short-term effect (γ_1 and γ_4) on seeking outpatient care for the early treatment group and late treatment group were similar and we did not observe statistical differences in this comparison (Appendix Table 5). In addition, there was a positive association between household income and outpatient care use over a 30-day reference period.

Delayed treatment was associated with a slightly higher probability of using inpatient services

relative to counterparts who began treatment earlier, although the differences were not statistically significant. Specifically, when the late treatment group initiated treatment in 2015, the probability of hospitalisation was 12% higher compared to the control group (Column 2, γ_4); whereas, when the early treatment group initiated treatment in 2013, the probability was 9% higher compared to the control group (Column 2, γ_1).

Table 3. Estimated effects of treatment on health service utilization among newly diagnosed hypertensive patients

	Outpatient care use			Inpatient care use	
	Outpatient visit last month	*p*-value		Hospitalisation last year	*p*-value
	(1)			(2)	
Early * t2 (γ1)	0.180**	0.042		0.091	0.142
	(0.104)			(0.085)	
Early * t3 (γ2)	0.061	0.248		0.040	0.285
	(0.089)			(0.070)	
Late * t2 (γ3)	0.026	0.818		-0.021	0.816
	(0.113)			(0.091)	
Late * t3 (γ4)	0.167*	0.080		0.119	0.126
	(0.118)			(0.103)	
age	-0.003	0.215		0.004*	0.062
	(0.002)			(0.002)	
gender	0.019	0.646		0.011	0.747
	(0.041)			(0.034)	
Natural logarithm of household income per capita last year	0.072***	0.002		0.016	0.433
	(0.023)			(0.020)	
Secondary Education level	-0.012	0.857		-0.010	0.841
	(0.066)			(0.050)	
Tertiary Education level	-0.111**	0.010		0.053	0.200
	(0.043)			(0.041)	
Observations	963			963	
R-squared	0.416			0.366	
Note: Standard errors in parentheses.					
We present one-sided *p*-value for γ1, γ2 and γ4, two-sided *p*-value for γ3 and covariates. *** p<0.01, ** p<0.05, * p<0.1					
Effects are estimated using using linear probability model.					
All models include time dummies, treatment dummies, community fixed effects and average time spent to the nearest health facilities					

The estimated effects of treatment on healthcare costs and OOP health expenditures are reported in Table 4. There are several noteworthy findings. First, delayed treatment was associated with a higher probability of incurring any healthcare costs (whether financed by OOP or insurance reimbursement), higher healthcare costs (including both OOP payments and insurer reimbursement) and lower OOP health expenditures when initiating treatment, relative to those who started treatment earlier. In our estimates, starting treatment early (in 2013) led to an 18% higher probability of incurring any healthcare costs between 2011 and 2013 compared to the control group (Column 1, γ_1, at 5% significance level); starting treatment late (in 2015) led to a 25% higher probability of incurring any health expenditures between 2011 and 2015 compared to the control group (Column 1, γ_4, at 5% significance level). Compared to the control group, the early treatment group experienced a 105% higher level of healthcare costs when initiating hypertension treatment in 2013 (Column 2, γ_1); the late treatment group experienced healthcare costs that was 116% higher relative to controls when initiating hypertension treatment in 2015 (Column 2, γ_4). In both cases, the magnitude of coefficient γ_1 was greater than γ_4. The effects of variation in treatment timing on OOP health expenditures were less clear. Compared to the control group at baseline in 2011, those who began treatment early experienced a 111% higher level of OOP health expenditures at the time when they initiated treatment in 2013 (Column 4, γ_1); while those who with delayed treatment experienced a 106% higher level of OOP expenditure when they initiated treatment in 2015 (Column 4, γ_4). These estimates likely reflect the higher likelihood of relying on outpatient care when seeking treatment early (and accompanying OOP spending) compared to seeking treatment later, which may involve a greater reliance on inpatient services (which are more likely to be covered by insurance). These differential effects of early versus late treatment on OOP health expenditures (γ_1 versus γ_4) were, however, not statistically significant (Appendix Table 5).

Second, hypertensive patients who started treatment earlier experienced declines in the probability of incurring any healthcare costs and the level of healthcare costs in the following period. For example, the early treatment group experienced a 20% higher probability of incurring OOP health expenditures between 2011 and 2013 compared to the control group (Column 3, γ_1); this effect decreased to 5% and became statistically insignificant between 2011 and 2015 (Column 4, γ_2). The difference of the two coefficients (γ_1 and γ_2) was statistically significant at the 10% level (Appendix Table 5).

Third, household income was positively associated with the probability of incurring healthcare costs (whether financed by OOP or insurance reimbursement), of incurring OOP health expenditures, and the level of healthcare costs.

Table 4. Estimated effects of treatment on total and oop health expenditures among newly diagnosed hypertensive patients

	Healthcare cost					OOP Health expenditures			
	Probability of inccuring healthcare cost	*p* -value	Healthcare cost	*p* -value		Probability of incurring OOP	*p* -value	OOP health expenditures	*p* -value
	(1)		(2)			(3)		(4)	
Early * t2 (γ1)	0.181**	0.041	1.052*	0.051		0.196**	0.032	1.112**	0.033
	(0.104)		(0.639)			(0.105)		(0.601)	
Early * t3 (γ2)	0.042	0.340	0.523	0.194		0.046	0.324	0.446	0.223
	(0.101)		(0.605)			(0.101)		(0.584)	
Late * t2 (γ3)	0.025	0.840	-0.175	0.807		0.036	0.769	-0.160	0.805
	(0.124)		(0.716)			(0.124)		(0.646)	
Late * t3 (γ4)	0.245**	0.031	1.158*	0.070		0.255**	0.026	1.055*	0.073
	(0.131)		(0.782)			(0.131)		(0.722)	
age	0.001	0.645	0.007	0.668		0.001	0.681	0.006	0.713
	(0.003)		(0.016)			(0.003)		(0.015)	
gender	0.016	0.750	0.075	0.811		0.022	0.666	0.145	0.632
	(0.050)		(0.314)			(0.050)		(0.303)	
Natural logarithm of household income per capita last year	0.073***	0.004	0.399**	0.011		0.071***	0.005	0.389***	0.006
	(0.025)		(0.156)			(0.025)		(0.142)	
Secondary Education level	-0.032	0.697	-0.007	0.989		-0.032	0.695	0.045	0.924
	(0.081)		(0.508)			(0.082)		(0.466)	
Tertiary Education level	-0.047	0.332	-0.284	0.355		-0.047	0.324	-0.299	0.300
	(0.049)		(0.306)			(0.048)		(0.289)	
Observations	963		963			963		963	
R-squared	0.423		0.410			0.422		0.403	

Note: Standard errors in parentheses.

We present one-sided p-value for γ1, γ2 and γ4, two-sided p-value for γ3 and covariates. *** p<0.01, ** p<0.05, * p<0.1

Health expenditure outcomes have been adjusted for inflation and are presented in the natural logarithm.

Effects are estimated using linear probability model for the binary probability outcomes and linear regression model for health expenditure outcomes

All models include time dummies, treatment dummies, community fixed effects and average time spent to the nearest health facilities

Table 5. Estimated effects of treatment on the incidence of catastrophic health expenditures among newly diagnosed hypertensive patients

	Catastrophic threshold (monthly OOP as a share of monthly non-food household expenditure)					
	20%	*p* -value	30%	*p* -value	40%	*p* -value
	(1)		(2)		(3)	
Early * t2 (γ1)	0.099	0.173	0.097	0.182	0.141*	0.090
	(0.105)		(0.106)		(0.105)	
Early * t3 (γ2)	0.054	0.297	0.080	0.206	0.079	0.212
	(0.100)		(0.098)		(0.098)	
Late * t2 (γ3)	0.001	0.997	0.003	0.979	0.024	0.846
	(0.122)		(0.123)		(0.123)	
Late * t3 (γ4)	0.166*	0.092	0.178*	0.076	0.168*	0.088
	(0.124)		(0.123)		(0.124)	
age	0.002	0.544	0.001	0.648	0.001	0.758
	(0.003)		(0.002)		(0.003)	
gender	0.042	0.401	0.020	0.699	0.018	0.722
	(0.050)		(0.051)		(0.052)	
Natural logarithm of household income per capita last year	0.054**	0.029	0.047*	0.058	0.046*	0.065
	(0.024)		(0.025)		(0.025)	
Secondary Education level	-0.026	0.755	-0.036	0.662	-0.014	0.867
	(0.083)		(0.083)		(0.083)	
Tertiary Education level	-0.026	0.593	-0.025	0.593	-0.033	0.486
	(0.048)		(0.046)		(0.048)	
Observations	963		963		963	
R-squared	0.404		0.391		0.366	
Note: Standard errors in parentheses.						
We present one-sided *p* -value for γ1, γ2 and γ4, two-sided *p* -value for γ3 and covariates. *** p<0.01, ** p<0.05, * p<0.1						
Effects are estimated using linear probability model.						
All models include time dummies, treatment dummies and community fixed effects, average time spent to the nearest health facilitie						

The estimated effects of medical treatment on CHE incidence are reported in Table 5. Using different CHE thresholds, unsurprisingly, starting treatment in 2013 led a roughly 10%-14% higher probability of having catastrophic health expenditures compared to the control group between 2011 and 2013 (γ_1 in Columns 1 to 3). This effect became smaller for the early treatment group in the longer period, between 2011 and 2015, compared to controls (γ_2 in Columns 1 to 3). In contrast, the hypertensive patients who delayed treatment had an approximately 17%-18% higher probability of experiencing CHE at the time when they began treatment in 2015, compared to controls (γ_4 in Columns 1 to 3).

4.2 Robustness Checks

We estimated two alternative specifications to test the robustness of our regression results. In the first set of analyses, we looked at the differential effects of delayed treatment on health service use and healthcare costs among populations with different levels of hypertension. One would expect that the more severe the hypertensive condition is, the more health services and higher health expenditure would be incurred at the time when the individuals initiate treatment. We repeated our main analysis in two groups: (1) level 1 mild hypertension group; and (2) a more severely hypertensive group of patients with level 2 and level 3 hypertension, respectively.[11] As shown in Appendix Tables 6 and 7, we find similar patterns as with our main results. The magnitude of the effect of delayed treatment was larger and the estimated effects were more likely to be statistically significant among patients with moderate to severe conditions. Specifically, healthcare cost was 104% higher among those who had severe hypertension and began treatment in 2013 when compared to the control group (γ_1, Column 4,

[11] We classified the level of hypertension following the Guidelines for Hypertension Prevention and Management in China (Committee on Guidelines for hypertension prevention and management in China, 2018) that level 1 Mild Hypertension is 140/90 to 159/99, level 2 Moderate Hypertension is 160/100 to 179/109 and level 3 Severe Hypertension is 180/110 or higher. We used the same early treatment group (309 observations across three wave) as with our main analysis, and the untreated hypertensive population (510 observations) as our control group. For the late treatment group, we separated the hypertensive patients into two groups: level 1 hypertension (93 observations) and level 2 and 3 hypertension (45 observations), according to their blood pressure in 2013. This allowed us to observe the delaying effect across different level of hypertension.

Appendix Table 7); and 285% higher among those who delayed treatment, relative to controls (γ_4, Column 4, Appendix Table 7). The incidence of CHE (using a threshold of 30%) was 10% higher among those who began treatment in 2013 when compared to control groups (γ_1, Column 7, Appendix Table 7); and 36% higher among those who delayed treatment (γ_4, Column 4, Appendix Table 7). The differences (γ_4 - γ_1) in the effects on total health expenditures and the incidence of CHE were statistically significant at 10% level.[12]

The use of healthy non-hypertensive individuals as a control group is less likely to satisfy the parallel path assumption (i.e., similar trends in outcomes for hypertensive individuals, in the absence of treatment). Nonetheless, we tried using healthy non-hypertensive individuals as an alternative comparison group and repeated the DID analysis.[13] As shown in Appendix Table 8, we find effects that are similar to our earlier results: that is, newly diagnosed hypertensive patients initiating treatment were associated with greater healthcare use and healthcare costs than among those who did not seek care. Hypertensive patients having started treatment experienced declines in healthcare use, and in healthcare costs (inclusive of OOP expenditure and insurance reimbursements) and OOP health expenditures in the following period. The magnitudes of the effects were larger compared to that of our main analysis (using hypertensive patients who were not in treatment as control). However, we did not observe any effects arising from variation in treatment timing, namely that delaying treatment led to higher healthcare costs and a higher probability of incurring CHE at the time of initiating treatment, relative to counterparts who began treatment earlier.

5. Discussion

[12] The corresponding z score was 1.49 and 1.39 for the differences (γ1 and γ4) in the level of healthcare cost and the incidence of catastrophic health spending, respectively.

[13] We constructed an alternatively control group as those who did not reported any diagnosed NCDs in all three waves. We matched them with early and late treatment group using the same matching variables except for sbp and number of NCDs. After matching, there were 321 observations and 162 observations in early and late treatment group respectively, and 1,629 observations in control groups.

Nearly half of Chinese adults have hypertension but less than one-third reported being treated, suggesting a large share of the hypertensive population is not accessing treatment in a timely way. To explore the economic implications of delayed hypertension treatment in Chinese population, we used three waves of the CHARLS panel dataset to compare the effects of early hypertension treatment and late hypertension treatment on healthcare use and healthcare costs at the time treatment was first sought; and to estimate the effects on healthcare use, costs and out of pocket spending over time among those who started treatment early. We find that hypertensive patients who started treatment earlier had a lower probability of incurring healthcare costs in the following period. Patients who delayed treatment had a higher level of healthcare costs (inclusive of OOP expenditure and insurance reimbursements) and were more likely to experience CHE at the time they initiated treatment, compared to counterparts who began hypertension treatment earlier.

Starting treatment early was associated with declines in health costs subsequently; and the magnitudes of decline, in both the levels of healthcare cost and OOP health expenditures, were larger for patients at mild hypertension stage compared to counterparts at a moderate and severe stage. This implies that the earlier (proxied by a less severe hypertension condition) one starts treatment, the more benefit (reduction in health expenditures) one may experience in the longer term. To the best of our knowledge, this is the first paper looking at how health expenditure (with and without insurance reimbursement) at the individual level would evolve with hypertension treatment using nationally representative longitudinal survey data in China. Delaying treatment was associated with higher health costs and the association was more pronounced among the more severely hypertensive patients. The results are consistent with the idea that without timely treatment, hypertension tends to develop complications that require inpatient and/or specialist care, with larger expenditure implications, in line with the current understanding of the pathology of this disease (Gu et al., 2008; Liu et al., 2007; Xu et al., 2015).

There is also an equity dimension to our findings, given that our sample of poorer hypertensive individuals was less likely to utilise health services, spend less out of pocket on healthcare, and have lower healthcare costs (including both OOP expenditure and insurance reimbursements) more generally. Our results show that patients from lower income households forego care, consistent with the argument advanced by other studies that the costs of treatment can prevent the economically disadvantaged population groups from seeking care (Elwell-Sutton et al., 2013; Li et al., 2017; H. Lu et al., 2017). Our results show that, foregoing (or delaying) treatment is associated with higher healthcare cost (inclusive of OOP spending and insurance reimbursements) and lower OOP health spending. This likely reflects the nature of insurance benefit in China that has focused on inpatient care and is also suggested by our results. Individuals seeking treatment early are likely to incur higher levels of OOP spending because they obtain outpatient care that has limited reimbursement. Poor individuals might wish to avoid that. But delayed treatment increases the risk of inpatient care, which is covered by health insurance. Further, although health insurance helps mitigate the burden of OOP to some degree, those who delay care are still facing high CHE. As a chronic condition, hypertension requires long-term management and control, which involves a long-term economic burden on households. Individuals and households confronted with potentially long-term (ongoing) OOP health expenditure and a decision of opting for treatment now, or treatment later, or even foregoing treatment. The economic burden of treatment, including access to drugs, can affect an individual's health care seeking behaviour through reduced willingness to pay and or reduced adherence to long-term treatment (Jan et al., 2018; Tang et al., 2010). Our results show the value of offering better outpatient care coverage in terms of equity and reduced risk of financial burden on the poor.

Notwithstanding what we consider novel findings, this study has several limitations. First, our analysis looked at a delay period that was relatively short (of two years) among the newly

diagnosed hypertensive population. This raises the concern whether such a short period of time is adequate to capture the effects of delaying treatment (enough for hypertension to develop severe complications). We attempted to address this issue by looking at the differential effects across different level of hypertension and found stronger effects associated with more severe hypertension. Clearly, future work would benefit from panel data that are available over a more extended period to estimate the longer-term impact of delayed treatment on household wellbeing. Second, our data set did not enable us to capture all health expenditures on hypertension treatment because CHARLS only collected outpatient service use and related costs in the month preceding the survey. Therefore, we confined our results regarding the comparison between early treatment and late treatment to "at the time when initiating treatment". Future work would benefit from linking household panel survey data and corresponding administrative data on health service use and expenditures. Third, our health expenditure outcomes could have included expenses incurred for treating other conditions, not directly linked to hypertension. Though the increase in health expenditures due to other NCDs such as heart disease, stroke and kidney diseases, can reflect the health consequences of delaying hypertension treatment, we cannot rule out the possibility that the increased health expenditures could have been due to other chronic and acute conditions. Last, there is always the risk of bias due to systematic differences among early, late and non-treatment groups. We used propensity score matching to alleviate bias due to such non-random entry into treatment, and note that the DID methodology helps to net out unobserved fixed effects that might influence healthcare use behaviour. We also explored pre-treatment trends to test to assess the parallel path assumption that is critical for the validity of DID approaches and found the assumption not to be violated.

Notwithstanding these caveats, this study highlights potential areas for research and policy action to address the economic burden on households of NCDs in China. These include the

need for greater attention towards understanding the causes for delays in treatment seeking for chronic conditions, and exploring the economic impact of delays in treatment for hypertension and other NCDs, including a multi-period understanding of the financial burden of NCDs. From the standpoint of policy, our research points to the importance of approaches to better incentivise the population to seek early treatment-seeking for chronic conditions. Insurance plans that offer broader coverage that includes outpatient care can provide this incentive; as can cash transfers that encourage improved health-seeking behaviours (Lagarde, Haines, & Palmer, 2007). Funding structures that shift health care delivery system focus from treatment and hospital-centred models to a primary health care based integrated health care model could manage NCD more effectively when they are less severe (The World Bank, 2016). Strategies that include population awareness of chronic conditions, including early diagnosis, could also help.

6. Conclusion

This study finds that hypertensive patients experienced declines in the probabilities of incurring healthcare cost in the period following treatment. Among those who were newly diagnosed with moderate to severe hypertension, delayed treatment was associated with higher healthcare cost and a higher probability of incurring catastrophic health expenditures when the patients initiated treatment, relative to counterparts who began treatment earlier. The study also highlights an equity dimension, as poorer patients were more likely to delay outpatient care. The results from this study suggest that ignoring the economic cost associated with delayed NCD treatment may lead to an underestimation of the economic impact of NCDs in the long-run. More research and policy attention is therefore required for a better understanding to inform the development of strategies to effectively address the economic consequences of delaying treatment for NCDs.

Appendix

Appendix Table 1. Reasons for delaying seeking health care (percentage) among the pooled sample

Reason	Percentage (%)
Already under treatment	11.0
Illness is not serious. Don't need treatment	53.1
Poor	16.1
No time	2.1
Inconvenient traffuce to health facility	2.8
Poor attitude of service providers	0.4
No effective treatment	2.8
Other	11.7
Observations	2051

Note: The full sample indicates a pooled sample of 22101 observations of 7367 individuals that are in all three waves and are with blood pressure measurement. Among them, 2051 report at lease once foregoing treatment and answered the question.

Appendix Table 2. Definitions of variables.	
Variables	Definition
Outcome Variable	
doc_visit	= 1 if the individual visited doctor during the last month; = 0 if otherwise.
hos_visit	= 1 if the individual were hospitalised during the last year; = 0 if otherwise.
p_he_tot	Probability of incurring healthcare costs (outpatient and inpatient costs)
log_he_tot	Natural logarithm of individual healthcare costs in the last month
p_he_oop	Probability of incurring out-of-pocket (OOP) health expenditures (outpatient and inpatient costs)
log_he_oop	Natural logarithm of individual OOP health expenditures in the last month
che20	=1 if the individual experienced catastrophic health expenditures using a threshold of 20%; = 0 if otherwise.
che30	=1 if the individual experienced catastrophic health expenditures using a threshold of 30%; = 0 if otherwise.
che40	=1 if the individual experienced catastrophic health expenditures using a threshold of 40%; = 0 if otherwise.
Independent Variable	
treatment	= 1 if the individual started treatmet in 2013 (Early); = 2 if the individual started treatment in 2015 (Late); = 0 if the individual did not have treatment in any waves.
Year	= 1 if in Year 2011; = 2 if in Year 2013; = 3 if in Year 2015
age	Age in years.
gender	= 1 if theindividual is female; = 0 if otherwise.
log_hhnhcper	Natural logarithm of household non-health consumption (as a proxy of permanent income) per capita during last
edu	= 1 if less than lower secondary; = 2 if iupper secondary & vocational training; = 3 if tertiary
time_health facility	average time spent to the nearest health facility (calculated the average time spent within one community and use that value for each individual.)
Matching Variable (baseline characteristics)	
age	Age in years.
female	= 1 if theindividual is female; = 0 if otherwise.
rural	= 1 if individual lives in rural; = 0 if otherwise.
immediate_reimbursement	= 1 if individual can get health insurance reimbursement immediately; = 0 if otherwise.
sbp	Measured systolic blood pressure in 2011.
num_NCDs	Number of self-reported doctor-diagnosed NCDs.
log_he_tot_2011	Natural logarithm of individual healthcare costs in the last month at baseline in 2011.
edu	= 1 if less than lower secondary; = 2 if iupper secondary & vocational training; = 3 if tertiary
log_hhnhcper_2011	Natural logarithm of household non-health consumption (as a proxy of permanent income) per capita during last year at baseline in 2011.
Note: The level of health expenditures and household income have been adjusted for inflation. (Base year: 2010)	

Appendix Table 3. Summary statistics of baseline covariates for treatment and control (matched) groups among newly diagnosed hypertensive individuals

	Variable	Mean (Treatment)	Mean (Control)	% bias	t-statistic	*P*-value
Early vs Control						
	age	59.769	60.649	-9.500	-0.710	0.477
	female	0.529	0.493	7.200	0.520	0.605
	rural	0.827	0.856	-6.700	-0.570	0.571
	immediate_reimbursement	0.298	0.260	8.200	0.620	0.539
	sbp	127.130	126.460	7.400	0.550	0.585
	num_NCDs	2.183	2.166	1.200	0.080	0.939
	log_he_tot_2011	1.219	1.153	2.900	0.220	0.829
	edu	1.058	1.024	10.600	1.220	0.222
	log_hhnhcper_2011	8.274	8.046	26.900	1.890	0.061
Late vs Control						
	age	59.741	60.106	-4.000	-0.210	0.836
	female	0.519	0.491	5.500	0.290	0.775
	rural	0.722	0.690	7.000	0.370	0.715
	immediate_reimbursement	0.259	0.194	14.100	0.800	0.426
	sbp	127.980	128.510	-6.000	-0.350	0.726
	num_NCDs	1.611	1.597	1.100	0.050	0.958
	log_he_tot_2011	1.382	1.492	-4.700	-0.230	0.818
	edu	1.074	1.074	0.000	0.000	1.000
	log_hhnhcper_2011	8.362	8.226	15.800	0.850	0.398
Early vs Late						
	age	59.673	59.344	3.800	0.280	0.782
	female	0.529	0.450	15.800	1.140	0.255
	rural	0.827	0.887	-14.400	-1.240	0.218
	immediate_reimbursement	0.298	0.300	-0.500	-0.040	0.970
	sbp	127.200	127.240	-0.400	-0.030	0.979
	num_NCDs	2.202	2.065	9.000	0.650	0.514
	log_he_tot_2011	1.286	1.053	9.600	0.730	0.463
	edu	1.058	1.084	-10.600	-0.740	0.460
	log_hhnhcper_2011	8.281	8.230	6.400	0.480	0.635

Note: Health expenditure outcomes have been adjusted for inflation and are presented in the natural logarith

Appendix Table 4. Descriptive statistics of the outcome variables among matched treatment and control group across three waves

	2011						2013						2015					
	Early		Late		Control		Early		Late		Control		Early		Late		Control	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
doc_visit	0.182	0.043	0.147	0.053	0.221	0.072	0.374	0.057	0.201	0.064	0.219	0.055	0.299	0.046	0.284	0.077	0.182	0.042
hos_visit	0.078	0.030	0.055	0.032	0.031	0.012	0.251	0.046	0.167	0.069	0.132	0.032	0.185	0.044	0.201	0.061	0.180	0.050
p_he_tot	0.236	0.046	0.205	0.060	0.256	0.069	0.477	0.057	0.319	0.082	0.287	0.057	0.398	0.053	0.421	0.081	0.301	0.054
log_he_tot	1.165	0.244	1.205	0.369	1.020	0.174	2.920	0.383	1.839	0.507	1.573	0.258	2.474	0.354	2.429	0.487	1.739	0.323
p_he_oop	0.225	0.046	0.205	0.060	0.256	0.069	0.468	0.059	0.330	0.084	0.295	0.057	0.383	0.054	0.421	0.081	0.283	0.053
log_he_oo	1.084	0.234	1.119	0.336	0.982	0.171	2.756	0.371	1.632	0.433	1.440	0.230	2.231	0.330	2.311	0.469	1.496	0.275
che20	0.213	0.045	0.205	0.060	0.153	0.031	0.461	0.064	0.277	0.087	0.262	0.044	0.367	0.061	0.378	0.088	0.225	0.054
che30	0.204	0.045	0.188	0.058	0.145	0.031	0.453	0.064	0.277	0.087	0.246	0.044	0.367	0.061	0.378	0.088	0.212	0.054
che40	0.189	0.043	0.188	0.058	0.139	0.030	0.453	0.064	0.277	0.087	0.218	0.042	0.359	0.060	0.378	0.088	0.212	0.054
Observatio	103		48		170		103		48		170		103		48		170	

Note: Health expenditure outcomes have been adjusted for inflation and are presented in the natural logarithm.

All estimates appropriately weighted to reflect the complex survey design.

Appendix Table 5. Differences in estimated effects of treatment on health service use and health expenditures							
	γ1-γ2				γ4-γ1		
Outcomes	difference	s.e.	z score		difference	s.e.	z score
Outpatient visit last month	0.119	0.103	1.155		-0.013	0.150	-0.087
Hospisalization last year	0.051	0.085	0.600		0.028	0.129	0.217
Probability of incurring healthcare cost	0.139	0.103	1.350*		0.064	0.150	0.427
Healthcare cost	0.529	0.666	0.794		0.106	0.936	0.113
Probability of incurring OOP	0.150	0.103	1.456*		0.059	0.156	0.378
OOP health expenditures	0.666	0.644	1.034		-0.057	0.874	-0.065
CHE_20%	0.045	0.108	0.417		0.067	0.150	0.447
CHE_30%	0.017	0.107	0.159		0.081	0.150	0.540
CHE_40%	0.062	0.109	0.569		0.027	0.149	0.181
Note: *** p<0.01, ** p<0.05, * p<0.1							
Healthcare cost and OOP expenditure outcomes have been adjusted for inflation and are presented in the natural logarithm.							

Appendix Table 6. Estimated effects of treatment on health service utilization and healthcare cost among newly diagnosed level 1 (sbp between 140-160 mm Hg) hypertensive patients														
	Outpatient visit last month	*p* -value	Hospitalisation last year	*p* -value	Probability of incurring healthcare cost	*p* -value	Healthcare cost	*p* -value	Probability of incurring OOP	*p* -value	OOP Expenditure	*p* -value	CHE 30%	*p* -value
	(1)		(2)		(3)		(4)		(5)		(6)		(7)	
Early * t2 (γ1)	0.177**	0.046	0.101	0.118	0.190**	0.036	1.098**	0.045	0.205**	0.027	1.159**	0.028	0.106	0.162
	(0.105)		(0.085)		(0.105)		(0.643)		(0.106)		(0.604)		(0.107)	
Early * t3 (γ2)	0.060	0.253	0.049	0.241	0.051	0.309	0.575	0.173	0.055	0.293	0.495	0.199	0.090	0.180
	(0.090)		(0.070)		(0.101)		(0.608)		(0.101)		(0.586)		(0.098)	
Late * t2 (γ3)	0.080	0.496	-0.038	0.737	0.010	0.948	-0.370	0.672	0.020	0.892	-0.287	0.722	-0.022	0.882
	(0.117)		(0.113)		(0.146)		(0.874)		(0.146)		(0.806)		(0.146)	
Late * t3 (γ4)	0.151	0.118	0.108	0.197	0.165	0.155	0.519	0.291	0.175	0.141	0.470	0.294	0.112	0.234
	(0.127)		(0.126)		(0.162)		(0.943)		(0.163)		(0.865)		(0.154)	
age	-0.003	0.129	0.003	0.127	0.000	0.949	0.000	0.999	0.000	0.963	-0.001	0.929	0.000	0.969
	(0.002)		(0.002)		(0.003)		(0.016)		(0.003)		(0.016)		(0.002)	
gender	0.027	0.548	0.021	0.551	0.018	0.734	0.069	0.839	0.023	0.679	0.139	0.671	0.015	0.771
	(0.045)		(0.036)		(0.054)		(0.341)		(0.054)		(0.326)		(0.053)	
Natural logarithm of household non-food consumption per capita last year	0.073***	0.003	0.020	0.339	0.074***	0.006	0.398**	0.015	0.071***	0.006	0.384**	0.010	0.050*	0.051
	(0.025)		(0.021)		(0.027)		(0.163)		(0.026)		(0.148)		(0.026)	
Secondary Education level	-0.004	0.952	0.017	0.688	0.003	0.966	0.178	0.733	0.002	0.980	0.228	0.633	-0.007	0.936
	(0.074)		(0.041)		(0.080)		(0.523)		(0.081)		(0.477)		(0.084)	
Tertiary Education level	-0.126***	0.006	0.035	0.362	-0.065	0.176	-0.396	0.195	-0.067	0.155	-0.408	0.160	-0.044	0.328
	(0.046)		(0.038)		(0.048)		(0.305)		(0.047)		(0.290)		(0.045)	
Observations	913		913		913		913		913		913		913	
R-squared	0.426		0.389		0.432		0.419		0.431		0.413		0.421	
Note: Standard errors in parentheses.														
We present one-sided *p* -value for γ1, γ2 and γ4, two-sided *p* -value for γ3 and covariates. *** p<0.01, ** p<0.05, * p<0.1														
Health expenditure outcomes have been adjusted for inflation and are presented in the natural logarithm.														
Effects are estimated using using linear probability model.														
All models include time dummies, treatment dummies, community fixed effects and average time spent to the nearest health facilities														

Appendix Table 7. Estimated effects of treatment on health service utilization and healthcare cost among newly diagnosed level 2 &3 (sbp between greater than 160 mm Hg) hypertensive patients

	Outpatient visit last month	*p* -value	Hospitalisation last year	*p* -value	Probability of incurring healthcare cost	*p* -value	Healthcare cost	*p* -value	Probability of incurring OOP	*p* -value	OOP Expenditure	*p* -value	CHE 30%	*p* -value
	(1)		(2)		(3)		(4)		(5)		(6)		(7)	
Early * t2 (γ1)	0.184**	0.040	0.088	0.153	0.181**	0.042	1.035*	0.054	0.196**	0.033	1.097**	0.035	0.095	0.188
	(0.104)		(0.086)		(0.104)		(0.643)		(0.106)		(0.604)		(0.107)	
Early * t3 (γ2)	0.063	0.243	0.046	0.255	0.051	0.310	0.589	0.167	0.055	0.295	0.511	0.193	0.090	0.180
	(0.090)		(0.070)		(0.102)		(0.609)		(0.102)		(0.589)		(0.098)	
Late * t2 (γ3)	0.032	0.882	0.095	0.496	0.135	0.524	0.660	0.560	0.147	0.488	0.514	0.604	0.126	0.541
	(0.216)		(0.140)		(0.211)		(1.132)		(0.212)		(0.989)		(0.206)	
Late * t3 (γ4)	0.288	0.100	0.279*	0.067	0.465***	0.005	2.854***	0.007	0.474***	0.005	2.692***	0.008	0.362**	0.022
	(0.223)		(0.185)		(0.179)		(1.148)		(0.179)		(1.115)		(0.179)	
age	-0.002	0.314	0.004*	0.063	0.002	0.445	0.013	0.443	0.002	0.484	0.012	0.456	0.002	0.522
	(0.002)		(0.002)		(0.003)		(0.017)		(0.003)		(0.016)		(0.003)	
gender	0.037	0.410	0.033	0.343	0.047	0.383	0.248	0.465	0.053	0.322	0.311	0.340	0.051	0.358
	(0.045)		(0.035)		(0.054)		(0.339)		(0.054)		(0.325)		(0.055)	
Natural logarithm of household non-food consumption per capita last year	0.072***	0.004	0.023	0.282	0.078***	0.004	0.445***	0.007	0.076***	0.004	0.428***	0.004	0.053**	0.048
	(0.024)		(0.021)		(0.027)		(0.163)		(0.026)		(0.149)		(0.026)	
Secondary Education level	-0.030	0.669	0.013	0.814	-0.037	0.695	0.175	0.771	-0.039	0.691	0.156	0.783	-0.008	0.934
	(0.071)		(0.055)		(0.095)		(0.599)		(0.097)		(0.565)		(0.101)	
Tertiary Education level	-0.103**	0.018	0.044	0.282	-0.038	0.453	-0.229	0.468	-0.038	0.435	-0.234	0.433	-0.022	0.650
	(0.044)		(0.041)		(0.051)		(0.315)		(0.049)		(0.298)		(0.047)	
Observations	864		864		864		864		864		864		864	
R-squared	0.408		0.393		0.438		0.422		0.437		0.419		0.421	

Note: Standard errors in parentheses.

We present one-sided *p* -value for γ1, γ2 and γ4, two-sided *p* -value for γ3 and covariates. *** p<0.01, ** p<0.05, * p<0.1

Health expenditure outcomes have been adjusted for inflation and are presented in the natural logarithm.

Effects are estimated using using linear probability model.

All models include time dummies, treatment dummies, community fixed effects and average time spent to the nearest health facilities

Appendix Table 8. Estimated effects of treatment on health service utilization and healthcare cost among newly diagnosed hypertensive patients,compared to healthy individuals

	Outpatient visit last month	*p* -value	Hospitalisation last year	*p* -value	Probability of incurring healthcare cost	*p* -value	Healthcare cost	*p* -value	Probability of incurring OOP	*p* -value	OOP Expenditure	*p* -value	CHE 30%	*p* -value
	(1)		(2)		(3)		(4)		(5)		(6)		(7)	
Early * t2 (γ1)	0.246***	0.001	0.167**	0.009	0.275***	0.001	1.981***	<0.001	0.283***	<0.001	1.916***	<0.001	0.244***	0.002
	(0.080)		(0.070)		(0.082)		(0.494)		(0.081)		(0.456)		(0.082)	
Early * t3 (γ2)	0.060	0.207	0.097*	0.049	0.080	0.168	0.876**	0.035	0.085	0.153	0.773**	0.048	0.111	0.081
	(0.073)		(0.058)		(0.083)		(0.483)		(0.083)		(0.464)		(0.079)	
Late * t2 (γ3)	0.034	0.711	0.055	0.426	0.061	0.544	0.499	0.383	0.051	0.609	0.336	0.521	0.115	0.261
	(0.092)		(0.069)		(0.100)		(0.572)		(0.101)		(0.524)		(0.102)	
Late * t3 (γ4)	0.035	0.357	0.178**	0.020	0.170*	0.054	1.049**	0.048	0.168*	0.055	0.891*	0.062	0.157	0.060
	(0.097)		(0.087)		(0.105)		(0.627)		(0.105)		(0.577)		(0.101)	
age	-0.004**	0.016	0.002**	0.020	0.000	0.770	-0.002	0.860	0.000	0.859	-0.002	0.825	-0.001	0.544
	(0.001)		(0.001)		(0.002)		(0.009)		(0.002)		(0.008)		(0.001)	
gender	0.011	0.620	0.012	0.409	0.022	0.401	0.251*	0.063	0.017	0.495	0.235*	0.067	0.036	0.121
	(0.023)		(0.014)		(0.026)		(0.135)		(0.025)		(0.128)		(0.023)	
Natural logarithm of household non-food consumption per capita last year	0.021*	0.089	0.019**	0.022	0.036**	0.011	0.252***	0.001	0.027**	0.048	0.215***	0.003	0.021	0.102
	(0.012)		(0.008)		(0.014)		(0.078)		(0.014)		(0.072)		(0.013)	
Secondary Education level	-0.052	0.119	0.012	0.609	-0.046	0.264	-0.227	0.240	-0.048	0.223	-0.223	0.208	-0.022	0.544
	(0.033)		(0.023)		(0.041)		(0.193)		(0.040)		(0.177)		(0.037)	
Tertiary Education level	-0.179***	0.003	0.497*	0.093	0.319	0.364	0.492	0.850	-0.112*	0.079	-0.892*	0.053	-0.295**	0.046
	(0.060)		(0.296)		(0.351)		(2.598)		(0.064)		(0.460)		(0.148)	
Observations	2112		2112		2112		2112		2112		2112		2112	
R-squared	0.259		0.291		0.272		0.296		0.273		0.293		0.260	

Note: Standard errors in parentheses.

We present one-sided *p* -value for γ1, γ2 and γ4, two-sided *p* -value for γ3 and covariates. *** p<0.01, ** p<0.05, * p<0.1

Health expenditure outcomes have been adjusted for inflation and are presented in the natural logarithm.

Effects are estimated using using linear probability model.

All models include time dummies, treatment dummies, community fixed effects and average time spent to the nearest health facilities

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Chapter 8 Discussion

8.1 Introduction

Households in China facing a rising burden of non-communicable diseases (NCDs) are bearing in the longer term the economic and health consequences of the coping strategies they adopt today. This adds a new sense of urgency to strengthening health systems to reduce the health burden and the financial burden of NCDs on households. Addressing modifiable risk behaviours is the starting point for households who will suffer the NCD burden and face high out-of-pocket (OOP) health expenditures required to treat the disease. If not well addressed, these behavioural risk factors will lead to NCDs. The main challenge is to receive an accurate diagnosis, followed by accessing treatment timely. Then the critical questions for the household are: how to finance the increased health costs, and in some circumstances, whether or not it is wise to delay treatment due to cost.

This thesis finds that those who paid for health care (commonly through OOP payments) were facing a decrease in wealth in the current period and the future, and patients who started treatment late were more likely to incur catastrophic health expenditures (CHE) once they initiated treatment, relative to counterparts who began hypertension treatment earlier. Households who chose to avoid treatment paid a price of health in the future. Individuals from poor households were less likely to be diagnosed with NCDs and were more likely to delay and forego NCD treatment. They faced a double financial burden as they had less access to health services to manage NCDs in a timely fashion as well as fewer resources to cushion the NCD shock.

Understanding the potential long-term economic burden of NCDs on households opens the space for much needed public policies and interventions in China. This is especially true in

circumstances where the health expenditure associated with managing NCDs continues to grow while at the same time, the growth of the national economy has slowed. Risk behaviours, coping strategies and delayed treatment increase the financial burden on households and, in the longer term, raise the overall national costs of addressing NCDs.

In this chapter, I start by synergising the critical findings from the three studies of this thesis. Based on the evidence about the long-term economic impact of NCDs on Chinese households, I discuss the policy implication for providing health care services and health financial protection schemes that can meet the growing needs of individuals and households to cope with NCDs. The findings from this thesis shed light on the importance of estimating the long-term economic impact of NCDs on households in China, as well as in other LMICs.

8.2 Synthesis of Key Findings

The three studies in this thesis contribute to the growing literature on the economic impact of NCDs on households in China by drawing new attention to the long-term economic consequences. Here, I present the major findings under four arguments: risk factors continue to contribute to NCDs; households sacrifice future wealth and health to cope with NCDs; delayed NCD treatment leads to higher health expenditure in the long run; and the poor suffer most from the economic consequences of NCDs. The validation of the results has been discussed in the previous chapters. Therefore, in the section, I focus on the long-term implication of these findings.

8.2.1 Risk Factors Continue to Contribute to NCDs

Understanding the modifiable risk behaviours is the starting point and the most important set of considerations in addressing the NCD burden. Using three waves of the China Family Panel Studies survey (2010–2014) and a dynamic model conditional on not having an NCD in the first period, I found positive associations of being obese, using solid cooking fuels, and a

history of frequent drinking during the preceding period on the self-reported diagnosis of NCDs. Individuals with a higher level of socioeconomic status (SES, measured by household consumption expenditure) were more likely to report a diagnosis of NCDs. These results are broadly in line with earlier findings in China (Li et al., 2013; Yang et al., 2013). However, my analysis adds to this literature by disaggregating the effects by age subgroups and indicating the generational shift in behaviours and its lifetime impact. There may exist generational change in risk behaviours. Obesity, solid fuel use and SES effects are confined statistically to people aged under 45 years, whereas effects associated with drinking history are confined statistically to the elderly population aged 60 years and above.

These results have several long-term implications for addressing the NCD burden on households in China. First, the younger obese generation (under 60 years) had a higher probability of being diagnosed with NCDs. It suggests that this working-age population could live with NCDs for a longer period, which has impacts on both health expenditures and income. For those younger females under 45 years old, they will require longer-term management to avoid obesity developing into severe health conditions and causing excessive long-term health spending. Households with middle-aged obese males (45 to 60 years), who have a higher probability of being in the middle- and higher-level administrative positions and whose earnings account for a higher proportion of total household income (Xie, 2013), face an increased risk of income loss due to lost productivity associated with NCDs. In addition, the association between risk factors such as obese and NCDs was more pronounced among younger generation compared to their older counterparts indicate that there may exist generational shifts in behaviours. Interventions designed to address current risk behaviours among younger generation suggest an opportunity for reducing the future burden of NCDs.

Second, I found robust positive effects of past drinking behaviour on NCD onset among elderly males (those over 60 years of age) but no significant effects associated with current excessive

drinking behaviours. These age-related effects imply a lifetime effect of drinking on health. Risk factors, such as excessive drinking, may not take effect immediately but have a cumulative influence in the long-term (Fillmore & Midanik, 1984). The implication is that, if such risks are not addressed at an early stage, they are likely to be the cause of rising NCDs in the future.

In summary, by identifying risk factors associated with the onset of an NCD for the at-risk population, results from study one provide valuable information from a prevention point of view. The results shed light on the lifetime impact of NCD risk factors, which vary at different stages in the life-cycle.

8.2.2 Households Sacrifice Future Wealth and Health to Cope with NCDs

When public health policies and interventions have not done enough to curb the burden of disease attributable to NCDs, a better understanding of how households cope with the onset of an NCD and the effects of the coping strategies on household welfare, in the long run, carries significant implications for the design of public insurance policies and financial protection programs. Using three waves of the China Family Panel Studies survey (2010-2014) and a fixed-effects specification, I found that Chinese households that experienced a significant increase in OOP health expenditures following an NCD shock can smooth consumption expenditure through the depletion of household housing assets and receipt of public transfers. Higher health spending by NCD patients in the preceding period led to improved health but also reduced household assets in the subsequent periods. For poor households, I found no significant increase in health expenditures, suggesting that they avoided treatment.

These findings illustrate the consequences of coping with NCDs on household welfare in the long run by revealing that both the non-poor and the poor are paying the price in terms of future wealth and health, respectively. For non-poor households who opted for treatment, their wealth decreased in the current period and the future. My results show that the market value of their

housing property fell by 28% between 2010 and 2012. During the same period in China, the price of housing property grew by more than 20% (Deng, Gyourko, & Wu, 2012). The implication of selling housing assets is that these households lose the opportunity to accumulate future wealth through appreciation of the housing assets, in a context where the real estate market continues to thrive. Also, the ownership and the market value of houses are closely associated with social outcomes such as education and marriage (Li & Wu, 2014; Wei & Zhang, 2011). The depletion of housing assets potentially has intergenerational effects.

In the longer-term, while those who sacrificed current wealth to pay for health enjoyed health gain in the future, they experienced a decline in assets during the same period. I found that a 10% increase in health expenditures between 2010 and 2012 led to a 0.7% reduction in the value of productive and durable assets between 2012 and 2014. Though this analysis of welfare effects related only to the two-year window provided by the data, the results demonstrated that the coping strategies households adopted in the current period (to smooth non-health consumption expenditures) were at the expense of future welfare.

My results suggest that poor households commonly opted to defer or forego treatment, as there were no significant effects of a new NCD onset on health expenditures or non-health consumption. When controlling for health insurance, there was a positive effect of health insurance on earnings, suggesting health insurance might provide protection on income for poor households (As shown in Appendix Table 4). However, the non-significant effects of NCDs on health expenditures, non-health consumption, depletion of assets, receipt of public and private transfers, or accumulation of debt remained unchanged. This “non-effect” suggests that poor households were willing to defer or even forego treatment to maintain current consumption. This finding is consistent with other studies in China which show that Chinese households are willing to undertake costly strategies to insure consumption against idiosyncratic shocks (Xu, 2008), and that health insurance provides limited protection against

health shocks (Meng et al., 2012; Wagstaff & Lindelow, 2008; Yip et al., 2019; Yip & Hsiao, 2009).

The consequence of delayed treatment was deteriorated health, as I found positive associations between health expenditures and improved future health. It can be inferred that poor households with an NCD-affected member may choose to continue deferring treatment and suffer human capital loss. When they choose to seek treatment later, the delay in treatment can lead to much higher health expenditures. The household economic and health consequences of this delay in seeking care have been demonstrated in study three.

In summary, study two illustrates the longer-term health and economic consequences of NCDs on household welfare by examining the longer-term effect of the coping strategies households adopt to finance health care in the short term. For policymakers, ignoring the issue of using coping strategies to maintain current consumption and the consequences of adopting coping strategies, can lead to underestimation of the long-run welfare loss caused by health expenditures necessitated by the NCD onset.

8.2.3 Delayed NCD Treatment Leads to Higher Health Expenditure in the Long Run

As shown in the literature, the increased level of health expenditures due to NCDs can create barriers for individuals and households to access quality health services when needed and affect their health-seeking behaviours through reduced adherence to long-term treatment and abandonment of treatment (Lexchin & Grootendorst, 2004; Tamblyn et al., 2001). In study three, I investigated the consequences of delayed treatment for NCDs, in a way that can enrich our understanding of the longer-term consequences for NCD-affected households. I illustrated the economic impact of delaying NCD treatment on individuals' health care utilisation and health expenditures using the example of hypertension. Using three waves of data from the China Health and Retirement Longitudinal Study and conducting a difference-in-difference

analysis, I found that patients who started treatment late spent more on health services and were more likely to have CHE once they initiated treatment, relative to counterparts who began hypertension treatment earlier. Hypertensive patients who started treatment earlier experienced declines in the probability of incurring health expenditures in the following period. Those who were in the lower-income range were less likely to utilise health services.

The finding that delaying treatment led to a higher level of healthcare costs when initiating the treatment, compared to those who started treatment earlier, has long-term implications for household welfare. The longer a patient delays hypertension treatment (proxied by a higher level of blood pressure), the more this person will spend on health care. For patients with chronic conditions, such as hypertension, where the risk of developing into a more severe condition is high, delay in treatment is likely to result in a higher level of health care in the future than households would incur with early intervention. In aggregate, the health system is facing devastating health expenditures because of the increasing episodes of higher levels of health care.

The findings on the downward trend in health expenditures among patients who start treatment early suggest the importance of considering how health expenditure would evolve with hypertension treatment. Health expenditures are not usually a one-off expense, particularly when associated with NCD management and treatment. While there is evidence that increasing health service use can lead to an increased level of health expenditures in the short term (Lei & Lin, 2009; Wagstaff, Lindelow, Gao, Xu, & Qian, 2009), the likelihood is that the overall health spending on hypertension treatment for those who start treatment early might be less than the overall health spending on hypertension and its complications for those who start treatment late. Future research on the overall health expenditures over a more extended period associated with early and late treatment is needed to test this hypothesis.

Current studies that ignore the household economic impact associated with delaying NCD

treatment leave open the possibility that there may be an underestimation of the future economic impact, thereby misleading NCD-affected household's and affecting policymaker's prioritisation of spending for health in the long-run.

8.2.4 The Poor Suffer Most from the economic burden of NCDs

The economic burden created by NCDs leads to unequal access to health services and inequality in health outcomes among households at different SES levels. All three studies identified financial barriers that reduce access to services by the population at risk and discourage NCD patients from opting for treatment in a timely way, particularly among individuals and households at a lower SES level. Individuals from poor households were less likely to have or report an NCD diagnosis, as shown in study one, and they were more likely to forego or delay NCD treatment, as shown in studies two and three.

On the one hand, the poor suffer the most from the economic burden of NCDs. The findings from study one suggest that the level of household consumption expenditure was positively associated with the rate of diagnosis of NCDs (that is, the rich were more likely to have their NCD diagnosed). This is in line with the literature in China and other LMICs that disadvantaged segments in social strata are less likely to seek health care and therefore be diagnosed (Cai et al., 2013; Elwell-Sutton et al., 2013; Subramanian, Corsi, Subramanyam, & Smith, 2013; Zimmer & Kwong, 2004). The delay in diagnosis ultimately leads to delays in treatment, raising the danger of developing to a more severe condition that requires a higher level of health care at a later time. Public safety nets (including social health insurance) provide only limited protection against the financial risk for treatment of NCDs and other health conditions. The poor are constrained by their low incomes in seeking care, with limited resources to mobilise, including the use of asset sales and access to formal credit (Dercon, 2002). Under such circumstances, the poor may avoid, interrupt or give up treatment. As revealed in study two, the poor avoided treatment and the consequence was worsened health.

As well, the financial burden from NCDs can push non-poor households into poverty in the long term. In this thesis, I identified the "potential poor" as those individuals and households who might become impoverished because of their coping strategies in response to NCDs. As shown in study two, non-poor households who sought treatment and financed their health payment in part through selling housing and land assets faced a decline in household wealth in the future. Such households potentially get into more profound long-term economic hardship through the reduction or exhaustion of household resources. The longer-term impoverishing effects of health expenditures on NCDs for non-poor but relatively low-SES households needs further study. Though not focusing on NCDs, earlier studies have indicated that coping strategies related to health expenditure may have detrimental effects on future consumption in Bangladesh (Khan et al., 2015), and ignoring how health payments are financed may have led to an underestimation of poverty in India (Flores et al., 2008).

A potential means for reducing the risk of impoverishment is through expanding public health insurance. As found in study two, rural households, particularly the rural non-poor, coped with NCDs in part through receipt of public transfers in the form of government subsidies. In 2011, the Chinese government introduced a revised poverty line for rural households, which meant that more rural near-poor households became eligible for poverty subsidies (Xian, Wang, & Wu, 2016). The extent to which these increased subsidies may be associated with reductions in the delay and avoidance of treatment needs further investigation.

In summary, I have demonstrated that NCDs pose a substantial threat to household welfare in the long run, especially for the poor. This long-term economic burden of NCDs creates barriers to alleviating poverty in China. From a policy point of view, preventing more households from falling into poverty due to the burden of health expenditures is equally as crucial as addressing the economic burden of NCDs on the existing poor. In the following section, I discuss the policy implications from the findings mentioned above.

8.3 Implications of the Study Findings

Since the launch of the new round of health system reforms in 2009, China has made significant progress in building the primary care system, enhancing basic public health services capacity, and expanding population coverage for financial protection. In 2012, the government announced a decision to expand the coverage of the healthcare insurance system to include the treatment of critical illnesses, including several severe NCDs (National Development and Reform Commission, 2012). In March 2019, the government announced it would increase the reimbursement rate for critical illnesses from 50% to 60% and reimburse 50% of the health spending on anti-hypertension drugs and diabetic medications prescribed through outpatient service (Wang, 2019). The evidence from my study that high health expenditures cause households to adopt costly coping strategies, including delaying and avoiding treatment for NCDs, makes these initiatives (and others like them) even more important.

This thesis provides evidence that the economic burden of NCDs puts households in danger of reduced economic welfare in the long-term. The continuously ageing population and the lowered level of national economic growth both continue to fuel the economic burden of NCDs. Risk factors have accumulative effects on health, and there are generational shifts in behaviours among Chinese adults. Only addressing the risk behaviours identified among the current elderly and those who have already been diagnosed with NCDs is not enough to curb the future disease burden for the current young generation. For households with members diagnosed with NCDs, those who seek health care and pay for health care through out-of-pocket will face more considerable economic burden in the future, because they finance today's health cost using methods that will undermine their future welfare. For NCD-affected individuals and households choosing to delay treatment, they are likely to face higher aggregate health expenditures in a longer-term compared to their counterparts who seek treatment earlier. In other words, under the current circumstance, (i.e. the current level of NCD disease burden and

current health service delivery and financing systems), NCD-affected individuals and households will face high economic burden due to NCDs in a long-term, whether hey seek and adhere treatment or not. If nothing is done to reduce the increasing burden of NCDs, the economic burden of NCDs on the household, the health system and the nation's economy would only be higher in the long term.

Several reasons are contributing to the high economic burden of NCDs on households in China. The primary and most direct reason is that Chinese households need to bear high out-of-pocket expenditure when seeking health care. Second, the poor suffer most from the economic burden, but current health insurance policies do not provide enough financial protection to this vulnerable population. Third, the health care delivery system is treatment-based and hospital-centric, with a weak primary health care (PHC) system and little focus on the prevention and management of NCDs.

First, the proportion of out-of-pocket expenditures to total national health expenditures was high. Though it significantly reduced from 60% in 2001 to 32% in 2014, it was still higher than the average level of 30% among the group of upper-middle-income countries, to which China belongs and higher than the average level of 24% among WHO Western Pacific region (World Health Organization, 2020b). China also has the second highest rate of increase in poverty gap (at the 1.90 international dollars a day poverty line) due to household health expenditures in WHO Western Pacific region (World Health Organization, 2020a). The high percentage of out-of-pocket health expenditure to total health expenditures is a product of the high health expenditures and low level of financial protection. The rapid increasing health expenditure is due to the current Fee-For-Service payment system in hospitals, which gives hospitals an incentive to try to attract and retain patients who may otherwise use primary healthcare providers (Meng et al., 2019). The low level of benefit package is due to the modest premiums. The annual per capita premium was only 370 Chinese Yuan, and 360 Chinese Yuan

(approximately 50 USD) for NRCMS and URBMI respectively, both of which were too low to offer any generous benefit coverage.

Second, the most vulnerable population (i.e. the poor) face a greater barrier to access to health service timely and to cope with health costs. However, there are not much effective policies targeted at them. The socio-economic deprived segment is mostly covered by NRCMS and URBMI; however, these two schemes provided less benefit compared to UEBMI for urban employees. Medical Financial Assistance provides subsidies for patients with catastrophic health expenditures to pay for their health insurance premiums and provides extra compensation to cover their OOP health expenditures, but only to a minority of patients with a modest level of reimbursement (757 Chinese Yuan which is approximately 12% of average inpatient spending per admission in 2017) (Fang et al., 2019). The Insurance Program for Critical Diseases (IPCD) was designed to reduce the burden of OOP health spending on individuals by providing reimbursement for health spending over the ceiling. However, the eligibility criteria for this insurance (out-of-pocket expenditures exceeds the average disposable income per capita in the local area) and cost-sharing rate (currently 50%) is identical regardless the patients' disease severity or economic status (Fang et al., 2019).

Third, the health care delivery system is treatment-based and hospital-focused with a weak primary health care system. The health resources were concentrated at tertiary hospitals (58%) and only 18% at PHC facilities. The share of service use and the unit cost per visit increased faster at tertiary hospitals compared to PHC centres, although government has made efforts to strengthen the primary health care system. The share of outpatient visits at PHC centres has decreased from 66% to 57% relative to those treated at tertiary hospitals (increased from 13% to 24%) between 2009 and 2018, and the share of hospitalisations at tertiary hospitals has increased from 34% to 50% during the same period (Yip et al., 2019). The average cost per outpatient visit and the annual growth of per outpatient visit cost was higher in tertiary hospitals

(increased by 7.2%) than in PHC centres (4.6%) during 2008 and 2017.

The results from the thesis have highlighted the need for new health service delivery and health financing models. A systemic approach is needed to tackle the economic burden of NCDs and its root cause as described above. To reduce OOP health expenditures, increasing government funding is a seemingly direct answer. Consolidating the basic health insurance schemes and equalising the benefit packages can narrow the current urban-rural disparities. Financial protection needs to be more focused on the vulnerable population. However, reforming the financing system only through increased government spending on healthcare will not be sustainable without further measures to strengthen PHC system, increase health system efficiency, and provide health education programs to promote healthy behaviours and navigate health-seeking behaviour towards PHC.

8.3.1 To Develop Health Education Programs and Targeted Health Promotion Interventions

The findings from study one indicate that avoidable risk behaviours are, conceptually, the starting point for households who go on to suffer poorer health and a higher economic burden in the longer term through their coping strategies and through avoidance or delay in seeking treatment. There are potential benefits to households and to the national situation from interventions designed to prevent the further emergence of NCDs.

Risk factors have accumulative effects on health, and there are generational shifts in behaviours among Chinese adults. Large-scale health education programs focusing on promoting healthy behaviours for long-term NCD prevention and control are needed. Also, there is significant heterogeneity in risk factors that contribute to NCDs across the Chinese population. Targeted public health interventions are needed. For example, interventions relating to eating, drinking and activity behaviours should be gender and age-sensitive, particularly to address elevated risks associated with obesity among young females. Interventions should also be

geographically targeted. For example, in urban areas, interventions to address elevated risks associated with obesity, past drinking habits and solid cooking fuel use are needed; while in rural areas, interventions to address the use of solid cooking fuels among middle-aged women are of importance. More importantly, interventions and public health messages should be delivered at an early stage in the lifecycle (aimed at younger people) since the health effects of some risk factors may take a long time to emerge, such as frequent drinking at younger ages. Better-informed public health policy can help to ensure that NCD risks are reduced and do not lead to lengthy and costly periods of illness.

In addition, health education programs that motivate individuals to seek treatment early and adherence to disease management are also important. Providing education programs to inform the population about the health and economic consequences of delaying treatment may lead to a longer-term reduction in delays in seeking care and help to avoid higher health expenses in the future. Programs that improve nationwide understanding of primary health care and its role in NCDs prevention and control may help navigate people to seek health care at PHC centres.

8.3.2 To Strength Primary Health Care System and Develop Integrated Health Care System

Health care delivery systems need to shift from treatment based and hospital-centred models to a PHC-based integrated health care model to more effectively manage NCDs when they are less severe (The World Bank, 2016). International experience has shown that a strong primary health care is associated with better prevention of NCDs and improved efficiency in health care delivery to manage patients with NCDs. Improving the quality of primary care might reorient patients to seek treatment early at this level. China could learn from countries that have strong primary health care systems like Australia and the United Kingdom.

To transform the current hospital centred system to a PHC based system, reforming the payment mechanism is needed to motivate coordination between hospitals and PHC facilities.

A population-based capitation payment and a pay-for-performance payment might be more suitable for the integrated delivery system and motivate doctors to provide quality care to manage NCDs. China can learn from countries such as Japan, Estonia, Canada (Ellis, Chen, & Luscomb, 2014; Joint Learning Network for Universal Health Coverage, 2017). Of course, sufficient trained general practitioners are vital to strengthening the PHC system. Governments should develop appropriate programs to train new general practitioners and improve the skills of the existing workforce at the PHC level.

8.3.3 To Provide Financial Interventions to Prevent Potentially Catastrophic Health Expenditures

Expansion of the financial interventions that relieve the long-term economic vulnerability generated by OOP health expenditure may lead to reduced long-term national costs of addressing the NCD burden. On the one hand, national programs such as Precise Poverty Alleviation Action should continue to focus on impoverished households who face a particular burden due to NCDs. On the other, those "potential" poor, who are drawing on their resources to cope with NCDs would benefit from the expansion of government subsidies, even if not targeted at NCDs specifically, particularly in rural areas.

Reviewing reimbursement levels and the benefit package of the national health financing schemes to reduce financial barriers to access to NCD management may work to encourage early treatment, thus to reduce the long-term economic burden, particularly for the poor. Long-term care and long-term care insurance may help to mitigate long-term economic burden, as shown in the international experience (Deraas, Berntsen, Hasvold, & Førde, 2011; Feng, Wang, & Yu, 2020; Fu, Noguchi, Kawamura, Takahashi, & Tamiya, 2017; Wang, Zhou, Ding, & Ying, 2017). In addition, supporting microfinance schemes that increase accessibility to formal loans (Islam & Maitra, 2012) and cash transfers (Lagarde et al., 2007) may encourage improved health-seeking behaviours (Jowett, Contoyannis, & Vinh, 2003; Lei & Lin, 2009; Sparrow et

al., 2013).

In summary, the results from this thesis call for policies that develop and scale up public health interventions and financial protection schemes to address the long-term impact of NCDs and to avoid further disparities in access, utilisation and health outcomes. The current health system in China is focused on serving more people in hospitals rather than at the PHC level (The World Bank, 2016). From a disease prevention perspective, if the system continues to focus on providing treatment for existing NCDs rather than impeding chronic conditions developing into more severe conditions, it faces the risk of failing to curb the disease burden in the long run and undermining the sustainability of the health system. From a financial risk prevention perspective, if the system ignores those who are delaying treatment due to financial constraints, the risk is that the health system will have to provide more resource-intensive treatment in the future, resulting in even higher health expenditures. If the system ignores those who are sacrificing future welfare to pay for NCD treatment in the current period, more households may fall into poverty, thereby adding additional burden for national poverty reduction. To address long-term economic burden of NCDs in China, health system reform should adopt a systematic approach that aligns different policy levers including developing public health education and intervention programs, strengthening primary health care system together with transforming financing models and payment incentives.

8.4 Limitations of the Study

This thesis has two main categories of limitations. The first category is associated with the quality of the datasets used in this thesis, including using self-reported data, attrition, the short period of the panel data and some inconsistency with the questionnaire structure. I discuss them in section 8.4.1. The second is endogeneity issues that may bias the estimations, including unobserved time-varying factors, simultaneous effects and selection bias. In section 8.4.2, I elaborate on these endogeneity problems in each of the three studies and how I have addressed

them. In section 8.4.3, I describe the directions for future research.

8.4.1 Quality of the Datasets and Limitations

I used two national longitudinal datasets in this thesis. CFPS collected data at individual, household and community levels with a focus on the economic and non-economic well-being of the Chinese people. CHARLS collected information on physical and psychological health, demographics and socioeconomic status of individuals aged 45 or over in China. Though both datasets contained rich information on NCD and economic outcomes, there are several limitations, including using self-reported measures, attrition, the short period covered by the available data and inconsistency with the questionnaire structure.

The first limitation is using self-reported measures. The NCDs measure in study one and study two is a self-reported measure of doctor-diagnosed NCD, which may systematically underestimate the true NCD magnitude and lead to artificial inequality that makes social gradients appear positive (Vellakkal et al., 2015; Vellakkal et al., 2013). There may exist a gap in access to healthcare, and the threshold of perceiving illness might be different between low and high SES individuals. To reduce this potential bias, I included a rich set of controls, such as years of schooling, a binary variable indicating whether the individual resided within a household within 15 minutes of the nearest health facility. In the thesis, I used self-reported NCDs and grouped them in the analyses. However, by doing so, I was not able to observe the differential effects of risk factors on the different type of NCDs onset, and the differential effect of different NCDs on household economic outcomes. The main reason of combining NCDs is due to the small sample size of some key NCDs (such as cancer, chronic lung diseases). To address these issues, I repeated the analysis of risk factors on cardiovascular diseases in study one. The effects of obese, underweight and heavy drinking history on cardiovascular diseases (CVD) onset were similar to that of NCD onset, which is expected. It is worth mentioning that, whilst there was a negative association between current smoking behaviour and CVD onset,

the association between past smoking behaviour and CVD onset was positive, particularly among respondents aged above 45 years. Though these effects were not statistically significant, the age-related effects may imply a life-time or chronic effect of smoking on CVD. This result is presented in Appendix Table 1. To investigate the effects of different NCDs on households economic burden in study two, I grouped some serious NCDs, including diseases that cause the most death and disability combined (cerebrovascular disease; cardiovascular disease excluding hypertension, acute rheumatic fever, angina; cancer; nervous system disease; diabetes; COPD; lumbar disc disease). I repeated the analysis as a robust check, and the results were qualitatively unchanged and the effects were larger compared to the main results. This is expected as more severe NCDs (such as a heart attack) are more likely to represent exogenous shocks. The result is presented in (Appendix Table 2). The hypertension measure in study three is less of a problem because it is an objective measure.

The measurement error also relates to household economic outcome measures. In all three studies, the household income and expenditures outcomes are self-reported data. Literature has shown that self-reported data on household income is less reliable. I followed the literature to use household non-health consumption expenditures as a proxy of permanent income and as the primary measure of household economic welfare (Deaton & Zaidi, 2002; Haughton & Khandker, 2009).

In study three, I used an objective measure of hypertension; thus this measure was unlikely associated with measurement error. However, there was a measurement error coming from the measure of healthcare cost and my identification of hypertension treatment status. The health care cost and OOP expenditures included expenses not only for hypertension. Though the increase in the health care costs due to other NCDs (such as heart disease, stroke and kidney diseases) can reflect the health consequences of delaying hypertension treatment, I cannot rule out the possibility that increased health care costs were due to other chronic infectious diseases

or acute diseases. With regards to treatment status, I assumed that treatment was irreversible that people adhered to treatment if they reported themselves as under treatment in 2013 and 2015. However, there were chances that they did not adhere to treatment during this period, but such information on treatment adherence was not available in CHARLS.

The second limitation is non-response and attrition. An inherent challenge in consecutive panel household surveys is to track respondents in the follow-up periods (Caruana, Roman, Hernandez-Sanchez, & Solli, 2015). As shown in the Method Chapter, the attrition in CFPS was approximately 30%, and that in CHARLS was around 45%. In CFPS, most of the attrition was due to loss of contact. For example, individuals or households that moved to another place or worked away from home; or because of death. The two types of attrition may have different implications on the sample characteristics. The lost in follow up due to working or living outside the original place suggested that these excluded people might be more likely at working age and potentially healthier; however, the lost in follow up due to death suggested that these excluded people tended to be less healthy. After applying survey weights that reflect the complex survey design and non-response issue, I compared the estimated mean age, proportion of female and NCD prevalence in the CFPS baseline sample (33600 individuals) and a restricted sample of those who remained in three waves (22791 individuals). In 2010, the estimated mean age was 45.8 years at baseline and 52% were female. In the restricted sample, the estimated mean age was 45.4 years in 2010 and 52% were female. The NCD prevalence in both sample in 2010 was 12%. It suggested that after applying sample weights, the key sample characteristics in the restricted sample were similar to that at baseline, and it was national representative. However, it is worth mentioning that for individuals who have moved out of the original sampling areas, a short form questionnaire was used and the NCDs questions were not included, which may impact on the estimated NCD prevalence.

The third limitation is the relatively short period of the available waves of data. Panel data have

become increasingly available in China and other LMICs but with a relatively shorter period of data collection compared to high-income countries (Caruana et al., 2015; Hsiao, 2003; UNICEF, 2014). At the time of my analyses, the overall periods of CFPS and CHARLS data were six years and four years, respectively. This short duration may not be enough to observe the long-term or lifetime health and economic impact of NCDs and health-seeking behaviours associated with NCDs on households. Therefore, instead of directly estimating the long-term economic impact of NCDs, I estimated the economic consequences that have been overlooked in the literature, which have long-run implications.

The final limitation of the survey data is that there were structural changes over the three waves in the CFPS dataset. For example, self-assessed health used a different scale; individual and household earnings included slightly different categories. I rescaled the self-assessed health variable into three categories of unhealthy, fair and healthy. I elected to use household consumption expenditure rather than income as a better measure of permanent income in the context of China (Deaton, 1997).

8.4.2 Limitations of the Econometric Methods

I discuss here what were the endogeneity problems I faced in each study, for example, unobserved time-varying factors, simultaneous effects and selection bias, and how I mitigated these biases in the analysis.

In study one, there were simultaneous biases, omitted variables and selection bias that potentially can bias the results when estimating the association between risk factors and NCD onset. First, there were two-way effects between the onset of NCDs and risk factors. For example, people diagnosed with an NCD in one period may change behaviour (smoking, drinking) in that or future periods. Therefore, I applied a dynamic model and restricted the sample to those who were free of NCDs in the initial period to mitigate possible bias from

disease onset to changes in risk behaviours. Second, unobserved determinants of both NCDs and risk factors can bias my estimation. Applying an FE model with panel data can address the unobserved heterogeneity at the individual level but the impacts of factors that lack variation over time, such as gender and education, can also be washed out. In addition, given the persistence of most NCDs, it is more important to identify risk factors associated with NCDs for the NCD-free population while a fixed-effects specification adds little in this context. Therefore, I elected to use the dynamic pooled Ordinary Least Square model as the preferred specification and acknowledged that the results might maintain bias in some unobserved heterogeneity. Third, there existed selection bias. I restricted the sample to respondents remained in all three waves of CFPS and were free of an NCD at baseline. Thus I could not observe the associations between some risk factors that have already caused an individual to develop an NCD. By extension, I could not observe people who already decreased where their risk factors and NCDs onset may have contributed to an early death. By using a sample of respondents who were healthier, the estimates of risk factors and NCD onset might be underestimated. To address this, I disaggregated the impacts by age subgroups in study one.

In study two, there existed simultaneous bias, unobserved heterogeneity, dynamic effect bias and selection bias. First, there existed two-way relationships between household economic welfare and NCDs. To ensure that the measured effects were due to the unexpected NCD shock (rather than households adjusting their consumption because they expected an NCD onset), I restricted the sample to households with only one working-aged member with a newly diagnosed NCD. Second, I applied the FE model to estimate the effects of NCD onset on household economic outcomes. The FE model eliminated the time-invariant unobserved heterogeneity but not the time-varying part. Third, when estimating the effects of health spending in the previous period on future health and wealth outcomes, I included a lagged term of household income as independent variables and applied dynamic FE models. However, it

led to inconsistent estimation when estimating the effects of health spending on future income (Cameron & Trivedi, 2009; Nickell, 1981). To address this, I removed lagged household income in the equation for income outcome. I additionally ran a robustness test by using twice-lagged household income as an instrumental variable for once-lagged income. The results were qualitatively unchanged. Lastly, my focus on those who survived throughout the survey period and restricted to the working-age population may underestimate the economic impact of NCDs on households. Literature has shown that households with members who died from NCDs face decreased consumption expenditure (Khan et al., 2015; Mirelman, 2014).

Treatment endogeneity effect is the main source of bias in study three. When estimating the effects of delayed treatment on health service use and expenditures, the main challenge was to find a good counterfactual to demonstrate the situation an individual who delayed treatment would have experienced had he or she not delayed treatment. There might exist some fundamental (unobserved) differences that determined a person seeking treatment early or later, or not. To control the systematic difference of early-late treatment group, I have matched individuals based on various factors that might influence individuals' health-seeking behaviour, such as demographic and socioeconomic factors, baseline health status and whether the individual can get immediate reimbursement from health insurance. However, the matching process still left space for unobserved factors such as the quality of health care, the level of reimbursement and modifiable lifestyle.

In addition, in all the three studies, I was not able to control for the different health insurance policies that vary across population, region (province and sub-province) and change over time. Urban employees, urban residents and rural residents are entitled to different basic health insurance schemes which have different funding, reimbursement policies. Local governments also develop and implement different policies which are tailored to local disease profile and economic development level. Health insurance policies and schemes were evolving rapidly

during the study period from 2010 to 2015. For example, the Insurance Program for Critical Diseases was introduced in 2012. The funding and reimbursement rate changed slightly over the years. In all of the three studies, I included provincial dummies and year dummies in the model to control for regional difference; in study two, I included an indicator of health insurance coverage in the estimation of NCDs impacts on household welfare. However, the differences in health insurance policies may still impact on the estimated effects of NCDs on individual health service use and household economic outcomes.

8.4.3 Directions for Future Research

The results of this study provide the starting point for future research designed to understand the long-term economic impact of NCDs on households better. Future research can focus on these following aspects: data collection and linkage, method development and providing more research evidence.

Understanding the long-term economic impact of NCDs on households requires good quality panel survey data. Future work would benefit from more extended panels that include health and economic information over a longer period. Aside from relying solely on panel data, data linkage with the surveillance systems or hospital administrative data could provide high-quality information on patient health and the character of the disease itself. Data linkage can help to address the measurement error associated with self-reported data in most of the household surveys.

Further development of an appropriate research methodology is also essential. Current methods widely used in the literature for estimating the economic burden of NCDs on households overlook the long-term nature of NCDs. One example is the catastrophic health expenditure approach. Most studies involving estimation of catastrophic health expenditure are cross-sectional: They use health expenditure information at one-time point. However, health

expenses for NCDs are not a one-off expenditure because NCDs generally require long-term management. Within the limitations of this doctoral work, I attempted to capture some of these needs in the study methods (for example, looking at how health expenditure evolves with the length of treatment in study three). However, further work to develop methods that incorporate a time dimension into current measures could pave the way for more effective research on the long-term economic impacts of NCDs.

Beyond the development of better-quality data and methods, more empirical evidence on the long-term economic impact is needed. When ideal long-term panel data is not available, future research can focus on the overlooked costs associated with coping with NCDs and their implications for household consumption in the long run. Research on the long-term economic consequences of NCDs can provide vital information for the design of appropriate policies to address the economic burden of NCDs in the long-term. Particularly, studies that examine the long-term economic burden of different NCDs and take account of differences in health insurance policies across regions and population segments can inform the design of targeted policies to provide financial protection of NCD-affected individuals and households.

8.5 Summary

The results from the three studies add to the picture of the long-term economic impact of NCDs on households in China. Risk factors such as drinking and being obese may not appear in the short term but have accumulated influence in the long-term, thereby creating a more significant burden of NCDs on households in the future. Households with members diagnosed with NCDs face potentially increased health expenditures necessitated for NCD management and treatment in the long term. Long-term adherence and the high health expenditure required for NCD treatment can be a financial obstacle for Chinese households. Those who can mobilise resources to pay for health care through depleting assets thus face a further reduction in wealth in the future. Those who have limited resources, such as the poor, may choose to delay or avoid

treatment. When they delay treatment, they face an increased level of health expenditure at the time they initiate treatment. When they decided to forego treatment, they risk a worsening health condition.

Several key policy messages follow from this thesis. First, large-scale health education programs to change population lifestyle relating to eating, drinking and exercise and adherence of NCD treatment is needed. Second, strengthening the primary health care system can manage NCDs more effectively. Reforming payment models and building capacity for the general practitioner at the primary care level are needed. Third, financial interventions are needed to protect individuals and households from delaying treatment and from potentially catastrophic expenses of treating NCDs. To address long-term economic burden of NCDs, health system reform should adopt a systematic approach that aligns different policy levers. Lastly, more research to understand the long-term economic impact of NCDs on households in China is needed to provide economic justification for appropriate intervention policies. Further operational research designed to understand whether intended programs work effectively, particularly measuring the impact of financial protection schemes on intended beneficiaries, is crucial for further national policy reform.

Chapter 9 Conclusion

This chapter concludes the thesis. It summaries each chapter and key research findings, how these findings fulfil the study aims and concludes with final comments.

This thesis aims to fill a gap in the literature by investigating the economic impact of non-communicable diseases (NCDs) on household welfare over time in China to inform the development of appropriate public policies and interventions to address the emerging disease and financial burden of NCDs. Chapter 1 "Introduction", states the problem of the economic impact of NCDs on household welfare as well as on productivity, economic growth and poverty reduction. It describes the context of the research and identifies the gap in the literature. It states the research questions and describes three research studies consisting of the thesis to answer the research questions. Chapter 2 "Literature Review" summarises the literature on NCDs and risk factors in China, the economic consequences of NCDs on households in China and health shock literature. It identifies gaps in the literature that show a lack of robust estimation of the association between risk factors and NCDs, lack understanding of how households cope with NCDs and lack evidence on the economic consequences of delaying treatment for NCDs. It suggests that taking into account how households cope (or not) with NCDs can enrich our understanding of the long-term economic impact of NCDs on households. Chapter 3 "Background" describes the study settings, including the demographic and socioeconomic changes over the past four decades, and how such changes lead to an emerging burden of NCDs in China. It describes the development of health system in China and states two main challenges the system is facing to address the emerging burden of NCDs: (1) a volume-driven service delivery system focused on treatment rather than prevention; and (2) an incomplete and unequal health financial protection scheme. Chapter 4 "Method" describes the analytical frameworks, data and econometric methods used to answer the research questions. Chapter 5 includes a

published paper that examined the association of risk factors and NCDs and presents evidence of heterogeneity in risks across age, gender and residency (Pan & Palmer, 2018). Chapter 6 provides findings on the coping mechanisms adopted by households in China in response to an NCD shock and reveals that both the non-poor and poor households were paying the price in terms of future wealth and health, respectively. Chapter 7 presents results from the analysis of the economic consequences of delayed treatment using an example of hypertension. Results suggest that delayed treatment was associated with a higher level of healthcare costs and a higher probability of incurring catastrophic health expenditures when the patients initiated treatment, relative to counterparts who began treatment earlier. Chapter 8 "Discussion" synergises the key findings from Chapter 5 to 7, interprets the long-term economic implication of NCDs on household welfare and delivers policy messages to address the increasing burden and economic burden of NCDs. Finally, it summarises the limitations of the study and provided suggestions for future research.

The emerging burden of NCDs poses a substantial financial burden on households in China. However, there is little understanding of the long-term economic impact of NCDs on households. To understand the economic impact of NCDs on household welfare over time in China, three specific aims were identified for this thesis:

(1) to understand the association of modifiable risk behaviours and NCD onset in China to provide an evidence base for policy development to reduce the burden of NCDs and protect households.
(2) to estimate the economic consequences of NCDs on current and future household welfare associated with household coping strategies following a diagnosis of an NCD and to understand the potential welfare gain brought by increasing financial protection.
(3) to evaluate the economic consequences at the household level of delayed treatment for NCDs on individuals' health care utilisation and health expenditures to provide

economic justification to design appropriate programs to motivate timely treatment for NCDs.

The first aim was achieved through analysis of the association of risk factors and NCD onset in China. The results show that being obese, using solid cooking fuels, history of frequent drinking, and the level of household consumption expenditure during the preceding period were positively associated with the onset of NCDs. More importantly, through disaggregating the effects by age subgroups, the analysis investigated the lifetime impact of risk factors on NCD onset. Some risk behaviours one established decades ago (such as frequent drinking) have long-term and accumulative effects on health, even people have changed behaviour at older ages. Also, there may exist generational shifts in behaviours. For example, younger generation aged under 45 years with obesity were more likely to be diagnosed with NCDs compared with their older counterparts. Only addressing the risk behaviours identified among the current elderly and those who have already been diagnosed with NCDs is not enough to curb the future disease burden for the current young generation. There are opportunities for reducing the future burden of NCDs of the relatively younger generation if targeted interventions and public health messages are delivered at an early stage.

The second aim was fulfilled by examining the effect of NCD shock on household consumption and the channels through which households maintain consumption. It unveils that Chinese households that experienced a significant increase in out-of-pocket health expenditures following an NCD shock can smooth consumption expenditure, through the depletion of housing assets and receipt of public transfers. For poor households, there was no significant increase in health expenditures, suggesting that they forego treatment. A significant contribution is that this analysis captured the consequences of coping with NCDs on household welfare in the long run, by unveiling that both the non-poor and poor were paying the price in terms of future wealth and health, respectively.

The third aim was achieved by estimating the differentiate effect of hypertension treatment associated with treatment timing on health care utilisation and health expenditures. The results show that patients who started treatment late spent more on health services and were more likely to have catastrophic health expenditures once they initiated treatment, relative to counterparts who began hypertension treatment earlier. Hypertensive patients having started treatment earlier experienced declines in the probability of incurring health expenditures in the following period. The results suggest that ignoring the economic burden associated with delaying NCD treatment today may lead to an underestimation of the economic impact in the future, thereby misleading NCD-affected household's and policymaker's prioritisation of spending for health in the long-run.

The results from the above three analyses present a longer-term economic impact of NCDs on household welfare, which is the main contribution of this thesis to the literature on the economic consequences of NCDs in China, as well as in low-and-middle-income countries, at the household level. The modifiable risk behaviours are the starting point for households who will suffer the NCD burden and face high OOP health expenditure required to treat the disease. Those who pay for health care are facing a decrease in wealth now and in the future. Those who delay treatment are incurring an increased level of health expenditure in the future. Those who choose to avoid treatment are trading future health with current consumption. Households will continue to face rising costs to health and the economic cost associated with coping strategies and with delaying NCD treatment if China fails to address the rising burden of NCDs.

New health system's policies and interventions are needed in China in the short term to address the costs of the rising NCD burden. This thesis delivers several key policy messages. First, large-scale health education programs to change population lifestyle relating to eating, drinking and exercise and adherence of NCD treatment is needed. Second, China needs to transform its current hospital centred delivery system to a primary care based integrated system. Reforming

payment models and building capacity for the general practitioner at primary care level are needed. Third, financial interventions are needed to protect individuals and households from potentially catastrophic expenses of treating NCDs. Health system reform should adopt a systematic approach that aligns different policy levers. Lastly, more research to understand the long-term economic impact of NCDs on households in China is needed to provide economic justification for intervention policies.

In conclusion, NCDs have a long-term impact on household welfare in China. Ignoring the economic cost associated with coping with NCDs, including delaying NCD treatment (as a coping strategy), can underestimate the economic cost in the future, thereby misleading NCD-affected household's and policymaker's prioritisation of spending for health in the long-run.

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Appendices

Appendix Table 1

Appendix Table 1. Pooled OLS estimated effects of risk factors on CVD onset for the full sample and by age group

	Full sample	< 45 years	45-60 years	> 60 years
Obese	0.044***	0.034***	0.025***	-0.015
	(0.008)	(0.009)	(0.009)	(0.029)
Underweight	-0.019***	-0.003	-0.021***	-0.053***
	(0.005)	(0.003)	(0.005)	(0.015)
Heavy drinker	-0.005	-0.008	-0.011	0
	(0.006)	(0.005)	(0.007)	(0.018)
Past frequent drinker	0.018**	0.01	0.020**	0.044*
	(0.008)	(0.007)	(0.010)	(0.024)
Smoker	-0.003	0.002	-0.001	-0.008
	(0.005)	(0.004)	(0.005)	(0.015)
Past smoker	0.01	-0.004	0.008	0.021
	(0.008)	(0.006)	(0.009)	(0.021)
Solid cooking fuels	0.004	0.003	0.003	-0.003
	(0.004)	(0.003)	(0.004)	(0.014)
Polluting enterprises within 5 km radius	-0.005	-0.002	-0.002	-0.013
	(0.004)	(0.003)	(0.004)	(0.015)
Self-rated health (reference category: healthy)				
Fair	0.011***	0.001	0.008**	0.028**
	(0.003)	(0.002)	(0.004)	(0.012)
Unhealthy	0.066***	0.040***	0.061***	0.097***
	(0.007)	(0.008)	(0.008)	(0.016)
Health care facility within 15 minutes	0.002	0.004	0.002	0.007
	(0.004)	(0.003)	(0.005)	(0.015)
Years of schooling	0.000	0.000	0.000	0.001
	(0.000)	(0.000)	(0.000)	(0.002)
Natural logarithm of household consumption expenditure	0.005**	0.000	0.001	-0.004
	(0.002)	(0.002)	(0.002)	(0.007)
Age	-0.002***	-0.001	-0.002***	0.046**
	(0.001)	(0.001)	(0.001)	(0.020)
Age squared	0.000***	0.000	0.000***	-0.000**
	(0.000)	(0.000)	(0.000)	(0.000)
Female	0.016***	0.005	0.014***	0.057***
	(0.004)	(0.004)	(0.005)	(0.016)
Married	0.001	0.000	0.001	0.013
	(0.006)	(0.004)	(0.006)	(0.016)
Household size	0.000	-0.001	-0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.003)
Urban hukou registration	0.016***	0.006	0.016***	0.041**
	(0.004)	(0.004)	(0.005)	(0.017)
Han ethnicity	-0.001	-0.004	-0.003	0.012
	(0.005)	(0.004)	(0.006)	(0.023)
Year	0.021***	0.005**	0.019***	0.072***
	(0.003)	(0.002)	(0.003)	(0.012)
Province dummies	Yes	Yes	Yes	Yes
Observations	19,956	10,573	13,662	3,089
R-squared	0.067	0.027	0.079	0.075

Source: China Family Panel Studies 2010-2014.

Standard errors in parentheses. Robust standard errors clustered at the household level.

*** p<0.01, ** p<0.05, * p<0.1.

Appendix Table 2

Appendix Table 2: FE estimates of having newly diagnosed serious NCD on economic outcomes and coping mechnanisms									
	Consumption expenditure	Health expenditure	Earnings	Public transfer	Private transfer	Housing assets	Financial assets	Productive assets	Debt
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
NCD	0.035	0.707**	-0.563	0.231	0.326	-0.465**	-0.345	0.042	0.062
	(0.058)	(0.276)	(0.387)	(0.295)	(0.337)	(0.205)	(0.379)	(0.255)	(0.376)
Family size	0.136***	0.179***	0.307***	-0.01	-0.078	0.121***	0.071	0.145**	0.246***
	(0.021)	(0.068)	(0.077)	(0.068)	(0.079)	(0.040)	(0.086)	(0.068)	(0.082)
Share of female members	-0.019	0.132	1.712***	0.784**	-0.075	0.148	0.379	-0.605	0.526
	(0.112)	(0.376)	(0.384)	(0.397)	(0.445)	(0.327)	(0.520)	(0.397)	(0.409)
Share of members under 16 years	-0.172	0.746	-0.364	-0.068	-0.147	-0.169	-0.671	-0.277	-0.389
	(0.147)	(0.668)	(0.652)	(0.535)	(0.662)	(0.513)	(0.684)	(0.441)	(0.667)
Share of members over 60 years	-0.362***	-0.36	-0.623	0.342	1.089*	-0.419	0.853	-0.428	-1.001**
	(0.134)	(0.433)	(0.476)	(0.484)	(0.624)	(0.340)	(0.584)	(0.348)	(0.441)
HH female	0.038	-0.052	-1.033***	0.142	0.043	0.132	-0.34	-0.416	-0.208
	(0.086)	(0.287)	(0.322)	(0.321)	(0.393)	(0.296)	(0.412)	(0.303)	(0.433)
HH age	-0.025	-0.091	0.163*	-0.098	-0.440***	0.230***	-0.145	0.079	-0.102
	(0.017)	(0.066)	(0.097)	(0.112)	(0.104)	(0.074)	(0.100)	(0.101)	(0.100)
HH age squared	0.000	0.001	-0.002	0.001	0.005***	-0.002***	0.001	-0.001	0.001
	0.000	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
HH highest education level (Ref: none)									
HH primary school	-0.003	-0.038	-0.146	-0.192	-0.339	-0.197	0.027	0.295	0.493
	(0.068)	(0.247)	(0.325)	(0.275)	(0.299)	(0.228)	(0.317)	(0.268)	(0.372)
HH lower secondary school	-0.019	0.045	0.228	-0.164	-0.061	-0.042	0.687	-0.087	0.529
	(0.083)	(0.353)	(0.359)	(0.411)	(0.408)	(0.349)	(0.486)	(0.372)	(0.546)
HH upper secondary school	0.039	-0.077	1.407**	-0.053	1.307	-1.102	0.123	0.135	0.602
	(0.165)	(0.662)	(0.627)	(0.763)	(0.863)	(0.715)	(0.928)	(0.678)	(0.924)
HH college above	0.086	-0.197	2.001*	0.174	-0.188	-1.045	0.758	-0.694	1.871*
	(0.198)	(0.880)	(1.169)	(2.064)	(1.823)	(1.402)	(1.704)	(1.045)	(1.033)
Urban residence	0.068	-0.013	-0.696**	-0.24	0.596	-0.411	0.106	0.647	-0.346
	(0.074)	(0.288)	(0.280)	(0.338)	(0.443)	(0.395)	(0.347)	(0.594)	(0.394)
Constant	9.729***	6.705***	2.964	3.638	12.182***	3.802*	7.469***	5.262**	2.056
	(0.471)	(1.767)	(2.316)	(3.150)	(2.804)	(2.083)	(2.866)	(2.466)	(2.548)
Number of households	7853	7853	7853	7853	7853	7853	7853	7853	7853
R-squared	0.266	0.025	0.096	0.324	0.079	0.032	0.449	0.273	0.017

NOTE: * p<0.1, ** p<0.05, *** p<0.01. Outcome variables are transformed into natural logarithm form. All models include month of interview, indicators of year of interview and province dummies. The FE sample includes the balanced sample of 7853 households in 2010 and 2012. Robust standard errors clustered at the county level are in parenthesis. All estimates are appropriately weighted to reflect the complex survey design. We identify serious NCDs based on the China country profile from the GBD study including those diseases that cause the most death and disability combined cerebrovascular disease; cardiovascular disease excluding hypertension,acute rheumatic fever, angina; cancer nervous system disease; diabetes; COPD; lumbar disc disease

Appendix Table 3

Appendix Table 3: FE estimates of having newly diagnosed NCD on economic outcomes and coping mechnanisms,controling for health insurance									
	Consumption expenditure	Health expenditure	Earnings	Public transfer	Private transfer	Housing assets	Financial assets	Productive assets	Debt
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
NCD	-0.066	0.524***	0.018	0.275	0.183	-0.284*	-0.018	0.130	-0.150
	(0.044)	(0.191)	(0.206)	(0.181)	(0.207)	(0.145)	(0.223)	(0.161)	(0.240)
Share of health insurance	0.191**	0.647***	1.330***	0.731***	0.469*	0.090	1.052***	0.269	0.694**
	(0.074)	(0.240)	(0.236)	(0.240)	(0.267)	(0.216)	(0.219)	(0.295)	(0.280)
Urban residence	0.059	-0.044	-0.728***	-0.437	0.512	-0.596	0.005	0.604	-0.355
	(0.076)	(0.263)	(0.272)	(0.358)	(0.429)	(0.426)	(0.317)	(0.571)	(0.367)
Family size	0.149***	0.207***	0.380***	0.017	-0.075	0.106**	0.137	0.145**	0.272***
	(0.021)	(0.058)	(0.072)	(0.072)	(0.074)	(0.042)	(0.090)	(0.065)	(0.081)
Share of female members	-0.137	-0.309	0.471	0.403	-0.223	0.173	-0.366	-0.861**	0.054
	(0.099)	(0.357)	(0.438)	(0.429)	(0.419)	(0.308)	(0.536)	(0.404)	(0.476)
Share of members under 16 years	-0.149	0.870	0.357	0.261	-0.156	-0.260	-0.121	-0.093	-0.376
	(0.155)	(0.653)	(0.640)	(0.553)	(0.636)	(0.476)	(0.664)	(0.461)	(0.612)
Share of members over 60 years	-0.396***	-0.383	-0.715	0.198	0.931	-0.411	0.761	-0.491	-1.088**
	(0.139)	(0.418)	(0.484)	(0.470)	(0.602)	(0.341)	(0.579)	(0.347)	(0.452)
HH female	0.066	0.072	-0.845***	0.262	0.054	0.088	-0.207	-0.362	-0.062
	(0.087)	(0.281)	(0.303)	(0.315)	(0.388)	(0.289)	(0.406)	(0.304)	(0.432)
HH age	-0.020	-0.086	0.083	-0.126	-0.401***	0.229***	-0.141	0.079	-0.095
	(0.017)	(0.064)	(0.098)	(0.108)	(0.101)	(0.071)	(0.099)	(0.096)	(0.097)
HH age squared	0.000	0.001	-0.001	0.002*	0.004***	-0.002***	0.001	-0.001	0.001
	0.000	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
HH highest education level (Ref: none)									
HH primary school	-0.002	-0.021	-0.108	-0.089	-0.303	-0.171	-0.016	0.210	0.487
	(0.069)	(0.236)	(0.300)	(0.264)	(0.288)	(0.217)	(0.300)	(0.273)	(0.360)
HH lower secondary school	-0.042	0.026	0.313	-0.227	-0.047	-0.014	0.637	-0.107	0.515
	(0.080)	(0.335)	(0.354)	(0.396)	(0.394)	(0.327)	(0.473)	(0.352)	(0.518)
HH upper secondary school	0.099	-0.091	1.442**	0.106	1.112	-1.113*	0.178	0.338	0.584
	(0.155)	(0.623)	(0.574)	(0.690)	(0.796)	(0.661)	(0.845)	(0.624)	(0.860)
HH college above	0.106	-0.193	2.002*	0.088	-0.272	-0.966	0.839	-0.691	1.817*
	(0.191)	(0.867)	(1.083)	(1.976)	(1.758)	(1.348)	(1.583)	(1.034)	(1.016)
Constant	9.552***	6.297***	3.836	4.302	11.399***	5.605***	6.878**	5.247**	1.782
	(0.480)	(1.765)	(2.433)	(3.090)	(2.617)	(2.102)	(2.880)	(2.414)	(2.628)
Number of households	7853	7853	7853	7853	7853	7853	7853	7853	7853
R-squared	0.266	0.03	0.103	0.332	0.076	0.031	0.452	0.281	0.017
NOTE: * p<0.1, ** p<0.05, *** p<0.01. Outcome variables are transformed into natural logarithm form. All models include month of interview, indicators of year of interview and province dummies. The FE sample includes the balanced sample of 7853 households in 2010 and 2012. Robust standard errors clustered at the county level are in parenth									
All estimates are appropriately weighted to reflect the complex survey design.									

Appendix Table 4

Appendix Table 4: FE estimates of having newly diagnosed NCD on economic outcomes and coping mechnanisms among poor households,controling for health insurance

	Consumption expenditure	Health expenditure	Earnings	Public transfer	Private transfer	Housing assets	Financial assets	Productive assets	Debt
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
NCD	-0.329	0.211	-0.303	-0.128	-0.659	0.394	-0.334	-0.501	0.587
	(0.235)	(0.505)	(0.726)	(0.612)	(0.554)	(0.712)	(0.741)	(0.546)	(1.362)
Share of health insurance	0.389	0.16	1.509**	-0.488	0.85	0.219	0.439	-0.175	1.786**
	(0.299)	(0.678)	(0.591)	(0.669)	(0.706)	(0.569)	(0.483)	(0.444)	(0.800)
Urban residence	-0.246	0.543	-1.432*	0.162	0.695	1.962*	-0.799	0.726	-1.049
	(0.260)	(0.672)	(0.859)	(0.945)	(0.541)	(1.095)	(0.746)	(0.934)	(0.661)
Family size	0.166***	0.454**	0.329**	-0.041	-0.06	0.105	0.27	0.103	0.343
	(0.041)	(0.205)	(0.160)	(0.251)	(0.202)	(0.095)	(0.173)	(0.167)	(0.221)
Share of female members	0.165	2.533**	1.832	0.38	-0.091	1.576*	1.656	-0.493	0.336
	(0.404)	(1.140)	(1.188)	(1.164)	(1.321)	(0.937)	(1.344)	(1.514)	(1.592)
Share of members under 16 years	-0.105	-3.629**	0.657	0.923	-3.182	-0.263	-2.122	-1.325	0.798
	(0.304)	(1.809)	(1.648)	(1.698)	(2.058)	(0.924)	(1.590)	(1.590)	(1.806)
Share of members over 60 years	-0.203	-0.852	-1.514	0.388	-0.634	-0.97	1.077	-1.251	-1.046
	(0.475)	(1.407)	(1.553)	(1.263)	(1.509)	(0.833)	(1.424)	(1.207)	(1.614)
HH female	0.630**	0.746	-1.501	0.255	0.87	0.985	0.049	0.322	1.199
	(0.276)	(1.357)	(1.197)	(1.422)	(1.079)	(1.247)	(1.555)	(1.249)	(1.611)
HH age	0.003	-0.214	-0.108	-0.105	-0.133	-0.013	0.073	0.012	-0.17
	(0.052)	(0.178)	(0.209)	(0.135)	(0.205)	(0.166)	(0.180)	(0.167)	(0.147)
HH age squared	0.000	0.003*	0.002	0.001	0.001	0	0	-0.001	0.002
	0.000	(0.002)	(0.003)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
HH highest education level (Ref: none)									
HH primary school	0.664***	0.164	-0.027	-0.275	-0.304	-0.638	0.235	0.781	1.969
	(0.233)	(0.741)	(1.596)	(0.976)	(0.819)	(0.602)	(0.773)	(0.843)	(1.272)
HH lower secondary school	0.418	0.39	-0.62	-0.497	-0.541	-1.365	2.021	0.571	2.513
	(0.283)	(1.037)	(1.521)	(1.132)	(1.039)	(1.304)	(1.404)	(1.343)	(1.968)
HH upper secondary school	0.994**	1.675	-0.597	-1.096	-2.042	-2.66	2.239	0.43	2.671
	(0.489)	(1.805)	(2.234)	(1.072)	(1.386)	(2.911)	(1.949)	(2.047)	(2.507)
HH college above	1.829**	7.078**	-4.941	-0.475	-6.225*	-1.091	9.356	1.304	2.124
	(0.749)	(2.797)	(3.132)	(2.392)	(3.256)	(2.952)	(7.279)	(2.580)	(3.130)
Constant	7.072***	5.161	5.877	7.968**	6.527	8.476*	-5.019	0.272	-1.741
	(1.638)	(4.428)	(5.343)	(3.847)	(5.385)	(4.609)	(5.835)	(4.647)	(6.360)
Number of households	690	690	690	690	690	690	690	690	690
R-squared	0.296	0.103	0.123	0.057	0.052	0.107	0.646	0.347	0.061

NOTE: * p<0.1, ** p<0.05, *** p<0.01. Outcome variables are transformed into natural logarithm form. All models include month of interview, indicators of year of interview and province dummies. The FE sample includes the balanced sample of 7853 households in 2010 and 2012. Robust standard errors clustered at the county level are in parenthesis. All estimates are appropriately weighted to reflect the complex survey design.

Appendix Table 5

Appendix Table 5. Estimated effects of treatment on blood pressure among newly diagnosed hypertensive patients					
	sbp			dbp	
	sbp	*p* -value		dbp	*p* -value
	(1)			(2)	
Early * t2 (γ1)	-12.270***	<0.0001		-8.659***	<0.0001
	(3.260)			(2.164)	
Early * t3 (γ2)	-17.912***	<0.0001		-8.052***	0.001
	(3.181)			(2.426)	
Late * t2 (γ3)	5.171	0.148		0.731	0.781
	(3.564)			(2.631)	
Late * t3 (γ4)	-12.898***	0.001		-8.040***	0.001
	(3.913)			(2.614)	
age	0.095	0.329		-0.340***	0.000
	(0.097)			(0.069)	
gender	-2.267	0.130		-2.355*	0.069
	(1.495)			(1.288)	
Natural logarithm of household non-food consumption per capita last year	0.150	0.868		-0.317	0.593
	(0.904)			(0.592)	
Secondary Education level	-0.168	0.961		-0.803	0.737
	(3.432)			(2.393)	
Tertiary Education level	6.435	0.333		-5.665	0.150
	(6.630)			(3.923)	
Observations	729			729	
R-squared	0.554			0.509	
Note: Standard errors in parentheses.					
We present one-sided *p* -value for γ1, γ2 and γ4, two-sided *p* -value for γ3					
and covariates. *** p<0.01, ** p<0.05, * p<0.1					
Effects are estimated using linear model.					
All models include time dummies, treatment dummies, community fixed effects					
and average time spent to the nearest health facilities					