

Socioeconomic differences in hospital care use for stroke and ischaemic heart disease in the China Kadoorie Biobank study

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Abstract

The rapid economic, demographic, and epidemiologic transitions that occurred in China in recent decades have increased the burden of non-communicable diseases, including cardiovascular diseases (CVD), as well as health expenditures and health inequalities. In 2009, China launched major healthcare reforms to provide equal and affordable basic healthcare for all by 2020.

This thesis aims to study healthcare use for CVD across socioeconomic groups in China by examining: (i) trends in hospital care utilisation and outcomes for stroke and ischaemic heart disease (IHD) by socioeconomic groups over an 8-year period; (ii) gender differences in the management of acute IHD; and (iii) impact of health insurance (HI) cost sharing and socioeconomic characteristics on choice of hospital tiers for stroke and IHD. The analyses involved half a million adults in the China Kadoorie Biobank, recruited in 2004-2008 and followed-up until 2017 through linked HI records, and disease and death registries.

After adjustment for demographic, socioeconomic, lifestyle and morbidity factors, hospitalisation rates for stroke and IHD each increased by 4-5% per year in 2009-2016. Higher socioeconomic groups had higher hospitalisation rates, but the annual proportional increases were greater among those with lower levels of education or income, urban or rural resident HI schemes, and in rural areas. Lower socioeconomic groups had higher stroke and IHD case fatality rates, but achieved greater proportional reductions in these during 2009-2016 than higher socioeconomic groups. The average length of hospital stay decreased by 2% annually and to a greater extent in higher than lower socioeconomic groups.

There were marked gender differences in the use of invasive coronary tests and procedures for acute IHD in 2004-2016. While the use of cardiac enzymes did not differ between women and men with acute myocardial infarction, women had 20% lower rates of coronary angiography and 15% lower rates of revascularisation. Compared to men, women with angina or other IHD had 3%, 13-34% and 39-44% lower rates of having cardiac enzyme tests, coronary angiography and revascularisation, respectively. However, socioeconomic and health system factors did not explain the gender differences in the use of invasive tests and procedures for IHD.

In China, hospitals are classified into three tiers, with higher tier hospitals being larger, better equipped, and typically located in urban areas. While over 60% of urban residents with first stroke or IHD admissions in 2009-2017 chose tier 3 hospitals, only around 30% of rural residents chose tier 3 hospitals. In urban areas, higher reimbursement rates were associated with higher odds of choosing all hospital tiers, and higher tier 3 deductibles with lower odds of choosing tier 3 hospitals. In rural areas, higher tier 3 reimbursement rates were associated with higher odds of choosing tier 3 hospitals, and higher tier 1 deductibles with lower odds of choosing tier 1 hospitals. However, higher tier 2 and 3 deductibles in rural areas were associated with higher odds of choosing these hospitals. Individuals with higher socioeconomic status and, separately, more severe disease were more likely to choose tier 3 than tier 1 or 2 hospitals.

These findings should inform further strategies to reduce socioeconomic and gender disparities and facilitate choice of appropriate hospital tiers in the use of hospital care for different types of CVD across China.

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List of Abbreviations

ACS	Acute coronary syndrome
ALOS	Average length of stay
AMI	Acute myocardial infarction
ARR	Actual reimbursement rate
BPHS	Basic public health service
BMI	Body mass index
CABG	Coronary artery bypass graft
CCC	Care for Cardiovascular Disease in China
CDC	Centre for Disease Control and Prevention
CHC	Community health centre
China-PEACE	China Patient-centred Evaluative Assessment of Cardiac Events
ChinaQUEST	China Quality Evaluation of Stroke Care and Treatment
CI	Confidence interval
CKB	China Kadoorie Biobank
CNSR	China National Stroke Registry
CPHS	Crucial public health service
CT	Computed tomography
CVD	Cardiovascular disease
DALY	Disability adjusted life year
DCE	Discrete choice experiment
DSP	Disease surveillance point
GDP	Gross domestic product
GIS	Government insurance system
GLM	Generalised linear model
GRP	Gross regional product
HI	Health insurance
HS	Haemorrhagic stroke
i-CASE	Internet-based case adjudication system for clinical events
ICD-10	International Statistical Classification of Diseases and Related Health Problems, 10th Revision
ICH	Intracerebral haemorrhage
IHD	Ischaemic heart disease
IIA	Independence of irrelevant alternatives
IS	Ischaemic stroke
LDL	Low-density lipoprotein
LIS	Labour insurance system

LOS	Length of stay
MET	Metabolic equivalent of task
MFA	Medical financial assistance
MHRSS	Ministry of Human Resources and Social Security
MRI	Magnetic resonance imaging
MSA	Medical savings account
NHFPC	National Health and Family Planning Commission
NRCMS	New rural cooperative medical scheme
NSTEMI	Non-ST-elevation myocardial infarction
OECD	Organisation for Economic Co-operation and Development
OOP	Out-of-pocket
OR	Odds ratio
PAF	Population attributable fraction
PCI	Percutaneous coronary intervention
PVD	Portable validation device
RR	Rate ratio
RRR	Relative risk ratio
SAH	Subarachnoid haemorrhage
SBP	Systolic blood pressure
SD	Standard deviation
SPA	Social pooling account
STEMI	ST-elevation myocardial infarction
TIA	Transient ischemic attack
TCM	Traditional Chinese medicine
THC	Township healthcare centre
UAP	Unstable angina pectoris
UEBMI	Urban employee basic medical insurance
URBMI	Urban resident basic medical insurance
URTI	Upper respiratory tract infection

Chapter 1. Introduction

1.1 Background

In recent decades, China has experienced a major epidemiologic transition from mainly infectious diseases to chronic non-communicable diseases (NCDs), in addition to an ageing population, greater urbanisation and rapid economic growth. Healthcare costs have increased more rapidly than the gross domestic product (GDP), with some estimates suggesting a 12% increase in healthcare costs per year between 1987 and 2003.[1] Economic development has had differential effects in urban and rural areas in China, resulting in substantial social and economic disparities.[2] In 2003, 59% of the Chinese population lived in rural areas, the per capita annual disposable income was three-fold higher in urban than rural households (8472 vs 2622 Yuan), and a substantial gap existed in the average number of years of full-time education between urban and rural adults.[3,4] The socioeconomic advantages of urban residents have resulted in inequalities in health status, access to healthcare and cause-specific mortality rates between urban and rural areas.[5-7] Furthermore, in China's three-tier hospital care system, higher tier hospitals which are larger and better equipped, are chiefly located in urban rather than in rural areas.

In response to such inequalities, the Chinese government introduced social health insurance schemes between 1998 and 2007, and launched a series of major healthcare system reforms in 2009, in order to provide affordable basic healthcare for all by 2020.[8] As part of these reforms, China's healthcare system has undergone considerable demand and supply-side policy changes, ranging from

the expansion of health insurance coverage (from 45% of the population in 2006 to 96% in 2011) to hospital reforms and the strengthening of primary care.[9]

Between 2009 and 2017, the percentage of health expenditure as a proportion of GDP increased from 5.2% to 6.4%, and the government's health expenditure increased by 10-15 billion Yuan ($15-22 billion) per year.[10] Rapid industrialisation and urbanisation have led to major changes in lifestyle, accompanied by increasing prevalence of hypertension, smoking, diabetes mellitus, alcohol consumption, dyslipidaemia, and physical inactivity. Currently, over 80% of deaths in China each year are caused by NCDs, and cardiovascular diseases (CVD) account for over 40% of all deaths.[11] Stroke and ischaemic heart disease (IHD) accounted for about 90% of all CVD deaths in China in 2016.[12] In contrast with other countries worldwide, the burden of stroke (2.2 million deaths) in China is higher than the burden of IHD (1.9 million deaths).[11,12] In 2010, annual cardiovascular events were projected to increase by more than 50% in the next 20 years due to ageing and population growth, and by an additional 14% due to unfavourable trends in blood pressure, dyslipidaemia, overweight and diabetes in the population.[13]

The increasing number of patients with CVD requiring treatment in China has resulted in escalating financial pressures on the healthcare system and on individual patients and their families, with major inequalities between urban and rural areas.[12] Since 2004, total expenses for hospitalisation for CVD have increased by an inflation-adjusted annual rate of more than 20%.[12] More specifically, the average cost for hospital admission for stroke was 6356 Yuan ($1001) in 2004, which was twice the annual income of rural residents.[14] The average cost of hospital admission for acute myocardial infarction (AMI) was about 77% of the disposable annual income in urban areas and 240% of the disposable

annual income in rural areas in 2011.[1] The high costs of healthcare for CVD have resulted in many individuals having to choose to either forgo treatment or incur substantial economic hardship after developing CVD, which exacerbated health inequities.[15]

Previous studies of trends in healthcare use for stroke and IHD in China have mainly involved hospital-centred studies, using routinely collected data, with analyses typically limited to urban areas or restricted to higher tier hospitals. Since health records do not generally collect information on socioeconomic, lifestyle or medical history characteristics, analyses of routine data sources cannot reliably assess differences in the use of hospital care services or health outcomes by socioeconomic characteristics. Previous studies on the choice of healthcare facilities have typically involved analyses of self-reported data from surveys and did not assess determinants of hospital tier choice for inpatient care for CVD.

Understanding the socioeconomic disparities in use of hospital care, health outcomes and healthcare provider preferences, in addition to the influence of health insurance characteristics on choice of healthcare providers for highly prevalent and serious diseases could enable Chinese policy-makers to evaluate the progress of the reforms in providing basic healthcare for all and inform future improvements. Such evidence can be generated from the China Kadoorie Biobank (CKB), an ongoing prospective biobank study of half a million Chinese adults with linked data to death and disease registries and health insurance records.

1.2 Aims and objectives

The aim of this thesis was to conduct a detailed analysis of socioeconomic differences in the use of hospital care services for stroke and IHD, during a period of major health system reforms in China. The analyses used the individual participant data from the CKB study and additional data collected for the present thesis.[16] The objectives of this thesis were to:

- Undertake a systematic literature review of studies assessing trends and socioeconomic differences in use of hospital care, including rates of hospitalisation, length of stay, case fatality or in-hospital mortality rates, and use of diagnostic tests and treatment procedures, for stroke and IHD in China since 2004.
- Estimate trends in annual rates of hospitalisations, 28-day case fatality rates and average length of stay (ALOS) for stroke, IHD, and any cause in Chinese adults and investigate differences in hospitalisation rates, 28-day case fatality rates and ALOS between different socioeconomic groups between 2009 and 2016.
- Estimate differences in the use of invasive diagnostic and therapeutic procedures for AMI, angina, and other IHD between Chinese men and women, and investigate the extent to which socioeconomic or health system factors could explain such differences.
- Estimate the effects of health insurance characteristics, including reimbursement rates, deductibles and ceiling, and socioeconomic characteristics on the choice of hospital tier for stroke, IHD and any cause in urban and rural areas in China.

1.3 Structure of the thesis

Chapter 2 describes the healthcare system and the recent health system reforms that have been implemented in China. The chapter also outlines the burden of stroke and IHD pathological types and trends in these diseases over time and across geographic regions in China.

Chapter 3 presents a literature review of studies examining hospital care use and outcomes for patients with stroke or IHD, and highlights some of the limitations of existing research and evidence gaps.

Chapter 4 summarises the study design, participant recruitment, baseline survey and resurveys, methods used for follow-up in the CKB, in addition to details of the data collected, and analytical framework used for analyses in chapters 5 to 7.

Chapter 5 examines the trends in hospital care utilisation and outcomes for stroke and IHD in CKB, and the differences by urban and rural area, education and income level, and health insurance type in 2009-2016.

Chapter 6 investigates gender differences in use of invasive diagnostic and therapeutic procedures for acute IHD and the role of socioeconomic and health system factors to such differences.

Chapter 7 examines the influence of health insurance and socioeconomic characteristics on the choice of hospital tiers for first admissions for stroke and IHD in urban and rural areas of CKB.

Chapter 8 summarises the findings of this thesis, considers the implications for policy on delivery of healthcare, acknowledges strengths and limitations of the work, and recommends areas for future research.

1.4 Role of the author in preparation of the thesis

I was awarded a Wellcome Trust Doctoral Studentship in Humanities and Social Science in October 2017 to undertake the research presented in this thesis. This fellowship application was developed with the support of the Nuffield Department of Population Health, in particular the Clinical Trial Service Unit and Epidemiological Studies Unit (Professor Robert Clarke, Dr Yiping Chen, Professor Zhengming Chen) and the Health Economics Research Centre, University of Oxford, UK (Associate Professor Borislava Mihaylova). I led the research presented in the thesis, devised the analyses plans, performed the analyses, and prepared manuscripts and thesis chapters.

My supervisors (Associate Professor Borislava Mihaylova, Professor Robert Clarke and Dr Yiping Chen) contributed to each aspect of this process for all research presented in this thesis. Professor Winnie Yip, from the Harvard T.H. Chan School of Public Health, Boston, USA contributed to the research presented in **Chapter 5**, by providing critical discussion of the analyses, and in **Chapter 7** by providing support with the additional data collection and the analysis plan. Dr Nina Wu, from the School of Public Health at Capital Medical University, Beijing, China contributed to the research presented in **Chapter 7** by providing support with the additional data collection. Dr John Buckell, from the Health Economics Research Centre, contributed to the research presented in **Chapter 7** by providing support with the statistical analyses.

1.5 Publications related to this thesis

By December 2021, I published two first-authored manuscripts based on work conducted for this thesis:

- The work presented in **Chapter 5** was published as Levy M, Chen Y, Clarke R, et al. Socioeconomic differences in health-care use and outcomes for stroke and ischaemic heart disease in China during 2009-16: a prospective cohort study of 0.5 million adults. *The Lancet Global Health*. 2020; **8**(4): e591-e602.
- The work presented in **Chapter 6** was published as Levy M, Chen Y, Clarke R, et al. Gender differences in use of invasive diagnostic and therapeutic procedures for acute ischaemic heart disease in Chinese adults. *Heart*. 2021: heartjnl-2021-318988.

In addition, a list of oral and poster presentations related to this thesis is summarised in **Appendix A**.

References

1. Wu Y, Benjamin EJ, MacMahon S. Prevention and Control of Cardiovascular Disease in the Rapidly Changing Economy of China. *Circulation*. 2016; **133**(24): 2545-60.

2. Zimmer Z, Kaneda T, Spess L. An examination of urban versus rural mortality in China using community and individual data. *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences*. 2007; **62**(5): S349-S57.

3. National Bureau of Statistics of China. China Statistical Yearbook 2004. Available from: http://www.stats.gov.cn/english/statisticaldata/yearlydata/yb2004-e/indexeh.htm (Accessed: 27 July 2019).

4. Zhang D, Li X, Xue J. Education Inequality between Rural and Urban Areas of the People's Republic of China, Migrants' Children Education, and Some Implications. *Asian Development Review*. 2015; **32**(1): 196-224.

5. Sun S, Chen J, Johannesson M, et al. Population health status in China: EQ-5D results, by age, sex and socio-economic status, from the National Health Services Survey 2008. *Quality of Life Research*. 2011; **20**(3): 309-20.

6. Zhu H, Xie Y. Socioeconomic Differentials in Mortality Among the Oldest Old in China. *Research on Aging*. 2007; **29**(2): 125-43.

7. Vedom J, Cao H. Health Care Access and Regional Disparities in China. *Espace populations sociétés*. 2011; **2011**: 63-78.

8. Yip WC, Hsiao WC, Chen W, Hu S, Ma J, Maynard A. Early appraisal of China's huge and complex health-care reforms. *The Lancet*. 2012; **379**(9818): 833-42.

9. Liu GG, Vortherms SA, Hong X. China's Health Reform Update. *Annual Review of Public Health*. 2017; **38**(1): 431-48.

10. National Bureau of Statistics of China. China Statistical Yearbook 2018. Available from: http://www.stats.gov.cn/english/Statisticaldata/AnnualData (Accessed: 27 July 2019).

11. Global Burden of Disease Collaborative Network. Global Burden of Disease Study 2019 (GBD 2019) Reference Life Table. Seattle, United States of America: Institute for Health Metrics and Evaluation (IHME); 2021. Available from: https://vizhub.healthdata.org/gbd-compare/ (Accessed: 12 November 2021).

12. Liu S, Li Y, Zeng X, et al. Burden of Cardiovascular Diseases in China, 1990-2016: Findings From the 2016 Global Burden of Disease Study. *JAMA Cardiology*. 2019; **4**(4): 342-52.

13. Moran A, Gu D, Zhao D, et al. Future cardiovascular disease in China: markov model and risk factor scenario projections from the coronary heart disease policy model-China. *Circulation Cardiovascular Quality and Outcomes*. 2010; **3**(3): 243-52.

14. Liu L, Wang D, Wong KSL, Wang Y. Stroke and stroke care in China: huge burden, significant workload, and a national priority. *Stroke*. 2011; **42**(12): 3651-4.

15. Heeley E, Anderson CS, Huang Y, et al. Role of health insurance in averting economic hardship in families after acute stroke in China. *Stroke*. 2009; **40**(6): 2149-56.

16. Chen Z, Chen J, Collins R, et al. China Kadoorie Biobank of 0.5 million people: survey methods, baseline characteristics and long-term follow-up. *International Journal of Epidemiology*. 2011; **40**(6): 1652-66

Chapter 2. The healthcare system and burden of stroke and ischaemic heart disease in China

2.1 The healthcare system in China

2.1.1 Historical background

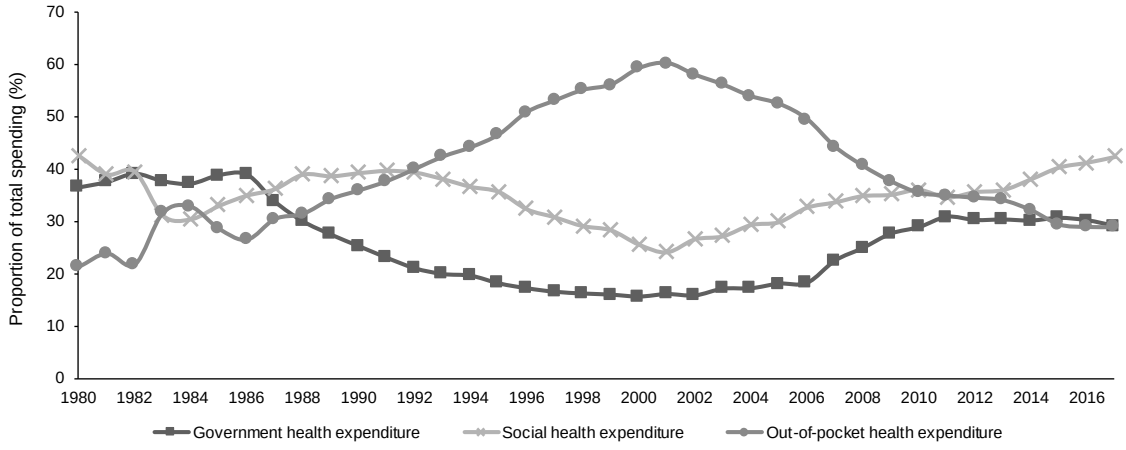
China initiated a transition from a closed, centralised and planned economy to a market-oriented economy in the early 1980s, which was followed by a decrease in the share of government health expenditure and an increase in the share of out-of-pocket (OOP) health expenditure during the 1990s (**Figure 2.1**). The market reforms led to increased pressure on urban and rural health insurance (HI) coverage. In urban areas, funding from state-owned enterprises for the Labour Insurance System (LIS) and from the government for the Government Insurance System (GIS) were progressively reduced. The percentage of the urban population covered by HI decreased from 75% in 1993 to 49% in 2002.[1] The situation was worse in rural areas, where the reduction in government support led to a collapse of the health system (Cooperative Medical System) and HI coverage declined from near-universal levels in 1978 to less than 20% in 2002.[2]

Healthcare providers were faced with three main challenges: (i) rising healthcare costs, (ii) low government set prices for basic services (e.g. routine visits, surgeries), and (iii) government funding only for healthcare worker salaries and major capital investment (e.g. facilities, beds, equipment). To remain solvent, public hospital providers charged 15% excess charges on the cost of drugs and high-technology diagnostic tests that were not included in the administered pricing

scheme, and advocated for their increased use.[3] As prevention and public health did not generate patient revenue, community-based primary care was considerably reduced. In the early 2000s, patient contributions accounted for 60% of total healthcare expenditure, while the government contributed less than 20% of expenditure (**Figure 2.1**).[4] As a result of low HI coverage and high healthcare costs, the proportion of individuals who did not visit a doctor when ill increased from 42% to 57% in urban areas and from 34% to 46% in rural areas between 1993 and 2002.[5]

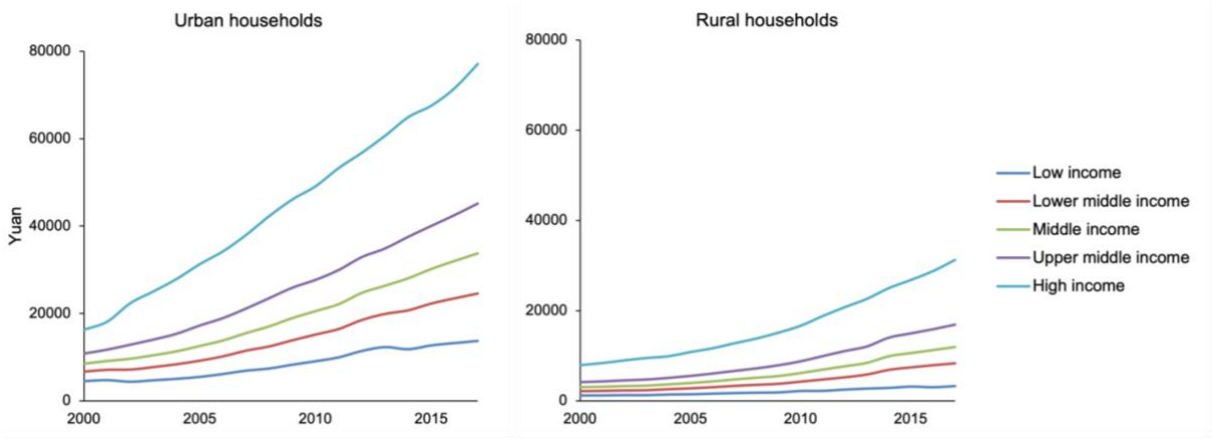
Simultaneously, the rapid economic, demographic, and epidemiologic transitions led to a mismatch between the supply and demand for healthcare, and to rising inequalities between urban and rural areas and between socioeconomic groups within these areas (**Figure 2.2** and **Figure 2.3**).[3] Consequently, starting in 2003, and more intensively from 2009, a number of healthcare system reforms were implemented to enable universal access to basic healthcare.

Figure 2.1 Government, social health insurance and out-of-pocket health expenditure as a proportion of total health expenditure in 1980-2017



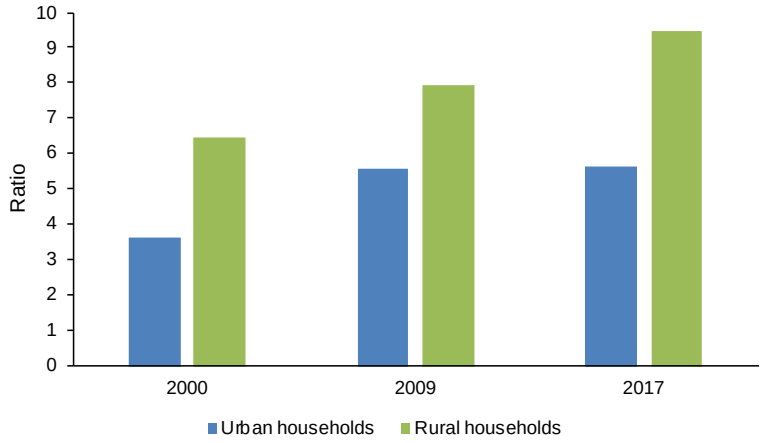
Source: National Bureau of Statistics of China, China Statistical Yearbooks

Figure 2.2 Per capita annual disposable income of urban and rural households by income quintile in 2000-2017



Disposable income is the income remaining after deduction of taxes. Values for disposable income are inflated to 2017 values using consumer price indices. Source: National Bureau of Statistics of China, China Statistical Yearbooks.

Figure 2.3 Ratio of highest to lowest quintile of per capita disposable income of urban and rural households in 2000, 2009 and 2017



Source: National Bureau of Statistics of China, China Statistical Yearbooks

2.1.2 Government institutions

At the central level, China's executive branch, called the State Council, outlines the national agenda and delegates responsibility to related ministries to define operational plans for their local executive bodies to implement. There are four levels of administration underneath the central government: provincial

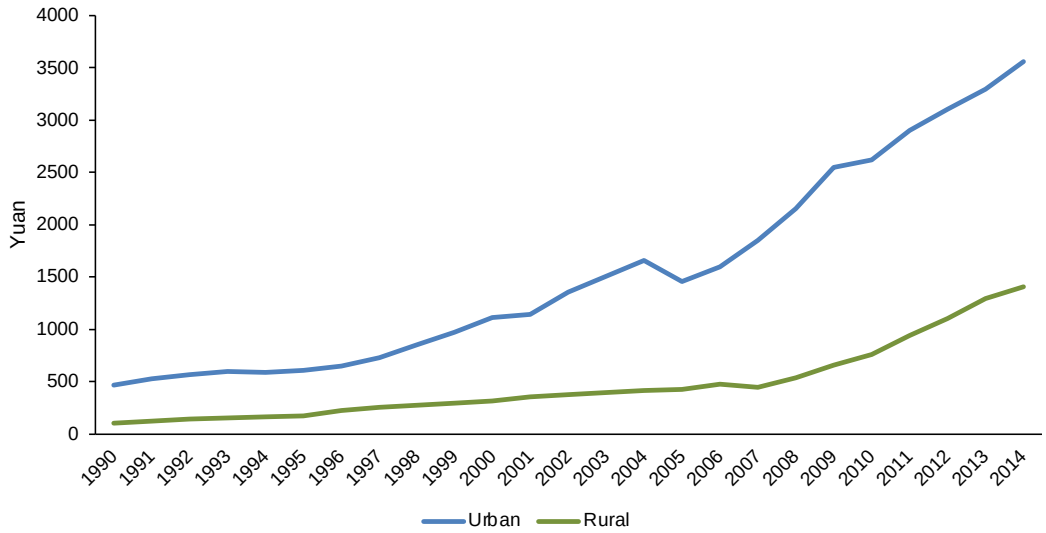
governments, prefectures, counties, and townships. Provinces generate their own revenue streams and are responsible for almost all public spending, including health (fiscal decentralisation). Each local government has autonomy to decide how to implement national policies, including the social health insurance (HI) schemes.[6] Healthcare services are financed by different sources: fiscal subsidies from the central, provincial, municipal and county governments, HI payments and patient OOP payments.

2.1.3 Health insurance system

In the late 1990s, China implemented new social HI schemes to narrow urban-rural disparities in healthcare access, control the exponential increase in health expenditure (**Figure 2.4**), and reduce patients' share of OOP payments for healthcare, especially for rural residents and lower socioeconomic groups. Three main social HI schemes operate in China: (i) the Urban Employee Basic Medical Insurance, (ii) the New Rural Cooperative Medical Scheme and (iii) the Urban Resident Basic Medical Insurance. The HI schemes differ from each other in eligibility criteria, administration, source of funding and benefits. Enrolment in a specific HI scheme depends on an individual's employment status, household registration (hukou) and place of residence. Selected characteristics of the three social HI schemes are summarised in **Table 2.1.** Each scheme includes cost-sharing mechanisms for inpatient and outpatient care, including deductibles, reimbursement rates, and reimbursement ceiling. The deductible is the amount of healthcare costs paid by the insured person per admission or visit to receive medical care (irrespective of coinsurance) after which a reimbursement schedule

is applied. The reimbursement rate is the percentage of total medical expenses minus the deductible paid by the HI scheme, and the coinsurance rate (1 - reimbursement rate) is the percentage paid by the insured person. The ceiling is the maximum amount paid by the insurance scheme in any year and is often at least four times the average income in the prefecture, municipality or county. While being important contributors to overall cost, the deductible and coinsurance rate also aim to reduce unnecessary hospital care use. In most locations, patients will only pay the share of the healthcare costs that are not covered by HI at discharge.[6] Healthcare providers bear the remaining of the costs and claim reimbursements from the corresponding HI agency afterwards.[7] Healthcare expenses from public and, increasingly, from selected private hospitals are eligible for reimbursement from the social HI schemes with cost sharing varying by hospital tier. Local governments are given autonomy to specify the benefit packages, provider payment arrangements and services covered by the HI schemes, based on the local economy and population needs.

Figure 2.4 Health expenditure per person in urban and rural areas in 1990-2014



Health expenditure values are inflated to 2017 values using consumer price indices. Source: National Bureau of Statistics of China, China Statistical Yearbooks

Urban Employee Basic Medical Insurance (UEBMI)

The UEBMI was launched in 1998 to cover all workers from the formal sector in urban areas and is operated by the Ministry of Human Resources and Social Security (MHRSS). This scheme replaced the previous LIS and GIS, by expanding coverage to the private sector employees and pooling risk at the municipal/prefecture level. UEBMI is managed by each city's social insurance bureau. The UEBMI is compulsory for urban employees and is financed by contributions from employers (6-10% of employee's wage) and employees (2% of their wage). The premiums are composed of the medical saving account (MSA) and the social pooling account (SPA). The employee share (2%) plus 30% of the employer's share account for the MSA, and the remaining 70% from employers are paid into the SPA. The SPA is used to cover inpatient and catastrophic expenses and the MSA is used for outpatient and drug expenses.[8] Retired employees previously covered by the UEBMI remain covered by the UEBMI, and their HI premiums are covered by their former employers. Retirees also have coinsurance rates that are about half of employees. Despite heterogeneity in insurance payments, the UEBMI offers the most comprehensive coverage of the available insurance schemes.

New Rural Cooperative Medical Scheme (NRCMS)

The NRCMS was launched in 2003 as a voluntary scheme for rural residents, to address the collapse of the Cooperative Medical System in the early 1980s, which left rural residents without HI. As the Chinese government actively encouraged farmers to join the scheme, insurance coverage increased between 2003 and 2011 from 13% to 98% of the rural population (832 million). The NRCMS is controlled

by the National Health and Family Planning Commission and its design is determined by county level governments. The main sources of funding come from individual contributions, and central, provincial, and county government funding, which includes subsidies from the Ministry of Finance and the Ministry of Civil Affairs. The per capita premium was around 410 Yuan in 2014, with government funding contributing 320 Yuan and individuals contributing 90 Yuan.[5] However, the premium varies greatly by region, as poorer regions of western and central China rely more on support from central government. Most premiums are divided into a risk pooled fund which covers inpatient care and a limited number of chronic conditions, and an individual savings account that covers outpatient care. Outpatient coverage is typically limited, forcing members to seek inpatient care.

Urban Resident Basic Medical Insurance (URBMI)

Following the implementation of UEBMI and NRCMS, 420 million urban residents remained ineligible for HI, mainly because of employment in the informal economy.[5] To reduce inequalities in HI coverage in urban areas and eliminate medical poverty, the URBMI was launched in 2007, as a voluntary scheme for children, students, urban residents without formal employment and elderly without previous employment.[9] The URBMI was initially piloted in 79 cities in 2007 and then implemented nationwide, covering 60% of the target population by the end of 2008.[8] The URBMI is similar to UEBMI in terms of administration, social pooling, and management of insurance funds. The URBMI is operated by the MHRSS and its design is determined by the municipal governments. The main sources (80%) of funding are obtained from central and local government subsidies, with the remainder provided by individual contributions. The main difference with UEBMI is

that the URBMI benefits are more limited, and only consist of a SPA to cover inpatient expenses and outpatient expenses for catastrophic illness. Some cities have established MSAs to cover outpatient expenses for chronic diseases.

In 2016, the Chinese government published the “Guiding opinions on integrating the Urban and Rural Residents Basic Medical Insurance System” to combine the URBMI and NRCMS.[10] While pilot schemes to combine these two HI schemes have been undertaken in several cities since 2010, the nationwide implementation of this reform is still ongoing.[11]

Table 2.1 Selected characteristics of the three main social health insurance schemes in China

Health insurance scheme	UEBMI	URBMI	NRCMS
Year of pilot/formal launch	1994/1998	2007/2009	2003/2006
Eligibility	Employees and retirees with formal employment in all institutions	Children, seniors, students, disabled, unemployed, self-employed, migrants in some cities, in urban areas	Rural residents
Type	Mandatory	Voluntary	Voluntary
Unit of enrolment	Individuals	Individuals	Households
Unit of pooling	Prefecture/municipality	Prefecture/municipality	County
Management	MHRSS	MHRSS	NHFPC
Finance	Employers: 6-10%, employees 2%	Government and individuals	Government and individuals
Inpatient reimbursement	80-95%	50-80%	50-80%
Outpatient reimbursement	50-80%	30-60%	30-60%

MHRSS: Ministry of Human Resources and Social Security, NHFPC: National Health and Family Planning Commission, NRCMS: new rural cooperative medical scheme, UEBMI: urban employee basic medical insurance, URBMI: urban resident basic medical insurance. Sources: 3,6,12,13.

Medical Financial Assistance programme

In 2003, the government launched the Medical Financial Assistance (MFA) programme as a supplement to social HI for low-income individuals in urban and rural areas. The MFA subsidises enrolment in NRCMS or URBMI and reduces catastrophic health expenditure by providing cash aid to cover OOP payments for eligible households.[14] The programme was expanded to provide nationwide coverage between 2006 and 2008. Enrolment in MFA is voluntary and free for insured individuals and the programme is managed by the Ministry of Civil Affairs which pools risk at the county level.[6] The majority of the funds are provided by central, provincial and county governments. In 2009, the MFA programme covered 93 million low-income individuals, of which one-third lived in urban areas (5% of urban residents) and two-thirds lived in rural areas (9% of rural residents).[15]

Other health insurance schemes

A small proportion of the Chinese population is enrolled in schemes different from the three main social HI schemes, including government and private HI schemes. In some cities in China, government officials are still covered by a separate insurance scheme, which does not have insurance premiums, deductibles, and ceilings and has higher reimbursement rates than social HI schemes.[16] However, in response to criticism by the public of preferential treatment for government officials, this scheme has gradually been replaced by the UEBMI. The coverage rate of private HI in China is increasing over time from around 4% in 2004-2006 to 12% in 2013.[17] Private HI is mainly used as a supplement to social HI and is purchased by employers for their employees or by wealthier individuals.

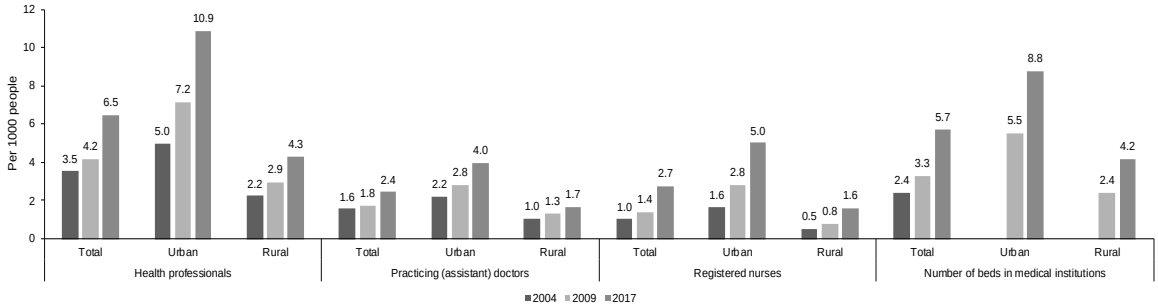
2.1.4 Health care provision

The Chinese healthcare system consists of a medical care delivery system and a public health delivery system. While the medical care delivery system includes different categories of hospitals and primary care facilities, the public health delivery system includes a national network of centres for disease control and prevention (CDCs), maternal and child health centres and other specialised public health facilities. These two systems converge at the primary care level, as primary care providers provide a mixture of public health and medical care services.

The number of hospitals in China increased by almost 2-fold between 2004 and 2017, from 18 398 to 31 056 hospitals.[4] The increase in the number of hospitals was mainly driven by an increase in private hospitals.[18] However, in 2013 public hospitals still accounted for 54% of all hospitals, and provided more than 80% of all beds.[18] In the same year, public hospitals (vs private hospitals) provided almost 90% of all inpatient and outpatient services, and accounted for over 80% of all healthcare professionals.[3] The majority of public hospitals (73%) are government-run institutions.[18] The National Health and Family Planning Commission classification divides Chinese hospitals into those who mainly use conventional medicine and those providing Traditional Chinese Medicine (TCM). In 2017, 61% of all hospitals were general, 23% were specialised, and 12% were TCM hospitals (4% were not classified).[4] Most healthcare facilities are paid using the fee-for-service approach, incentivising physicians to overprovide services, particularly those with higher profit margins.[19] The number of healthcare workers, including practicing doctors and registered nurses, and the number of beds in medical

institutions also increased considerably in 2004-2017, but remained lower in rural than in urban areas (**Figure 2.5**).

Figure 2.5 Number of medical personnel and number of beds (per 1000 people) in urban and rural areas in 2004, 2009 and 2017 in China

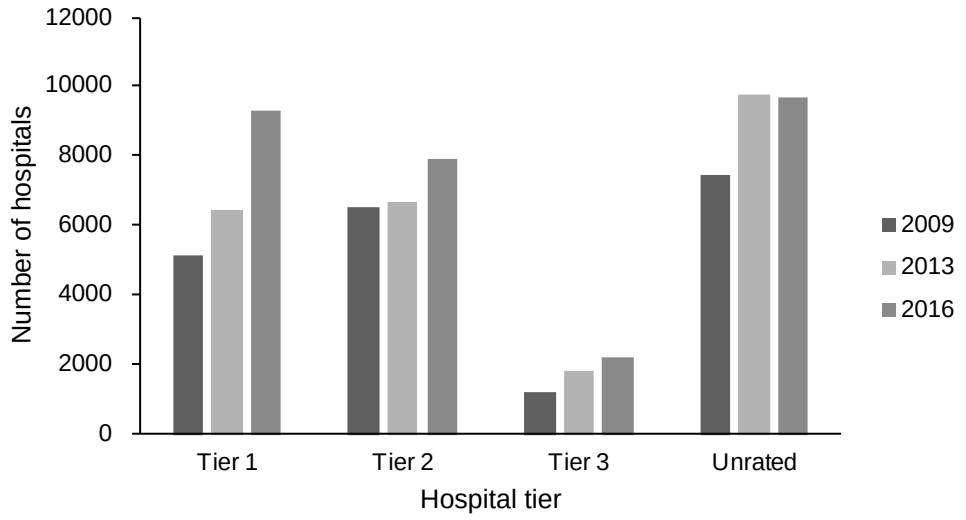


Source: National Bureau of Statistics of China, China Statistical Yearbooks

Since the 1990s, hospitals in China are certified after national audit into tiers (also known as hospital rank, class or level) based on their capacity, including the number of beds, the department setting, the number of medical personnel, the type of equipment, and the floor area per bed. Tier 3 (tertiary level) hospitals are generally ministerial, provincial, municipal or teaching hospitals, that provide high-level and specialised medical services and are responsible for higher education and scientific research. They have at least 500 beds and typically have a 100% occupancy rate. Tier 2 (secondary level) hospitals are mainly county and district level hospitals, often including TCM hospitals. These hospitals provide comprehensive medical and health services to multiple communities and offer medical training as well as research. Tier 2 hospitals have between 100 and 500 beds each, and typically have about 90% occupancy rate. Tier 1 (or primary level) hospitals provide preventive services, clinical treatment, rehabilitation services and health education in the community. Tier 1 hospitals have a bed capacity ranging from 20 to 99 beds and typically have about 64% occupancy rate.[3] Tier 1

healthcare facilities include community health centres (CHCs) and stations in urban areas and township health centres (THCs) and village clinics in rural areas, and are part of the primary care system.[20] An increasing number of tier 1 facilities are privately owned (e.g. private clinics).[3] In 2016, there were around 9282 tier 1 hospitals, 7944 tier 2 hospitals, 2232 tier 3 hospitals in China, and 9682 unrated[1] tier hospitals (**Figure 2.6**).

Figure 2.6 Number of hospitals by tier in 2009, 2013 and 2016 in China



Source: National Bureau of Statistics of China, China Statistical Yearbooks

The design of the three-tier healthcare system aimed to promote efficient utilisation of healthcare resources in China, with tier 1 and 2 hospitals fulfilling the basic medical needs of residents and tier 3 hospitals providing specialist care for major diseases. However, due to the lack of a referral system, patients can choose to visit a healthcare provider of any tier, leading to an overuse of tier 3 hospitals regardless of the severity of their illness. Furthermore, evidence suggested that

[1]Includes both public and private/joint-venture hospitals, and most have a size similar to tier 1 hospitals.

the quality of primary care remained suboptimal and that patients had a lack of trust in care provided in lower tier facilities.[21]

2.1.5 Healthcare reforms in 2009

The increasing burden of chronic non-communicable diseases (NCDs), health expenditure, and urban-rural disparities prompted the Chinese government to launch major healthcare reforms in 2009 to provide equal and affordable basic healthcare for all by 2020.[22] The five main objectives of these reforms were to: (i) expand HI benefits, (ii) improve the delivery of primary care, (iii) provide equal access to public health services, (iv) establish a national system of essential medicine and (v) implement hospital care reforms. The reforms can be divided into three main phases according to the publication of official documents. The first phase (2009-2011) corresponded to the initiation of the reforms and the publication of the "Opinions on Deepening the Reform of the Healthcare System" by the Central Committee of the Communist Party of China and the State Council. The second phase (2012-2015) corresponded to the publication of China's "12th Five-Year Plan". The third phase (2016-2020) corresponded to the publication of the "13th Five-Year Plan on deepening the health care system reform" and was also guided by the "Healthy China 2030" strategy, which promoted a Health in All Policies approach.[23]

The first phase of the reforms focused on expanding HI to the overall population and increasing its benefits, and on strengthening primary healthcare and public health services. The second and third phases focused more on reforming the healthcare delivery system through comprehensive reforms of public hospitals and

the establishment of a primary healthcare-based integrated delivery system.[12] During these reforms, several policy changes occurred simultaneously, and policies varied between municipalities or counties.

Expansion of health insurance coverage

The first component of the healthcare reforms was to expand HI, by first extending coverage with a shallow benefit package and then gradually expanding the services and proportion of expenses covered. The coverage of the three main HI schemes increased over time and their benefit packages were extended to cover catastrophic illnesses, an increasing number of drugs and outpatient care. The government also encouraged private insurance companies to enter the market and play an important role in managing catastrophic coverage, to supplement the social HI schemes.

In 2012, the critical illness insurance for NRCMS enrollees was implemented to provide additional financial protection against catastrophic illnesses in the most vulnerable groups. Initially, the critical illness insurance reimbursed 20 critical diseases at higher rates, but quickly became an add-on insurance covering healthcare cost for critical illnesses exceeding certain limits for both rural and non-working urban residents.[24]

Furthermore, as different HI schemes operate in isolation within and between regions, the government introduced plans to integrate the NRCMS and URBMI to minimise funding differences between urban and rural HI schemes.[25] The central government also sought to integrate the management and provision of HI to allow individuals to access benefits nationally and minimise geographic differences.

Improvements in the delivery of primary care

The government increased investment in primary care, by strengthening the infrastructure of primary healthcare facilities, updating medical equipment, recruiting doctors and nurses, establishing a general practitioner system, and providing training and education to primary healthcare workers.[26] Since 2009, the number of primary care doctors and nurses increased by 3.3% and 9.9% per year, respectively.[21] Investments were prioritised in rural and low-income regions.

Provision of equal access to public health services

In order to reduce the rural-urban gap in access to public health services, the national Basic Public Health Service (BPHS) and the Crucial Public Health Service (CPHS) programmes were implemented. The BPHS supported primary healthcare facilities to deliver a defined package of basic health services. The aim of this programme was to relieve the increasing burden of NCDs through a range of measures to better manage hypertension and diabetes, including health education, adherence to medication and control of cardiovascular risk factors.[27] The CPHS was focused on the control of infectious diseases, supported the health needs of socially vulnerable groups, and included screening programmes for breast and cervical cancer in rural areas.[26]

Establishment of a national system of essential medicines

The aim of the national system of essential medicines was to reduce the incentives of healthcare institutions to prescribe unnecessary drugs and improve access to and quality of essential medications. The inappropriate use of antibiotics in China has been widely documented and previous studies have reported that almost 50%

of all prescriptions were inappropriate.[28,29] As part of this reform, healthcare facilities were required to prescribe and stock medications from a list of approved essential medicines, the National Essential Medicines List, which selected low-cost treatments for common treatable diseases.[30] In 2009, the National Essential Medicines List included 307 Western and traditional Chinese medicines reimbursed by HI. This list was adjusted every three years to reflect use and needs and was extended from tier 1 healthcare facilities to tier 2 and 3 hospitals in 2013.[24]

Hospital reforms

Key tasks in the public hospital reforms included: (i) reform of the governance of the public hospital system, (ii) changes in revenue sources, (iii) more efficient methods for provider payment, (iv) changes in income policy for physicians to reflect the characteristics of the medical profession and (iv) participation of private agencies to supply medical services. The reforms incentivised several provinces and cities to stop using fee-for-service payments and experiment with alternative forms of payment methods for inpatient and outpatient care, including diagnosis related groups, prospective global budget, and capitation.[19] The government also implemented a zero mark-up drug policy in all public hospitals, to control costs and prevent healthcare providers from including a mark-up on drugs. The drug mark-up was reduced incrementally starting in 2009 and in lower tier facilities until it was removed completely and nationally in 2018. Another priority was to establish a hierarchical medical system, under which facilities at each level would deliver specific services according to their function. The hierarchical medical system aimed to prevent patients from bypassing primary care facilities through a range of supply and demand side strategies. Pilots of the hierarchical medical system were

implemented across China starting in 2014-2015, with full implementation achieved by 2018.[31] This fostered the development of two main types of medical alliances between hospitals of different tiers.[32] In a loose collaboration model, a tier 3 hospital provides training to lower tier hospitals and offers fast tracks for referrals and centralised advanced diagnostic tests. A collaborative model is similar to the previous model in its functioning, except that all hospitals share resources, management, and economic interests.

2.1.6 Equity in healthcare use following healthcare reforms

Previous studies have investigated the impact of healthcare reforms on socioeconomic disparities in healthcare utilisation in China, with most studies focusing on the effect of the implementation of social HI schemes. Data from cross-sectional surveys were used and socioeconomic status were quantified using self-reported data on household income, residence in urban or rural areas, region of residence, marital status, highest level of educational attainment, details of occupation, health insurance, time or distance to the nearest healthcare facilities, income, serious financial difficulties in the past two years, and living expenditure.[33-39] Healthcare utilisation was also measured using self-reported data by asking participants if they utilised outpatient or inpatient services during the past four weeks, received any treatment during the last two weeks, were admitted to hospital during the past year or received adequate medical services when needed.[34,36,37,39] Income-related inequality in healthcare utilisation was typically measured using the concentration index and the extent of horizontal inequity was measured using the

horizontal inequity index which takes into account need-standardised utilisation.[33,39,40,41]

In most studies, socioeconomic disparities in healthcare utilisation decreased in the years following the expansion of HI and implementation of healthcare reforms, yet in some studies disparities remained stable or increased over time. For example, Li et al (2018) reported that trends in use of self-care, outpatient care and inpatient care increased in 2004-2011 and urban-rural disparities in healthcare utilisation gradually narrowed among Chinese adults in 1993-2011.[42] Xie (2011) reported that pro-rich inequities in healthcare utilisation decreased between 2000 and 2006 in nine provinces in China.[43] Pan et al (2017) reported that the implementation of NRCMS was associated with a small reduction in pro-rich inequities in use of inpatient care use between 2003/2004 and 2014 in Jiangxi province.[40] Ying et al (2020) reported that older individuals living in urban areas had better adequate access to care than those living in rural areas and that urban-rural differences in health outcomes and adequate access to care narrowed between 2011 and 2014.[34] Guo et al (2020) reported that the healthcare reforms had a positive influence on the rate of and equity in both inpatient and outpatient healthcare utilisation in Ningxia province between 2009 and 2019 and increased the use of healthcare services by rural residents, especially among low-income groups.[39] In a study by Fu et al (2020) pro-rich inequities in the probability and frequency of inpatient care utilisation for middle-aged and elderly individuals with NCDs decreased by 28% between 2011 and 2015.[41] Similarly, Liu et al (2021) reported that pro-rich inequities in health services utilisation by patients with hypertension in the Pearl River Delta decreased between 2015 and 2019.[38]

Alternatively, Yuan et al (2014) reported that the use of inpatient care by NRCMS enrollees in Junan county was pro-rich and inequalities increased between 2007 and 2011, while the use of outpatient care was pro-poor and inequalities decreased over time.[44] Flato et al (2016) reported that although the overall use of healthcare had not changed significantly between 2004 and 2011, a higher proportion of individuals used higher levels facilities and pro-rich inequity in healthcare utilisation increased in 30 counties in Sichuan, with wealthy individuals more likely to seek care at hospitals than at clinics or health centres.[33] In summary, results of previous studies on changes in equity in healthcare use following health reforms were mixed, typically focused on overall healthcare use rather than use of healthcare for specific diseases and were limited to specific regions or areas.

2.2 Burden of stroke and ischaemic heart disease in China

With China's rapid demographic and epidemiologic transition in recent decades, over 80% of annual deaths were due to NCDs, with cardiovascular diseases (CVD) accounting for over 40% of all deaths in 2009 (**Table 2.2**).[45] Stroke and ischaemic heart disease (IHD) accounted for about 90% of all CVD deaths in China in 2009. Stroke and IHD share common atherosclerotic disease mechanisms and the major risk factors include hypertension, smoking, diabetes mellitus, alcohol consumption, dyslipidaemia, and physical inactivity.

Understanding the trends in the burden of stroke and IHD over time and by geographic region in China, is critical to evaluate healthcare use and plan improved services to address healthcare needs for these diseases. Trends were mainly summarised between 1990 and 2016 to cover the years before and during the time period used for analyses in Chapters 5, 6, and 7.

Table 2.2 The five leading causes of death in urban and rural areas in China in 2009

	Urban areas			Rural areas		
Rank	Disease	Standardised mortality rate (1/100 000)	% of all deaths	Disease	Standardised mortality rate (1/100 000)	% of all deaths
1	Malignant tumour	159	27	Cerebrovascular disease	197	23
2	Heart disease	128	21	Malignant tumour	187	24
3	Cerebrovascular disease	123	20	Heart disease	150	17
4	Diseases of the respiratory system	66	11	Diseases of the respiratory system	134	15
5	External causes of injury and poison	34	6	External causes of injury and poison	60	8

Source: National Bureau of Statistics of China, China Statistical Yearbooks

2.2.1 Classification of stroke and ischaemic heart disease pathological types

Stroke

A stroke, also known as a cerebrovascular accident, occurs when a blood vessel that carries oxygen and nutrients to the brain is blocked by a clot, bursts, or ruptures. This leads to reduction in blood and oxygen supply to the brain that results in brain death. The two main types of strokes are ischaemic stroke (IS) and haemorrhagic stroke (HS). An IS occurs when the blood supply to the brain is blocked by a blood clot or vascular occlusion. Lacunar IS, a subtype of IS, is a small infarct resulting from the occlusion of a single small perforating artery supplying blood to the brain's deep structures.[46] A HS is caused by a rupture of a blood vessel and involves two main types: subarachnoid haemorrhage (SAH) and intracerebral haemorrhage (ICH).[47] SAH is less common and is caused by the bleeding in the area between the brain and the thin tissues that cover it. ICH is the most common type of HS and occurs when there is a rupture of an artery to the brain with release of blood into the surrounding tissue in the brain.[48] A transient ischemic attack (TIA) or "mini stroke" is caused by a temporary interruption (<24 hours) of blood supply to the brain. Diagnosis of the pathological type of stroke requires the presence of clinical criteria of stroke together with confirmation by autopsy or brain imaging involving computed tomography (CT) scan or magnetic resonance imaging (MRI).[49]

Depending on the region of the brain that is affected, a stroke can cause paralysis, speech impairment, loss of memory and reasoning ability, coma, or death. Stroke is a medical emergency and requires immediate treatment in hospital, to improve

the chances of survival and reduce disability. The specific treatments depend on the stroke type, and a combination of medicines to treat the disease and prevent recurrence is recommended. For IS, treatments to remove blood clots and restore blood flow to the brain include thrombolysis ("clot buster" medicine) and thrombectomy (emergency revascularisation procedures). These treatments are most effective when started as soon as possible after a stroke. Patients with IS are typically treated with aspirin and other antiplatelet agents, blood pressure lowering and low-density lipoprotein (LDL)-cholesterol lowering medicines (statins) to reduce the risk of recurrence or death. Anticoagulants are indicated for patients with atrial fibrillation. For HS, treatment can include a craniotomy or a surgery for hydrocephalus. Apart from lowering blood pressure, there are no other specific treatments for HS.

Ischaemic heart disease

Ischaemic heart disease (IHD), also known as coronary heart disease or coronary artery disease, refers to heart problem caused by occlusion of a coronary artery that supplies blood to the heart muscle. The narrowing is typically caused by the building of plaque called atherosclerosis. The different types of IHD include stable angina (angina pectoris), unstable angina, myocardial infarction (MI) and other IHD. Stable angina corresponds to chest pain or discomfort due to IHD and occurs when one or more of the coronary arteries is narrowed or blocked. Unstable angina is caused by a partial or intermittent blockage of one or more of the coronary arteries.[50] MI, also known as a heart attack, is when the blood flow to the heart muscle is completely blocked, causing the heart muscle cells to die. There are two types of MI: ST segment elevation MI (STEMI) and non-ST segment elevation MI

(NSTEMI). STEMI is due to complete and prolonged occlusion of a major coronary artery and results in extensive heart damage. NSTEMI is due to the blockage of a minor coronary artery or partial occlusion of a major coronary artery and results in less extensive heart damage. IHD is diagnosed using clinical criteria, medical and family history, a physical examination and one or more diagnostic tests and procedures, including: cardiac enzymes, electrocardiogram, and coronary angiography. Additional tests may include cardiac MRI, cardiac CT scans or echocardiograms. Severe forms of IHD, such as MI or unstable angina, require emergency treatment. To restore blood supply to the heart, revascularisation procedures, such as percutaneous coronary intervention or coronary artery bypass surgery, may be required. Medications used to treat IHD include anti-platelet treatments, statins, beta blockers, nitrates, angiotensin-converting enzyme inhibitors, angiotensin-2 receptor blockers, calcium channel blockers, and diuretics.

2.2.2 Trends in stroke and IHD incidence

Stroke

The Global Burden of Disease study reported that the age-standardised incidence rates of stroke in China remained stable in 1990-2016 with 200-222 new cases per 100 000 population. The incidence rate of stroke in China was 34% higher than the global average (200 vs 149 per 100 000 population in 2016). China had 3.5 million new stroke cases and IS accounted for 70% of new-onset strokes in China in 2016.[51] While the age-standardised incidence rate of IS increased from 107 to 141 new cases per 100 000, the rate of ICH decreased from 95 to 48 between 1990 and 2016. However, there were substantial geographic differences in stroke

incidence in China, with a much higher incidence reported in the northeast (486 per 100 000) compared to the south (136 per 100 000).[52]

IHD

The age-standardised incidence rates of IHD in China were stable in 1990-2016 with 177-199 new IHD cases per 100 000, and were 28% lower than the global average (199 vs 265 per 100 000 in 2016).[45] In 2016, China had 3.2 million new IHD cases, and incidence rates were higher for men than women (243 vs 166 per 100 000).

2.2.3 Trends in stroke and IHD prevalence

Stroke

In 1990-2016, the age-standardised prevalence rate of stroke increased from 1297 to 1439 per 100 000, with a 30% increase for IS (941 to 1228 per 100 000) and 33% reduction for ICH (214 to 315 per 100 000).[53] The prevalence rates of stroke types varied by geographic region in China. The age-standardised prevalence rates for IS were higher in northern and north-eastern provinces than the rest of China. In contrast, the prevalence rates of HS were the highest in Tibet, Qinghai, Hebei, and Henan, and the lowest in the coastal provinces.[53] The prevalence of stroke was higher in urban than rural areas in high- and middle-income regions, but similar across urban and rural areas in low-income regions.[54] The prevalence of stroke was higher in older individuals (>75 years) and the male to female ratio of stroke was 1.3 to 1.5:1.[52]

IHD

Between 1990 and 2016, the age-standardised prevalence rate for IHD remained stable with 2185-2342 prevalent cases per 100 000.[53] Prevalence rates were higher in northern and north-eastern provinces, and higher in urban than rural areas in high- and middle-income regions, but similar across urban and rural areas in low-income regions.[54]

2.2.4 Trends in stroke and IHD mortality

Stroke

Between 1990 and 2016, the number of stroke deaths increased by 50%, from 1.4 million to 2.1 million, with IS accounting for 50% of stroke deaths in 2016. The age-standardised mortality rate for stroke decreased by 36% (from 211 to 135 per 100 000), which was chiefly due to a significant reduction in the mortality rate for ICH (from 116 to 65 per 100 000) and SAH (from 31 to 5 per 100 000). Mortality rates for IS and HS were higher among men than women across China. There were wide geographic variations in the mortality for IS (range 11.1-92.1 per 100 000 in 2016), and HS (13.3-259.4 per 100 000).[53] The population in north-east China had a 40% higher mortality rate from stroke than populations living in the south of China.[55] Mortality rates for all stroke types were higher in China than the global average. The difference in mortality rates between ICH and IS were substantially higher in China compared to Western countries, yet this difference has declined over time.[56]

IHD

Between 1990 and 2016, the number of deaths due to IHD increased by 185% from 607 756 to 1.7 million deaths. The age-standardised mortality rate increased from 99 to 122 per 100 000 during this period, and varied greatly across provinces, from 51.4 to 233.2 per 100 000 in 2016.[53] While 22 out of the 31 provinces in China had increasing mortality rates from IHD, 11 provinces had declining rates during this period, especially economically developed areas.[57] Mortality rates for IHD were higher in men than women and higher in rural than urban areas. One study reported that WHO-standardised IHD mortality increased by 9.2% per year in 2004-2010 for rural men and this trend was higher than in urban men by 6.4% per year.[58] During the same period, the annual increase in rates for rural women was also higher than for urban women (7.0% vs 2.7% per year). In contrast to most Western populations, a higher proportion of people die from stroke than IHD in China, but these differences have declined over time.[56] Factors related to the increasing mortality rates for IHD include under-use of guideline-recommended therapies (e.g. beta-blockers, angiotensin-converting enzyme inhibitors), and inadequate healthcare professional knowledge and healthcare provision.[59-61]

2.2.5 Trends in stroke and IHD disability-adjusted life-years

Disability-adjusted life-years (DALYs) are a widely used measure of health burden. One DALY represents the loss of the equivalent of one year of full health. DALYs for a disease are the sum of the years of life lost due to premature mortality and the years lived with a disability due to prevalent cases of the disease in a population.[62]

Stroke

Between 1990 and 2016, age-standardised DALY rates decreased by 30% or from 4134 to 2541 per 100 000 persons for stroke, due to a substantial reduction in the rate for ICH (-45%) and SAH (-80%).[53] While all provinces in China experienced reductions in DALY rates for HS, a few provinces had experienced increases in DALY rates of IS (e.g. Jiangsu and Zhejiang). The burden of HS varied substantially between provinces (range: 300 to >4800 per 100 000) and was greatest in the poorest and western provinces, and lowest in Beijing and developed eastern coastal provinces. In contrast, the burden of IS was highest (>1400 per 100 000) in north-eastern and northern provinces, and lowest in western and south-eastern provinces.[53] The decline in IS and HS burden was slower in men than women.

IHD

Between 1990 and 2016, age-standardised DALY rates for IHD increased by 6% from 1844 to 1949 DALYs per 100 000. The increase in DALY rates in recent years was greater in western provinces and among men. DALY rates for IHD were 4-fold greater in north-eastern and north-western provinces than those in south-eastern coastal provinces in 2016.

2.2.6 Trends in CVD risk factors

In addition to differences in the provision of care for CVD,[59,63,64] differences in CVD risk factors account for differences in the burden of stroke and IHD over time and across geographic regions in China.[65,66] High systolic blood pressure (SBP), high LDL cholesterol, high blood glucose, high body-mass index (BMI), smoking,

physical inactivity and a diet high in sodium accounted for most CVD morbidity and mortality in China.[67] Based on data from the China Health and Nutrition Survey, the mean levels of SBP and BMI increased progressively between 1991 and 2011, and to a greater extent in younger individuals and rural residents.[67] It has been estimated that about 46% and 41%[2] of stroke and IHD events, respectively, were attributable to high SBP in 2011.[67] The prevalence of hypertension in China increased from 18% in 2002 to 23% in 2012-2015, accounting for approximately 240 million patients.[68] With the transition to Western dietary patterns, blood levels of LDL-cholesterol have increased in recent years and the prevalence of dyslipidaemia increased from 19% in 2002 to 40% in 2012.[51] The population attributable fraction (PAF) of high LDL-cholesterol was 37% for IHD (second leading risk factor) and 11% for IS. High blood glucose was associated with 11% of IS and HS burden, and 15% of IHD burden. The prevalence of smoking, one of the main risk factors for CVD, particularly among men, declined in recent years, but 54% of men in China continued to smoke in 2011. Current smoking was associated with 20% of burden for IHD and stroke.[67] The average physical activity level declined between 1991-2011 and was the third main risk factor for IHD (PAF: 31%) in 2011. Sodium intake declined in recent years, but remained high compared to the theoretical minimum risk exposure level in 2011.

Mean levels of different CVD risk factors varied between regions in China. The absolute risks of CVD were highest in north-east and north China, due to high levels of blood pressure and obesity, and consumption of unhealthy non-staple

[2]The population attributable fractions/percentages mentioned in this section exceed 100% of a particular disease burden, because some individuals with more than one risk factor can have disease prevented in more than one way.

food. However, south China, region with the lowest CVD risk, had a high prevalence of intake of unhealthy staple foods, higher blood levels of total cholesterol, and low levels of physical activity.[69] Compared to individuals living in eastern China, those living in western provinces had a higher prevalence of smoking, higher salt consumption, less optimal control of hypertension and hyperglycaemia, and lower levels of physical activity.[53]

Although unmodifiable, population ageing is one of the most important factors contributing to the increasing prevalence of CVD. In 2014, 15% of China's population was aged over 60 years, and it is projected that this proportion will increase to 37% in 2050.[70] The number of CVD events attributable to population growth and ageing is projected to increase by more than 50% between 2010 and 2030, and trends in current risk factors would add another 23% increase in CVD events.[71]

2.3 Summary

This chapter described the healthcare system in China, and outlined the financing and provision of healthcare and recent health system reforms. The chapter also reviewed trends in the burden of stroke and IHD pathological types over time and across geographic regions. Chapter 3 appraises the available literature on trends and variations in hospital care use and outcomes for individuals with stroke and IHD in China.

References

1. Burns LR, Huang Y. History of China's Healthcare System. In: Liu GG, Burns LR, editors. China's Healthcare System and Reform. Cambridge: Cambridge University Press; 2017. p. 31-74.

2. Liu Y. Development of the rural health insurance system in China. *Health Policy and Planning*. 2004; **19**(3): 159-65.

3. Milcent C. Healthcare reform in China: From violence to digital healthcare: Palgrave Pivot, Cham; 2018.

4. National Bureau of Statistics of China. China Statistical Yearbook 2018. Available from: http://www.stats.gov.cn/english/Statisticaldata/AnnualData (Accessed: 27 July 2019).

5. La Forgia A, Burns LR. Health Insurance in China. In: Liu GG, Burns LR, editors. China's Healthcare System and Reform. Cambridge: Cambridge University Press; 2017. p. 291-320.

6. Liang L, Langenbrunner J. The Long March to Universal Coverage: Lessons from China. Washington DC: World Bank; 2013.

7. Fang H. China: The Commonwealth Fund; 2020. Available from: https://www.commonwealthfund.org/international-health-policy-center/countries/china (Accessed: 28 November 2021).

8. Zhong H. Effect of patient reimbursement method on health-care utilization: evidence from China. *Health Economics*. 2011; **20**(11): 1312-29.

9. Barber SL, Yao L. Health insurance systems in China: A briefing note. World Health Organisation; 2010.

10. State Council. Opinion on integration of basic medical insurance systems between urban and rural residents (in Chinese) 2016. Available from: http://www.gov.cn/zhengce/content/2016-01/12/content_10582.htm (Accessed: 6 April 2022).

11. Liu P, Guo W, Liu H, Hua W, Xiong L. The integration of urban and rural medical insurance to reduce the rural medical burden in China: a case study of a county in Baoji City. *BMC Health Services Research*. 2018; **18**(1): 796.

12. Yip WC, Hsiao WC, Chen W, Hu S, Ma J, Maynard A. Early appraisal of China's huge and complex health-care reforms. *The Lancet*. 2012; **379**(9818): 833-42.

13. Dong W, Zwi AB, Bai R, Shen C, Gao J. Benefit of China's Social Health Insurance Schemes: Trend Analysis and Associated Factors Since Health Reform. *International Journal of Environmental Research and Public Health*. 2021; **18**(11).

14. Liu K, Yang J, Lu C. Is the medical financial assistance program an effective supplement to social health insurance for low-income households in China? A cross-sectional study. *International Journal for Equity in Health*. 2017; **16**(1): 138.

15. Barber SL, Yao L. Development and status of health insurance systems in China. *The International Journal of Health Planning and Management*. 2011; **26**(4): 339-56.

16. Zhang C, Lei X, Strauss J, Zhao Y. Health Insurance and Health Care among the Mid-Aged and Older Chinese: Evidence from the National Baseline Survey of CHARLS. *Health Economics*. 2017; **26**(4): 431-49.

17. Wu R, Li N, Ercia A. The Effects of Private Health Insurance on Universal Health Coverage Objectives in China: A Systematic Literature Review. *International Journal of Environmental Research and Public Health*. 2020; **17**: 2049.

18. La Forgia GM, Yip W. China's Hospital Sector. In: Liu GG, Burns LR, editors. China's Healthcare System and Reform. Cambridge: Cambridge University Press; 2017. p. 219-49.

19. Xu J, Jian W, Zhu K, Kwon S, Fang H. Reforming public hospital financing in China: progress and challenges. *BMJ*. 2019; **365**: l4015.

20. Shi H, Fan M, Zhang H, et al. Perceived health-care quality in China: a comparison of second- and third-tier hospitals. *International Journal for Quality in Health Care*. 2021; **33**(1).

21. Li X, Lu J, Hu S, et al. The primary health-care system in China. *The Lancet*. 2017; **390**(10112): 2584-94.

22. State Council. Opinions of the CPC Central Committee and the State Council on Deepening the Health Care System Reform. 2009. No. 6. Available from: http://www.china.org.cn/government/scio-press-conferences/2009-04/09/content_17575378.htm (Accessed: 23 June 2021).

23. Tan X, Liu X, Shao H. Healthy China 2030: A Vision for Health Care. *Value in Health Regional Issues*. 2017; **12**: 112-4.

24. Süssmuth-Dyckerhoff C, Then F. China's Healthcare Reform: Status and Outlook. In: Liu GG, Burns LR, editors. China's Healthcare System and Reform. Cambridge: Cambridge University Press; 2017. p. 137-49.

25. Shan L, Zhao M, Ning N, et al. Dissatisfaction with current integration reforms of health insurance schemes in China: are they a success and what matters? *Health policy and planning*. 2018; **33**(3): 345-54.

26. Tao W, Zeng Z, Dang H, et al. Towards universal health coverage: lessons from 10 years of healthcare reform in China. *BMJ Global Health*. 2020; **5**(3): e002086-e.

27. Qin J, Zhang Y, Fridman M, et al. The role of the Basic Public Health Service program in the control of hypertension in China: Results from a cross-sectional health service interview survey. *PLOS One*. 2021; **16**(6): e0217185.

28. Reynolds L, McKee M. Factors influencing antibiotic prescribing in China: an exploratory analysis. *Health Policy*. 2009; **90**(1): 32-6.

29. Dong L, Yan H, Wang D. Drug prescribing indicators in village health clinics across 10 provinces of Western China. *Family Practice*. 2011; **28**(1): 63-7.

30. Cheng Z, Cai M, Tao H, et al. Efficiency and productivity measurement of rural township hospitals in China: a bootstrapping data envelopment analysis. *BMJ Open*. 2016; **6**(11).

31. Zhou Z, Zhao Y, Shen C, Lai S, Nawaz R, Gao J. Evaluating the effect of hierarchical medical system on health seeking behavior: A difference-in-differences analysis in China. *Social Science & Medicine*. 2021; **268**: 113372.

32. Yip W, Fu H, Chen AT, et al. 10 years of health-care reform in China: progress and gaps in Universal Health Coverage. *The Lancet*. 2019; **394**(10204): 1192-204.

33. Flatø H, Zhang H. Inequity in level of healthcare utilization before and after universal health coverage reforms in China: evidence from household surveys in Sichuan Province. *International Journal for Equity in Health*. 2016; **15**(1): 96.

34. Ying M, Wang S, Bai C, Li Y. Rural-urban differences in health outcomes, healthcare use, and expenditures among older adults under universal health insurance in China. *PLOS ONE*. 2020; **15**(10): e0240194.

35. Zhou W, Chen R, Hopkins A, et al. Association between socioeconomic status and incident stroke in China. *Journal of Epidemiology and Community Health*. 2020; **74**(6): 519.

36. Zhu D, Guo N, Wang J, Nicholas S, Chen L. Socioeconomic inequalities of outpatient and inpatient service utilization in China: personal and regional perspectives. *International Journal for Equity in Health*. 2017; **16**(1): 210.

37. Guo B, Xie X, Wu Q, et al. Inequality in the health services utilization in rural and urban china: A horizontal inequality analysis. *Medicine*. 2020; **99**(2): e18625-e.

38. Liu Y, Liu N, Cheng M, et al. The changes in socioeconomic inequalities and inequities in health services utilization among patients with hypertension in Pearl River Delta of China, 2015 and 2019. *BMC Public Health*. 2021; **21**(1): 903.

39. Guo W, Liu G, Ma L, et al. The impact of healthcare reform on the dynamic changes in health service utilization and equity: a 10-year follow-up study. *Scientific Reports*. 2022; **12**(1): 3576.

40. Pan B, Towne SD, Jr., Chen Y, Yuan Z. The inequity of inpatient services in rural areas and the New-Type Rural Cooperative Medical System (NRCMS) in China: repeated cross sectional analysis. *Health Policy and Planning*. 2017; **32**(5): 634-46.

41. Fu X-z, Wang L-k, Sun C-q, et al. Inequity in inpatient services utilization: a longitudinal comparative analysis of middle-aged and elderly patients with the chronic non-communicable diseases in China. *International Journal for Equity in Health*. 2020; **19**(1): 6.

42. Li J, Shi L, Liang H, Ding G, Xu L. Urban-rural disparities in health care utilization among Chinese adults from 1993 to 2011. *BMC Health Services Research*. 2018; **18**(1): 102.

43. Xie E. Income-related inequalities of health and health care utilization. *Frontiers of Economics in China*. 2011; **6**(1): 131-56.

44. Yuan S, Rehnberg C, Sun X, Liu X, Meng Q. Income related inequalities in New Cooperative Medical Scheme: a five-year empirical study of Junan County in China. *International Journal for Equity in Health*. 2014; **13**(1): 38.

45. Global Burden of Disease Collaborative Network. Global Burden of Disease Study 2019 (GBD 2019) Reference Life Table. Seattle, United States of America: Institute for Health Metrics and Evaluation (IHME); 2021. Available from: https://vizhub.healthdata.org/gbd-compare/ (Accessed: 12 November 2021).

46. Wardlaw JM. What causes lacunar stroke? *Journal of Neurology, Neurosurgery & Psychiatry*. 2005; **76**(5): 617-9.

47. Centers for Disease Control and Prevention. Types of Stroke. Available from: https://www.cdc.gov/stroke/types_of_stroke.htm#hemorrhagic (Accessed: 6 October 2021).

48. Aguilar MI, Brott TG. Update in intracerebral hemorrhage. *Neurohospitalist*. 2011; **1**(3): 148-59.

49. World Health Organization. WHO STEPS Stroke manual: the WHO STEPwise approach to stroke surveillance. 2006.

50. American Heart Association. Unstable Angina. Available from: https://www.heart.org/en/health-topics/heart-attack/angina-chest-pain/unstable-angina (Accessed: 6 October 2021).

51. Zhao D, Liu J, Wang M, Zhang X, Zhou M. Epidemiology of cardiovascular disease in China: current features and implications. *Nature Reviews Cardiology*. 2019; **16**(4): 203-12.

52. Liu L, Wang D, Wong KSL, Wang Y. Stroke and stroke care in China: huge burden, significant workload, and a national priority. *Stroke*. 2011; **42**(12): 3651-4.

53. Liu S, Li Y, Zeng X, et al. Burden of Cardiovascular Diseases in China, 1990-2016: Findings From the 2016 Global Burden of Disease Study. *JAMA Cardiology*. 2019; **4**(4): 342-52.

54. Yan R, Li W, Yin L, et al. Cardiovascular diseases and risk-factor burden in urban and rural communities in high-, middle-, and low-income regions of China: A large community-based epidemiological study. *Journal of the American Heart Association*. 2017; **6**(2): e004445.

55. Wang W, Wang D, Liu H, et al. Trend of declining stroke mortality in China: reasons and analysis. *Stroke Vasc Neurol*. 2017; **2**(3): 132.

56. Du X, Patel A, Anderson CS, Dong J, Ma C. Epidemiology of Cardiovascular Disease in China and Opportunities for Improvement: JACC International. *Journal of the American College of Cardiology*. 2019; **73**(24): 3135-47.

57. Zhang G, Yu C, Zhou M, Wang L, Zhang Y, Luo L. Burden of Ischaemic heart disease and attributable risk factors in China from 1990 to 2015: findings from the global burden of disease 2015 study. *BMC Cardiovascular Disorders*. 2018; **18**(1): 18.

58. Zhang X, Khan AA, Haq EU, et al. Increasing mortality from ischaemic heart disease in China from 2004 to 2010: disproportionate rise in rural areas and elderly subjects. 438 million person-years follow-up. *European Heart Journal Quality of Care & Clinical Outcomes*. 2017; **3**(1): 47-52.

59. Li J, Li X, Wang Q, et al. ST-segment elevation myocardial infarction in China from 2001 to 2011 (the China PEACE-Retrospective Acute Myocardial Infarction Study): a retrospective analysis of hospital data. *The Lancet*. 2015; **385**(9966): 441-51.

60. Du X, Gao R, Turnbull F, et al. Hospital Quality Improvement Initiative for Patients With Acute Coronary Syndromes in China. *Circulation: Cardiovascular Quality and Outcomes*. 2014; **7**(2): 217-26.

61. Ranasinghe I, Rong Y, Du X, et al. System Barriers to the Evidence-Based Care of Acute Coronary Syndrome Patients in China. *Circulation: Cardiovascular Quality and Outcomes*. 2014; **7**(2): 209-16.

62. Department of Health Statistics and Information Systems. WHO methods and data sources for global burden of disease estimates 2000-2011 Geneva World Health Organization; 2013.

63. Li Z, Wang C, Zhao X, et al. Substantial Progress Yet Significant Opportunity for Improvement in Stroke Care in China. *Stroke*. 2016; **47**(11): 2843-9.

64. Bi Y, Gao R, Patel A, et al. Evidence-based medication use among Chinese patients with acute coronary syndromes at the time of hospital discharge and 1 year after hospitalization: Results from the Clinical Pathways for Acute Coronary Syndromes in China (CPACS) study. *American Heart Journal*. 2009; **157**(3): 509-16.e1.

65. Li Y, Wang L, Feng X, et al. Geographical variations in hypertension prevalence, awareness, treatment and control in China: findings from a nationwide and provincially representative survey. *Journal of hypertension*. 2018; **36**(1): 178.

66. Zhou M, Astell-Burt T, Bi Y, et al. Geographical Variation in Diabetes Prevalence and Detection in China: Multilevel Spatial Analysis of 98,058 Adults. *Diabetes Care*. 2015; **38**(1): 72.

67. Li Y, Wang DD, Ley SH, et al. Potential Impact of Time Trend of Life-Style Factors on Cardiovascular Disease Burden in China. *Journal of the American College of Cardiology*. 2016; **68**(8): 818-33.

68. Wang Z, Chen Z, Zhang L, et al. Status of Hypertension in China. *Circulation*. 2018; **137**(22): 2344-56.

69. Li X, Wu C, Lu J, et al. Cardiovascular risk factors in China: a nationwide population-based cohort study. *The Lancet Public Health*. 2020; **5**(12): e672-e81.

70. Department of Economic and Social Affairs Population Division. World Population Ageing 2015. New York: United Nations; 2015. Report No.: 9789210578547.

71. Moran A, Gu D, Zhao D, et al. Future cardiovascular disease in China: markov model and risk factor scenario projections from the coronary heart disease policy model-China. *Circulation Cardiovascular Quality and Outcomes*. 2010; **3**(3): 243-52.

Chapter 3. Literature review on use of hospital care for stroke and ischaemic heart disease in China since 2004

3.1 Introduction

While cardiovascular diseases (CVD) are the leading cause of mortality and morbidity in China, few studies have examined the use of hospital care for CVD in China. Similar evidence-based treatments and guidelines for stroke and ischaemic heart disease (IHD) to those from other developed countries have been adopted in China, to reduce CVD mortality and improve the quality of cardiovascular care.[1-4] These guidelines have prompted the design and implementation of several nationwide registries of patients with CVD in China to assess the current management and health outcomes of these patients. Studies of stroke patients included the China Quality Evaluation of Stroke Care and Treatment (ChinaQUEST) study and the China National Stroke Registry (CNSR).[5,6] Studies of patients with IHD included the Clinical Pathways for Acute Coronary Syndromes (ACS) study,[7] the China Acute Myocardial Infarction (AMI) registry,[8] the Improving Care for Cardiovascular Disease in China (CCC) project,[9] and the China Patient-centred Evaluative Assessment of Cardiac Events (China PEACE) studies.[10-14]

This review examined the results of available published studies on trends and differences in use of hospital care for stroke and IHD in different population groups in China. The measures of hospital care use included rates of hospitalisation, length of hospital stay, case fatality or in-hospital mortality rates, in addition to use of diagnostic tests and treatment procedures for stroke and IHD.

3.2 Methods

3.2.1 Search strategy

A systematic search was performed using MEDLINE and EMBASE from 1 January 2004 to 7 July 2020. The search strategies were developed in conjunction with an information specialist[1] and are presented in **Appendix Table B.1** and **Table B.2**.

3.2.2 Inclusion criteria

Using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement, studies were selected based on the following stages: excluding duplicate studies, screening studies by titles, screening studies by abstracts and reviewing full texts for eligibility. Studies were excluded at each of the three last stages if they did not fulfil any of the following criteria:

- Outcome measures included hospitalisations, length of hospital stay (LOS), case fatality or in-hospital mortality and use of tests or procedures. Case fatality was defined as the proportion of deaths from a certain disease compared to the total number of people diagnosed with the disease for a particular period. In-hospital mortality was defined as death occurring during the hospital stay.
- Population-based studies as opposed to studies with selective recruitment.
- Studies conducted in mainland China only.
- Healthcare utilisation was limited to stroke or IHD.
- Studies involved at least 1000 participants.

[1]I thank Nia Roberts from the University of Oxford Bodleian Health Care Libraries for her advice.

- The data collection period for each study was in or after 2004.
- Peer-reviewed, full-text reports published in the English language.

The reference lists of included studies were checked to identify any additional studies that had not been identified by the database search. In the event of duplicate reports from the same study or dataset, the report including the largest amount of information for data extraction was retained. Studies using the same dataset with some overlapping years were retained for data extraction if the analytical methods or outcomes measured differed.

3.2.3 Quality assessment

Study quality was assessed using a combination of questions from the National Heart, Lung, and Blood Institute's quality assessment tool for observational cohort and cross-sectional studies and from the quality assessment checklist for prevalence studies (**Appendix Table B.3**). These tools were focused on assessing the internal validity of the studies and included questions on risk of selection bias, information bias, measurement bias and confounding. The quality of all studies meeting the inclusion criteria was assessed and classified as good, fair or poor, based on the number of negative or unreported answers. Studies that provided negative answers (negative or unreported) for at least 40% of relevant questions were classified as having poor overall quality. Studies that provided negative answers for 20% to 40% of questions were classified as having fair overall quality, and those that provided negative answers for less than 20% of questions were classified as having good overall quality.

3.2.4 Data extraction and analysis

Among the studies which fulfilled the inclusion criteria, detailed information was extracted on population and settings, methods, outcomes measured and factors of interest, and results. The results for individual studies were summarised in the units in which they were reported. Where possible, results were extracted by year, disease type, sex, urban/rural, health insurance (HI) type and hospital tier. The extracted data were reviewed and data for stroke and IHD were summarised separately. When an outcome was reported in a similar unit in at least two studies, unadjusted (if not otherwise specified) estimates were averaged across studies for similar subgroups[2].

[2]This ensured that studies using the same data were not included more than once in the averages across studies.

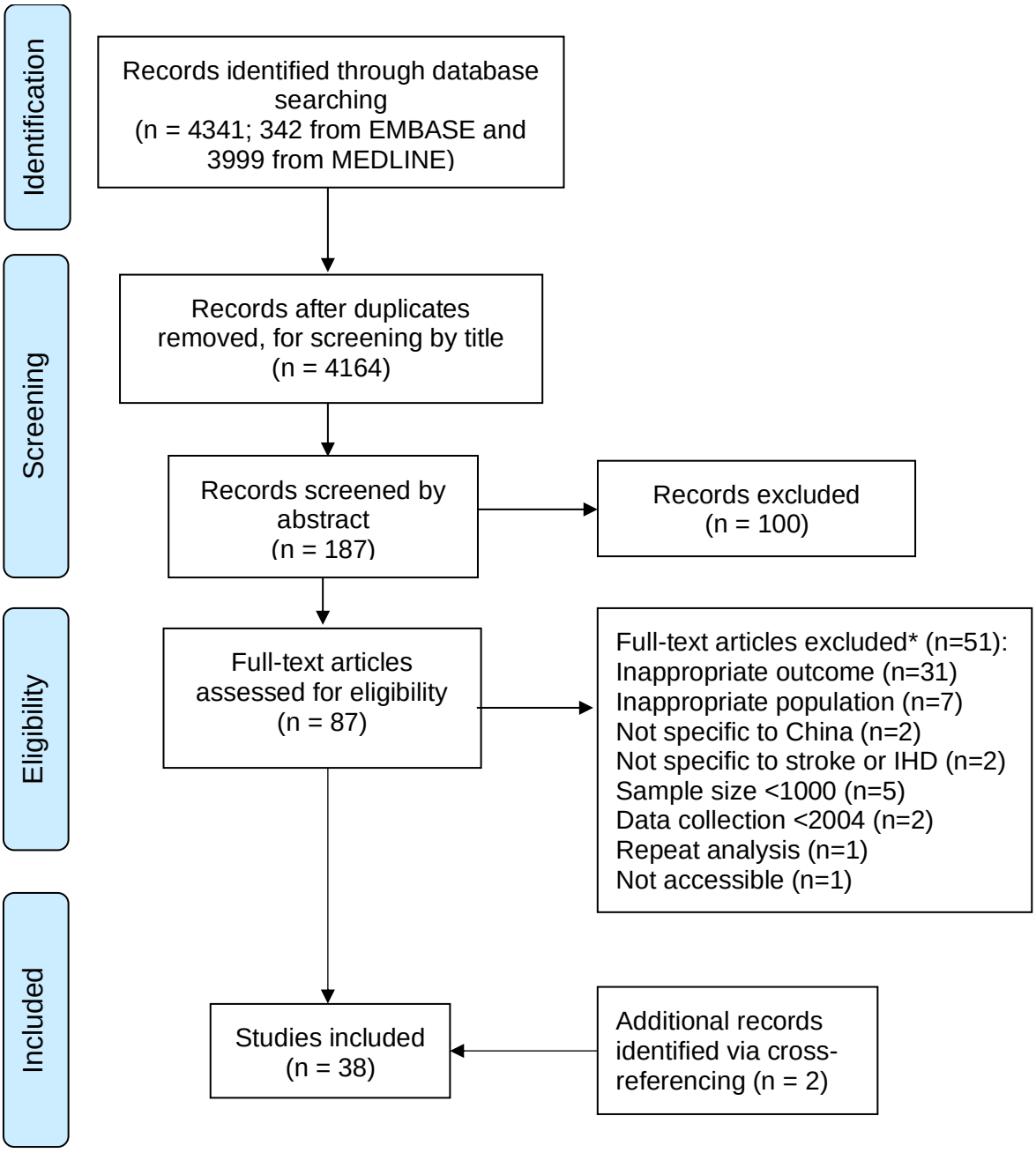
3.3 Results

3.3.1 Search strategy

The literature search yielded 4341 records (342 from EMBASE; 3999 from MEDLINE) (**Figure 3.1**). A total of 87 studies were included in the full-text review after exclusion by titles and abstracts; 36 met all inclusion criteria. Two further studies were identified and included following review of the reference list of included articles. Overall, a total of 38 studies were included in the literature review, including 14 studies of stroke, 23 studies of IHD and 1 study with results for both stroke and IHD[3].

[3]This study was counted both in the total number of studies for stroke (n=15) and for IHD (n=24).

Figure 3.1 Flow diagram of included studies



*If a study did not meet more than one of the criteria, it was reported under the first criteria it did not meet, following the order of the criteria listed in the box.

3.3.2 Characteristics of included studies

Selected characteristics of each included study are presented in **Appendix Table B.4** for stroke and **Table B.5** for IHD.

Stroke

The median sample size of the 15 studies reporting results for stroke was 22 077 participants (interquartile range [IQR]: 5397 to 67 049). Two studies (13% of all stroke-related studies) used data from one or both phases of the CNSR, three studies (20%) used Beijing's database of patients' medical records, two (13%) used data from the ChinaQUEST study, five studies (33%) used data from hospital records, two studies (13%) used urban residents' HI claims data, and one (7%) study used data from an Internet-based Comprehensive Chronic Disease Surveillance System. Regarding the geographic location, five studies (33%) were based in Beijing, four studies (27%) had nationwide representation, two studies (13%) used data from 37 cities across 8 regions, two studies (13%) were based in cities in Guangdong province, one (7%) in the municipality of Tianjin and one (7%) study in the province of Zhejiang.

Four studies (27%) used data from tier 3 hospitals only, six studies (40%) used data from tier 3 and tier 2 hospitals only, two studies (13%) included hospitals from all tiers, and three (20%) did not report the hospitals tiers from which patients were selected. Regarding the type of stroke patients included, nine studies (60%) included adult patients with any stroke, three (20%) studies only included patients with ischemic stroke (IS), two studies (13%) only included patients with haemorrhagic stroke (HS), and one study (7%) included all registered residents.

Most studies (n=11, 73%) measured LOS as an outcome, four studies (27%) estimated rates of hospitalisation or distribution of admissions, six studies (40%)

measured in-hospital mortality rates, one study (7%) measured case fatality rates and two studies (13%) measured the use of tests.

Seven studies (47%) had data collected during one year and eight studies (53%) had data collected during at least two different years. More than half of studies (n=8) reported results by stroke type, five studies (33%) by hospital tier or type, four studies (27%) by age group, three studies (20%) by year, three studies (20%) by sex, one study (7%) by urban and rural area, and one study (7%) by province economic development level.

Ischaemic heart disease

The median sample size across the 24 studies reporting results for IHD was 11 986 (IQR: 5234 to 15 929). Nine studies (38%) used data from the China PEACE study, from which seven used the retrospective AMI study, one used the prospective AMI study and one used the cathPCI study. Two studies (8%) used data from the Clinical Pathways for ACS (CPACS). Ten studies (42%) used data from local hospital records. The three remaining studies (13%) used data from the CCC-ACS project, the EPICOR Asia registry and the Internet-based Comprehensive Chronic Disease Surveillance System.

Ten studies (42%) were nationally representative or used data from all provinces in China, six studies (24%) were based in several provinces, two studies (8%) were based in Shanxi province, two studies (8%) were based in rural areas in Liaoning province, and the other four studies (17%) were based in different single provinces. Eight studies (33%) used data from tier 3 hospitals only, two studies (8%) used data from tier 2 hospitals only, four studies (17%) used data from tier 2 and 3 hospitals, and ten studies (42%) used data from different hospital tiers, but mainly tier 2 and 3.

Eight studies (33%) included patients with AMI, eight studies (33%) included patients with ST-elevation myocardial infarction (STEMI), three studies (13%) included patients with ACS, three studies (13%) included patients with IHD, one study (4%) included only non-ST-elevation ACS (NSTE-ACS) patients and one study (4%) included patients undergoing coronary catheterisation and percutaneous coronary intervention (PCI).

Five studies (22%) measured hospitalisation rates or number of admissions, eleven studies (48%) measured in-hospital mortality, one study (4%) measured case fatality, eleven studies (48%) measured LOS, and eighteen studies (78%) measured use of tests or procedures.

Eight studies (21%) using China PEACE included data collected at three time points (2001, 2006 and 2011), seven studies (29%) used data from at least two years and nine studies (38%) used data collected during a single year.

Eight studies (33%) reported results for at least one outcome of interest by sex, four studies (17%) by disease type, three studies (13%) by hospital tier, ten studies (42%) by year, four studies (17%) by urban and rural area, two studies (8%) by HI type or payment type, three studies (13%) by age group and one (17%) by risk level.

Analytical methods of included studies

The characteristics of the methods used in each included study are presented in **Appendix Table B.6** for stroke and **Table B.7** for IHD. Among the stroke studies, extracted results for ten studies (67%) were based on descriptive statistics and results for five studies (33%) were derived from multivariable linear or logistic

regression analyses. Seven studies (29%) presented age-standardised outcomes or adjusted for age in their regression analyses.

Among IHD studies, extracted results for ten studies (43%) were based on descriptive statistics and results from other studies (57%) were derived from multivariable regression analyses. Studies estimating in-hospital mortality rates, and rates of having tests or procedures mainly involved logistic regression analyses, while studies estimating LOS used linear regression analyses, linear mixed models or negative binomial regression analyses. Thirteen studies (54%) presented age-standardised outcomes or adjusted for age in their regression analyses.

Overall, eleven studies (29%) were classified as having good quality, 23 (61%) as having fair quality, and four (10%) as having poor quality (a quality score for each study is reported in **Appendix Table B.8**).

3.3.3 Summary of results

Stroke

Rates of hospitalisation

Using data from 109 tier 3 hospitals, one study reported that between 2007 and 2010 hospital admissions for all stroke increased by 7% (and by 15.32%, 4.75% and 18.80% for subarachnoid haemorrhage [SAH], intracerebral haemorrhage [ICH] and IS, respectively).[15] In 2005-2006, rates of hospitalisation for IS standardised to the WHO world population were 48.18 (95% CI: 43.75, 52.60) per 100 000 person-years for men and 35.49 (31.78, 39.21) for women.[16] Rates of hospitalisation for ICH were 25.61 (22.43, 28.78) per 100 000 person-years for men and 20.06 (17.33, 22.79) for women. The age-adjusted hospitalisation rates

were 57.4 (54.2, 60.5) per 100 000 person-years for all stroke, 36.1 (33.6, 38.6) for IS, 20.1 (18.2, 21.9) for ICH, and 1.2 (0.7, 1.6) for SAH. Another study reported the distribution of stroke admissions by hospital tier and found that overall 60.1% of admissions were in tier 3, 30.4% in tier 2 and 9.5% of admissions in tier 1 hospitals.[17] The corresponding distributions were 60.8%, 29.7%, and 9.5% for admissions due to IS, 78.3%, 18.7%, and 3.0% for SAH admissions, 66.3%, 26.5%, and 7.2% for ICH admissions, and 61.9%, 33.8%, and 4.3% for transient ischaemic attack (TIA) admissions.

Length of hospital stay

Across all studies reporting the median LOS, the average median LOS between 2008 and 2013 was 15.3 days (IQR: 11.3) for any stroke, 14.3 days (8.9) for IS, 16.3 days (15.0) for HS, 18.0 days (14.0) for ICH and 15.0 days (12.8) for SAH (**Table 3.1**). For any stroke, the average median LOS was 15.5 days in tier 2 and 17.0 days in tier 3. The average median LOS decreased over time for both IS (14.8 days before 2010 vs 12.7 days after 2010) and HS (18.0 vs 15.5 days). Tian et al (2018) also reported a decreasing trend in the mean LOS for IS (from 18.0 days in 2006-2008 to 14.8 days in 2013-2015) and ICH (19.2 to 16.4 days).[18] Huang et al (2018) reported no gender differences in LOS for stroke, and Wen et al (2017) reported that the mean LOS was higher for participants with atrial fibrillation (18.9 days) compared to those without (17.3 days).[19,20] Two studies reported that the LOS was higher in traditional Chinese medicine (TCM) hospitals compared to western medicine hospitals.[21,22] Furthermore, the median LOS for IS was higher in university hospitals than non-university hospitals (14 vs 13 days, $p<0.001$), yet this was not the case for ICH and SAH.[23]

In-hospital mortality or case fatality

Across all studies reporting in-hospital mortality rates, the average mortality rate was 2.7% for any stroke (2.0% for IS, 9.7% for HS, 10.3% for ICH: **Table 3.2**). In-hospital mortality rates decreased over time from 3.2% in 2007 to 2.5% after 2010 for any stroke,[15] and from an average of 2.8% before 2010 to 1.5% after 2010 for IS. While one study reported that in-hospital mortality rates for any stroke were slightly lower in tier 3 than tier 2 hospitals (2.7% vs 2.8%, $p<0.001$),[21] another one study reported a greater difference between in-hospital mortality rates for ICH in tier 2 (9.2%) and tier 3 hospitals (7.5%).[24] In-hospital mortality rates were also higher in western medicine hospitals (3.0%) than TCM hospitals (1.7%).[21] In contrast, Wang et al (2017) reported that there were no significant differences in death at discharge (or 30 days if not discharged) between non-university and university hospitals.[23] Regarding differences across socioeconomic factors, Ji et al (2013) reported that higher average gross regional product (GRP) per capita was associated with better prehospital stroke management[4], in-hospital quality of stroke care[5] and functional outcome at discharge.[22] However, there were no significant differences between adjusted in-hospital mortality rates in developed and underdeveloped areas both for acute IS/TIA and SAH/ICH. He et al (2014) reported that for SAH and ICH admissions, older age, HI (vs self-pay), higher comorbidity level, severity status, and northern and southern regions (vs western) were associated with a higher odds of in-hospital mortality, and more recent year, female, and longer LOS with a lower odds of in-hospital mortality.[15] The higher

[4]Prehospital stroke management was evaluated using transportation mode to hospital and time from symptom onset to hospital arrival

[5]In-hospital quality of stroke care was measured using ten performance measures based on prior studies, such as antithrombotic within 48 hours of admission or discharge on antithrombotic medication

odds of in-hospital mortality for individuals with HI reflected their higher probability of choosing treatment in hospital than self-pay patients, who due to cost concerns might decide to be discharged earlier and were thus more likely to die outside of hospital. Results were similar for hospitalisation due to IS, except for the non-significant associations with southern regions and being female.

In the one study that measured 28-day case fatality rather than in-hospital mortality, the age-standardised (to the WHO standard population 2000-2025) case fatality rate after first or recurrent stroke was 27.2% in Zhejiang in 2012, with higher rates for older age groups.[25] While crude case fatality rates were higher in women than men and in urban than rural residents, these differences disappeared once rates were standardised for age.

Use of tests and procedures

Two of the included studies reported data on use of diagnostic tests for stroke.[18,20] Huang et al (2010) examined gender differences in the management of IS in China, and reported no significant differences in the use of computed tomography (CT), magnetic resonance imaging (MRI), carotid Doppler, transcranial Doppler and transthoracic or transoesophageal echocardiograms between men and women. In the study by Tian et al (2018), significant increases were observed between 2006-2008 and 2013-2015 in the use of intracranial artery investigations[6] (from 25.6% to 75.4%), extracranial artery investigations [7] (from 82.4% to 87.8%),

[6]Intracranial artery investigations included transcranial doppler, magnetic resonance angiography of the intracranial artery, computerized tomography angiography of the intracranial artery and digital subtraction angiography.

[7]Extracranial artery investigations included carotid duplex ultrasound, cervical magnetic resonance angiography, cervical computerized tomography angiography and digital subtraction angiography.

echocardiography (from 47.4% to 82.6%), and Holter monitoring (from 0.4% to 8.2%) in IS patients.[18]

Table 3.1 Summary of median (IQR) length of hospital stay (LOS) in days for stroke, by stroke type, year and hospital type

Study	Year	Subgroup (hospital tier or type)	Any stroke	IS	HS	ICH	SAH
He et al (2014)[15]	2007	All		13 (9-18)		14 (6-23)	12 (5-20)†
	2010	All		12 (8-16)		15 (7-24)	12 (5-19)
Huo et al (2017)[21]	2012	All	14 (9-19)	13 (9-18)	16 (9-25)		
		Tier 2	13 (9-18)				
		Tier 3	14 (10-20)				
		TCM	14 (10-21)				
		Western	13 (9-18)				
Ji et al (2013)[22]	2007-2008	All	15 (10-21)	14 (10-20)	18 (11-26)		
Li et al (2016)[26]	2012-2013	All		13 (9-16)			
Liu et al (2018)[24]	2012-2015	All			15.0 (9.1-23.0)		
		Tier 2			16.0 (8.7-25.0)		
		Tier 3			15.0 (9.5-22.2)		
		TCM			18.3 (12.0-26.0)		
		Western			15.0 (9.0-22.8)		
Wang et al (2017)[23]	2006	All		13.5 (8.5)		16.5 (11)	18 (11)
Wei et al (2010)[27]	2006-2007	All	17 (12-25)	19		23	
		Tier 2	18				
		Tier 3	20				
Average across studies							
		All	15.3 (11.3)	14.3 (8.9)	16.3 (15.0)	18.0 (14.0)	15.0 (12.8)
	≤2010	All		14.9	18.0		
	>2010	All		12.7	15.5		
	2006-2012	Tier 3	17.0				
	2006-2012	Tier 2	15.5				

HS: haemorrhagic stroke, ICH: intracerebral haemorrhage, IS: ischaemic stroke, IQR: interquartile range, SAH: subarachnoid haemorrhage, TCM: traditional Chinese medicine hospital, Western: western medicine hospital. †A simple average of values for 2007 and 2010 was taken as the overall value for this study.

Table 3.2 Summary in-hospital mortality rates (%) for stroke, by stroke type, year, hospital tier and economic development level

Study	Year	Subgroup	Any stroke	IS	HS	ICH	SAH
He et al (2014)[15]	2007	All	3.16[†]				
	2010	All	2.30				
Huo et al (2017)[21]	2012	All	2.7	1.8	9.1		
		Tier 2	2.8				
		Tier 3	2.7				
Ji et al (2013)[22]	2007-2008	All		3.2	10.3		
		Developed area[*]		3.5	11.4		
		Under-developed area		2.7	8.9		
Li et al (2016)[26]	2012-2013	All		1.1			
Liu et al (2018)[24]	2012-2015	All				8.1	
		Tier 2				9.2	
		Tier 3				7.5	
Wang et al (2017)[23]	2006	All		2.3		9.4	6.0
Yan et al (2018)[28]	2010-2016	All				12.5	
Average across studies							
		All	2.7	2.0	9.7	10.3	
	≤2010	All		2.8			
	>2010	All	2.5	1.5			

*Developed area: gross regional product per capita above average level, underdeveloped area: gross regional product per capita below average level. HS: haemorrhagic stroke, ICH: intracerebral haemorrhage, IS: ischaemic stroke, SAH: subarachnoid haemorrhage. [†]A simple average of values for 2007 and 2010 was taken as the overall value for this study.

Ischaemic heart disease

Rates of hospitalisation

Based on four studies, rates of hospitalisation for AMI subtypes increased over time (**Table 3.3**).[29-32] Based on data from the China PEACE Retrospective AMI study, the nationally representative hospitalisation rates for STEMI patients increased from 7.6 per 100 000 persons in 2006 to 14.3 in 2011 and from 1.0 to 3.3 for NSTEMI patients.[31] The rates of hospitalisation for STEMI were higher for men than women in both 2006 (10.0 vs 4.1 per 100 000 persons) and 2011 (18.0 vs 8.0).[29] A study using data from higher tier hospitals in Beijing, reported that age-standardised (to the 2000 Census population of Beijing) hospitalisation rates for AMI increased from 55.8 to 73.3 per 100 000 population between 2007 and 2012, with a slight decrease in rates for STEMI and a 3-fold increase in rates for NSTEMI.[32] Rates of hospitalisation for AMI, STEMI and NSTEMI were also higher in men than women in 2007-2012, and the greatest increase was in the youngest age group (<55 years) for both sexes. Although not standardised to the same population, rates of hospitalisation for STEMI and NSTEMI were much higher in Beijing over time than those reported at the national level in the China PEACE study. In addition, trends in rates of hospitalisation for STEMI were moving in the opposite direction in Beijing and at the national level. The decreasing rates of hospitalisation for STEMI over time in Beijing might reflect more advanced primary and secondary prevention of CVD, as well better treatment for AMI in Beijing than in the rest of China. The increasing trend in rates of hospitalisation for NSTEMI in Beijing might be related to the increased use of troponins for diagnosing AMI since 2001 in China, and especially in urban cities, and changes in patient characteristics.[32]

Table 3.3 Summary of rates of hospitalisations for AMI per 100 000 persons, by AMI type, year and sex

Study	Population	Year	Subgroup (by sex)	AMI	STEMI	NSTEMI
Du et al (2016)[29]	Nationally representative	2006	Men		10.0	
		2006	Women		4.1	
		2011	Men		18.0	
		2011	Women		8.0	
Murugiah et al (2017)[31]	Nationally representative	2006	All		7.6	1.0
		2011	All		14.3	3.3
Zhang Q et al (2016)[32]	Beijing, age-standardised to 2000 Census population of Beijing	2007	All	55.8	47.3	6.8
			Men	75.5	64.9	59.3
			Women	34.7	28.4	5.4
		2012	All	73.3	40.5	26.9
			Men	99.9	59.3	33.5
			Women	44.7	20.3	19.8
Average across studies*						
		≤2010	All		27.5	3.9
			Men		37.5	
			Women		16.3	
		>2010	All		27.4	15.1
			Men		38.7	
			Women		14.2	

AMI: acute myocardial infarction, NSTEMI: Non-ST-elevation myocardial infarction, STEMI: ST-elevation myocardial infarction. *As Du et al (2016) and Murugiah et al (2017) used data from the same study, they were not included together in the average.

Length of hospital stay

Overall, LOS for different types of IHD ranged between 4 and 12 days, with higher LOS for AMI subtypes (**Table 3.4**). Across studies, the average median LOS for STEMI remained similar over time (9.7-10.0 days). Li et al (2017) found that the median LOS for patients in rural hospitals was slightly shorter than in urban hospitals in 2006 (9 days [IQR: 5-15] vs 12 days [7-16]) but not in 2011 (11 days [7-14] vs 10 days [7-15]).[33] Based on results from a cluster-randomised controlled trial, women with ACS had a shorter LOS than men (mean difference [95% CI]: -0.42 [-0.73, -0.12] days).[34] However, Zhang et al (2016) reported that the geometric mean of LOS for AMI was longer for women than men in Beijing.[32] In the latter study, the LOS was also longer for patients with NSTEMI than those with STEMI, and the LOS for AMI decreased from 10.6 days to 9.7 days in 2007-2012.

Patients with AMI enrolled in the urban resident basic medical insurance (URBMI), new rural cooperative medical scheme (NRCMS) or with self-payment had a shorter LOS than patients enrolled in the urban employee basic medical insurance (UEBMI).[35] Likewise, patients who received compensation from HI funds had a higher median LOS than patients who paid out-of-pocket.[36] Patients with STEMI also had a longer LOS in tier 3 than in tier 2 hospitals.[37]

In-hospital mortality or case fatality

Across the included studies, the average in-hospital mortality rates for ACS, NSTE-ACS, AMI, STEMI, and NSTEMI were 3.4%, 0.8% (after 2010), 4.8% (after 2010), 6.1% (after 2010), and 5.6%, respectively (**Table 3.5**). The average in-hospital mortality rate for STEMI decreased over time, from 9.7% before 2010 to 6.1% after 2010. Chen et al (2018) and Zhang et al (2016) reported that in-hospital mortality rates were higher for STEMI than NSTEMI.[32,38] One study highlighted that adjusted in-hospital mortality rates for AMI were higher in urban than in rural areas, yet the gap decreased in 2013-2017.[39] Adjusting for patient demographics and clinical characteristics, Li et al (2017) did not find any differences in the risk of the composite measure of in-hospital death or withdrawal from treatment[8] between patients in rural and urban areas in both 2006 and 2011.[33] In three studies, in-hospital mortality rates for AMI or its subtypes were higher in women than men, and the difference persisted over time (average after 2010: 9.4% vs 5.4%).[32,40,41] However, Hao et al (2019) reported that after adjustment for clinical characteristics and acute treatments, sex differences in in-hospital mortality rates for STEMI and

[8]This composite measure was used because withdrawal from treatment is common in China due to terminally ill patients' reluctance to die in hospital.

NSTE-ACS were no longer significant.[41] Zheng et al (2015) reported that the adjusted women-to-men odds ratio of mortality following STEMI was 1.69 (95% CI: 1.01, 2.83), 1.64 (1.24, 2.19), 1.15 (0.90, 1.46) and 0.82 (0.60, 1.11) for ages <60, 60-69, 70-79 and ≥80 years, respectively. The gender-age interaction for mortality was statistically significant (p=0.009), even after adjusting for a wide range of confounders, and did not vary over time or across rural/urban areas.[40] However, Hao et al (2019) found no significant interaction between sex and age in patients with STEMI (p=0.07) and NSTE-ACS (p=0.64) in multivariable analyses.[41] Two studies found that in-hospital mortality rates for STEMI were similar in tier 2 and tier 3 hospitals between 2004 and 2011.[37,39] While in one nationwide study UEBMI enrollees had higher adjusted odds of in-hospital mortality for AMI than individuals enrolled in other HI schemes (e.g. NRCMS),[42] another study found opposite results in Shanxi.[35] The latter study also reported that age-standardised in-hospital mortality rates for NSTEMI decreased over time for men only. In the one study reporting 28-day case fatality, the age-standardised (to the WHO standard population 2000-2025) case fatality rate after first or recurrent IHD was 42.8%[9] in Zhejiang in 2012, with higher rates for older age groups.[25] While crude case fatality rates were higher in women than men and in rural than urban residents, these differences disappeared once rates were standardised for age.

[9]The very high case fatality rate for IHD reported in this study was likely due to the inclusion of ischaemic cardiac arrests (ICD-10 I46) in the definition of IHD events.

Table 3.4 Summary of median (IQR) length of hospital stay (LOS) in days for IHD, by IHD type, year and other subgroup

Study	Year	Subgroup	IHD	ACS	AMI	STEMI	NSTE-ACS
Bueno et al (2018)[43]	2011-2012	All					9 (6-12)
Ding et al (2017)[36]	2015	Compensation	5.0 (3.0-7.0)				
		OOP	4.0 (3.0-7.0)				
Han et al (2019)[44]	2007-2010	All				10 (6-14)	
Hao et al (2019)[41]	2014-2018	All		9.7 (7-13)		10 (7-13)	9 (7-12)
		Men		9 (7-12)		9 (7-13)	9 (7-12)
		Women		10 (7-13)		10 (8-13)	10 (7-13)
Li G-X et al (2017)[45]	2010	All				9 (3-13)	
	2015	All				9 (4-12)	
Li J et al (2015)[30]	2006	All				10 (6-15)	
	2011	All				10 (6-14)	
Li Q et al (2015)[46]	2006	All			11 (7-16)		
	2011	All			11 (7-15)		
Li X et al (2017)[33]	2006	Rural				9 (5-15)	
	2006	Urban				12 (7-16)	
	2011	Rural				11 (7-14)	
	2011	Urban				10 (7-15)	
Wang et al (2019)[47]	2014	All	8				
Zhang Y et al (2016)[37]	2011	All				11.0 (7.0-14.0)	
		Tier 2				10.0 (6.0-14.0)	
		Tier 3				12.0 (8.0-15.0)	
Average across studies*							
	≤2010	All				9.7 (9.0)	
	>2010	All				10.0 (7.7)	9 (6.5-12.0)

ACS: acute coronary syndrome, AMI: acute myocardial infarction, Compensation: received compensation from medical insurance funds, IHD: ischaemic heart disease, IQR: interquartile range, NSTE-ACS: ST-elevation acute coronary syndrome, OOP: out-of-pocket payment, STEMI: ST-elevation myocardial infarction. *Only results for similar subgroups were averaged across studies.

Table 3.5 Summary in-hospital mortality rates (%) for IHD, by IHD type, year and other subgroup

Study	Year	Subgroup	ACS	AMI	STEMI	NSTEMI	NSTE-ACS	UAP
Bueno et al (2018)[43]	2011-2012	All					0.3	
Cai et al (2018)[39]	2013-2017	Urban		3*				
		Rural		1				
Chen et al (2018)[42]	2015	All		4.71	5.05	3.59		
		Women		6.65				
		Men		3.92				
		UEBMI		5.92				
		URBMI		4.88				
		NRCMS		2.60				
		Self-payment		4.36				
Gao et al (2008)[48]	2004-2005	All	5.0		7.9	7.7		1.5
		Tier 2			8.5	6.5		1.4
		Tier 3			7.5	9.0		1.5
Han et al (2019)[44]	2007-2010	All			8.23			
Hao et al (2019)[41]	2012-2018	All	1.78		2.14		1.21	
		Women	2.60		3.68		1.42	
		Men	1.50		1.71		1.11	
Li G-X et al (2017)[45]	2010	All			13.01			
	2015	All			10.20			
Li J et al (2015)[30]	2006	All			9.6			
	2011	All			7.1			
Lin et al (2017)[35]	2014-2015	All		4.0				
		UEBMI		3.1				
		URBMI		4.4				
		NRCMS		4.7				
		Self-payment		4.2				
Zhang Q et al (2016)[32†]	2007	All		11.2				
	2012	All		8.6				
	2007	Women		16.3	17.2	11.6		
	2007	Men		8.8	9.0	6.4		
	2012	Women		12.1	12.5	8.7		

	2012	Men		6.8	6.6	5.3	
Zhang Y et al (2016)[37]	2011	All			5.8		
		Tier 2			6.0		
		Tier 3			5.6		
Zheng et al (2015)[40‡]	2001, 2006,	Women			17.2		
	2011	Men			9.1		
Average across studies							
		All	3.4			5.6	
	≤2010	All			9.7		
	>2010	All		4.8	6.1		0.8
	>2010	Women		9.4	8.1		
	>2010	Men		5.4	4.2		
	2004-2011	Tier 2			7.3		
	2004-2011	Tier 3			6.6		
	2014-2015	UEBMI		4.5			
	2014-2015	URBMI		4.6			
	2014-2015	NRCMS		3.7			
	2014-2015	Self-payment		4.3			

ACS: acute coronary syndrome, AMI: acute myocardial infarction, NRCMS: new rural cooperative medical scheme, NSTE-ACS: ST-elevation acute coronary syndrome, NSTEMI: non-ST-elevation myocardial infarction, STEMI: ST-elevation myocardial infarction, UAP: unstable angina pectoris, UEBMI: urban employee basic medical insurance, URBMI: urban resident basic medical insurance. †Age-standardised according to the weights of all patients hospitalised for AMI in 2007-2012, and by sex as needed. ‡This study was not used in the averages across studies, as data before 2004 were included. *A simple average of values for 2007 and 2010 was taken as the overall value for this study.

Use of tests and procedures

Across studies, the use of diagnostic tests and procedures for patients with AMI increased over time. Large variations in the use of tests and procedures existed across studies depending on the time period, area (urban vs rural), hospital tier and sex of participants (**Table 3.6**). The average use of troponin, creatinine kinase, cardiac enzymes, echocardiogram, coronary angiography, and PCI in STEMI cases increased from 39.3% before 2010 to 82.1% after 2010, 83.0% to 93.8%, 91.0% to 95.5%, 39.0% to 62.3%, 36.5% to 41.9%[10], and 26.9% to 49.7%, respectively. The average use of PCI for NSTEMI also increased from 25.5% before 2010 to 33.6% after 2010, while the use of coronary artery bypass graft (CABG) remained stable (1.9% vs 1.5%).

In most studies, the use of diagnostic tests and therapeutic procedures was higher in patients with STEMI and unstable angina pectoris (UAP) compared to NSTEMI.[38,48] However, Gao et al (2008) found that in both tertiary and non-tertiary hospitals, patient risk was inversely related to the probability of having an invasive diagnostic test or procedure.[48] Zhan et al (2015) reported no differences in the probability of having troponin or creatinine kinase tests for STEMI and NSTEMI patients in 2006 (85.1% vs 88.7%, p=0.046) and 2011 (95.1% vs 94.9, p=0.696), but a lower probability of having troponin test for STEMI than NSTEMI (2006: 43.0% vs 52.8%, 2011: 63.2% vs 67.3%).[49]

Based on studies comparing the use of tests and procedures for men and women with STEMI, women had a lower average use of coronary angiography (2011: 35.5% vs 51.1%)[29] and PCI investigations (average after 2010: 30.7% vs 37.9%).[29,38,40,41]

[10]This value is based on data from a single study (Li J et al, 2015) and is not an average across studies.

Even after adjusting for patient characteristics, women had a lower odds of having non-primary PCI and cardiac catheterisation, and sex differences in the use of primary PCI increased in 2001-2011.[29] A randomised controlled trial also reported that women with ACS were less likely than men to undergo coronary angiography when indicated (adjusted rate ratio: 0.89 [95% CI: 0.85, 0.93]).[34] However, one study reported a similar use of revascularisation for men and women (men: 6.5%, women: 6.2%; p=0.78).[50]

Three studies reported a higher use of cardiac catheterisation, PCI (elective), troponin, creatinine kinase or echocardiogram in urban than rural areas in 2001-2011 and in 2014-2017.[33,39,49] One study reported that the differences in use of diagnostic tests, including troponin, creatinine kinase, and echocardiograms, between urban and rural hospitals were attenuated over time.[33] The use of elective PCI and cardiac catheterisation was reported to increase over time in both urban and rural hospitals. Zhan et al (2015) also found a substantial increase in the use of blood biomarkers in rural hospitals between 2001 (35.9%) and 2011 (94.0%).[49] Differences in the use of tests and procedures by hospital tier were also reported in two studies.[37,48] The use of echocardiography, cardiac catheterisation, and primary and elective PCI procedures was higher in tier 3 than tier 2 hospitals. Chen et al (2018) found a higher use of PCI in grade[11] A (rank "excellent") than grade B (rank "good") hospital, and in teaching than non-teaching hospital after adjusting for patient and hospital characteristics.[38] In addition, the latter study reported a higher use of PCI in the east of China compared to other regions, in younger than

[11]Tier 2 and 3 hospitals are further divided into A, B or C grades based on several measures of hospital infrastructure, staffing, size and clinical capacity.

in older patients, in those with lower than higher morbidity index, and those enrolled in UEBMI compared to other HI schemes.[38]

Table 3.6 Summary of use of diagnostic tests and procedures (%) for STEMI patients, by year and other subgroup

Study	Year	Subgroup	Troponin	Creatinine	Cardiac enzymes	Echocar-diagram	Coronary angiography	PCI	CABG
Chen et al (2018)[42]	2015	Tier 3						47.8	
Du et al (2016)[29]	2006	Men					41.7	19.4	
	2006	Women					25.0	10.2	
	2011	Men					51.1	24.4	
	2011	Women					35.5	17.1	
Gao et al (2008)[48]	2004-2005	All				55.2	44.7	40.1	2.0
		Tier 2				39.0	27.5	22.2	0.2
		Tier 3				66.5	56.8	52.7	3.2
Han et al (2019)[44]	2007-2010	All						37.22	1.85
Hao et al (2019)[41]	2014-2018	All						49.8	
		Men						51.4	
		Women						44.1	
Jian et al (2019)[51]	2012-2013	All						66.3†	
	2017-2018	All						80.1	
Li G-X et al (2017)[45]	2009-2010	All	31.63	81.38	88.80	14.17			
	2015	All	95.60	92.78	93.72	56.99			
Li J et al (2015)[30]	2006	All	46.9	84.7	93.1	47.6	25.8	12.3	0.9
	2011	All	68.6	94.9	97.2	67.7	41.9	20.3	0.6
Li X et al (2017)[33]	2006	Urban	55	90		57	37	17	
	2006	Rural	34	77		33	8	4	
	2011	Urban	71	96		75	55	28	1
	2011	Rural	65	94		54	19	6	0
Zhang Q et al (2016)[32]	2007	All						28.7	2.7
	2012	All						55.6	2.3
Zhang Y et al (2016)[37]	2011	All						19.5	
		Tier 2						10.3	
		Tier 3						27.5	
Zheng et al (2015)[40‡]	2001, 2006, 2011	Men	49.9			52.6	28.8	13.9	0.61
		Women	48.9			46.1	18.8	8.6	0.34

Average across studies*									
	≤2010	All	39.3	83.0	91.0	39.0	35.3	26.1	1.9
	>2010	All	82.1	93.8	95.5	62.3		49.7	1.5
	>2010	Men						37.9	
	>2010	Women						30.7	
	2004-2011	Tier 2						16.3	
	2004-2015	Tier 3						42.7	

CABG: coronary artery bypass graft, PCI: percutaneous coronary intervention, STEMI: ST-elevation myocardial infarction. †A simple average of values for 2012-2013 and 2017-2018 was taken as the overall value (>2010) for this study. ‡This study was not used in the averages across studies, as data before 2004 were included. *Only results for similar subgroups were averaged across studies.

3.4 Discussion

3.4.1 Summary of results

This review summarised the available evidence from previous published studies on trends and variations in hospital care use and outcomes for stroke and IHD in China. The majority of studies were classified as having fair quality. Despite the large variations in data, settings and methods used, some distinct patterns emerged.

Stroke

Although only one study reported rates of hospitalisation for stroke over several years, an increase in hospital admissions for stroke by 7% between 2007 and 2010 was observed. The increase was greater for IS compared to other stroke pathological types. Rates of hospitalisation were higher for men than women. Most stroke admissions occurred in tier 3 hospitals, with a higher proportion of admissions occurring in tier 3 for SAH, then ICH and finally TIA and IS. On average, the median LOS for stroke was 15 days, but was longer for more severe stroke types. Importantly, the median LOS decreased over time across stroke types and varied across different types of hospitals. In-hospital mortality rates ranged from 1.1% to 12.5% across stroke types, with higher in-hospital mortality rates for more severe stroke types (i.e. ICH and SAH). In-hospital mortality rates decreased over time, possibly reflecting improved hospital care after the occurrence of a stroke, implementation of national guidelines on stroke prevention and treatment, and increased detection of minor IS due to the widespread use of brain imaging.[15,52] In fact, in 2011 the government established the National Centre for Stroke Care Quality to standardise evidence-based stroke care across China.[53] While one

study reported similar in-hospital mortality rates in economically developed (GRP per capita above average level) and underdeveloped (GRP per capita below average level) provinces for stroke,[22] another study found that northern (for SAH, ICH and IS) and southern (for SAH and ICH) regions had higher odds of in-hospital mortality than western regions.[15] Generally, older age, higher comorbidity level, and severity status were associated with higher in-hospital mortality rates, while female and higher LOS were associated with lower rates. The use of tests and procedures for stroke increased over time and did not vary between men and women.

Ischaemic heart disease

The majority of studies measuring hospital care use and outcomes for IHD, focused on patients with AMI or STEMI. Average hospitalisation rates for AMI subtypes increased over time, with a greater increase for NSTEMI especially in urban areas. Rates of hospitalisation for ACS tended to be higher for men than women over time. The LOS for different types of ACS ranged between 9 and 12 days and was stable over time for STEMI. Significant heterogeneity in LOS by urban and rural area, sex, HI type and hospital tier was observed. Across studies, the average in-hospital mortality rate for AMI was 4.8%, and rates decreased over time for STEMI. This decreasing trend was consistent with reports that quality of medical care for heart disease has improved in China, especially for acute conditions like STEMI.[54] There was significant heterogeneity in in-hospital mortality rates by AMI subtype, sex, urban-rural and HI type. Inconsistent results were reported across studies regarding variation in in-hospital mortality by sex, urban-rural area and HI type. Most studies for IHD reported some measures of use of

invasive diagnostic tests or procedures. The use of troponin, creatinine, cardiac enzymes, echocardiogram, coronary angiography, and PCI increased over time for patients with STEMI. Across studies, the average use of cardiac enzymes, echocardiogram, coronary angiography, and PCI in patients with STEMI was 95.5%, 62.3%, 41.9%[12] and 49.7% after 2010, respectively. In most studies, the use of these tests or procedures was higher in patients with STEMI or UAP than NSTEMI, in men than women, and in urban than rural areas, yet this gap seemed to decrease over time. The use of tests and procedures was also higher in hospitals with higher tier, higher grade, or teaching status and in more economically developed regions.

Limitations of the included studies

Very few of the included studies measured differences in hospital care use or outcomes by socioeconomic characteristics, as the majority used data from medical records, which do not routinely collect this type of information. The most common sources of heterogeneity studied were disease subtypes, sex, urban/rural, HI type and hospital tier. Most studies only had access to data for hospitalised patients and to data during their admission, and did not have follow-up data or linked data to mortality registers. Thus, such studies could not estimate rates of hospitalisations or outcomes following hospitalisation, such as case fatality rates. The reported rates of hospitalisation were not standardised to the same population limiting comparison of results between studies. Most studies did not distinguish between first and recurrent hospital admissions and only two studies focused on

[12]This value is based on data from a single study (Li J et al, 2015) and is not an average across studies.

first-ever admissions.[28,55] Comparisons of measures of use of diagnostic tests and procedures might be biased as some studies recorded the use of primary PCI, while others recorded non-primary or elective PCI or did not specify the type of PCI used. A majority of studies were based in urban areas or used data from tier 2 or 3 hospitals only. Except for three studies,[25,36,47] most studies of IHD focused on ACS or AMI. In addition, included studies were small to moderate in size and extracted results were often descriptive statistics and were thus not adjusted for key confounders.

Limitations of the literature review

This review was restricted to English language peer-reviewed research, and relevant studies in other languages, especially Chinese, or in the non-peer reviewed literature may therefore have been missed. The exclusion of studies reported only in the Chinese language might have introduced some selection bias due to omission of some of these studies.

We searched only MEDLINE and EMBASE, and other databases such as EconLit or GlobalHealth or searches in the grey literature may have identified additional studies not reported here.

The literature review might be outdated, as was limited to studies published prior to 7 July 2020. Four new relevant studies were identified. Most of these studies used more recent data from HI claims, the Chinese Stroke Centre Alliance programme, the China AMI registry or CPACS. These studies added to the previous evidence by examining differences in inpatient healthcare utilisation for stroke between UEBMI and URBMI enrollees,[56] in-hospital mortality rates for stroke by urban-rural area,[57] in-hospital mortality rates and use of tests and

procedures for STEMI by hospital level,[58] and associations between education level and in-hospital treatment and outcomes among ACS patients.[59]

The quality assessment was performed by a single reviewer instead of two reviewers.

Several of the studies used similar data sources, highlighting the need for more diverse data sources when evaluating cardiovascular care in China to confirm previous results.

Due to considerable heterogeneity between studies in terms of populations, methods, and reporting of results, a quantitative summary of results was only performed for a subset of outcomes and studies. The quantitative summaries lacked measures of uncertainty if these were not reported in the individual studies. This also explains why a formal meta-analysis, in which studies are given differential weight when estimating the average, was not performed. Thus, comparisons of rates of hospitalisation, LOS, in-hospital mortality rates and use of tests and procedures, may be confounded by differences between studies.

Studies that focused on overall CVD or measured disease incidence or prevalence using self-reported doctor-diagnosed CVD event were excluded of from the review as they did not meet the inclusion criteria. However, they may have provided relevant information on socioeconomic differences in major CVD outcomes. For example, using data from the China Chronic Disease and Risk Factor Surveys in 2007, 2010 and 2013, Yao et al (2019) reported that prevalence rates of stroke and MI increased over time, and higher levels of income were inversely associated with prevalence rates of stroke and MI.[60] However, such health disparities have been attenuated in recent years, and health disparities have varied by gender, region and health behaviours.[60] Based on data from the 2006 second China

National Sample Survey on Disability, Wang et al (2016) reported that rural residents, men and individuals with low education levels had higher risks of CVD-related disability than urban residents, women and those with higher levels of education, respectively.[61] Zhou et al (2020) reported that living in rural (vs urban) areas and being a woman with low (vs high) socioeconomic status were associated with higher risks of stroke in China.[62] Dou et al (2015) reported that among older patients with CVD (hypertension, stroke or angina) recruited in the WHO Study on Global Aging and Adult Health, only being insured was associated with increased use of inpatient care in 2008-2010.[63]

3.4.2 Conclusions

This chapter showed that since 2004, the utilisation of hospital care for stroke and AMI increased, LOS for stroke decreased, in-hospital mortality rates decreased for both stroke and AMI, and the use of diagnostic tests and procedures increased for patients with stroke and AMI. Heterogeneity existed in results by disease subtype, sex, urban or rural area, HI type and hospital tier. Most studies focused on urban areas and higher tier hospitals, and lacked a long follow-up period. In addition, as most studies used data from hospital discharge records, the investigation of differences in hospital care use by socioeconomic characteristics was limited.

3.5 Summary

In this chapter, the available published evidence on variations in hospital care use and outcomes for patients with stroke and IHD was summarised, and limitations of existing research were identified. Several of these limitations are addressed in my thesis in an analysis of middle-aged and older adults in the China Kadoorie Biobank. Chapter 4 outlines the design of the China Kadoorie Biobank, the data sources to which it has been linked, additional data collected, and the analytical framework used for the analyses.

References

1. Chinese Society of Cardiology. Chinese guideline for percutaneous coronary intervention (pocket guideline). *Chinese Journal of Cardioliogy*. 2012; **40**(4): 271-7.

2. Chinese Society of Cardiology. Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation. *The Chinese Journal of Cardiology*. 2012; **40**: 353–67.

3. Cardiovascular Branch of Chinese Medical Association Editorial Board of The Chinese Journal of Cardiology. Guidelines for Diagnosis and Treatment of Acute ST-elevation Myocardial Infarction. *Chinese Journal of Cardiology*. 2015; **43**(5): 380-93.

4. Liu M, Wu B, Wang WZ, Lee LM, Zhang SH, Kong LZ. Stroke in China: epidemiology, prevention, and management strategies. *The Lancet Neurology*. 2007; **6**(5): 456-64.

5. Delcourt C, Hackett M, Wu Y, et al. Determinants of quality of life after stroke in China: the ChinaQUEST (QUality Evaluation of Stroke care and Treatment) study. *Stroke*. 2011; **42**(2): 433-8.

6. Wang Y, Cui L, Ji X, et al. The China National Stroke Registry for patients with acute cerebrovascular events: design, rationale, and baseline patient characteristics. *Int J Stroke*. 2011; **6**(4): 355-61.

7. Rong Y, Turnbull F, Patel A, Du X, Wu Y, Gao R. Clinical pathways for acute coronary syndromes in China: protocol for a hospital quality improvement initiative. *Crit Pathw Cardiol*. 2010; **9**(3): 134-9.

8. Xu H, Li W, Yang J, et al. The China Acute Myocardial Infarction (CAMI) Registry: A national long-term registry-research-education integrated platform for exploring acute myocardial infarction in China. *American Heart Journal*. 2016; **175**: 193-201.e3.

9. Hao Y, Liu J, Liu J, et al. Rationale and design of the Improving Care for Cardiovascular Disease in China (CCC) project: A national effort to prompt quality enhancement for acute coronary syndrome. *American heart journal*. 2016; **179**: 107-15.

10. Dharmarajan K, Li J, Li X, Lin Z, Krumholz HM, Jiang L. The China Patient-Centered Evaluative Assessment of Cardiac Events (China PEACE) Retrospective Study of Acute Myocardial Infarction: Study Design. *Circulation: Cardiovascular Quality and Outcomes*. 2013; **6**(6): 732-40.

11. Li J, Dreyer RP, Li X, et al. China Patient-centered Evaluative Assessment of Cardiac Events Prospective Study of Acute Myocardial Infarction: Study Design. *Chin Med J (Engl)*. 2016; **129**(1): 72-80.

12. Li J, Dharmarajan K, Li X, et al. Protocol for the China PEACE (Patient-centered Evaluative Assessment of Cardiac Events) retrospective study of

coronary catheterisation and percutaneous coronary intervention. *BMJ Open*. 2014; **4**(3): e004595.

13. Du X, Pi Y, Dreyer RP, et al. The China Patient-centered Evaluative Assessment of Cardiac Events (PEACE) prospective study of percutaneous coronary intervention: Study design. *Catheterization and Cardiovascular Interventions*. 2016; **88**(7): E212-E21.

14. Rao C, Bongiovanni T, Li X, et al. The China Patient-Centred Evaluative Assessment of Cardiac Events (China PEACE)-Prospective Study of 3-Vessel Disease: rationale and design. *BMJ Open*. 2016; **6**(2): e009743.

15. He Q, Wu C, Luo H, et al. Trends in in-hospital mortality among patients with stroke in China. *PLoS ONE*. 2014; **9**(3): e92763.

16. Liang W, Huang R, Lee AH, Hu D, Binns CW. Hospitalizations for incident stroke in Shunde District, Foshan, South China. *Neuroepidemiology*. 2008; **30**(2): 101-4.

17. Zhang H, Yin Y, Zhang C, Zhang D. Costs of hospitalization for stroke from two urban health insurance claims data in Guangzhou City, southern China. *BMC Health Services Research*. 2019; **19**(1): 671.

18. Tian D, Yang Q, Dong Q, Li N, Yan B, Fan D. Trends in stroke subtypes and vascular risk factors in a stroke center in China over 10 years. *Scientific Reports*. 2018; **8**(1): 5037.

19. Wen L, Wu J, Feng L, Yang L, Qian F. Comparing the economic burden of ischemic stroke patients with and without atrial fibrillation: a retrospective study in Beijing, China. *Current medical research and opinion*. 2017; **33**(10): 1789-94.

20. Huang Y, Wang J-G, Wei JW, et al. Age and gender variations in the management of ischaemic stroke in China. *International journal of stroke : official journal of the International Stroke Society*. 2010; **5**(5): 351-9.

21. Huo X, Jiang B, Chen Z, et al. Difference of hospital charges for stroke inpatients between hospitals with different levels and therapeutic modes in Beijing, China. *The International journal of neuroscience*. 2017; **127**(9): 752-61.

22. Ji R, Wang D, Liu G, et al. Impact of macroeconomic status on prehospital management, in-hospital care and functional outcome of acute stroke in China. *Clinical Practice*. 2013; **10**(6): 701-12.

23. Wang D, Liu J, Liu M, Lu C, Brainin M, Zhang J. Patterns of Stroke Between University Hospitals and Nonuniversity Hospitals in Mainland China: Prospective Multicenter Hospital-Based Registry Study. *World neurosurgery*. 2017; **98**: 258-65.

24. Liu X, Kong D, Lian H, et al. Distribution and predictors of hospital charges for haemorrhagic stroke patients in Beijing, China, March 2012 to February 2015: a retrospective study. *BMJ open*. 2018; **8**(3): e017693.

25. Gong W, Wei X, Liang Y, et al. Urban and Rural Differences of Acute Cardiovascular Disease Events: A Study from the Population-Based Real-Time Surveillance System in Zhejiang, China in 2012. *PLOS ONE*. 2016; **11**(11): e0165647.

26. Li Z, Wang C, Zhao X, et al. Substantial Progress Yet Significant Opportunity for Improvement in Stroke Care in China. *Stroke*. 2016; **47**(11): 2843-9.

27. Wei JW, Heeley EL, Jan S, et al. Variations and determinants of hospital costs for acute stroke in China. *PLOS One*. 2010; **5**(9): e13041.

28. Yan F, Yi Z, Hua Y, et al. Predictors of mortality and recurrent stroke within five years of intracerebral hemorrhage. *Neurological research*. 2018; **40**(6): 466-72.

29. Du X, Spatz ES, Dreyer RP, et al. Sex Differences in Clinical Profiles and Quality of Care Among Patients With ST-Segment Elevation Myocardial Infarction From 2001 to 2011: Insights From the China Patient-Centered Evaluative Assessment of Cardiac Events (PEACE)-Retrospective Study. *Journal of the American Heart Association*. 2016; **5**(2).

30. Li J, Li X, Wang Q, et al. ST-segment elevation myocardial infarction in China from 2001 to 2011 (the China PEACE-Retrospective Acute Myocardial Infarction Study): a retrospective analysis of hospital data. *The Lancet*. 2015; **385**(9966): 441-51.

31. Murugiah K, Wang Y, Nuti SV, et al. Are non-ST-segment elevation myocardial infarctions missing in China? *European Heart Journal - Quality of Care and Clinical Outcomes*. 2017; **3**(4): 319-27.

32. Zhang Q, Zhao D, Xie W, et al. Recent Trends in Hospitalization for Acute Myocardial Infarction in Beijing: Increasing Overall Burden and a Transition From ST-Segment Elevation to Non-ST-Segment Elevation Myocardial Infarction in a Population-Based Study. *Medicine*. 2016; **95**(5): e2677.

33. Li X, Murugiah K, Li J, et al. Urban-Rural Comparisons in Hospital Admission, Treatments, and Outcomes for ST-Segment-Elevation Myocardial Infarction in China From 2001 to 2011: A Retrospective Analysis From the China PEACE Study (Patient-Centered Evaluative Assessment of Cardiac Events). *Circulation Cardiovascular Quality and Outcomes*. 2017; **10**(11).

34. Du X, Patel A, Li X, Wu Y, Turnbull F, Gao R. Treatment and outcomes of acute coronary syndromes in women: An analysis of a multicenter quality improvement Chinese study. *International Journal of Cardiology*. 2017; **241**: 19-24.

35. Lin X, Cai M, Tao H, et al. Insurance status, inhospital mortality and length of stay in hospitalised patients in Shanxi, China: A cross-sectional study. *BMJ Open*. 2017; **7**(7): e015884.

36. Ding JM, Zhang XZ, Hu XJ, Chen HL, Yu M. Analysis of hospitalization expenditures and influencing factors for inpatients with coronary heart disease in a tier-3 hospital in Xi'an, China A retrospective study. *Medicine*. 2017; **96**(51): e9341.

37. Zhang Y, Yang S, Liu X, et al. Management of ST-segment elevation myocardial infarction in predominantly rural central China: A retrospective observational study. *Medicine*. 2016; **95**(49): e5584.

38. Chen H, Shi L, Xue M, et al. Geographic Variations in In-Hospital Mortality and Use of Percutaneous Coronary Intervention Following Acute Myocardial Infarction in China: A Nationwide Cross-Sectional Analysis. *Journal of the American Heart Association*. 2018; **7**(8): e008131.

39. Cai M, Liu E, Li W. Rural Versus Urban Patients: Benchmarking the Outcomes of Patients with Acute Myocardial Infarction in Shanxi, China from 2013 to 2017. *International Journal of Environmental Research and Public Health*. 2018; **15**(9).

40. Zheng X, Dreyer RP, Hu S, et al. Age-specific gender differences in early mortality following ST-segment elevation myocardial infarction in China. *Heart*. 2015; **101**(5): 349-55.

41. Hao Y, Liu J, Liu J, et al. Sex Differences in In-Hospital Management and Outcomes of Patients With Acute Coronary Syndrome. *Circulation*. 2019; **139**(15): 1776-85.

42. Hui C, Lizheng S, Ming X, et al. Geographic Variations in In-hospital Mortality and Use of Percutaneous Coronary Intervention Following Acute Myocardial Infarction in China: A Nationwide Cross-sectional Analysis. *Journal of the American Heart Association*. 2018; **7**(8): e008131.

43. Bueno H, Rossello X, Pocock S, et al. Regional variations in hospital management and post-discharge mortality in patients with non-ST-segment elevation acute coronary syndrome. *Clinical Research in Cardiology*. 2018; **107**(9): 836-44.

44. Han H, Wei X, He Q, et al. Comparison of In-Hospital Mortality and Length of Stay in Acute ST-Segment-Elevation Myocardial Infarction Among Urban Teaching Hospitals in China and the United States. *Journal of the American Heart Association*. 2019; **8**(22): e012054.

45. Li G-X, Zhou B, Qi G-X, et al. Current Trends for ST-segment Elevation Myocardial Infarction during the Past 5 Years in Rural Areas of China's Liaoning Province: A Multicenter Study. *Chinese medical journal*. 2017; **130**(7): 757-66.

46. Li Q, Lin Z, Masoudi FA, et al. National trends in hospital length of stay for acute myocardial infarction in China. *BMC cardiovascular disorders*. 2015; **15**: 9.

47. Wang Q, Zhang S, Wang Y, Zhang X, Zhang Y. Factors Associated With Hospitalization Costs of Coronary Heart Disease in Township Hospitals in Rural China. *Inquiry*. 2019; **56**: 46958019886958.

48. Gao R, Patel A, Gao W, et al. Prospective observational study of acute coronary syndromes in China: practice patterns and outcomes. *Heart*. 2008; **94**(5): 554-60.

49. Zhan L, Masoudi FA, Li X, et al. Trends in cardiac biomarker testing in China for patients with acute myocardial infarction, 2001 to 2011: China PEACE-Retrospective AMI Study. *PLOS One*. 2015; **10**(4): e0122237.

50. Dreyer RP, Zheng X, Xu X, et al. Sex differences in health outcomes at one year following acute myocardial infarction: A report from the China Patient-Centered Evaluative Assessment of Cardiac Events prospective acute myocardial infarction study. *European Heart Journal - Acute Cardiovascular Care*. 2019; **8**(3): 273-82.

51. Jian W, Figueroa J, Woskie L, et al. Quality of care in large Chinese hospitals: an observational study. *BMJ Quality & Safety*. 2019; **28**(12): 963-70.

52. Hao Z, Chen Y, Wright N, et al. Natural history of silent lacunar infarction: 10-year follow-up of a community-based prospective study of 0.5 million Chinese adults. *The Lancet Regional Health - Western Pacific*. 2021; **17**: 100309.

53. Liu L, Wang D, Wong KSL, Wang Y. Stroke and stroke care in China: huge burden, significant workload, and a national priority. *Stroke*. 2011; **42**(12): 3651-4.

54. Downing NS, Wang Y, Dharmarajan K, et al. Quality of Care in Chinese Hospitals: Processes and Outcomes After ST-segment Elevation Myocardial Infarction. *Journal of the American Heart Association*. 2017; **6**(6): e005040.

55. Li Y, Liu H, Wang J, et al. Variable lengths of stay among ischemic stroke subtypes in Chinese general teaching hospitals. *PloS one*. 2012; **7**(9): e45101.

56. Yang Y, Nicholas S, Li S, et al. Health care utilization for patients with stroke: a 3-year cross-sectional study of China's two urban health insurance schemes across four cities. *BMC Public Health*. 2021; **21**(1): 531.

57. Gu H-Q, Yang X, Wang C-J, et al. Clinical Characteristics, Management, and In-Hospital Outcomes in Patients With Stroke or Transient Ischemic Attack in China. *JAMA Network Open*. 2021; **4**(8): e2120745-e.

58. Xu H, Yang Y, Wang C, et al. Association of Hospital-Level Differences in Care With Outcomes Among Patients With Acute ST-Segment Elevation Myocardial Infarction in China. *JAMA Network Open*. 2020; **3**(10): e2021677-e.

59. Peng Y, Du X, Li X, et al. Associations Between Education Level and In-hospital Treatment and Outcomes Among Acute Coronary Syndrome in China. *The American Journal of the Medical Sciences*. 2021; **361**(2): 253-60.

60. Yao Y, Liu G, Wang L, et al. Disease and disparity in China: a view from stroke and MI disease. *International Journal for Equity in Health*. 2019; **18**(1): 85.

61. Wang Z, Cao C, Guo C, Chen G, Chen H, Zheng X. Socioeconomic inequities and cardiovascular disease-related disability in China: A population-based study. *Medicine (Baltimore)*. 2016; **95**(32): e4409.

62. Zhou W, Chen R, Hopkins A, et al. Association between socioeconomic status and incident stroke in China. *Journal of Epidemiology and Community Health*. 2020; **74**(6): 519.

63. Dou L, Liu X, Zhang T, Wu Y. Health care utilization in older people with cardiovascular disease in China. *International journal for equity in health*. 2015; **14**: 59.

Chapter 4. Data and methodology

4.1 The China Kadoorie Biobank study

The China Kadoorie Biobank (CKB) is a community-based prospective cohort study of half a million Chinese adults that was established in 2004. CKB is coordinated by a collaboration between the Clinical Trial Service Unit and Epidemiological Studies Unit, the University of Oxford and the Chinese Academy of Medical Sciences and China National Centre for Disease Control and Prevention (CDC). The primary aim of CKB was to conduct a prospective study to generate reliable evidence on associations of lifestyle, environmental and genetic risk factors with a wide range of diseases.

All participants in CKB completed a detailed questionnaire at recruitment, which collected data on demographic, socioeconomic, lifestyle, behavioural characteristics, and physical measurements, and provided a blood sample. Participants were linked to cause-specific morbidity and mortality registries and to health insurance (HI) records for all hospitalisations via their unique national identity number. The CKB recruitment methods and participant characteristics have been described previously in two published cohort profiles,[1,2] and are summarised in this chapter.

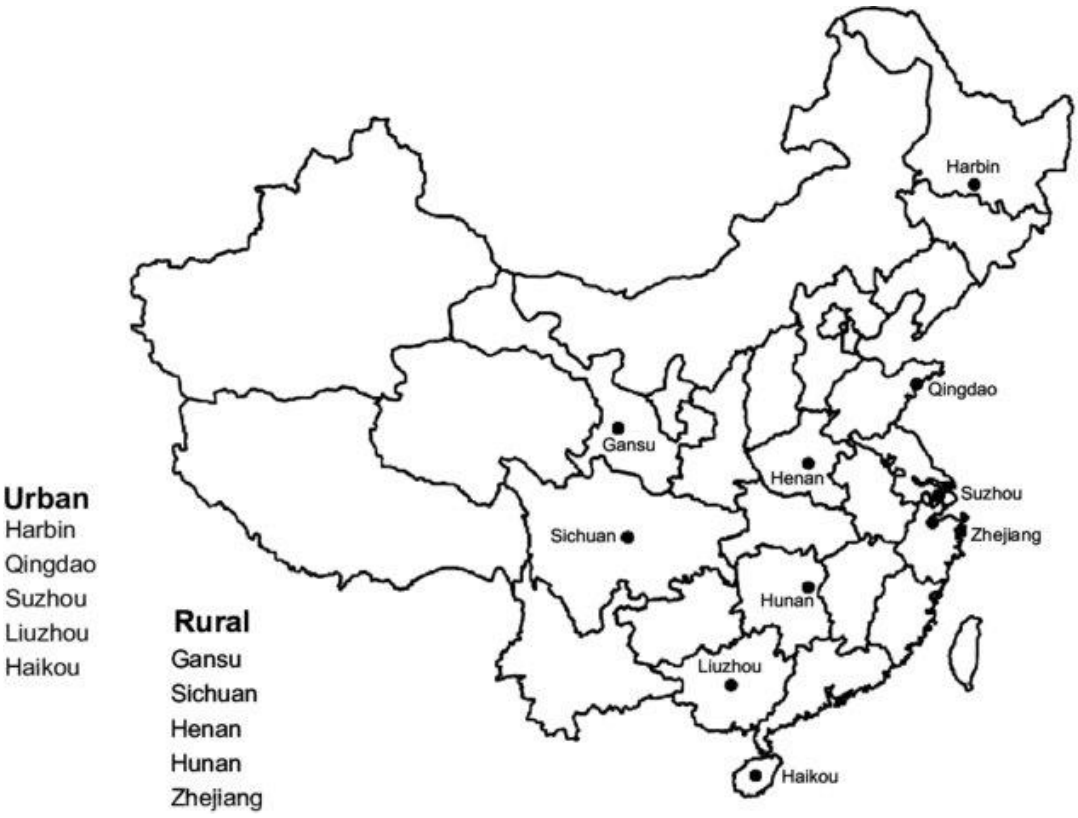
4.1.1 Recruitment and characteristics of participants

During 2004-2008, 512 726[1] men and women aged 30-79 years were recruited from ten provinces of China, including five rural and five urban areas (**Figure 4.1** and **Table 4.1**). Throughout this thesis, the urban centres are referred to by the city name and the rural centres are referred to by the province name. The ten study areas were selected to maximise diversity in socio-demographic characteristics, risk factor exposures and disease patterns, and also considering population stability, quality of death and disease registries and local capacity and commitment. Although classified as either urban or rural areas, some areas are semi-urban or semi-rural, as is the case with Suzhou and Zhejiang. The CKB was not designed to be representative of the Chinese population as the main objectives were to investigate the causes rather than the incidence of common chronic diseases.

At each study area, a total of 100-150 administrative units (rural villages or urban street committees) were selected for participant recruitment. At each administrative unit, all permanent residents aged 35-74 years without known physical or mental disability were identified via official residential records and invited to attend a temporary assessment centre. Invitation letters to assessment centres were delivered door-to-door by local community leaders and health workers. In each area, the recruitment teams used extensive publicity campaigns to increase awareness of the study among the local residents.

[1]The number of participants reported in this chapter is based on the release 17.00 of the CKB data.

Figure 4.1 Locations of the 10 study areas of the CKB study



Source: Picture from Chen et al. 2005.[2]

Table 4.1 Names of the 10 study areas included in the CKB study

City or county	Province
Urban areas (city)	
Qingdao	Shandong
Harbin	Heilongjiang
Haikou	Hainan
Suzhou	Jiangsu
Liuzhou	Guangxi Zhuang Autonomous Region
Rural areas (county)	
Pengzhou	Sichuan
Tianshui	Gansu
Huixian	Henan
Tongxiang	Zhejiang
Liuyang	Hunan

Among the 1 801 167 individuals contacted, 495 626 within and, to encourage participation, 17 100 individuals slightly outside the targeted age range were included. Approximately 30% of invited participants were recruited, with response

rates varying between 26% and 38% in rural areas and between 16% and 50% in urban areas. The age of study participants varied from 30-79 years.

4.1.2 Ethical approval and funding

Ethical approval for the CKB study was obtained from the Oxford Tropical Research Ethics Committee at the University of Oxford (approval number 025-04, 3rd February 2005) and the Chinese CDC Ethical Review Committee (approval number 005/2004, 9th July 2004). Approval was also granted by institutional research boards at the local CDCs in each of the survey areas.

4.1.3 Baseline survey

During the baseline survey, temporary study assessment centres were set up in the local community and invited participants were screened for eligibility using their unique national identity cards. Eligible individuals provided written informed consent to participate in the study, which included permission for long-term storage of blood for anonymised and non-specified medical research, and access to their medical records using local clinics, hospital and official disease registration systems for follow-up.

Participants underwent a 60-75 minutes assessment at the local study clinics, which included 10 stations. Trained health workers administered a laptop-based, electronic questionnaire, which included a range of detailed built-in logic and error checks to minimise missing values, errors and inconsistencies. This electronic questionnaire collected information on general demographic (e.g. age, gender),

socioeconomic characteristics (e.g. income, education, occupation), lifestyle factors (e.g. smoking, alcohol, physical activity), personal and family medical history (doctor diagnosed diabetes, IHD, and stroke/transient ischemic attack [TIA], hypertension), current medication, sleeping habits, mental health, and, for women, reproductive history. Participants who reported a history of doctor-diagnosed diabetes, IHD, stroke/TIA or hypertension were also asked about their age at diagnosis and current use of medications.

Physical measurements were made including measurements of height, weight, hip and waist circumference, bio-impedance, lung function tests, heart rate, a carbon monoxide breath test and blood pressure using standard, calibrated instruments with standard protocols. A 10 ml non-fasting venous blood sample was collected for long-term storage, with a small proportion used for blood spot tests on random blood glucose. Participants received feedback on the physical measurements and blood spot tests recorded at the assessment centre by a medically qualified member of the study staff. The quality of data collection was closely monitored, with regular feedback and further training provided to health workers. The complete baseline questionnaire is provided in **Appendix C.1**.

4.1.4 Resurveys

Following the baseline survey, two resurveys were undertaken between August and October 2008 and during 2013-2014 in a randomly selected sample of about 5% of surviving participants from each study area. The first resurvey invited 24 760 participants and 19 786 participated (response rate: 79.9%). The second resurvey invited 33 073 participants and 25 239 participated (response rate: 76.3%). Among

all CKB participants, 14 902 participated in all three surveys. The data collection (both questionnaires, interviews and physical measurements) and resurvey procedures were similar to those used in the baseline survey, but additional data were collected (e.g. better measures of physical activity) in order to enhance and calibrate baseline data and conduct analyses of temporal trends in risk factor exposures.

4.1.5 Follow-up

Death registries

The vital status of all participants was monitored through the Disease Surveillance Point (DSP) system of the Chinese CDC, which covers all study areas. The DSP system was established by the Chinese Ministry of Health in the 1980s to provide nationally representative mortality statistics. Annual checks with local residential records of the Public Security Bureau, HI records, and active confirmation of survival were conducted by local residential administrators to minimise any under-reporting of deaths. This also allowed the identification of participants who have moved permanently out of the study areas. The DSP provided reliable and complete registration for causes of death in almost all adults. For any additional deaths not identified through routine procedures (<5%), the causes were sought by reviewing hospital records or by conducting a verbal autopsy using a validated instrument.

Between entry into the CKB study and 31 December 2017, only 5302 (1%) individuals were lost to follow-up. Participants who permanently moved out of the region where they were recruited were considered to be lost to follow-up.

All deaths were classified according to the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10) by trained staff of the DSP system and medical professionals in hospitals, respectively, all of whom were blinded to baseline and resurvey information. Death registries included information on main diagnoses (ICD-10) for cause of death, date of death, hospital tier, hospital name and hospital code.

Disease registries

Study participants were followed-up for incident disease outcomes using local disease registries for IHD, stroke, cancer and diabetes, which were prospectively set up by CKB Regional Coordinating Centres in collaboration with the CDC. Disease registries recorded details of inpatient hospital admissions for IHD, stroke, cancer and diabetes in the ten study areas. Disease registries included information on main diagnoses (ICD-10), admission date, hospital tier, hospital name and code, and were mainly used to complement hospital admissions not recorded in HI records, especially for uninsured individuals.

Health insurance records

Information on hospital admissions was obtained through electronic linkage to national HI claim databases, using participants' unique national identity number, complemented by other personal information (e.g. date of birth, sex and home address). The linkage of CKB participants to national HI claim databases was established in different years in the different study areas and was completed for all centres from 2008/2009 onwards. Around 98% of study participants were linked successfully. HI records recorded all inpatient hospital admissions in all CKB

centres. Outpatient data were not routinely available, albeit were provided in a few CKB centres and for some years only. HI records typically included information on disease descriptions, diagnoses (and their ICD-10 codes), admission and discharge dates, use of selected diagnostic and treatment procedures, hospital tier, hospital name and code. For the small proportion of CKB participants not covered by HI (i.e. uninsured), hospital admissions were also obtained by asking participants if they had been hospitalised in the last year and for what conditions (i.e. active follow-up) on an annual basis.[3]

Health insurance scheme membership

Starting in 2012, data on participants' HI scheme membership were also available and updated annually. Participants were enrolled in one of the following HI types: New Rural Cooperative Medical Scheme (NRCMS), Urban Employee Basic Medical Insurance (UEBMI), Urban Resident Basic Medical Insurance (URBMI), merged NRCMS and URBMI, provincial, railway, uninsured, and unknown. The provincial scheme covered civil servants and the railway scheme covered employees of a railway company in Harbin. Participants enrolled in the provincial or railway scheme were combined with those enrolled in the UEBMI, as these schemes were only relevant in one CKB centre and HI benefits were similar to those of the UEBMI. Data on participants' insurance status (insured vs uninsured) were also available from 2012 onwards. Missing HI scheme membership for the period 2009-2011 was imputed using the earliest participant's HI scheme available between 2012 and 2017. This imputation was considered appropriate for several reasons. Between 2012 and 2017, the proportion of CKB participants enrolled in each scheme remained stable: NRCMS or URBMI (55.7-58.1%), UEBMI (37.2-

38.2%), unknown: (1.6-1.0%), uninsured (5.5-2.8%), and 94% of participants with available data remained enrolled in the same HI type. As CKB participants were middle-aged and older individuals (i.e. mean age 54.7 years in 2009), it was unlikely for them to change employment, hence only a small proportion of participants changed HI scheme. Furthermore, at entry into the study (2004-2008), 82% of participants self-reported being insured. This proportion increased to 97% and 98% in the 5% sample of individuals who participated in the 1st (2008) and the 2nd (2013-2014) resurveys, respectively. Thus, it was unlikely for participants to be uninsured. The steps used to impute the missing HI membership information are described in **Appendix C.2.**

Hospital information

Hospital information including hospital tier, name and code was provided in HI records. However, the information on hospitals was typically not standardised and included missing hospital codes and names. A hospital standardisation tool was developed by the CKB IT team and incorporated information from an official list of hospitals in China, which was further checked and modified by local study staff.[3] This provided additional information on the province name, the city name and the area name where hospitals were located. The remaining missing hospital tier information was completed with the help of CKB researchers using Google and Baidu searches of hospital names.

4.1.6 Outcome adjudication

The objectives of the outcome adjudication were to: (i) verify the reporting accuracy of the disease and classify the main subtypes of the disease, (ii) collect additional

information (e.g. diagnostic tests and procedures used to classify pathological subtypes), and (iii) establish reliability and validity of reported diseases from different sources. Currently, outcome adjudication includes all non-fatal and first-ever incident cases of stroke and IHD.

Two different platforms were used to conduct outcome adjudication: (i) the portable validation device (PVD) and (ii) the internet-based case adjudication system for clinical events (i-CASE). Medical records were retrieved for incident events with a main diagnosis of stroke or IHD, which were identified using disease registries and HI records. Regional CDC staff sought access to medical records in participating hospitals. The PVD tablets were used to photograph the relevant medical records and key clinical information were recorded electronically using standardised protocols.[3] Extracted information included discharge summary and reports of cardiac enzymes, coronary angiography, coronary revascularisation, electrocardiogram, echocardiogram, computed tomography (CT), coronary computed tomography angiography, magnetic resonance imaging (MRI), and Holter monitor tests. The PVD system was used to verify disease diagnoses from disease registries and HI records against diagnoses from the retrieved medical notes. The retrieved information was reviewed by the CKB adjudication committee, which consists of senior neurologists and cardiologists in China and research clinicians in Oxford, using the i-CASE system. The outcome adjudication committee, who was blinded to baseline and resurvey data, confirmed, re-classified or refuted disease events, and, for some diseases, enabled more detailed phenotyping.

4.2 Health insurance characteristics questionnaire

To collect local information on health policy variables, questionnaires were sent to public health administrators in the 10 CKB centres to complete. In addition to demographic and epidemiologic transitions and individual characteristics, use of hospital care may also be affected by health policy factors, such as HI cost sharing. As HI cost sharing differs between provinces in China, particularly between urban and rural areas, and over time, it is often difficult to identify relevant and up-to-date data. The HI characteristics questionnaire was designed to collect annual information on characteristics of HI schemes for inpatient and outpatient care in 2008-2017, including reimbursement rates, deductibles, ceilings, and provider payment method (**Appendix C.3**).

There were three main phases of data collection: (i) the first one involved CKB centres completing the questionnaire, (ii) the second phase involved data collection using secondary sources, and (iii) the third phase involved checking and verifying the reliability of the data collected.

For the first phase, six CKB centres (Harbin, Sichuan, Gansu, Henan, Zhejiang, Hunan) completed the HI characteristics questionnaire. The main data source used by the public health administrators in the CKB centres to complete the questionnaires was the social security bureaus. The level of completeness of these questionnaires varied across centres.

During the second phase, the missing HI characteristics data for the four urban centres (Qingdao, Haikou, Suzhou, Liuzhou) were completed using secondary data collection. With the help of researchers in China and a collaborator at the China Health Insurance Association, policy documents using Google, Baidu and

HowNet and the following key words: “county/district/city name”, “medical insurance/New Rural Cooperative Medical Insurance/Urban Resident Medical Insurance/Urban Employee Medical Insurance”, and “reimbursement/deductible/ceiling” were systematically searched. A range of different data sources were used including local government websites, copies of HI policy documents, insurance websites, and news websites. In some instances, large local hospitals also provided information.

The aim was to create a dataset of HI characteristics that could be matched to the long-term follow-up data of CKB participants. The variables that were used for the matching were: region, year, HI scheme, hospital tier, and retirement status (only relevant for UEBMI enrollees). The assumptions made during the second phase of data collection to enable the matching of data are described in **Appendix C.4**. In the third phase, HI characteristics data were double checked and verified with the help from researchers at the CKB National Coordinating Centre.

4.3 Analytical framework

4.3.1 Andersen's behavioural model

The choice of variables included in the statistical models in Chapters 5, 6 and 7 was influenced by Andersen's behavioural model of health care utilisation.[4] This conceptual model is commonly used to study the impact of different characteristics on the use of or access to healthcare services.[5-8] The model identified three main categories of characteristics that impact healthcare use:

1) Individual characteristics:

- Predisposing: existing factors that predispose individuals to use or not healthcare services, even though these factors are not directly the cause of the use.
- Enabling: factors that facilitate or impede the use of healthcare services.
- Need: factors that individuals themselves or healthcare providers recognise as requiring medical treatment.

2) Health behaviour characteristics: personal practices performed by the individual that have an influence on health outcome.

3) Contextual characteristics: factors characterising society and the environment in which an individual lives (e.g. health system and policies, environmental factors).

Based on this conceptual model and on data available in the CKB, variables were grouped in five main categories of factors: demographic, socioeconomic, lifestyle, morbidity and contextual factors.

4.3.2 Definitions of factors of interest

This section defines the variables used in the statistical analyses. The subset of variables used in each model and the corresponding categorisation are described in Chapters 5, 6 and 7.

Demographic factors

Demographic factors included age in years (continuous), sex (binary) and recruitment centre or region (10 categories).

Socioeconomic factors

Socioeconomic factors included household size (continuous), marital status (binary), highest level of education received (categorical), annual household income level (categorical), urban or rural area of residence (binary) and HI type (categorical). Marital status was recoded as married and other (i.e. widowed, separated/divorced, or never married). The variable for education was recoded as: no formal school, primary or middle school, high school or above (i.e. technical school/college or university). The variable for income was recoded as: <¥10 000, ¥10 000-19 999, ¥20 000-34 999, ≥¥35 000. In sensitivity analyses, an approximate measure of equivalent income was estimated and substantial overlap existed between the original income groups and quartiles of approximated equivalent income (**Appendix C.5**). The HI type variable was recoded as UEBMI, URBMI or NRCMS and other (i.e. unknown, missing or uninsured). URBMI and NRCMS were combined because in four of the ten CKB regions the two schemes merged into a single scheme from 2012-2013 onwards and because they provided

similar benefits. In contrast to other socioeconomic variables, HI type was updated annually since 2012. Occupation status was not included in the socioeconomic factors, due to high heterogeneity in the proportions of individuals in each occupation category across CKB regions and within urban and rural regions. For instance, in urban areas, less than 1% of participants in Qingdao, Harbin and Liuzhou were agricultural workers, yet 8-15% of participants in Haikou and Suzhou were agricultural workers. In rural areas, less than 2% of participants in Sichuan and Gansu were factory workers, yet 28% of participants in Zhejiang were factory workers.

Lifestyle factors

Lifestyle factors included smoking (binary), alcohol consumption (binary), body-mass index (BMI, categorical), physical activity (continuous), and self-rated health status (categorical). All lifestyle factors were recorded at baseline only. For smoking, participants were categorised as current smokers or non-current smokers (i.e. never smokers, occasional smokers or ex-regular smokers). For alcohol consumption, participants were categorised as regular alcohol drinkers (i.e. those who drank alcohol monthly or at least weekly) and non-regular alcohol drinkers (i.e. never/rarely or occasional) based on the frequency of their usual consumption over the last year. BMI was calculated by dividing weight in kilograms (kg) by the square of their height in metres (m), and was recoded as underweight or normal weight (<25kg/m^2), overweight (25 to 29.9 kg/m^2) and obese (≥30 kg/m^2) based on the World Health Organisation's classification. Physical activity was expressed in metabolic equivalent of task hours performed per day, on average, over the last year. Self-rated health was recorded as excellent, good, fair or poor.

Morbidity factors

To adjust for evolving morbidity status during follow-up, a set of binary variables for eight main categories of diseases were generated using all available data in CKB. The main categories of diseases were: IHD (ICD-10: I20-I25), cerebrovascular disease (ICD-10: I60-69), malignant neoplasms (ICD-10: C00-C97), disease of the respiratory system (ICD-10: J00-J99), infectious and parasitic disease (ICD-10: A00-B99), diabetes mellitus (ICD-10: E10-E14), chronic kidney disease (ICD-10: N02-N03, N07, N11, N18) and tuberculosis (ICD-10: A15-A19, J65, K23.0, K67.3, M01.1, M49.0, M90.0, N33.0, N74.0, N74.1, O98.0, P37.0). These variables were updated annually at the start of each year from recruitment to the end of the study period, and indicated whether a participant had developed respective morbidities over time. To avoid over adjustment, morbidity for cerebrovascular disease and IHD only started the year after the first event occurred in analyses for stroke and IHD, respectively. In addition, the variables for cerebrovascular disease, IHD and diabetes mellitus were additionally updated for reported morbidity at entry into the study, by using the corresponding prior diagnosis at baseline variables (i.e. stroke/TIA, IHD, and diabetes).

Systolic blood pressure was calculated as the mean of two blood pressure measurements recorded at baseline. Self-reported mental illness at baseline (binary) was defined as having at least one symptom of depression or anxiety in the past 12 months. Symptoms of depression included feeling much more sad or depressed than usual, loss of interest in most things like hobbies or activities that usually give pleasure, loss of appetite for favourite food, or feeling worthless or useless for a period of two or more weeks. Symptoms of anxiety included

experiencing continuous anxiety for a period lasting one month or longer, feeling continuous pain in body lasting more than four months, panic attacks, or phobias.

Contextual factors

Contextual factors included a categorical variable for hospital tier: tier 1, tier 2, tier 3 or other (i.e. missing or unrated).

4.3.3 Definitions of disease outcomes

Hospital admissions were identified using ICD-10 codes I60-I61 and I63-I64 for stroke, and I20-I25 for IHD. Overall, 92% of reported incident strokes had their diagnoses confirmed by CT or MRI and 97% of incident IHD cases had electrocardiogram reports. Stroke types were identified using ICD-10 codes I60-61 for haemorrhagic stroke (HS), I63 for ischaemic stroke (IS) and I64 for other or unspecified stroke type. Admissions for IS were further classified into lacunar IS, using ICD-10 code I63.8, and non-lacunar IS (ICD-10: I63 excluding I63.8). IHD types were identified using ICD-10 codes I21 for AMI, I20 for angina and I22-I25 for other IHD. Hospital admissions for any cause were identified using all ICD-10 codes, and were used as a measure of overall healthcare use and for comparison purposes with stroke and IHD.

4.3.4 Definitions of outcomes of interest

The outcomes of interest in this thesis were number of inpatient admissions, 28-day case fatality, length of hospital stay, use of diagnostics tests and procedures and choice of hospital tier (tier 1, 2 or 3). Length of stay was defined as the duration

of hospitalisation and calculated by subtracting the day of admission from the day of discharge or date of death, when relevant. Case fatality was defined as the proportion of patients who died within the first 28 days after their first stroke or IHD.

4.4 Summary

In this chapter, the study design, participant recruitment, baseline survey and resurveys, methods used for follow-up in the CKB, as well as data collected and analytical framework used, were described. Chapter 5 outlines the results of socioeconomic differences in hospital care utilisation and outcomes for stroke and IHD between 2009 and 2016 in the CKB study population.

References

1. Chen Z, Chen J, Collins R, et al. China Kadoorie Biobank of 0.5 million people: survey methods, baseline characteristics and long-term follow-up. *International Journal of Epidemiology*. 2011; **40**(6): 1652-66.

2. Chen Z, Lee L, Chen J, et al. Cohort Profile: The Kadoorie Study of Chronic Disease in China (KSCDC). *International Journal of Epidemiology*. 2005; **34**(6): 1243-9.

3. Chen Z. Population Biobank Studies: A Practical Guide: Springer; 2020.

4. Andersen RM. National health surveys and the behavioral model of health services use. *Medical Care*. 2008; **46**(7): 647-53.

5. Xie X, Wu Q, Hao Y, et al. Identifying Determinants of Socioeconomic Inequality in Health Service Utilization among Patients with Chronic Non-Communicable Diseases in China. *PLOS One*. 2014; **9**(6): e100231.

6. Elwell-Sutton TM, Jiang CQ, Zhang WS, et al. Inequality and inequity in access to health care and treatment for chronic conditions in China: the Guangzhou Biobank Cohort Study. *Health Policy and Planning*. 2013; **28**(5): 467-79.

7. Li X, Zhang W. The impacts of health insurance on health care utilization among the older people in China. *Social Science & Medicine*. 2013; **85**: 59-65.

8. Gong CH, Kendig H, He X. Factors predicting health services use among older people in China: An analysis of the China Health and Retirement Longitudinal Study 2013. *BMC Health Services Research*. 2016; **16**: 63.

Chapter 5. Socioeconomic differences in hospital care utilisation and outcomes for stroke and ischaemic heart disease in China

5.1 Background

The rapid demographic and epidemiologic transitions that have occurred in China in recent decades have resulted in an increased burden of cardiovascular diseases (CVD) and greater financial pressures on the healthcare system.[1-3] Since 2009, China implemented major healthcare reforms to provide basic healthcare for all by 2020 and reduce healthcare inequalities, especially between urban and rural areas. As discussed in the review of previous published studies (**Chapter 3**), the available data indicate that since 2004 rates of hospitalisation for stroke and acute myocardial infarction (AMI) have increased, length of hospital stay (LOS) for stroke has decreased, and in-hospital mortality rates have decreased for both stroke and AMI in China. However, most previous studies used data from higher tier hospitals and very few measured socioeconomic inequalities in healthcare use for CVD in the general population in China. In previous studies, the age-standardised case fatality rates for stroke and IHD were similar in urban and rural areas in Zhejiang in 2012,[4] results on in-hospital mortality rates for AMI by urban-rural areas and health insurance (HI) type were inconclusive,[5-8] and LOS for ST-elevation MI (STEMI) was slightly lower in rural than urban hospitals in 2006 but not in 2011.[5] As most studies were based on routinely collected data in hospitals, they were constrained by a short duration of follow-up and no data were available on outcomes after discharge. To address these limitations, the aims of the present

study were to use data from the China Kadoorie Biobank (CKB) study to: (1) examine trends in annual rates of hospitalisations, 28-day case fatality rates and average length of hospital stay (ALOS) for stroke, IHD, and any cause between 2009 and 2016; and (2) investigate differences in hospitalisation rates, 28-day case fatality rates and ALOS between different socioeconomic groups over this period.

5.2 Methods

5.2.1 Participants and follow-up

All CKB participants alive in 2009 were included in the present analyses. Participants contributed person years of outcome data from 1 January 2009 until the earliest of their date of death, loss-to-follow up, or the end of follow-up for hospital admissions (31 December 2016). The study period was restricted to admissions after 2009, because recruitment to the CKB was completed on July 15, 2008 and record linkage to HI records was most complete starting in 2009. This chapter is based on release 16 of the CKB data.

5.2.2 Outcome measures

The main outcome measures were the annual number of hospital admissions, 28-day case fatality, and length of stay of admissions for stroke, IHD, and any cause (see **Chapter** 4). Day case admissions (i.e. participants admitted and discharged on the same day) were counted as having a length of stay of 0.5 days. The 28-day case fatality was defined as death within 28 days from the first-ever event for stroke or IHD for participants with no prior history of stroke, transient ischaemic attack (TIA), or IHD before 2009. Deaths without a related prior hospital admission within 28 days and identified using death registries, were also included in the outcome for case fatality. The outcomes were selected as they are internationally recognised indicators that reflect the utilisation of healthcare services. The rate of hospitalisation is a widely used measure of healthcare utilisation. The ALOS for hospital care is a comprehensive index, used by the Organisation for Economic

Co-operation and Development (OECD), that reflects medical quality and efficiency.[9] Case fatality, also used by the OECD and the Agency for Healthcare Research and Quality, measures access to, quality and outcomes of care.

Hospital admissions included all first and subsequent inpatient admissions occurring in public and private hospitals across all hospital tiers. For rates of hospitalisation and ALOS, data for all hospital admissions in 2009-2016 from HI records and disease registries were used. In the study of case fatality rates, only the first hospital admission or death event in 2009-2016 from HI records or disease or death registries were used.

5.2.3 Key factors of interest

To assess temporal trends in rates of hospitalisations, case fatality rates and ALOS, the variable for calendar year (2009 to 2016) was used. Calendar years (1 January to 31 December) were used to align with fiscal year for the Chinese government and related agencies (i.e. HI providers).

To measure differences in hospitalisation rates, case fatality rates and ALOS between socioeconomic groups, the socioeconomic characteristics studied were urban and rural area of residence, highest level of education attained (no formal school, primary or middle school, high school or above), annual household income in Chinese Yuan (<10 000, 10 000-19 999, 20 000-34 999, ≥35 000), and HI type (Urban Employee Basic Medical Insurance [UEBMI], Urban Resident Basic Medical Insurance [URBMI] or New Rural Cooperative Medical Scheme [NRCMS] and other). While information on education and income level was collected at entry into the CKB study only, HI type information was updated annually since 2012.

5.2.4 Other determinants of healthcare utilisation and outcome

Based on the analytical framework in **Chapter** 4, different groups of covariates were adjusted for in the models, including demographic, socioeconomic, lifestyle and morbidity factors. Demographic factors included continuous age, age-squared, age-cubed, sex, and region. Socioeconomic factors included marital status, household size, highest level of education attained, annual household income, and HI type. Lifestyle factors included smoking and alcohol consumption, body-mass index (BMI), physical activity assessed using metabolic equivalents of task (MET), and self-rated health status. Morbidity factors included history of self-reported doctor-diagnosed diseases at entry into CKB, with updated history of eight major diseases as defined in **Chapter 4**. Additional adjustments were made for stroke type (ischaemic [IS], haemorrhagic [HS], or unspecified) and IHD type (AMI or other IHD) in analyses of case fatality and ALOS.

5.2.5 Statistical analysis

Statistical models

Models for rates of hospitalisation, case fatality rates and ALOS were first estimated with adjustment for demographic factors only (i.e. minimally adjusted models), and then with adjustment for demographic, socioeconomic, lifestyle, and morbidity factors (i.e. fully adjusted models).

Based on the distribution and type (e.g. count data) of outcome measures, and on the literature on modelling measures of healthcare utilisation,[10,11] the Generalised Linear Model (GLM) framework was chosen as it offers greater flexibility for

modelling non-normally distributed data. Annual rates of hospital admissions were modelled using GLM with log-link function and negative binomial distribution. Annual 28-day case fatality rates were modelled using GLM with logit link function and binomial distribution. Annual ALOS per admission was estimated using GLM with log link function and gamma distribution.[10] These model specifications were selected from a wider pool of candidate models using a range of common specification tests and a comparison of model fit (**Appendix D).** Cluster adjusted robust standard errors were estimated to account for the likely dependence between multiple hospital admissions of participants across different years. The year-specific 95% confidence intervals (CIs) for rate ratios (RRs) were estimated from the variance of the log risk in each year (including the reference year category).[12] Such CIs are approximately independent, enabling comparisons between any two years, irrespective of the choice of a reference year.

Analyses by socioeconomic characteristics were estimated using an interaction between calendar year and each socioeconomic variable. Participants who were uninsured were excluded from analyses by HI type because of the small number of cases. Models by urban or rural areas did not include adjustments for HI type, because of substantial correlation between these two variables. Individuals with missing data on BMI were excluded from analyses involving BMI.

As disease registers only included admission dates but not discharge dates for all events, the LOS for admissions from disease registers could not be calculated and were denoted as being missing (stroke: 12 586 [16.9%], IHD: 5535 [8.0%], any cause: 30 232 [3.8%]). Multiple imputation was used to replace the missing values for LOS (**Appendix D**).

Trends in annual rates of hospitalisation, case fatality and ALOS

To assess trends in annual rates of hospitalisation, case fatality rates and ALOS, the percentage changes per calendar year for these outcomes were estimated, by including calendar year as a continuous variable in models. Heterogeneity or, if relevant (i.e. more than two ordered categories), trends in annual rates of hospitalisation, case fatality, and ALOS between categories of participants by urban and rural areas, education, income, and HI type were assessed using χ^2 tests for heterogeneity or trend.

Rates of hospitalisation, case fatality and ALOS

Following existing recommendations of reporting both relative and absolute measures to assess health inequalities, absolute measures of hospitalisation rates, case fatality rates and ALOS were estimated.[13,14] Indeed, relative and absolute differences can have opposing temporal trends, and relative measures do not capture information on levels of healthcare utilisation. Absolute outcome measures involved standardised average admission rates (per 1000 person-years), case fatality rates (per 100 events), and ALOS (in days) for each calendar year of follow-up derived from the estimation models previously described, but with calendar year included as a categorical variable. The method of recycled predictions (or predictive margins) using characteristics of all CKB study participants in 2009 was applied. The estimates for urban and rural areas, in which adjustment for region was used, were standardised using the separate CKB populations in urban and rural areas in 2009 (instead of all CKB study participants), because each CKB region only contributed data for urban or rural areas.

To assess whether differences in healthcare utilisation and outcome between socioeconomic groups have narrowed over time, annual differences in rates of hospitalisation, case fatality rates, and ALOS between the two most extreme groups of each socioeconomic characteristic, and an annual slope index of inequality for each characteristic except urban and rural area, were also estimated, together with a test for linear trend. The slope index of inequality[1] is a weighted measure of inequality that takes account of the entire distribution of each socioeconomic characteristic, rather than only comparing the two most extreme groups.[15,16]

Sensitivity analyses

It is important to assess the sensitivity of the estimated annual trends and standardised estimates of rates of hospitalisation, case fatality and ALOS, to the methodological assumptions made. To explore the effect of recurrent admissions on annual trends in rates of hospitalisation and ALOS, hospital admissions were restricted to first-ever admissions for stroke or IHD in the study. To examine the sensitivity of standardised estimates in urban and rural areas to standardisation using separate urban or rural CKB populations in 2009, the annual differences in hospitalisation rates, case fatality rates, and ALOS, and slope index of inequality between urban and rural area were standardised for the overall CKB study population in 2009, but without adjustment for region. To check if trends in healthcare utilisation were sensitive to the type of income measure used, annual

[1]It is estimated as the difference in predicted rates between the highest (ridit score of 1) and the lowest (ridit score of 0) values of the distribution of each socioeconomic characteristic.

trends by income were estimated using quartiles of approximated equivalent income.

Further analyses

To gain a better understanding of trends in healthcare utilisation for stroke and IHD, models for rates of hospitalisation, case fatality rates and ALOS were estimated by stroke type (ischaemic or haemorrhagic) and IHD type (AMI or other IHD). Models for rates of hospitalisation, case fatality rates and ALOS were also estimated by age group (<60, 60-69, ≥70 years) to check for the suitability of adjustments for age and for remaining differential trends by age. To explore non-linear trends over time and the effect of different healthcare reform cycles, trends in hospitalisation rates, case fatality rates, and ALOS were assessed during the first (2009-2012) and the second half (2013-2016) of the study period separately.

5.3 Results

5.3.1 Participant characteristics at recruitment and details of follow-up

Enrolment in the CKB took place between June 25, 2004, and July 15, 2008. Among the 512 715 participants in the CKB, 6469 died and 251 were lost to follow-up before 2009, leaving 505 995 (99%) participants contributing data between January 1, 2009, and December 31, 2016, for the present analyses. In 2009-2016, 4500 participants were lost to follow-up. Two individuals had missing data on BMI. Among the 505 995 participants, the mean age was 54.7 years (SD 10.6) in 2009 and 59.2% (299 793) were women (**Table 5.1**). At entry into the CKB (2004-2008), the mean (SD) age was: 51.7 (10.6) years for all, 52.8 (10.8) years for urban and 51.2 (10.4) years for rural participants

There were marked differences in the distribution of CVD risk factors between urban and rural areas. The prevalence of diabetes (5.6% vs 1.9%), hypertension (13.7% vs 9.8%), IHD (4.6% vs 1.7%) and stroke or TIA (2.3% vs 1.2%) at entry into the study were all higher in urban than in rural areas. Likewise, a higher proportion of urban residents were overweight or obese (40.1%) compared to rural residents (27.5%). The mean levels of physical activity were higher in rural (23.3 MET.hours/day) than in urban areas (18.5 MET.hours/day). In both urban and rural areas, a higher proportion of men than women were current smokers (61.1% vs 2.3%) and regular alcohol drinkers (44.7% vs 3.9%). The proportion of men who were current smokers was higher in rural than in urban areas (66.0% vs 54.9%), while the proportion of men who were regular drinkers was higher in urban than

rural areas (50.0% vs 40.5%). A higher proportion of individuals in rural than urban areas self-reported poor health status (11.0% vs 9.0%).

A lower proportion of individuals living in urban than rural areas was married (89.4% vs 91.8%) and the mean household size was higher in rural than urban areas (4.2 vs 3.2 persons). The proportion of participants who had completed high school education was higher in those living in urban than in rural areas (36.0% vs 9.3%), as was the proportion of participants with an annual household income of ¥35 000 or greater (25.4% vs 12.3%). In 2012, 56.8% of participants were enrolled in URBMI or NRCMS (53.4% in NRCMS and 3.4% in URBMI), 37.7% were enrolled in UEBMI, and only 5.5% were uninsured or had missing HI type (1%). Most participants living in urban areas were enrolled in the UEBMI (71.9%), while most participants living in rural areas were enrolled in the NRCMS (86.2%). The distribution of participants by education level, household income level and HI type varied substantially between the ten CKB areas and within urban and rural areas (**Table 5.2**).

During 3.92 million person-years of follow-up between 2009 and 2016, 794 824 hospital admissions were recorded for 268 070 participants, which included 74 313 (9.3%) admissions for stroke and 69 446 (8.7%) admissions for IHD. Among all stroke admissions, 87.3% were IS, 10.6% were HS (9.4% subarachnoid haemorrhage and 90.6% intracerebral haemorrhage) and 2.1% were unspecified stroke types. From all IHD admissions, 4.7% were AMI and 95.3% were other IHD. Between 2009 and 2016, 47.0% of participants had no hospital admission, 21.9% had one admission and 31.1% had at least two admissions for any cause. For stroke, 91.0% of participants had no admission, 6.0% had one admission and 3.0%

had at least two admissions. For IHD, 92.5% of participants had no admission, 4.8% had one admission and 2.7% had at least two admissions.

Table 5.1 Selected characteristics of study participants at entry into CKB in all areas and by urban and rural areas

	All (n=505 995)		Urban (n=224 093)		Rural (n=281 902)	
Demographic characteristics						
Age[1], Mean (SD)	54.7	(10.6)	55.4	(10.9)	54.2	(10.4)
Women, n (%)	299 793	(59.3)	133 933	(59.8)	165 860	(58.8)
Self-reported prior medical history, n (%)						
Diabetes	15 604	(3.1)	10 255	(4.6)	5349	(1.9)
Hypertension	58 237	(11.5)	30 625	(13.7)	27 612	(9.8)
IHD	15 018	(3.0)	10 267	(4.6)	4751	(1.7)
Stroke or TIA	8454	(1.7)	5081	(2.3)	3373	(1.2)
Lifestyle characteristics						
BMI, n (%)						
Normal	338 770	(67.0)	134 233	(59.9)	204 537	(72.6)
Overweight	146 475	(28.9)	77 721	(34.7)	68 754	(24.4)
Obese	20 750	(4.1)	12 139	(5.4)	8609*	(3.1)
Physical activity (MET. hours/day), mean (SD)	21.2	(13.9)	18.5	(12.6)	23.3	(14.4)
Current smoker, n (%)						
Men	126 084	(61.1)	49 517	(54.9)	76 567	(66.0)
Women	6981	(2.3)	2713	(2.0)	4268	(2.6)
Regular alcohol drinker, n (%)						
Men	92 090	(44.7)	45 067	(50.0)	47 023	(40.5)
Women	11 695	(3.9)	5749	(4.3)	5946	(3.6)
Self-reported poor health status, n (%)	51 187	(10.1)	20 205	(9.0)	30 982	(11.0)
Socioeconomic characteristics						
Married, n (%)	459 051	(90.7)	200 278	(89.4)	258 773	(91.8)
Household size, Mean (SD)	3.8	(1.5)	3.2	(1.3)	4.2	(1.5)
Education, n (%)						
No formal school	92 965	(18.4)	26 434	(11.8)	66 531	(23.6)
Primary/middle school	306 273	(60.5)	117 066	(52.2)	189 207	(67.1)
High school and above	106 757	(21.1)	80 593	(36.0)	26 164	(9.3)
Household income (¥/year), n (%)						
<10 000	141 424	(28.0)	30 188	(13.5)	111 236	(39.5)
10 000-19 999	147 143	(29.1)	65 436	(29.2)	81 707	(29.0)
20 000-34 999	125 696	(24.8)	71 495	(31.9)	54 201	(19.2)
≥35 000	91 732	(18.1)	56 974	(25.4)	34 758	(12.3)
Health insurance type[2], n (%)						
UEBMI	186 369	(37.7)	158 288	(71.9)	28 081	(10.2)
URBMI or NRCMS	280 967	(56.8)	44 505	(20.2)	236 462	(86.2)
Uninsured	27 027	(5.5)	17 321	(7.9)	9 706	(3.5)

[1]Age is for the year 2009. [2]Information on HI type is for the year 2012 (n=494 363), as annual linkage to participants' HI scheme was only available from 2012 and missing HI type in 2009-2011 was imputed based on the HI scheme participants were enrolled in 2012. *Two individuals had missing data for BMI.

Table 5.2 Number of participants by socioeconomic category, in each CKB region in 2009

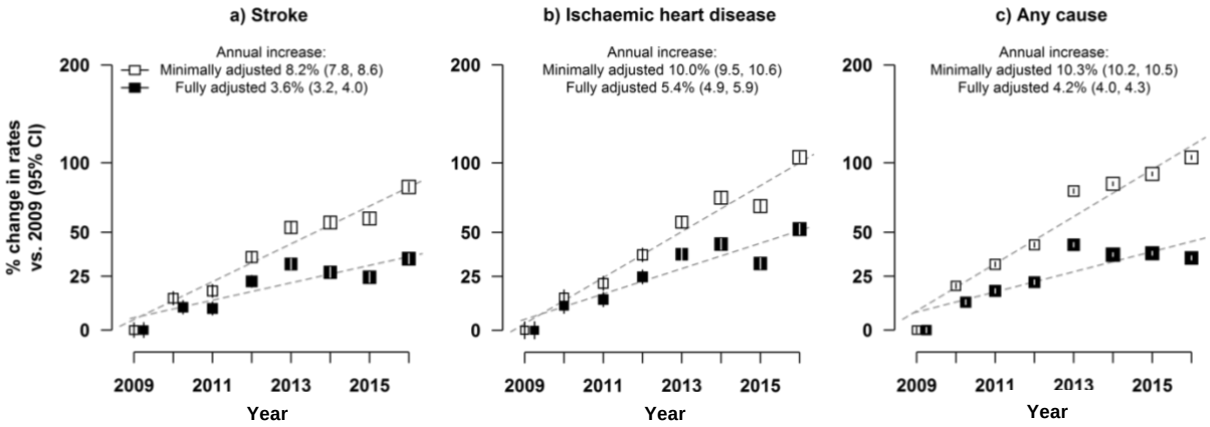
		Education, n (%)			Household income (¥/year), n (%)				Health insurance type in 2012, n (%)		
		No formal school	Primary/middle school	High school and above	<10 000	10 000-19 999	20 000-34 999	≥35 000	URBMI or NRCMS	UEBMI	Uninsured/Others
Urban	**Qingdao n=35 202**	2025	20 614	12 563	2748	11 258	15 302	5 894	689	33 204	793
		(5.8)	(58.6)	(35.7)	(7.8)	(32.0)	(43.5)	(16.7)	(2.0)	(95.7)	(2.3)
	Harbin n=56 763	2305	23 056	31 402	7129	19 028	17 800	12 806	3646	47 556	4189
		(4.1)	(40.6)	(55.3)	(12.6)	(33.5)	(31.4)	(22.6)	(6.6)	(85.9)	(7.6)
	Haikou n=29 568	4347	14 097	11 124	6504	9382	6464	7218	10 967	12 760	5531
		(14.7)	(47.7)	(37.6)	(22.0)	(31.7)	(21.9)	(24.4)	(37.5)	(43.6)	(18.9)
	Suzhou n=52 795	15 699	31 925	5171	6267	7650	16 729	22 149	22 580	24 329	5160
		(29.7)	(60.5)	(9.8)	(11.9)	(14.5)	(31.7)	(42.0)	(43.4)	(46.7)	(9.9)
	Liuzhou n=49 765	2058	27 374	20,333	7540	18 118	15 200	8907	6623	40 439	1648
		(4.1)	(55.0)	(40.9)	(15.2)	(36.4)	(30.5)	(17.9)	(13.6)	(83.0)	(3.4)
	Total n=281 902	26 434	117 066	80 593	30 188	65 436	71 495	56 974	44 505	158 288	17 321
		(11.8)	(52.2)	(36.0)	(13.5)	(29.2)	(31.9)	(25.4)	(20.2)	(71.9)	(7.9)
Rural	**Sichuan n=54 619**	8257	41 953	4409	34 002	15 665	3131	1821	39 477	11 599	1986
		(15.1)	(76.8)	(8.1)	(62.3)	(28.7)	(5.7)	(3.3)	(74.4)	(21.9)	(3.7)
	Gansu n=48 880	22 274	22 140	4466	38 165	9623	977	115	44 815	1100	1524
		(45.6)	(45.3)	(9.1)	(78.1)	(19.7)	(2.0)	(0.2)	(94.5)	(2.3)	(3.2)
	Henan n=62 401	8085	44 571	9745	25 612	27 600	7405	1784	56 151	1986	2606
		(13.0)	(71.4)	(15.6)	(41.0)	(44.2)	(11.9)	(2.9)	(92.4)	(3.3)	(4.3)
	Zhejiang n=57 027	24 994	29 840	2193	3824	8061	23 580	21 562	43 747	10 592	1530
		(43.8)	(52.3)	(3.9)	(6.7)	(14.1)	(41.4)	(37.8)	(78.3)	(19.0)	(2.7)
	Hunan n=58 975	2921	50 709	5354	9633	20 758	19 108	9476	52 272	2804	2060
		(5.0)	(86.0)	(9.1)	(16.3)	(35.2)	(32.4)	(16.1)	(91.5)	(4.9)	(3.6)
	Total n=281 902	66 531	189 207	26 164	111 236	81 707	54 201	34 758	236 462	28 081	9706
		(23.6)	(67.1)	(9.3)	(39.5)	(29.0)	(19.2)	(12.3)	(86.2)	(10.2)	(3.5)

5.3.2 Trends in annual rates of hospitalisation

Overall trends and estimates of annual rates of hospitalisation

The hospitalisation rates adjusted for age, sex, and region increased by 8.2% for stroke (95% CI 7.8, 8.6), 10.0% for IHD (9.5,10.6), and 10.3% for any cause (10.2, 10.5) per year between 2009 and 2016. Following further adjustment for individual socioeconomic, lifestyle, and morbidity factors, the corresponding annual increases in hospitalisation rates decreased by about half to 3.6% for stroke (3.2, 4.0), 5.4% for IHD (4.9, 5.9), and 4.2% for any cause (4.0, 4.3) (**Figure 5.1**). The fully adjusted annual hospital admission rates increased from 10.9 (95% CI 10.5, 11.2) in 2009 to 14.5 (14.2, 14.9) admissions per 1000 person-years in 2016 for stroke; from 9.3 (8.9, 9.6) to 14.1 (13.7, 14.4) for IHD, and from 112.2 (111.0, 113.3) to 151.2 (150.0, 152.5) for any cause (**Appendix Figure D.1**).

Figure 5.1 Adjusted annual percentage change in rates of hospitalisation for stroke, ischaemic heart disease and any cause, since 2009

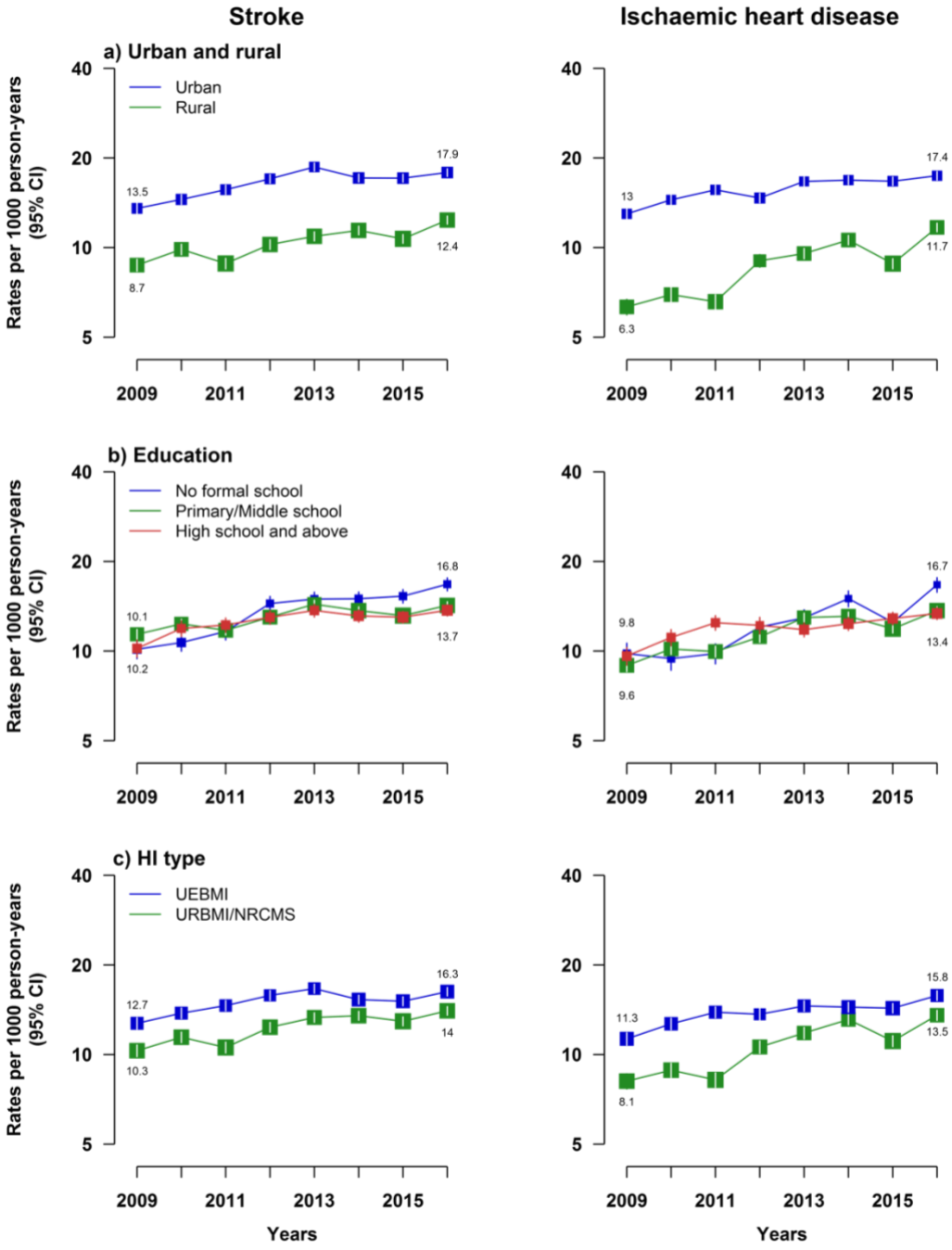


The area of each square is inversely proportional to the variance of the estimate.

Trends and estimates of annual rates of hospitalisation between socioeconomic groups

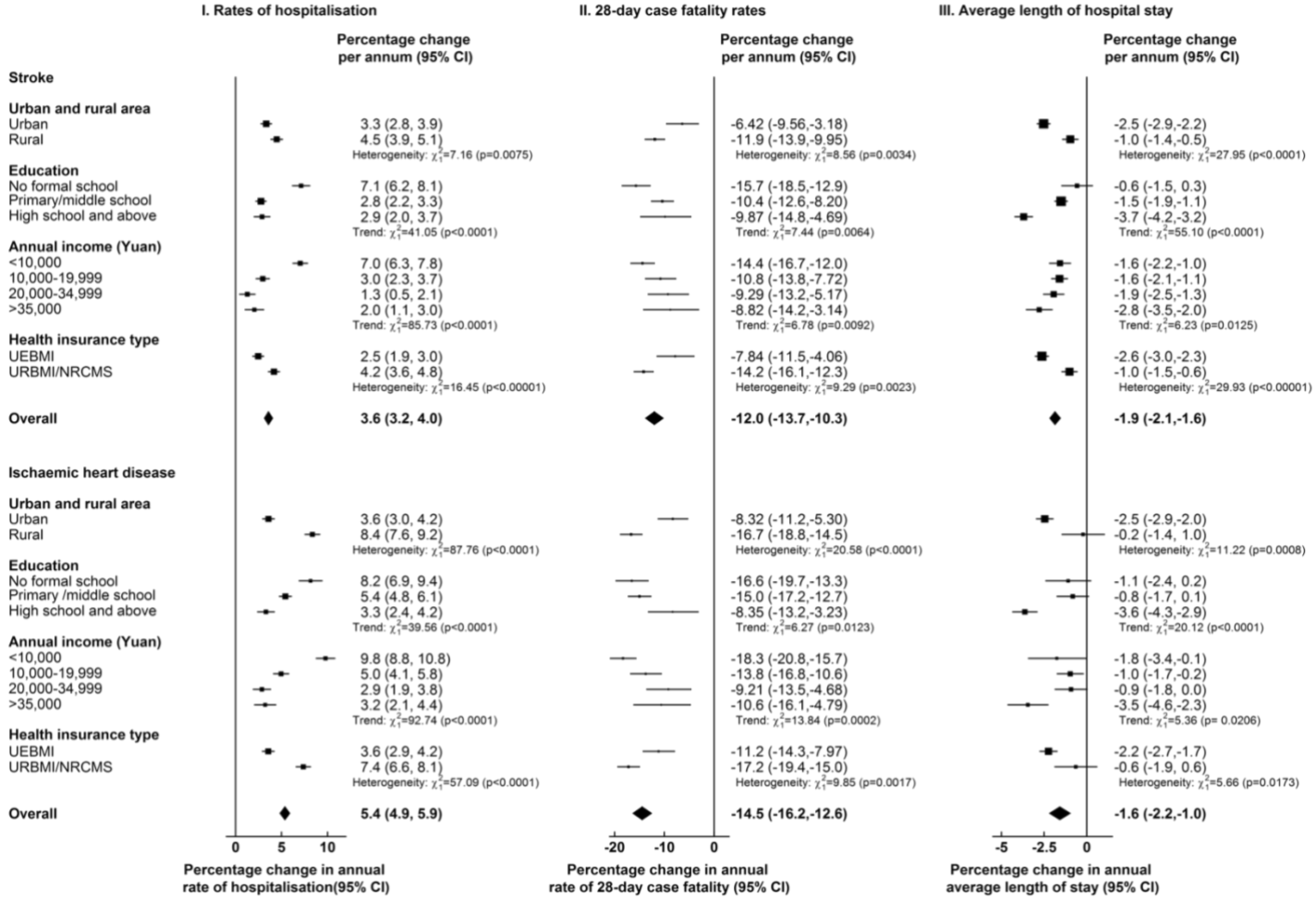
In 2009, the rates of hospitalisation were higher in urban than in rural areas for stroke (13.5 vs 8.7 admissions per 1000 person-years) and for IHD (13.0 vs 6.3; **Figure 5.2**). The differences in hospitalisation rates between individuals living in urban and rural areas in 2009-2016 only decreased for IHD (trend: p=0.013; **Appendix Table D.1**). The fully adjusted annual increases in hospitalisation rates were higher for individuals living in rural than in urban areas for stroke (4.5% vs 3.3%) and IHD (8.4% vs 3.6%; **Figure 5.3**). Although the fully adjusted hospitalisation rates for stroke and IHD were largely similar by levels of education for most of the study period, individuals with no formal education had the greatest annual increase in hospitalisation rates for both stroke (7.1%) and IHD (8.2%). Similarly, individuals in the lowest income group had the highest annual increase in fully adjusted hospitalisation rates for stroke (7.0%) and IHD (9.8%). Individuals enrolled in UEBMI had higher rates of hospitalisation for stroke and IHD than those enrolled in URBMI or NRCMS (stroke: 12.7 vs 10.3 per 1000 person-years in 2009; IHD: 11.3 vs 8.1 per 1000 person-years in 2009; **Figure 5.2**). The differences and slope index of inequality in hospitalisation rates between UEBMI and URBMI or NRCMS enrollees decreased over time for stroke (trend: differences p=0.039; slope p=0.014) and IHD (both p<0.0001; **Appendix Table D.1**). The annual increases in rates were higher for individuals enrolled in URBMI or NRCMS than in UEBMI (stroke: 4.2% vs 2.5%; IHD: 7.4% vs 3.6%; **Figure 5.3**).

Figure 5.2 Fully adjusted annual rates of hospitalisation for stroke and ischaemic heart disease, by urban/rural area, education and health insurance type



NRCMS: new rural cooperative medical scheme, UEBMI: urban employee basic medical insurance, URBMI: urban resident basic medical insurance. Rates per 1000 person-years are shown from 2009 to 2016. The area of each square is inversely proportional to the variance. 95% confidence intervals are shown.

Figure 5.3 Fully adjusted annual percentage change in rates of hospitalisation, 28-day case fatality, and average length of stay for stroke and IHD, by urban/rural, education, income and health insurance type



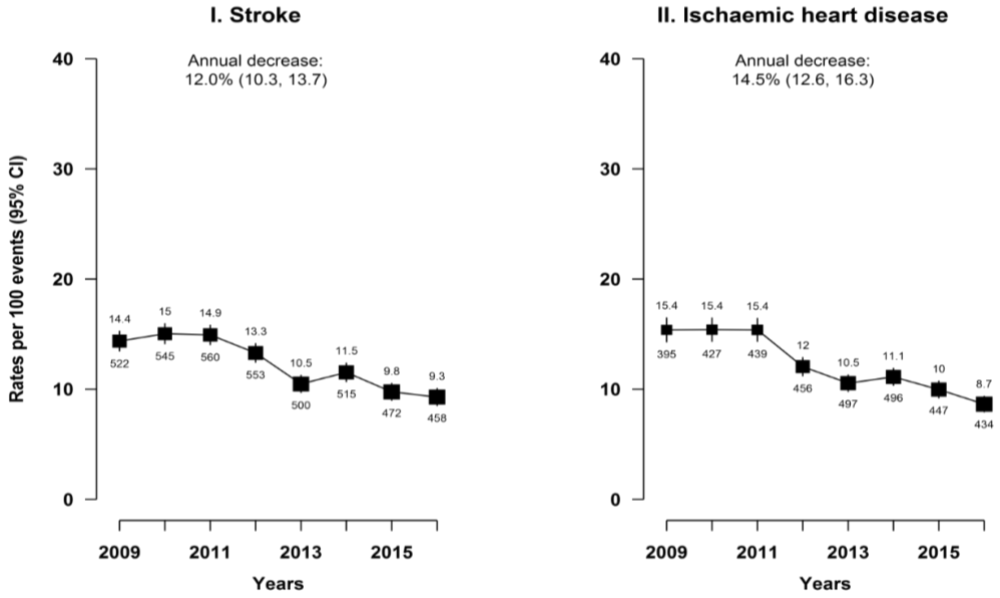
NRCMS: new rural cooperative medical scheme, UEBMI: urban employee basic medical insurance, URBMI: urban resident basic medical insurance. The area of each square is inversely proportional to the variance.

5.3.3 Trends in annual 28-day case fatality rates

Overall trends and estimates of annual 28-day case fatality rates

The minimally and fully adjusted 28-day case fatality rates were very similar. The fully adjusted 28-day case fatality rates for stroke decreased over time, from 14.4 to 9.3 deaths per 100 events (by 12.0% [10.3, 13.7] per year), and for IHD from 15.4 to 8.7 deaths per 100 events (by 14.5% [12.6, 16.3] per year; **Figure 5.4**). The proportion of deaths within 28 days that were without a prior hospital admission decreased over time from 80.3% in 2009 to 60.3% in 2016 for stroke and from 91.1% to 77.7% for IHD.

Figure 5.4 Fully adjusted 28-day case fatality rates for stroke and ischaemic heart disease, by calendar year

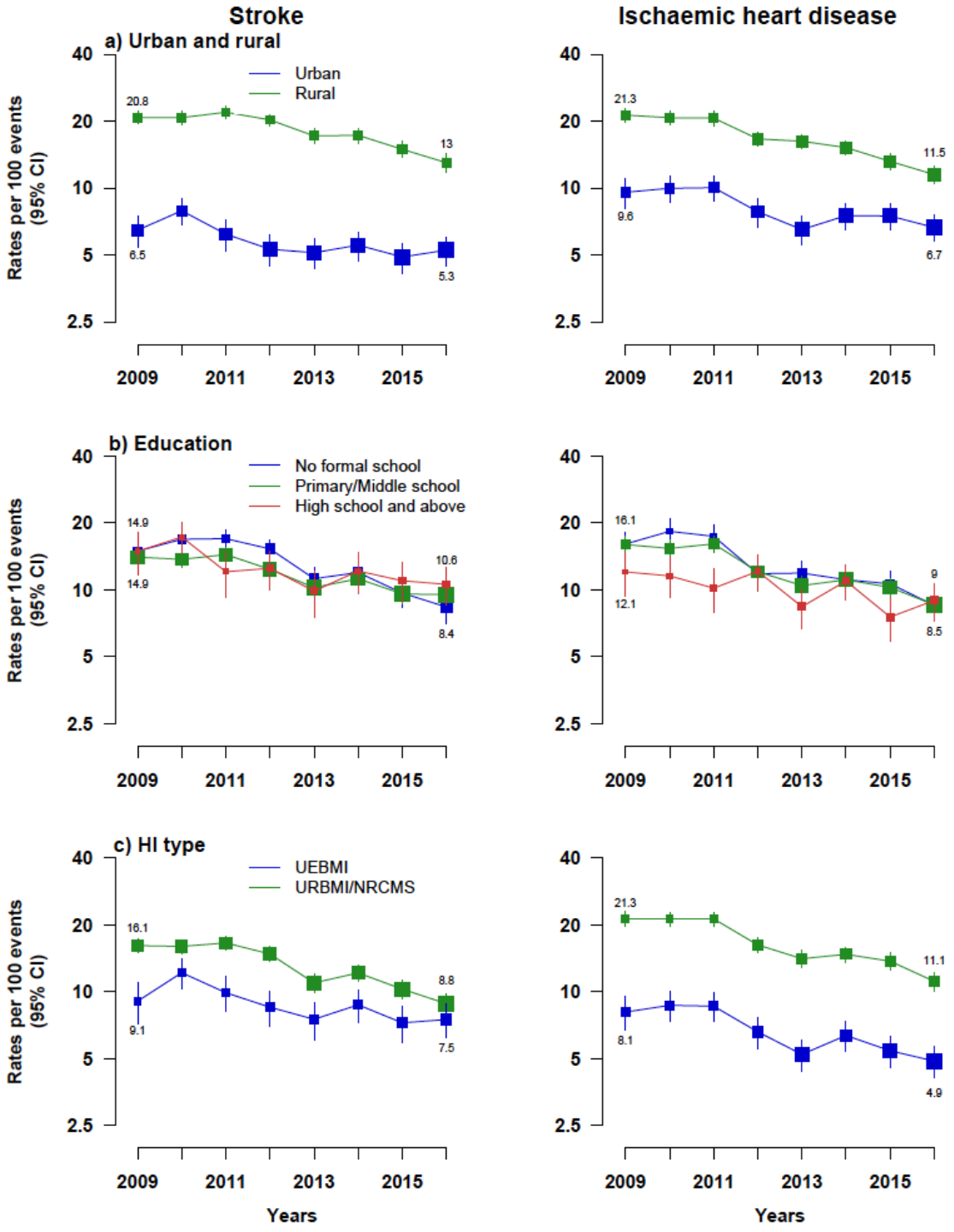


Numbers above the squares are 28-day case fatality rates and numbers below the squares are the number of cases.

Trends and estimates of annual 28-day case fatality rates between socioeconomic groups

Case fatality rates for stroke and IHD were much higher for individuals living in rural than in urban areas in 2009-2016 (stroke: 20.8 vs 6.5 deaths per 100 events, IHD: 21.3 vs 9.6 in 2009; **Figure 5.5**). However, the annual proportional reduction in case fatality rates was around 2-fold greater for rural than urban residents (stroke: 11.9% vs 6.4%; IHD: 16.7% vs 8.3%; **Figure 5.3**). During the study period, case fatality rates decreased to a greater extent in individuals with lower levels of education or income (**Figure 5.3**; **Appendix Figure D.2**). Likewise, while 28-day case fatality rates were higher for URBMI or NRCMS than for UEBMI enrollees (stroke: 16.1 vs 9.1 deaths per 100 events; IHD: 21.3 vs 8.1 in 2009; **Figure 5.5**), the annual reduction in case fatality rates was greater in URBMI or NRCMS enrollees (stroke: 14.2% vs 7.8%, IHD: 17.2% vs 11.2%; **Figure 5.3**). Both the differences and slope index of inequality in case fatality rates for stroke and IHD between individuals living in rural vs urban areas, and those enrolled in URBMI or NRCMS vs UEBMI decreased over time (all trends $p<0.05$; **Appendix Table D.2**).

Figure 5.5 Fully adjusted annual 28-day case fatality rates for stroke and ischaemic heart disease, by urban/rural area, education and health insurance type



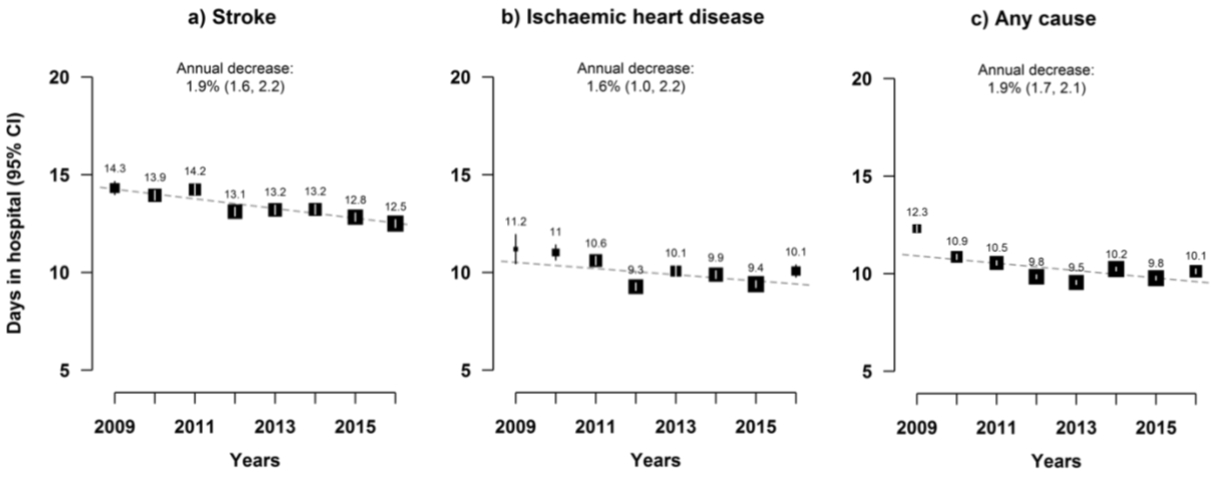
NRCMS: new rural cooperative medical scheme, UEBMI: urban employee basic medical insurance. URBMI: urban resident basic medical insurance. Rates per 100 events are shown for the years 2009 and 2016. The area of each square is inversely proportional to the variance. 95% confidence intervals are shown.

5.3.4 Trends in annual average length of hospital stay

Overall trends and estimates of annual average length of hospital stay

Trends and estimates of annual ALOS from minimally adjusted models were very similar to those from fully adjusted models. Between 2009 and 2016, the annual ALOS decreased progressively by 1.9% for stroke (from 14.3 in 2009 to 12.5 days in 2016), 1.6% for IHD (from 11.2 to 10.1 days) and 1.9% for any cause (from 12.3 to 10.1 days), respectively (**Figure 5.6**).

Figure 5.6 Fully adjusted average length of hospital stay for stroke, ischaemic heart disease, and any cause, by calendar year



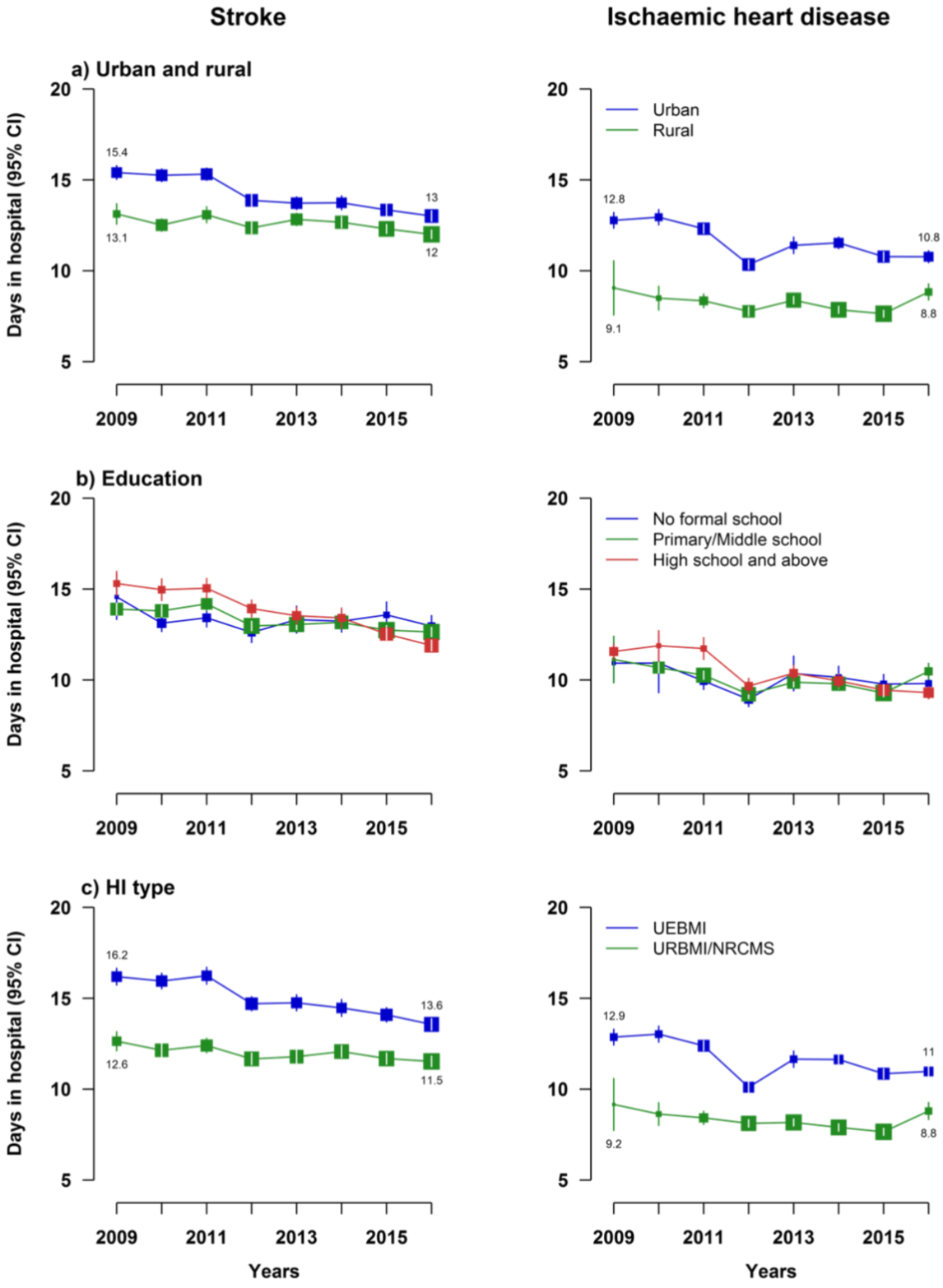
Numbers above the squares are the average length of stay in days. The area of each square is inversely proportional to the variance. 95% confidence intervals are shown.

Trends and estimates of annual average length of stay between socioeconomic groups

Urban residents had a longer ALOS for stroke and IHD than rural residents (stroke: 15.4 vs 13.1 days; IHD: 12.8 vs 9.1, in 2009) and likewise for UEBMI vs URBMI or NRCMS enrollees (**Figure 5.7**). For both stroke and IHD, individuals in the highest education and income group had longer ALOS only during the first few years of

follow-up, then ALOS were similar across groups (**Figure 5.7**, **Appendix Figure D.2**). The annual decrease in ALOS was greater for individuals with the highest levels of education or income for stroke, IHD and any cause, and for individuals living in urban areas and those enrolled in UEBMI for stroke and IHD (**Figure 5.3**, **Appendix Figure D.3**). The differences in ALOS for stroke and IHD between the highest and lowest category and the slope index of inequality decreased over time for most socioeconomic characteristics (**Appendix Table D.3**).

Figure 5.7 Fully adjusted annual average length of hospital stay for stroke and ischaemic heart disease, by urban/rural area, education and health insurance type

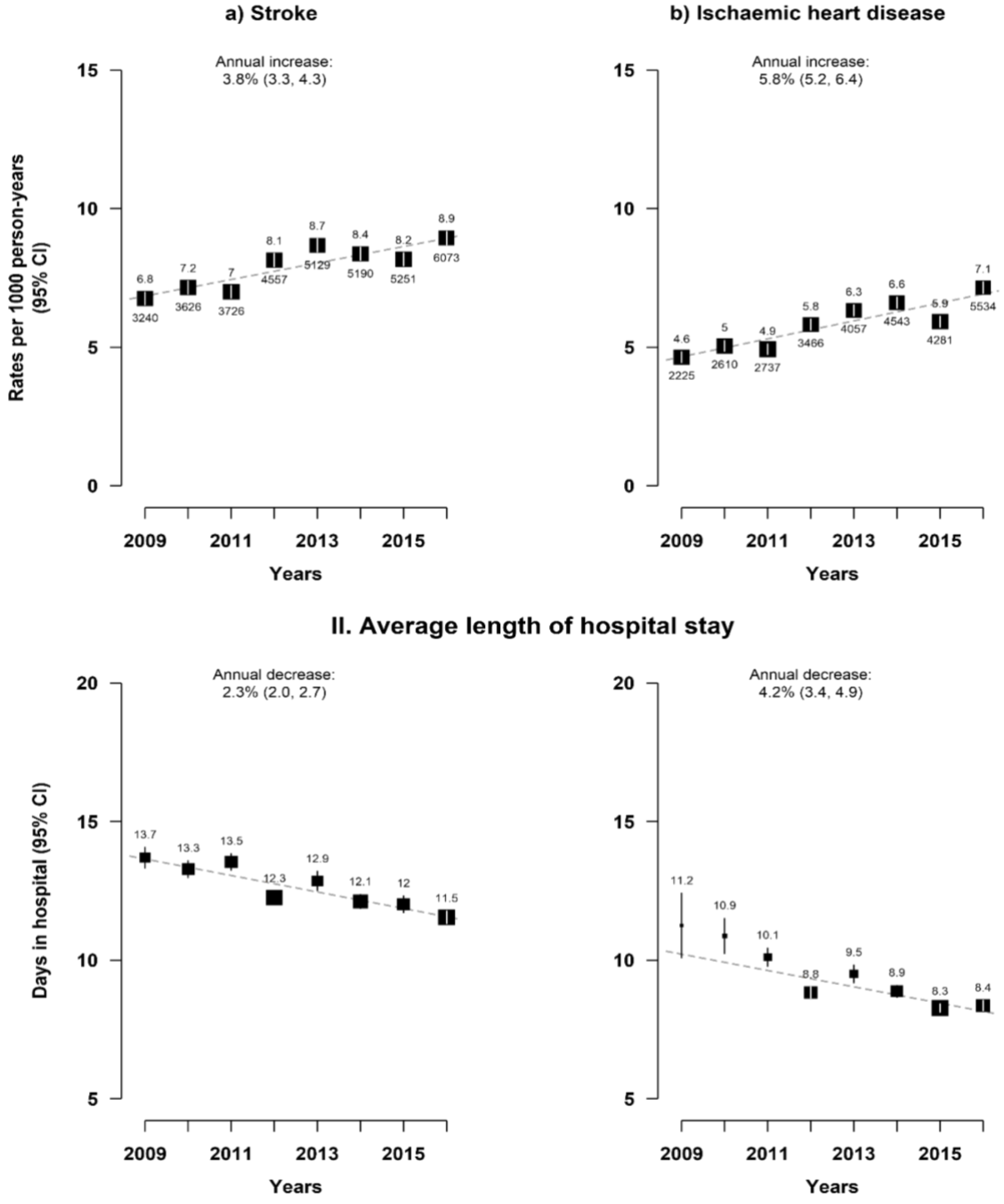


Numbers above the squares are ALOS in days. The area of each square is inversely proportional to the variance. 95% confidence intervals are shown.

5.3.5 Sensitivity analyses

The fully adjusted probabilities of first-ever hospitalisation for stroke and IHD increased by 3.8% (3.3, 4.3) and 5.8% (5.2, 6.4) per year, respectively in 2009-2016 (**Figure 5.8**); which was similar to the increase for all admissions. Likewise, the ALOS of first-ever hospitalisation for stroke and IHD decreased by 2.3% (2.0, 2.7) and by 4.2% (3.4, 4.9) per year, respectively; the decrease was similar to the one for all admissions for stroke and was greater for IHD. Annual differences in rates of hospital admissions and case fatality between urban and rural areas were smaller when standardised across the entire study population but without adjustment for region (**Appendix Table D.4**). Fully adjusted annual percentage changes in rates of hospitalisation, case fatality rates and ALOS for stroke and IHD by quartile of approximated equivalent income were similar to the results of the main analysis (**Appendix Table D.5**).

Figure 5.8 Sensitivity analysis of fully adjusted rates of hospitalisation and average length of hospital stay for first-ever hospital admission for stroke and ischaemic heart disease



Numbers above the squares are rates per 1000 person-years or average length of stay in days, as appropriate. Numbers below the squares are numbers of admissions. The area of each square is inversely proportional to the variance. 95% confidence intervals are shown.

5.3.6 Further analyses

Trends and estimates of annual rates of hospitalisation and ALOS by stroke and IHD type

The annual increase in hospitalisation rates for stroke was chiefly due to increases in admissions for IS rather than HS (4.9% [3.5, 4.4] vs 1.1% [-0.2, 2.3]), while the annual increase in rates of hospitalisation for IHD was due to increases in both AMI (6.4% [4.6, 8.3]) and other IHD (5.3% [4.8, 5.8]) (**Figure 5.9**). Standardised rates of hospitalisation were higher for IS than HS, and for other IHD than AMI in 2009-2016. The annual decrease in 28-day case fatality for stroke was due to annual decreases in both IS (11.3% [8.5, 14.1]) and HS (10.6% [8.1, 12.9]). Standardised case fatality rates were more than 10-fold higher for HS than IS (2009: 38.7 [35.6, 41.1] vs 3.4 [2.7, 4.1] deaths per 100 events). The annual decrease in case fatality for IHD was due to decreases in both AMI (12.1% [8.6, 15.5]) and other IHD (15.5% [13.2, 17.6]). Standardised case fatality rates were more than 7-fold higher for AMI than other IHD (2009: 59.8 [54.4, 65.1] vs 8.0 [6.9, 9.1] deaths per 100 events). The annual decrease in ALOS for stroke was chiefly due to decreases in LOS for IS rather than HS (2.1% [1.8, 2.4] vs -0.03% [-1.2, 1.1]; **Figure 5.9**). Standardised ALOS were higher for HS than IS over time. For IHD, ALOS for both AMI and other IHD decreased over time, but the annual decrease was greater for AMI admissions (3.4% [2.5, 4.4] vs 1.5% [0.9, 2.1]; **Figure 5.9**). Standardised ALOS were similar for AMI and other IHD.

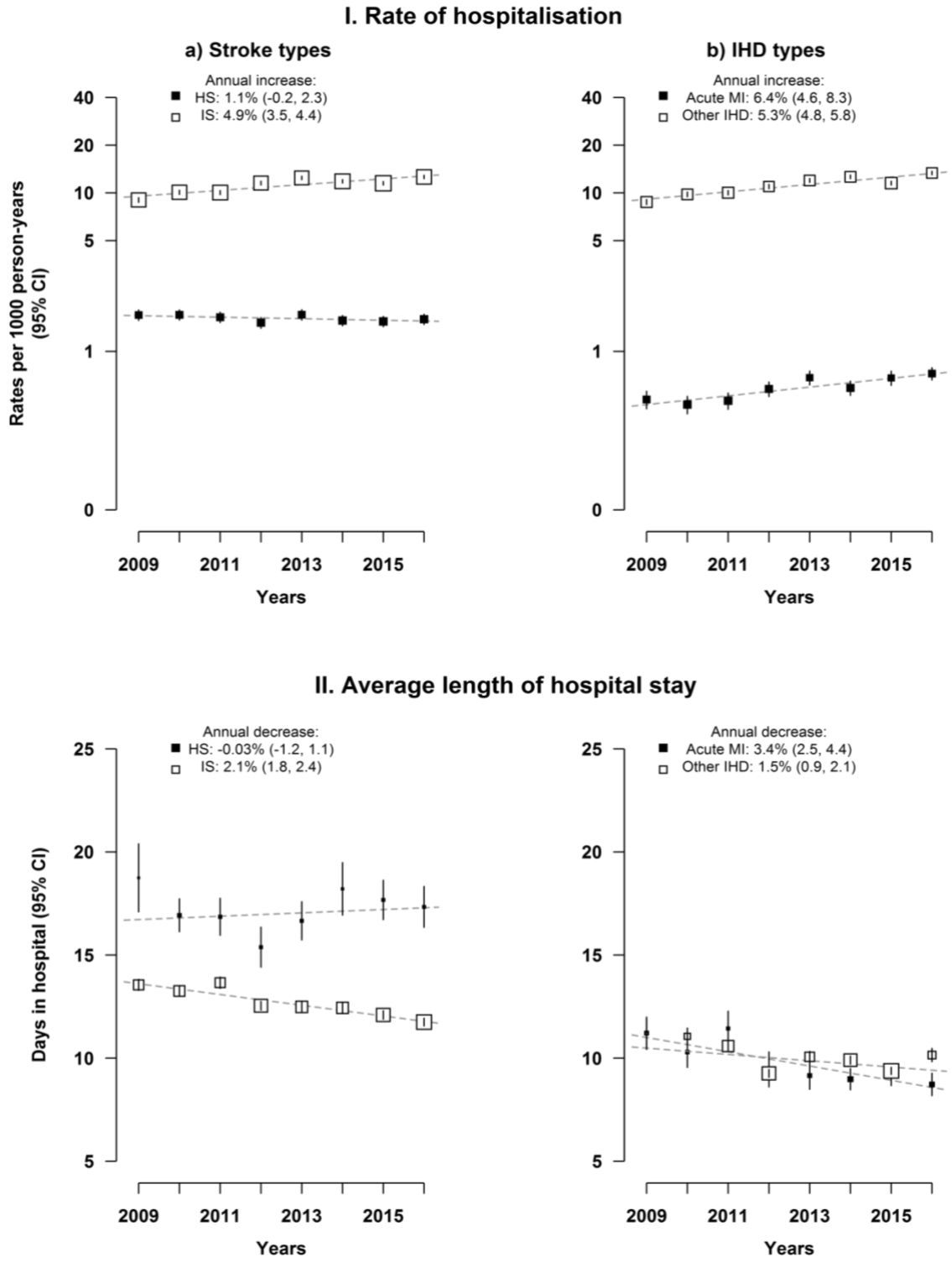
Trends and estimates of annual rates of hospitalisation, case fatality rates and ALOS by age group

Annual rates of hospitalisation, case fatality rates and ALOS for stroke, IHD and any cause were similar across age groups, and annual percentage changes by age group were broadly similar to the overall annual percentage change (**Appendix Figure D.4** and **Table D.6**).

Trends in annual rates of hospitalisation, case fatality rates and ALOS by study periods

The annual increases in rates of hospitalisation for stroke, IHD, and any cause were higher during the first half of the study period (2009-2012) than the second half (2013-2016). The annual increases in rates of hospitalisation for stroke were 5.7% (95% CI: 4.4, 7.0) in the first half vs 0.5% (-0.4, 1.5) in the second half; for IHD were 7.0% (5.4, 8.5) vs 2.6% (1.5, 3.6); and for any cause were 5.0% (4.6, 5.5) vs -0.7% (-1.1, -0.4; **Table 5.3**). The annual decreases in case fatality rates for stroke and IHD did not vary significantly between 2009-2012 and 2013-2016. The annual decrease in ALOS was higher in the first half than the second half for stroke (-3.1% [-4.0, -2.3] vs -2.1% [-2.8, -1.5]), IHD (-6.5% [-7.9, -5.1] vs -0.5% [-1.5, 0.5]) and any cause (-6.8% [-7.2, -6.3] vs 0.8% [0.4, 1.2]).

Figure 5.9 Fully adjusted rates of hospitalisation and average length of hospital stay, by type of stroke and ischaemic heart disease



The area of each square is inversely proportional to the variance. 95% confidence intervals are shown.

Table 5.3 Fully adjusted annual percentage change in rates of hospitalisation, average length of hospital stay and 28-day case fatality rates (95% CI) for stroke, ischaemic heart disease and any cause in 2009-2012 and in 2013-2016

		Stroke	Ischaemic heart disease	Any cause
Rates of hospitalisation	**2009-2012**	5.7 (4.4, 7.0)	7.0 (5.4, 8.5)	5.0 (4.6, 5.5)
	2013-2016	0.5 (-0.4, 1.5)	2.6 (1.5, 3.6)	-0.7 (-1.1, -0.4)
Average length of hospital stay	**2009-2012**	-3.1 (-4.0, -2.3)	-6.5 (-7.9, -5.1)	-6.8 (-7.2, -6.3)
	2013-2016	-2.1 (-2.8, -1.5)	-0.5 (-1.5, 0.5)	0.8 (0.4, 1.2)
28-day case fatality rates	**2009-2012**	-4.7 (-9.6, 0.6)	-13.0 (-17.8, -7.8)	
	2013-2016	-7.7 (-12.4, -2.8)	-10.8 (-15.4, -5.8)	

5.4 Discussion

5.4.1 Findings and interpretation of results

Summary of results

This study of 0.5 million adults who were followed for an 8-year period from 2009 to 2016 during healthcare reforms in China found that, after controlling for demographic, socioeconomic, lifestyle and morbidity factors, hospital care admissions for stroke and IHD increased by approximately 4-5% per year. Moreover, although hospital utilisation rates were higher among individuals living in urban areas and those enrolled in UEBMI, annual increases in hospitalisation rates for stroke and IHD were greater among individuals living in rural areas, those with lower levels of education or income, and those enrolled in URBMI or NRCMS. In addition, case fatality rates for stroke and IHD decreased over the period. While case fatality rates were greater in lower than higher socioeconomic groups, annual reductions in case fatality rates were greater in the lower socioeconomic groups. Over the same period, the ALOS decreased by around 2% per year for stroke, IHD, and any cause. ALOS were higher in higher socioeconomic groups, but also decreased to a greater extent in these population groups. These trends indicated modest improvements in utilisation, quality and efficiency of hospital care use for stroke, IHD and all causes, and some attenuations in differences across socioeconomic groups in China.

Rates of hospitalisation

The increasing trends in rates of hospitalisation f or stroke and IHD were consistent with results from the literature review (**Chapter 3**) that rates of hospitalisation for stroke and AMI subtypes increased in 2006-2012. Consistent with findings of an earlier study in 2007-2010, the present study reported a higher increase in hospital admissions for IS than HS in 2009-2017.[17] National statistics also reported increased rates of hospital admissions for any cause over the calendar period of the study.[18] However, age, sex and region-adjusted admission rates for any cause in the CKB study were higher (CKB: 23% vs national data: 17%, in 2016), which may reflect the older age of the population studied in the CKB study.[18] Estimated annual increases in hospitalisation rates for stroke, IHD and any cause were halved after adjustment for socioeconomic, lifestyle and morbidity factors. The observed reduction was consistent with reports that a large proportion of the increasing CVD burden in China reflects epidemiologic changes and poor control of established CVD risk factors (smoking, blood pressure, LDL-cholesterol, blood glucose, BMI and physical activity).[19]

Apart from established CVD risk factors and morbidities, health system factors could also play an important role in the increasing trends in hospital utilisation.[20] Although the present trends cannot attribute causality between healthcare reforms and changes in hospital utilisation and outcomes between different socioeconomic groups, they could still guide future health policies to reduce inequalities in healthcare delivery in China. These results suggested greater increases in hospital utilisation during the first cycle of the reforms (2009-2011), coinciding with greater expansion of HI coverage.[21] During the reform period, inpatient reimbursement rates and ceilings increased to a greater extent for NRCMS and URBMI than

UEBMI, which may partly account for the higher annual increases in hospital utilisation for enrollees of such schemes compared to UEBMI enrollees.[20] In 2012, China launched a critical illness insurance, which covers patients enrolled in NRCMS or URBMI with diseases whose annual healthcare costs exceed the annual mean disposable income per capita in the local area.[22] Thus, individuals who have critical illnesses, including stroke and IHD subtypes, receive additional reimbursements for treatment costs,[20] which increases affordable access to hospital care. In addition, the medical financial assistance programme covers premiums and/or any remaining co-payments for priority diseases for low-income households enrolled in NRCMS or URBMI.[23] The rapid urbanisation of rural areas in China in the last decades and improvements in road networks, also contributed to increasing access to hospital care for rural residents.

The increasing rates of hospital utilisation, although at a lower rate, for urban residents and higher socioeconomic groups, might reflect continued patients' distrust of primary healthcare services combined with the design of HI packages, which continues to provide lower levels of coverage for outpatient than inpatient care.[24] Moreover, between 2009 and 2016 the number of hospitals in China increased by 44% nationally, while the population grew by 4%. The number of beds in medical institutions increased by 42% in urban areas and by 50% in rural areas, while the population increased by 23% in urban areas and decreased by -14% in rural areas.[18] Thus, the increase in the number of hospitals and beds also likely contributed to the increased hospital utilisation.

Case fatality rates

The decreasing trends in case fatality rates among all socioeconomic groups, may partly reflect better access to hospital, improvements in quality of care, and more effective hospital treatment.[17,25] The increasing proportion of less severe stroke types (IS vs HS) over time in China may also have contributed in part to the decline in case fatality rates for stroke.[26] Substantial reductions in case fatality rates for stroke and IHD over time also took place in Western countries.[9,27-29] The findings in the present study were consistent with the decreasing in-hospital mortality rates reported in the literature review in **Chapter 3**. In addition, case fatality rates for stroke in this study were in the range of those reported by previous studies in China (5-35%).[4,30,31] Possible reasons for differences in case fatality rates include differences in severity of stroke types, quality of care, or thresholds for diagnosis over time.[30,31] While case fatality rates for both stroke and IHD were higher in rural than urban areas in 2009-2016, one study reported higher case fatality rates in urban than rural residents for stroke and in rural than urban residents for IHD in Zhejiang in 2012.[4] However, these differences disappeared once case fatality rates were standardised for age to the WHO standard population 2000-2025. The study's finding of higher case fatality rates for IHD patients enrolled in NRCMS or URBMI (vs UEBMI) were consistent with findings from Lin et al (2017) that AMI patients enrolled in NRCMS and with self-payment had higher adjusted in-hospital mortality rates than those enrolled in UEBMI.[7]

Length of hospital stay

The decreasing trend in ALOS for stroke over time and the higher ALOS for HS than IS were consistent with results from the review of previous studies (**Chapter**

3). The average median LOS for any stroke (15.3 days) in 2006-2012 in the literature review was similar to the ALOS for stroke in the first half of the study period. The ALOS for IHD in this study were similar to those for ACS in the literature review (range 9-12 days). Lower ALOS for stroke and IHD patients enrolled in URBMI or NRMCS than those enrolled in UEBMI were consistent with findings from the literature review and from a recent study in four large cities.[7,32] Decreasing annual trends in ALOS for stroke, IHD and any cause likely reflect the government introducing a target ALOS as a performance indicator to reduce healthcare expenditure, and other efforts by HI agencies to reduce costs.[33] China has also implemented standard clinical pathways for major CVD conditions (e.g. acute IS and MI) and established an official monitoring system for these pathways in 2009.[33] Such reforms appear to have contributed to reductions in ALOS, and improvements in survival after stroke and IHD.[34] The greater reduction in ALOS for higher socioeconomic groups may reflect the greater reductions in ALOS in large urban hospitals, mostly utilised by these groups.[35] However, ALOS in China are still greater than those in OECD countries,[9] with patterns of behaviour of Chinese doctors seeking to comply with patient wishes; the adverse incentives generated by the use of fee-for-service reimbursement; and the limited availability of rehabilitation services for post-acute care identified as possible determinants.[33,36]

5.4.2 Limitations

The chief strengths of the present study include its longitudinal nature covering eight years, the diversity in regions and hospitals included, and the extensive data

collected on individual participants which enabled adjustment for a wide range of confounders. However, the study also had several limitations.

Socioeconomic characteristics

Socioeconomic characteristics of participants, except HI type, were available only at entry into the study. As the study population is middle-aged and older, education is unlikely to change further. Income, however, has likely increased during the study period, though relative income is expected to be more stable over time. Spearman's rank-order correlation coefficients between participants' self-reported education and income level at baseline and at subsequent first and second resurveys (in ~5% of participants) were 0.8-0.9 (education) and 0.7 (income). Population level changes in socioeconomic status were partially adjusted for in the models using the HI type variable as HI enrolment is based on employment status, and was updated annually between 2012 and 2016.

Data on participant's HI type were only available from 2012 onwards and, therefore, an assumption had to be made that participant's HI type in 2009-2011 was the same as that recorded in 2012. However, data from resurveys of CKB participants indicated that 97% of participants reported being insured in both 2008 and 2014, and 94% of participants remained enrolled in the same HI type between 2012 and 2016.

Estimation of healthcare utilisation

The data available in the present study did not allow for a more detailed measure of hospital care access with hospital utilisation capturing exclusively health demand presenting for hospital care. However, case fatality rates included deaths

with and without a related prior hospital admission within 28 days. Multilevel models were not used because the number of participants in the different categories of socioeconomic variables were not evenly distributed across regions. In addition, there were only ten different regions and this number was reduced to five for analyses by urban and rural area. However, models stratified for region instead of adjusted for region as fixed effects were estimated, and annual trends for stroke, IHD and any cause were very similar in both models. Variations in trends in hospital care utilisation by hospital characteristics, such as hospital tier, were not examined, as complete hospital tier data was not available at the time of this study.

Given the large proportion of admissions for IHD that were classified as other IHD, it is possible that admissions for AMI were misclassified as other IHD, which might have overestimated standardised hospitalisation rates for other IHD and underestimated those for AMI. However, 97% of incident IHD cases had their diagnosis confirmed by clinical adjudication of hospital records including electrocardiogram reports and cardiac enzymes test results. In addition, annual trends in hospitalisation rates, and case fatality rates were unlikely to be affected as annual trends were similar for AMI and other IHD admissions.

Generalisability of results

The CKB study is not representative of the general Chinese population,[37] so results should be interpreted with caution. However, the very large sample size and the diversity of the population covered (e.g. urban and rural, men and women, young and old, and people with different levels of socioeconomic status) are such that the lack of representativeness is unlikely to bias the estimated relative trends which

are expected to be more generalisable to the wider Chinese population even if the absolute rates might differ. Unfortunately, there are no data to check if the cohort is representative of the underlying populations in the counties where participants were recruited.

Limitations of observational cohort data

Despite adjustments for participants' characteristics at entry, their age and morbidities during follow-up, and standardisation of estimates, the study was constrained by having a longitudinal fixed cohort study design with participants ageing over time. In the CKB study, periodic resurveys only included a random subset of participants (~5%), so some of the covariates included in the analyses could not be updated during follow-up.

Interpreting fully adjusted trends in hospitalisation rates as health system effects relies on the assumption that adjustments for demographic (i.e. age), socioeconomic, lifestyle and morbidity factors were successful. Thus, residual confounding due to incomplete adjustment for these factors or to some unknown or unmeasured confounders cannot be excluded. Fully adjusted trends need to be interpreted in light of other possible demand and supply-side factors, including details of HI coverage and healthcare costs, hospital-level characteristics, distance between household and hospitals, outpatient care provision and use, physician-related factors, and changes in admission thresholds or use of diagnostic tests for stroke and IHD.[32] More generally, the associations reported in this prospective observational cohort study, cannot be causally attributed to the healthcare reforms and different study designs (e.g. randomised experiments or quasi-experiments), would be required to address this question. Longer duration of follow-up may also

be needed to reliably assess the longer-term consequences of the healthcare reforms in China.

5.4.3 Conclusions

This large prospective study examined changes in hospital care utilisation and outcomes for individuals with stroke and IHD, both overall and across different socioeconomic groups between 2009 and 2016. The findings of increasing hospital admissions rates and decreasing case fatality rates, particularly in rural areas and for the most vulnerable populations, reflected improvements in utilisation, access and quality of care in 2009-2016. The progressive reductions in ALOS also indicated improvements in hospital efficiency. Nevertheless, there is substantial scope to achieve further reductions in socioeconomic healthcare inequalities, by increasing HI benefits for lower socioeconomic groups, and implementing cost-effective interventions to decrease the CVD burden.

5.5 Summary

This chapter provided novel evidence on the temporal trends and socioeconomic differences in hospital care utilisation and outcomes for stroke and IHD in China in 2009-2016, using data from the CKB. Chapter 6 will present analyses on gender differences in the use of invasive diagnostic and therapeutic procedures for acute IHD and the contribution of socioeconomic and health system factors to such differences.

References

1. Yang G, Kong L, Zhao W, et al. Emergence of chronic non-communicable diseases in China. *The Lancet*. 2008; **372**(9650): 1697-705.

2. Liu S, Li Y, Zeng X, et al. Burden of Cardiovascular Diseases in China, 1990-2016: Findings From the 2016 Global Burden of Disease Study. *JAMA Cardiology*. 2019; **4**(4): 342-52.

3. Liu M, Wu B, Wang WZ, Lee LM, Zhang SH, Kong LZ. Stroke in China: epidemiology, prevention, and management strategies. *The Lancet Neurology*. 2007; **6**(5): 456-64.

4. Gong W, Wei X, Liang Y, et al. Urban and Rural Differences of Acute Cardiovascular Disease Events: A Study from the Population-Based Real-Time Surveillance System in Zhejiang, China in 2012. *PLOS ONE*. 2016; **11**(11): e0165647.

5. Li X, Murugiah K, Li J, et al. Urban-Rural Comparisons in Hospital Admission, Treatments, and Outcomes for ST-Segment-Elevation Myocardial Infarction in China From 2001 to 2011: A Retrospective Analysis From the China PEACE Study (Patient-Centered Evaluative Assessment of Cardiac Events). *Circulation: Cardiovascular Quality and Outcomes*. 2017; **10**(11).

6. Cai M, Liu E, Li W. Rural Versus Urban Patients: Benchmarking the Outcomes of Patients with Acute Myocardial Infarction in Shanxi, China from 2013 to 2017. *International Journal of Environmental Research and Public Health*. 2018; **15**(9).

7. Lin X, Cai M, Tao H, et al. Insurance status, inhospital mortality and length of stay in hospitalised patients in Shanxi, China: A cross-sectional study. *BMJ Open*. 2017; **7**(7): e015884.

8. Hui C, Lizheng S, Ming X, et al. Geographic Variations in In-hospital Mortality and Use of Percutaneous Coronary Intervention Following Acute Myocardial Infarction in China: A Nationwide Cross-sectional Analysis. *Journal of the American Heart Association*. 2018; **7**(8): e008131.

9. OECD. Health at a Glance 2017: OECD Indicators. Paris: OECD; 2017.

10. Mihaylova B, Briggs A, O'Hagan A, Thompson SG. Review of statistical methods for analysing healthcare resources and costs. *Health Economics*. 2011; **20**(8): 897-916.

11. Verburg IW, de Keizer NF, de Jonge E, Peek N. Comparison of regression methods for modeling intensive care length of stay. *PLoS One*. 2014; **9**(10): e109684.

12. Plummer M. Improved estimates of floating absolute risk. *Statistics in Medicine*. 2004; **23**(1): 93-104.

13. King NB, Harper S, Young ME. Use of relative and absolute effect measures in reporting health inequalities: structured review. *BMJ*. 2012; **345**: e5774.

14. Kelly MP MA, Bonnefoy J, Butt J, Bergmann V. The social determinants of health: developing an evidence base for action. World Health Organization Commission on Social Determinants of Health; 2007.

15. Mackenbach JP, Kunst AE. Measuring the magnitude of socio-economic inequalities in health: an overview of available measures illustrated with two examples from Europe. *Social Sciences & Medicine*. 1997; **44**(6): 757-71.

16. Igland J, Vollset SE, Nygård OK, Sulo G, Ebbing M, Tell GS. Educational Inequalities in Acute Myocardial Infarction Incidence in Norway: A Nationwide Cohort Study. *PLOS One*. 2014; **9**(9): e106898.

17. He Q, Wu C, Luo H, et al. Trends in in-hospital mortality among patients with stroke in China. *PLOS One*. 2014; **9**(3): e92763.

18. National Bureau of Statistics of China. China Statistical Yearbook 2018. Available from: http://www.stats.gov.cn/english/Statisticaldata/AnnualData (Accessed: 27 July 2019).

19. Li Y, Wang DD, Ley SH, et al. Potential Impact of Time Trend of Life-Style Factors on Cardiovascular Disease Burden in China. *Journal of the American College of Cardiology*. 2016; **68**(8): 818-33.

20. Meng Q, Xu L, Zhang Y, et al. Trends in access to health services and financial protection in China between 2003 and 2011: a cross-sectional study. *The Lancet*. 2012; **379**(9818): 805-14.

21. Yip W, Hsiao WC. What Drove the Cycles of Chinese Health System Reforms? *Health Systems & Reform*. 2015; **1**(1): 52-61.

22. The State Council Information Office of the People's Republic of China. Guiding opinions on carrying out major disease insurance for urban and rural residents 2012. Available from: http://www.scio.gov.cn/32344/32345/32347/33156/xgzc33162/Document/1442272/1442272.htm (Accessed: July 27).

23. Yip WC, Hsiao WC, Chen W, Hu S, Ma J, Maynard A. Early appraisal of China's huge and complex health-care reforms. *The Lancet*. 2012; **379**(9818): 833-42.

24. Yip W, Hsiao W. Harnessing the privatisation of China's fragmented health-care delivery. *The Lancet*. 2014; **384**(9945): 805-18.

25. Jiang L, Krumholz HM, Li X, Li J, Hu S. Achieving best outcomes for patients with cardiovascular disease in China by enhancing the quality of medical care and establishing a learning health-care system. *The Lancet*. 2015; **386**(10002): 1493-505.

26. Wang W, Jiang B, Sun H, et al. Prevalence, Incidence, and Mortality of Stroke in China. *Circulation*. 2017; **135**(8): 759-71.

27. Carandang R, Seshadri S, Beiser A, et al. Trends in incidence, lifetime risk, severity, and 30-day mortality of stroke over the past 50 years. *JAMA*. 2006; **296**(24): 2939-46.

28. Lee S, Shafe AC, Cowie MR. UK stroke incidence, mortality and cardiovascular risk management 1999-2008: time-trend analysis from the General Practice Research Database. *BMJ Open*. 2011; **1**(2): e000269.

29. Krumholz HM, Normand SL, Wang Y. Trends in hospitalizations and outcomes for acute cardiovascular disease and stroke, 1999-2011. *Circulation*. 2014; **130**(12): 966-75.

30. Wu S, Wu B, Liu M, et al. Stroke in China: advances and challenges in epidemiology, prevention, and management. *The Lancet Neurology*. 2019; **18**(4): 394-405.

31. Zhang L-F, Yang J, Hong Z, et al. Proportion of Different Subtypes of Stroke in China. *Stroke*. 2003; **34**(9): 2091-6.

32. Yang Y, Nicholas S, Li S, et al. Health care utilization for patients with stroke: a 3-year cross-sectional study of China's two urban health insurance schemes across four cities. *BMC Public Health*. 2021; **21**(1): 531.

33. Gao C, Xu F, Liu GG. Payment reform and changes in health care in China. *Social Science & Medicine*. 2014; **111**: 10-6.

34. Pearson SD, Kleefield SF, Soukop JR, Cook EF, Lee TH. Critical pathways intervention to reduce length of hospital stay. *The American Journal of Medicine*. 2001; **110**(3): 175-80.

35. Liu Y, Kong Q, Yuan S, van de Klundert J. Factors influencing choice of health system access level in China: A systematic review. *PLOS One*. 2018; **13**(8): e0201887.

36. Li Q, Lin Z, Masoudi FA, et al. National trends in hospital length of stay for acute myocardial infarction in China. *BMC Cardiovascular Disorders*. 2015; **15**: 9-.

37. Chen Z, Chen J, Collins R, et al. China Kadoorie Biobank of 0.5 million people: survey methods, baseline characteristics and long-term follow-up. *International Journal of Epidemiology*. 2011; **40**(6): 1652-66.

Chapter 6. Gender differences in use of invasive diagnostic and therapeutic procedures for acute ischaemic heart disease in Chinese adults

6.1 Background

Previous studies in Western populations have reported a lower incidence of acute coronary syndrome (ACS) but higher case fatality rate following ACS in women compared to men.[1,2] It has also been reported that women experience longer delays in accessing hospital care and are less likely than men to have invasive diagnostic procedures,[2,3] which may contribute to the differences in the prognosis of acute IHD between men and women. However, the reasons for such differences in the clinical management of acute IHD remain unexplained.

Following China's major healthcare reforms, increased investments in hospitals and medical equipment improved access to diagnostic tests and therapeutic procedures.[4] Nevertheless, out-of-pocket expenses as percentage of total healthcare expenditure have remained high in China (29% in 2016),[5] and women remain less likely to use inpatient care and more likely to defer use of healthcare for economic reasons.[6-8]

In the literature review presented in **Chapter 3**, four out of five studies reporting the use of tests and procedures for patients with ACS by sex, observed lower use of coronary angiography and percutaneous coronary intervention (PCI) in women than men.[9-13] Only two studies focused explicitly on sex differences and adjusted their analyses for patients' characteristics.[9,13] The five studies were restricted to tier 2 or 3 hospitals, and failed to investigate the effects of socioeconomic or health system factors such as health insurance (HI) type. Indeed, the influence of social,

cultural, and economic factors, such as socioeconomic deprivation and poor health literacy, on cardiovascular healthcare outcomes in women remains understudied globally.[14,15]

As women in China tend to have lower socioeconomic status than men,[6,7] and financial factors are strong contributors to inequalities in healthcare provision,[16] this chapter examines whether the more adverse socioeconomic and health system factors experienced by women contributed to their lower use of tests and procedures for acute IHD. The aims of this chapter are: (1) to analyse differences in the use of invasive diagnostic and therapeutic procedures for acute myocardial infarction (AMI), angina, and other IHD in Chinese men and women in the CKB; and (2) to investigate the extent to which socioeconomic or health system factors could explain such differences.

6.2 Methods

6.2.1 Participants and follow-up

Analyses were restricted to participants' first hospitalisations for acute IHD recorded during the study between 25 June 2004 and 31 December 2016. Acute IHD admissions were classified as AMI (ICD-10 codes I21), angina pectoris (ICD-10 codes I20), and other IHD (ICD-10 codes I22-I25). The category "other IHD" included admissions that were not due to AMI, nor angina pectoris. The range of ICD-10 codes included was I22-I25 and 92% of admissions for other IHD had atherosclerotic heart disease (I25.1). The remaining 8% included mainly chronic IHD, such as unspecified heart disease (I25.9), other forms of acute IHD (I24.8), acute IHD unspecified (I24.9) or old myocardial infarction (I25.2).

6.2.2 Study outcomes

The primary outcomes for the present analyses were use of non-invasive cardiac enzyme tests, coronary angiography, and coronary revascularisation. The use of cardiac enzyme tests and coronary angiography was recorded for the first acute IHD admission after entry into the study, while the use of coronary revascularisation was measured within 3 months of admission for acute IHD. Cardiac enzyme tests included creatine kinase myocardial band or troponins, and coronary revascularisation procedures chiefly involved PCI, as few participants had coronary artery by-pass graft operations. The secondary outcomes were the use of electrocardiogram (ECG), echocardiogram, coronary computed tomography angiography (CCTA), and Holter monitor tests.

Study populations

When the outcomes were cardiac enzyme tests, coronary angiography, ECG, echocardiogram, CCTA, or Holter monitor tests, the study population was restricted to participants with available retrieved medical records for first IHD admissions. Data on any use of these diagnostic tests and procedures were extracted from the medical records (see **Chapter 4**). The most common reason for non-retrieval of medical notes was that records could not be found in the hospital. This was likely to be due to the lack of storage of medical records especially in lower tier hospitals, rural areas and during the first few years of follow-up.

When the outcome was coronary revascularisation, the study population included all participants with a first IHD admission, regardless of whether admission's medical records were successfully retrieved. Data on coronary revascularisation procedures were obtained from HI records, supplemented by retrieved medical records. Half of IHD admissions (AMI: 67%, angina: 82%, other IHD: 34%) had data both in HI and retrieved medical records. Forty-five percent of IHD admissions (AMI: 23%, angina: 14%, other IHD: 60%) had data in HI records only. Five percent of IHD admissions (AMI: 10%, angina: 4%, other IHD: 5%), had data in retrieved medical records only.

6.2.3 Participant characteristics

The main independent variable in this study was the variable for sex.

The socioeconomic factors included marital status (married vs other), household size, highest level of education attained (no formal school, primary or middle school, high school or above), annual household income in Chinese Yuan (<10 000, 10 000-19 999, 20 000-34 999, ≥35 000). Health system factors included HI type

(Urban Employee Basic Medical Insurance [UEBMI], Urban Resident Basic Medical Insurance [URBMI] or New Rural Cooperative Medical Scheme [NRCMS] and other) and hospital tier (unrated/missing or 1, 2 and 3).

6.2.4 Covariates

Models were adjusted for groups of covariates, including demographic, lifestyle, and morbidity factors. Demographic factors included annually updated age (i.e. age, age-squared, age-cubed), region and calendar year. Lifestyle factors, collected at entry into the study, included smoking, alcohol consumption, body mass index, and physical activity assessed using metabolic equivalents of task. Morbidity factors included systolic blood pressure (SBP), self-rated health status, self-reported mental illness, self-reported doctor-diagnosed diseases at entry into CKB, with history of major diseases updated during follow-up until censored by the onset of IHD in the present analyses (see **Chapter 4**).

6.2.5 Statistical analysis

The method used to impute missing values for length of hospital stay is described in **Appendix E.1**.

Statistical models

All analyses were performed separately for AMI, angina and other IHD. The women-to-men (i.e. men as the reference group) rate ratios (RRs) of having a diagnostic test or procedure were estimated using Poisson regression with robust variance estimation to minimise overestimation of variance for binary data.[17] Poisson regression was preferred to logistic regression to estimate relative risks to

facilitate comparisons between different categories of patients, rather than odds ratios which could be misinterpreted. The use of relative risks enabled comparisons of effect estimates between patient phenotypes with rare (i.e. use of invasive diagnostic procedures for other IHD) and frequent outcomes (i.e. use of invasive diagnostic procedures for AMI).

Age- and region-adjusted rates of having a diagnostic test or procedure were estimated in men and women, by age group (<55, 55-65, 65-75 and ≥75 years old). Models were sequentially adjusted for groups of potential confounders or effect modifiers of the association between gender and the use of invasive diagnostic procedures. These groups of factors were demographic, lifestyle and morbidity risk factors, followed by HI type, socioeconomic factors and hospital tier. The order in which groups of factors were included was chosen to reflect likely strength of effect and to facilitate elucidation on the independent role of socioeconomic and health system factors.

Heterogeneity by socioeconomic factors

For tests and procedures with statistically significant women-to-men RRs, effect modification by socioeconomic and health system factors was assessed by adding an interaction between the sex variable and each socioeconomic or health system variable to the Poisson regression models. The socioeconomic and health system factors included area of residence, marital status, education, annual income (<10 000¥, 10 000-19 999¥, ≥20 000¥), HI type and hospital tier (tier 3 vs other). In analyses by HI type, uninsured participants were excluded due to small number of cases. Models by area of residence were not adjusted for HI type, due to the high correlation between these two variables. Heterogeneity or trends in women-to-men

RRs of having diagnostic tests or procedures were assessed using χ^2 tests by categories of selected factors.

Standardised predicted rates of having diagnostic test or procedure

Gender differences in use of invasive diagnostic tests and procedures were also evaluated on an absolute scale using standardised mean rates per 100 admissions of having a diagnostic test or procedure. The method of recycled predictions (or predictive margins) using characteristics of CKB participants with AMI, angina or other IHD in 2004-2016 was used. As each CKB region contributed data for only urban or only rural areas, the estimates for urban and rural areas, in which adjustment for region was used, were standardised separately for the CKB population characteristics in the relevant urban or rural areas.

Sensitivity analyses

Sensitivity analyses were performed to assess the impact of model assumptions and data on estimated associations between gender and use of tests and procedures for acute IHD. To explore whether main results varied by AMI subtype, analyses of use of tests and procedures were repeated for ST-segment elevation MI (STEMI) and non-STEMI (NSTEMI) in a subsample of AMI admissions with retrieved medical records (60%). To check whether main results were influenced by prior history of CVD, analyses were repeated in participants with first-ever AMI, angina and other IHD (i.e. excluding participants with previous CVD) rather than adjusting for prior CVD in the models. To examine if the heterogeneity by region was appropriately accounted for, main analyses were stratified by region and synthesized using inverse-variance weighting method, instead of adjusted for

region as fixed effects. Analyses were repeated excluding participants who died during admission to investigate possible differences in treatment for such individuals. Indeed, individuals who died during admission might not have been able to receive a procedure. Sensitivity analyses were also performed for the use of coronary procedures among those who received cardiac enzyme tests, and assuming that all individuals who had coronary revascularisation also had coronary angiography even when not explicitly recorded in their medical records. The adjusted women-to-men rates ratios of having revascularisation for admissions with and without retrieved medical records were also estimated to check for potential bias due to the use of different data sources.

Further analyses

Women-to-men RRs by categories of established IHD risk factors, including age, body mass index (underweight or normal weight vs overweight or obese), hypertension, diabetes, prior CVD, prior kidney disease, self-rated health status, mental illness, and calendar period were also estimated. Risk factors excluded smoking and alcohol consumption because of their low prevalence in Chinese women. To investigate gender differences in healthcare outcomes, adjusted women-to-men RRs of 28-day case fatality for AMI and other IHD were estimated, as well as standardised case fatality rates for men and women.

6.3 Results

6.3.1 Participant characteristics at recruitment and details of follow-up

All participants

Between 2004 and 2016, 38 928 participants (61% women) were admitted to hospital with a first episode of IHD, including 2911 (8%) with AMI, 9817 with angina (25%) and 26 200 (67%) with other IHD. Compared to men, women were less likely to be admitted with AMI (5% vs 12% of respective admissions by sex), but more likely to be admitted with angina (26% vs 24%) and other IHD (69% vs 64%) (**Table 6.1**). Women admitted with AMI were older than men at baseline (mean age 61.7 vs 58.7 years), and at admission to hospital (67.8 vs 64.7 years). Compared to men, women with AMI had a higher prevalence of diabetes, overweight or obesity, self-rated poor health status, mental illness, and higher mean SBP. Women had lower physical activity levels and a lower prevalence of prior stroke or transient ischemic attack, or being a current smoker or drinker than men. Women were less likely to be married (77.6% vs 94.5%) and more likely to be widowed (21.2% vs 3.8%) than men. A lower proportion of women had completed high school or above (14.1% vs 30.1%), had an annual household income above 20 000¥ (32.6% vs 47.2%), lived in urban areas (60.9% vs 64.3%), and were enrolled in the UEBMI scheme (50.4% vs 62.6%).

Differences in baseline characteristics between men and women admitted with angina or other IHD were similar, albeit less extreme than those for AMI (**Table 6.1**). Women with AMI or other IHD were more likely than men to be admitted to

smaller (tier 1) rather than larger (tier 3) hospitals. Duration of hospital stay did not differ by gender for AMI, angina and other IHD (mean: 10-11 days).

Participants with retrieved medical records

Overall, the baseline characteristics of 24 408 individuals with retrieved medical records were comparable to those of all individuals with AMI, angina and other IHD (**Table 6.1** and **Appendix Table E.1**). However, a few differences were observed. Among individuals with angina, the proportions living in rural areas; enrolled in URBMI or NRCMS; and attending tier 1 hospitals were lower among both men and women with retrieved medical records compared to all men and women. Among individuals with angina, the proportions of men and women with retrieved medical records did not vary significantly by HI type and hospital tier. Among individuals with other IHD, the proportion of men enrolled in URBMI or NRCMS and the proportion of women attending tier 3 hospitals were higher for participants with retrieved medical records than for all participants.

Table 6.1 Selected characteristics of men and women with hospital admission for acute MI, angina and other IHD during 2004-2016

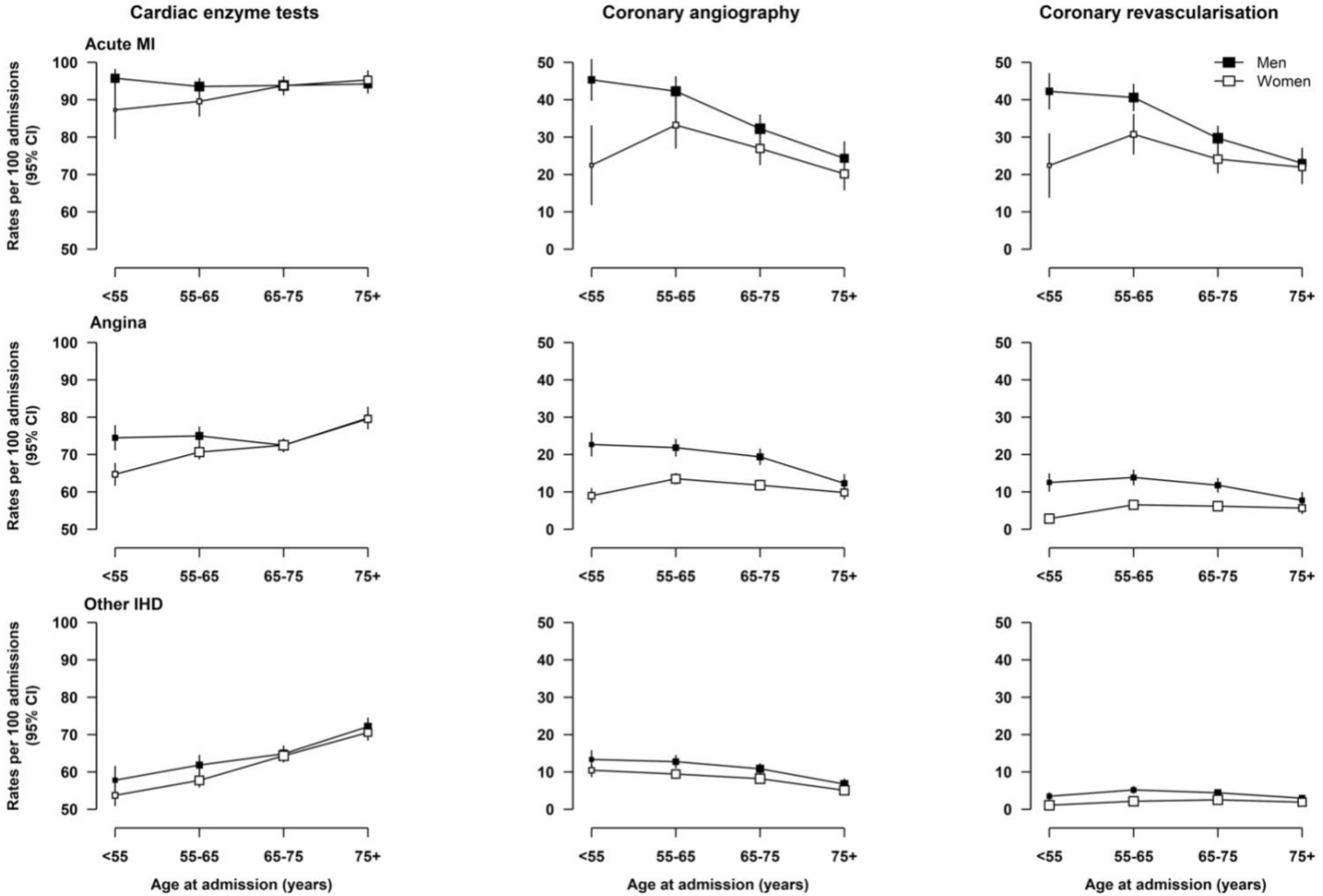
	Acute MI			Angina			Other IHD		
	Men (n=1799)	**Women (n=1112)**	***P***	**Men (n=3626)**	**Women (n=6191)**	***P***	**Men (n=9792)**	**Women (n=16408)**	***P***
(A) Characteristics at baseline									
Age (years), Mean (SD)	58.7 (10.1)	61.7 (9.2)	**	58.0 (10.2)	58.0 (9.5)		59.8 (10.1)	58.7 (9.6)	**
Self-reported medical history, %									
Diabetes[1]	14.8	25.1	**	12.6	13.2		11.6	13.1	**
Hypertension[1]	55.0	58.4		51.4	44.5	**	53.4	46.8	**
Stroke or TIA	6.7	3.7	**	5.1	3.6	**	6.0	3.8	**
IHD	11.4	13.3		16.4	19.7	**	14.5	14.6	
CKD	1.6	1.9		2.7	3.4		2.3	2.9	*
Poor health status	12.0	17.8	**	12.1	15.3	**	15.0	20.2	**
Mental illness	9.6	12.6	**	10.0	13.4	**	10.6	13.5	**
Physical measurements									
Overweight or obese[2], %	43.5	47.8	*	47.3	49.2		40.2	46.9	**
SBP (mmHg), Mean (SD)	141.8 (22.4)	144.4 (24.6)	**	138.6 (20.9)	134.9 (23.3)	**	139.9 (21.8)	137.1 (23.8)	**
Lifestyle characteristics									
Current smoker, %	61.6	7.3	**	53.9	3.5	**	52.8	5.0	**
Regular alcohol drinker, %	40.2	3.3	**	46.5	5.1	**	42.9	4.8	**
Physical activity (MET-h/day), Mean (SD)	15.5 (13.4)	13.3 (9.0)	**	14.9 (11.8)	13.6 (8.6)	**	15.1 (12.9)	14.7 (9.6)	**
Socioeconomic characteristics									
Married, %	94.5	77.6	**	93.6	83.5	**	91.2	82.1	**
Household size, Mean (SD)	3.5 (1.6)	3.5 (1.8)		3.4 (1.5)	3.2 (1.5)	**	3.5 (1.6)	3.4 (1.6)	**
High School or above, %	30.1	14.1	**	38.7	30.0	**	30.1	20.3	**
Annual income ≥20 000¥, %	47.2	32.6	**	52.3	46.3	**	43.8	36.3	**
Rural residents, %	35.6	39.1		31.4	23.5	**	48.2	46.4	**
(**B) Characteristics at hospital admission**									
Age (years), Mean (SD)	64.7 (10.0)	67.8 (9.1)	**	64.0 (10.1)	64.1 (9.3)		66.2 (10.2)	65.0 (9.8)	**
Health insurance type[3], %			**			*			**
NRCMS or URBMI	36.0	48.1		29.8	28.2		44.7	48.1	
UEBMI	62.8	51.0		69.4	71.4		54.7	51.7	
Other or uninsured	1.2	0.9		0.7	0.5		0.6	0.3	
Hospital tier, %			**						**
Tier 1 or missing	9.1	12.1		16.0	14.7		31.3	36.2	
Tier 2	15.3	17.4		18.7	18.8		19.3	18.8	
Tier 3	75.7	70.5		65.3	66.6		49.4	45.1	
Length of stay (days), Mean (SD)	10.9 (6.6)	10.8 (6.9)		10.0 (5.9)	9.9 (11.1)		10.3 (5.4)	9.8 (10.2)	

SD: standard deviation, TIA: transient ischemic attack, MET: metabolic equivalents of task, URBMI: urban resident basic medical insurance, NRCMS: new rural cooperative medical scheme, UEBMI: urban employee basic medical insurance. **p-value <0.01 and *p-value<0.05. [1]Self-reported and screen-detected. [2]Defined as body mass index >25 kg/m^2. [3]Data on HI types for each participant was identified annually in 2012-2016. Missing data on HI type in 2004-2011 were imputed based on the HI scheme in which participants were enrolled in 2012.

6.3.2 Estimates of gender differences in use of tests and procedures

Among AMI admissions, age and region-adjusted rates of having cardiac enzyme tests were almost 95%, with no material differences between men (94% [95% CI: 93, 95]) and women (93% [91, 94]). In contrast, among AMI cases, women had lower rates than men of coronary angiography (28% [25, 31] vs 35% [33, 37]) and coronary revascularisation (26% [24, 29] vs 33% [31, 35]). Among cases with angina and other IHD, women had slightly lower rates than men of use of cardiac enzyme tests (72% [71, 73] vs 76% [75, 77] and 62% [61, 63] vs 65% [64, 66], respectively), and much lower rates of coronary angiography (12% [11, 12] vs 20% [18, 21] and 8% [8, 9] vs 11% [10, 12]) and coronary revascularisation (6% [5, 6] vs 12% [11, 13] and 2% [2, 2] vs 4% [4, 5]). These differences in the use of invasive coronary investigations attenuated with increasing age (**Figure 6.1**).

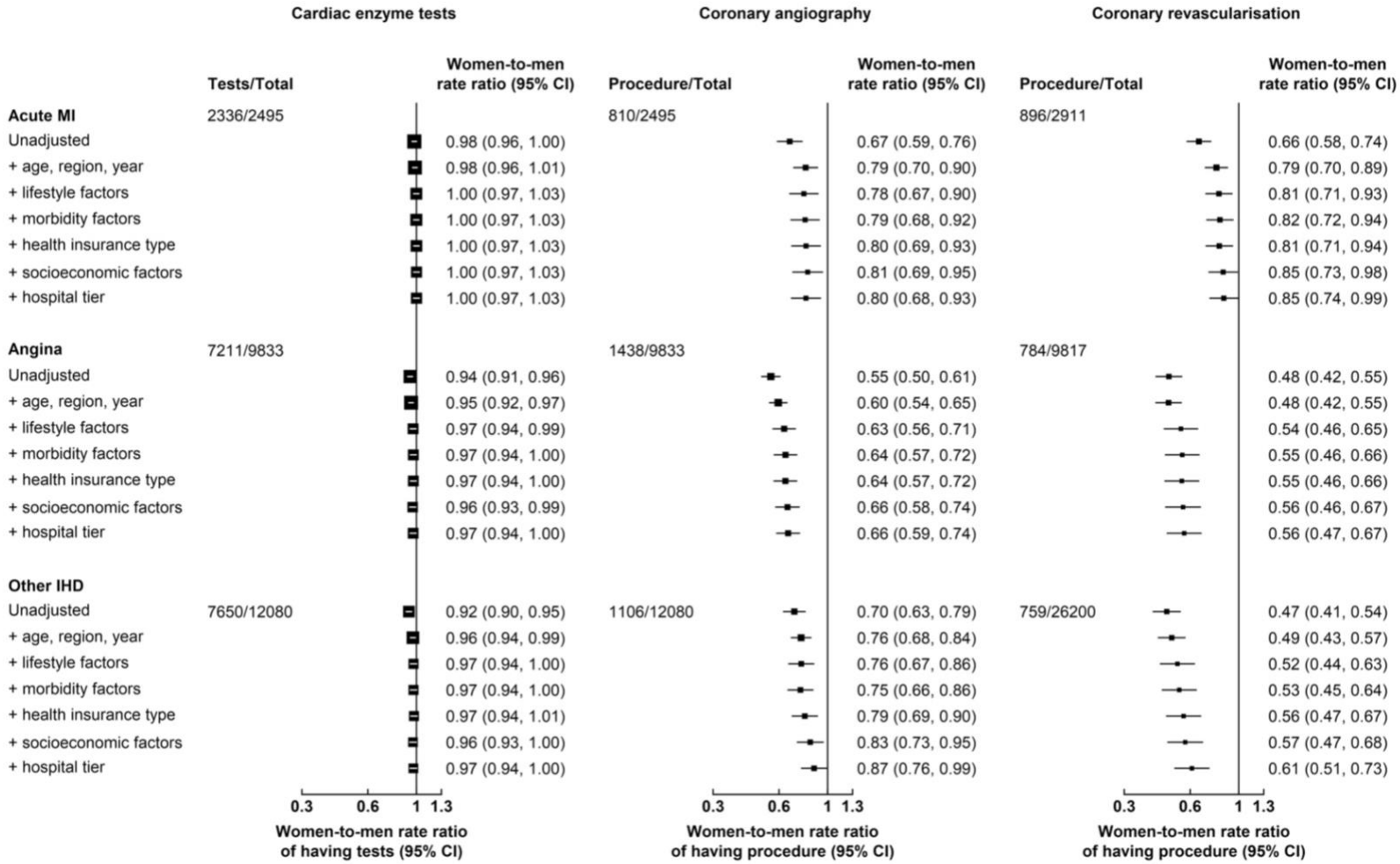
Figure 6.1 Age- and region-adjusted rates of having cardiac enzyme tests, coronary angiography and coronary revascularisation per 100 admissions for acute MI, angina and other IHD in men and women, by age group



Rates were standardised for the overall CKB participant population with acute MI, angina and other IHD, respectively.

Following adjustment for all relevant factors, the women-to-men RRs of having cardiac enzyme tests, coronary angiography, and coronary revascularisation increased marginally for AMI, angina and other IHD. The attenuation in differences was mainly due to adjustment for age and region. Further adjustment for HI type, socioeconomic factors and hospital tier, did not materially alter the women-to-men RRs of having cardiac enzyme tests, coronary angiography, and coronary revascularisation. The fully adjusted RRs of having diagnostic tests and procedures for AMI were: 1.00 (95% CI 0.97, 1.03) for cardiac enzyme tests, 0.80 (0.68, 0.93) for coronary angiography, and 0.85 (0.74, 0.99) for coronary revascularisation. The corresponding RRs for angina were 0.97 (0.94, 1.00), 0.66 (0.59, 0.74), 0.56 (0.47, 0.67) and those for other IHD were 0.97 (0.94, 1.00), 0.87 (0.76, 0.99) and 0.61 (0.51, 0.73), respectively (**Figure 6.2**).

Figure 6.2 Adjusted women-to-men rate ratios of having cardiac enzyme tests, coronary angiography and coronary revascularisation for acute MI, angina and other IHD, after sequential adjustment for confounding factors

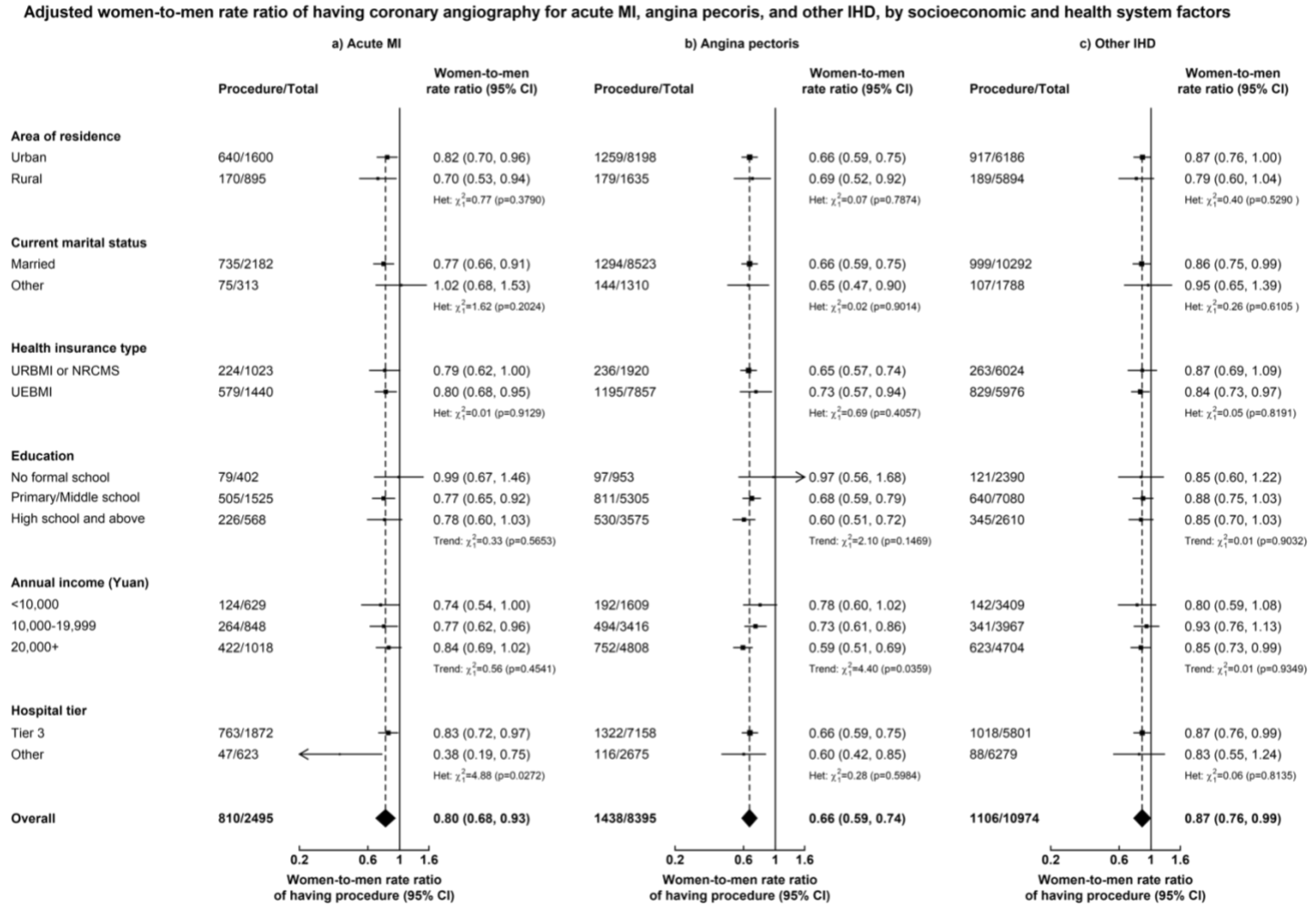


The total number for analyses of cardiac enzyme tests and coronary angiography included first admissions for participants with retrieved medical records. The total number for analyses of coronary revascularisation included all first IHD admissions for participants with and without retrieved medical records. The area of each square is inversely proportional to the variance.

6.3.3 Heterogeneity by socioeconomic factors

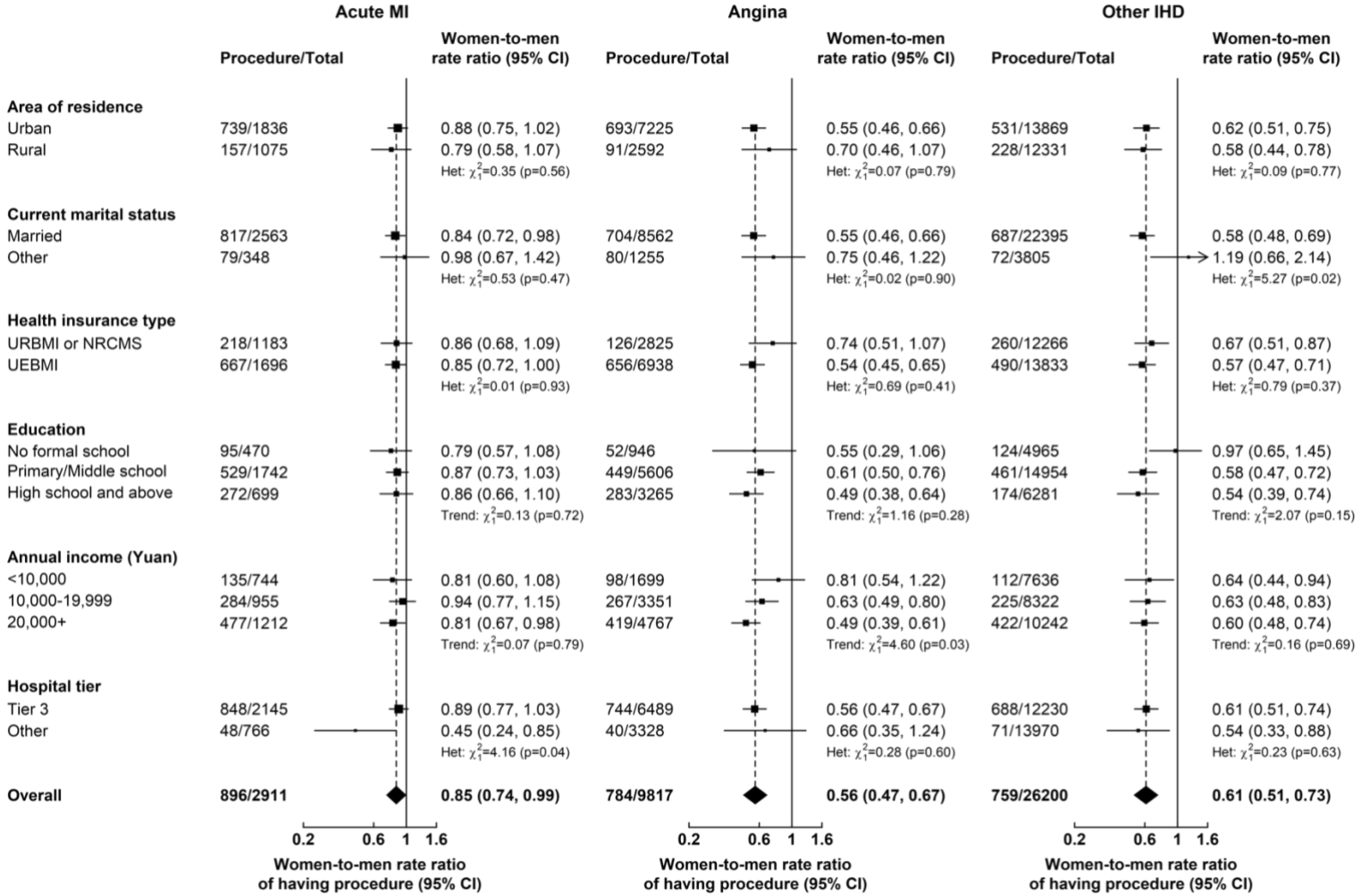
Among cases with AMI, the fully adjusted women-to-men RRs of having coronary angiography or revascularisation did not vary significantly by area of residence, marital status, HI type, education, and income (**Figure 6.3** and **Figure 6.4**). However, the fully adjusted women-to-men RRs of having coronary angiography and coronary revascularisation were higher for individuals admitted to tier 3 hospitals than lower tier hospitals (p-value for heterogeneity: coronary angiography p=0.03, revascularisation p=0.04). Among cases with angina and other IHD, there was little evidence of heterogeneity in the adjusted women-to-men RRs of having coronary procedures between different participant categories with the exception of income and marital status. The difference in the rates of having coronary angiography or coronary revascularisation between men and women with angina was higher for individuals with higher income (coronary angiography: p-trend<0.01, revascularisation: p-trend=0.03). For individuals with other IHD, the difference in the rates of having coronary revascularisation between men and women was higher for those that were married than those that were widowed, separated/divorced or never married (p-value for heterogeneity=0.02)

Figure 6.3 Adjusted women-to-men rate ratios of having coronary angiography for acute MI, angina and other IHD, by socioeconomic and health system factors



NRCMS: new rural cooperative medical scheme, UEBMI: urban employee basic medical insurance, URBMI: urban resident basic medical insurance. The area of each square is inversely proportional to the variance. For current marital status, the other category includes widowed, separated/divorced or never married individuals. For hospital tier, the other category includes tier 1, 2 or missing/unrated.

Figure 6.4 Adjusted women-to-men rate ratios of having coronary revascularisation for acute MI, angina and other IHD, by socioeconomic and health system factors



NRCMS: new rural cooperative medical scheme, UEBMI: urban employee basic medical insurance, URBMI: urban resident basic medical insurance. The area of each square is inversely proportional to the variance. For current marital status, the other category includes widowed, separated/divorced or never married individuals. For hospital tier, the other category includes tier 1, 2 or missing/unrated.

6.3.4 Standardised rates of having tests and procedures

For admissions for acute MI, angina and other IHD, the rates of having cardiac enzyme tests, coronary angiography, and revascularisation were higher in urban than in rural areas and in tier 3 than lower tier hospitals for both men and women (**Table 6.2**, **Table 6.3** and **Table 6.4**). The rates of having cardiac enzyme tests and coronary angiography were also higher for men and women enrolled in UEBMI than in those enrolled in URBMI or NRCMS. Rates of coronary procedures following AMI increased with levels of education in both men and women (**Table 6.2**). For all individuals with acute IHD, the rates of having cardiac tests, coronary angiography and coronary revascularisation increased over time.

Table 6.2 Adjusted rates (95% CI) of having cardiac enzyme tests, coronary angiography and coronary revascularisation for acute MI per 100 admissions for men and women, by socioeconomic and health system factors

	Cardiac enzymes tests		Coronary angiography		Coronary revascularisation	
	Men	Women	Men	Women	Men	Women
Area of residence						
Urban	94.7 (93.1, 96.3)	94.4 (92.4, 96.5)	38.3 (34.8, 41.8)	31.3 (27.5, 35.2)	35.6 (32.6, 38.6)	31.1 (27.5, 34.7)
Rural	84.8 (81.1, 88.5)	85.2 (81.3, 89.1)	13.8 (11.4, 16.1)	9.7 (7.3, 12.1)	8.9 (7.3, 10.6)	7.1 (5.3, 8.9)
Current marital status						
Married	91.7 (89.8, 93.7)	91.6 (89.4, 93.8)	29.9 (27.3, 32.5)	23.1 (20.2, 26.0)	25.4 (23.3, 27.4)	21.3 (18.8, 23.9)
Other	88.0 (82.1, 93.9)	89.4 (85.5, 93.3)	26.6 (17.7, 35.5)	27.3 (21.0, 33.5)	18.9 (13.0, 24.8)	18.5 (14.8, 22.2)
Health insurance type						
URBMI or NRCMS	85.6 (82.0, 89.1)	86.9 (83.6, 90.3)	15.7 (13.2, 18.3)	12.4 (10.1, 14.7)	26.4 (21.1, 31.7)	22.7 (18.2, 27.2)
UEBMI	94.6 (93.0, 96.3)	93.8 (91.5, 96.0)	38.2 (34.7, 41.7)	30.5 (26.5, 34.6)	24.1 (22.0, 26.3)	20.5 (17.8, 23.1)
Education						
No formal school	87.4 (82.0, 92.7)	90.1 (87.0, 93.2)	15.9 (10.8, 21.0)	15.7 (12.3, 19.0)	15.4 (11.7, 19.2)	12.1 (9.7, 14.6)
Primary/Middle school	90.8 (88.6, 92.9)	90.3 (87.7, 92.9)	29.7 (26.8, 32.6)	23.0 (19.7, 26.2)	22.7 (20.5, 24.8)	19.7 (17.0, 22.3)
High school and above	93.9 (91.8, 96.0)	93.6 (89.3, 97.8)	37.2 (32.8, 41.7)	29.2 (22.2, 36.2)	34.9 (31.1, 38.7)	29.9 (23.2, 36.5)
Annual household income (¥)						
<10 000	92.1 (88.4, 95.7)	93.5 (89.8, 97.2)	29.2 (23.3, 35.1)	21.5 (16.2, 26.8)	24.6 (19.8, 29.4)	19.8 (15.1, 24.5)
10 000-19 999	92.3 (90.1, 94.5)	90.1 (87.0, 93.2)	29.3 (25.8, 32.8)	22.7 (18.6, 26.8)	23.1 (20.4, 25.8)	21.7 (18.3, 25.2)
≥20 000	90.0 (87.5, 92.4)	91.3 (88.5, 94.1)	30.5 (27.2, 33.8)	25.6 (21.4, 29.8)	25.7 (23.1, 28.2)	20.8 (17.4, 24.1)
Hospital tier						
Tier 3	95.5 (94.0, 97.1)	95.5 (93.6, 97.3)	44.0 (40.2, 47.8)	36.7 (32.5, 40.8)	36.9 (33.7, 40.2)	32.8 (29.2, 36.4)
Other	86.7 (83.0, 90.4)	86.8 (82.3, 91.3)	11.2 (7.9, 14.6)	4.3 (1.6, 6.9)	10.1 (6.8, 13.3)	4.6 (2.0, 7.1)
Calendar period						
2004-2011	88.3 (85.6, 90.9)	87.8 (84.2, 91.4)	22.8 (19.9, 25.8)	18.4 (14.5, 22.2)	19.6 (17.4, 21.7)	14.9 (12.0, 17.8)
2012-2014	92.8 (90.5, 95.1)	92.8 (89.9, 95.6)	29.5 (26.1, 32.9)	22.7 (18.7, 26.7)	27.3 (24.3, 30.2)	25.4 (21.4, 29.3)
2015-2016	93.4 (90.5, 96.3)	93.6 (92.3, 94.9)	39.6 (34.8, 44.4)	32.5 (26.8, 38.3)	30.3 (26.6, 34.0)	26.6 (21.9, 31.2)
Overall	93.6 (92.3, 94.9)	93.7 (91.7, 95.6)	34.9 (32.5, 37.2)	27.8 (24.5, 31.0)	32.3 (30.3, 34.3)	27.6 (24.5, 30.7)

NRCMS: new rural cooperative medical scheme, UEBMI: urban employee basic medical insurance, URBMI: urban resident basic medical insurance. For current marital status, the other category includes widowed, separated/divorced or never married individuals. For hospital tier, the other category includes tier 1, 2 or missing/unrated.

Table 6.3 Adjusted rates (95% CI) of having cardiac enzyme tests, coronary angiography or coronary revascularisation for angina per 100 admissions for men and women, by socioeconomic and health system factors

	Cardiac enzymes tests		Coronary angiography		Coronary revascularisation	
	Men	**Women**	**Men**	**Women**	**Men**	**Women**
Area of residence						
Urban	77.8 (75.9, 79.6)	74.7 (73.3, 76.1)	22.5 (20.6, 24.3)	14.9 (13.6, 16.1)	14.1 (12.4, 15.7)	7.8 (6.8, 8.7)
Rural	57.8 (52.4, 63.2)	57.6 (52.3, 62.8)	8.7 (7.0, 10.3)	6.0 (4.7, 7.3)	3.8 (2.1, 5.5)	2.7 (1.6, 3.8)
Current marital status						
Married	71.1 (68.7, 73.4)	68.8 (66.7, 70.9)	17.9 (16.5, 19.3)	11.8 (10.8, 12.8)	10.1 (8.8, 11.4)	5.6 (4.8, 6.4)
Other	71.4 (65.9, 76.9)	67.8 (64.8, 70.7)	17.2 (12.4, 21.9)	11.1 (9.1, 13.1)	7.4 (4.2, 10.6)	5.5 (4.2, 6.9)
Health insurance type						
URBMI or NRCMS	58.9 (54.3, 63.4)	60.0 (55.8, 64.2)	10.8 (8.8, 12.9)	7.9 (6.6, 9.3)	8.8 (5.9, 11.8)	6.6 (4.8, 8.3)
UEBMI	77.6 (75.8, 79.3)	74.1 (72.7, 75.5)	21.7 (20.0, 23.4)	14.1 (13, 15.3)	10.1 (8.6, 11.6)	5.4 (4.6, 6.3)
Education						
No formal school	67.3 (58.6, 76.0)	63.6 (57.3, 70.0)	8.4 (4.0, 12.8)	8.2 (6.5, 9.8)	7.6 (3.0, 12.2)	4.2 (2.7, 5.7)
Primary/Middle school	71.4 (69.2, 73.7)	68.7 (66.8, 70.6)	17.9 (16.2, 19.6)	12.2 (11.0, 13.4)	9.6 (8.2, 11.1)	5.9 (5.0, 6.8)
High school and above	73.0 (70.8, 75.1)	71.1 (69.1, 73.1)	21.1 (19.0, 23.2)	12.8 (11.1, 14.4)	11.8 (10.2, 13.4)	5.8 (4.6, 7.0)
Annual household income (¥)						
<10 000	76.8 (72.6, 81.0)	70.2 (67.1, 73.3)	15.4 (12.2, 18.5)	12 (9.9, 14.2)	7.6 (5.2, 10.0)	6.1 (4.5, 7.8)
10 000-19 999	69.9 (67.0, 72.8)	68.4 (66.0, 70.8)	16.9 (14.9, 18.8)	12.3 (10.8, 13.7)	9.4 (7.8, 11.1)	5.9 (4.8, 7.0)
≥20 000	69.8 (67.2, 72.4)	67.9 (65.6, 70.2)	19.0 (17.0, 21.0)	11.3 (10.1, 12.5)	10.7 (9.0, 12.3)	5.2 (4.3, 6.1)
Hospital tier						
Tier 3	82.0 (79.6, 84.3)	80.3 (78.3, 82.3)	26.4 (24.2, 28.5)	17.5 (16.1, 18.9)	17.7 (15.1, 20.3)	9.9 (8.4, 11.4)
Other	59.0 (55.5, 62.4)	53.6 (50.7, 56.4)	5.5 (4.1, 6.8)	3.3 (2.4, 4.1)	1.6 (0.9, 2.3)	1.1 (0.6, 1.5)
Calendar period						
2004-2011	61.5 (58.7, 64.4)	55.7 (53.4, 58.1)	15.2 (13.3, 17.0)	10.8 (9.4, 12.1)	8.7 (7.2, 10.3)	5.1 (4.1, 6.1)
2012-2014	73.7 (71.0, 76.5)	73.1 (70.7, 75.5)	18.9 (16.9, 21.0)	12.2 (10.8, 13.5)	11.2 (9.4, 13.1)	6.4 (5.3, 7.6)
2015-2016	78.3 (75.2, 81.3)	79.0 (76.3, 81.6)	19.9 (17.5, 22.3)	12.7 (11.1, 14.4)	10.1 (8.2, 12.0)	5.3 (4.2, 6.5)
Overall	75.1 (73.4, 76.7)	72.5 (71.4, 73.6)	18.3 (16.9, 19.7)	12.1 (11.2, 13.0)	10.8 (9.6, 12.0)	6.1 (5.4, 6.7)

NRCMS: new rural cooperative medical scheme, UEBMI: urban employee basic medical insurance, URBMI: urban resident basic medical insurance. For current marital status, the other category includes widowed, separated/divorced or never married individuals. For hospital tier, the other category includes tier 1, 2 or missing/unrated.

Table 6.4 Adjusted rates (95% CI) of having cardiac enzymes tests, coronary angiography or coronary revascularisation for other IHD per 100 admissions for men and women, by socioeconomic and health system factors

	Cardiac enzymes test		Coronary angiography		Coronary revascularisation	
	Men	Women	Men	Women	Men	Women
Area of residence						
Urban	69.2 (67.2, 71.2)	67.5 (66.1, 69.0)	13.2 (11.9, 14.4)	11.5 (10.5, 12.4)	5.1 (4.5, 5.8)	3.1 (2.7, 3.5)
Rural	59.7 (57.7, 61.7)	56.8 (55.2, 58.4)	4.1 (3.3, 5.0)	3.3 (2.6, 3.9)	2.5 (2.1, 3.0)	1.5 (1.2, 1.8)
Current marital status						
Married	65.7 (64.1, 67.3)	63.8 (62.5, 65.1)	10.2 (9.3, 11.2)	8.8 (8.0, 9.5)	4.3 (3.8, 4.8)	2.5 (2.2, 2.8)
Other	67.7 (63.7, 71.7)	64.4 (62.0, 66.7)	8.0 (5.4, 10.6)	7.6 (6.2, 9.1)	1.8 (0.8, 2.7)	2.1 (1.6, 2.7)
Health insurance type						
URBMI or NRCMS	61.3 (59.2, 63.4)	58.7 (57.1, 60.2)	5.6 (4.7, 6.5)	4.8 (4.1, 5.6)	3.5 (2.8, 4.1)	2.3 (1.8, 2.8)
UEBMI	68.4 (66.5, 70.4)	66.9 (65.4, 68.4)	12.8 (11.5, 14.0)	10.8 (9.8, 11.7)	4.3 (3.8, 4.9)	2.5 (2.1, 2.9)
Education						
No formal school	69.2 (64.6, 73.9)	64.6 (62.7, 66.6)	5.9 (4.1, 7.8)	5.0 (4.2, 5.9)	2.7 (1.8, 3.7)	2.6 (2.1, 3.1)
Primary/Middle school	65.5 (63.6, 67.3)	64.2 (62.8, 65.7)	10.2 (9.1, 11.3)	9.0 (8.1, 9.9)	4.4 (3.8, 4.9)	2.5 (2.2, 2.9)
High school and above	65.7 (63.1, 68.2)	62.8 (60.4, 65.1)	11.9 (10.3, 13.5)	10.1 (8.8, 11.5)	3.8 (3.1, 4.5)	2.0 (1.5, 2.6)
Annual household income (¥)						
<10 000	67.6 (64.4, 70.8)	66.2 (63.6, 68.7)	9.2 (7.1, 11.4)	7.4 (5.8, 8.9)	3.4 (2.4, 4.3)	2.2 (1.6, 2.8)
10 000-19 999	65.7 (63.2, 68.2)	64.2 (62.3, 66.1)	9.7 (8.3, 11.2)	9.1 (7.9, 10.2)	4.1 (3.4, 4.8)	2.6 (2.1, 3.1)
≥20 000	65.3 (63.2, 67.4)	62.4 (60.7, 64.1)	10.4 (9.2, 11.5)	8.8 (7.9, 9.7)	4.2 (3.6, 4.8)	2.5 (2.1, 2.9)
Hospital tier						
Tier 3	73.0 (71.1, 75.0)	74.6 (73.0, 76.1)	15.3 (13.9, 16.7)	13.3 (12.2, 14.4)	7.4 (6.4, 8.4)	4.5 (3.9, 5.1)
Other	52.9 (50.9, 54.8)	47.1 (45.6, 48.5)	1.6 (1.1, 2.1)	1.3 (1.0, 1.7)	0.6 (0.4, 0.9)	0.3 (0.2, 0.5)
Calendar period						
2004-2011	53.3 (50.9, 55.8)	50.4 (48.4, 52.5)	6.9 (5.8, 8.0)	5.6 (4.7, 6.5)	2.9 (2.4, 3.4)	1.8 (1.4, 2.1)
2012-2014	70.5 (68.3, 72.8)	69.5 (67.8, 71.2)	9.7 (8.4, 10.9)	9.0 (8.0, 10.1)	4.3 (3.6, 5.1)	2.4 (1.9, 2.9)
2015-2016	73.6 (71.0, 76.1)	72.5 (70.5, 74.4)	14.3 (12.4, 16.1)	12.5 (11.1, 14.0)	5.0 (4.2, 5.9)	3.6 (2.9, 4.2)
Overall	64.6 (63.1, 66.1)	62.5 (61.4, 63.7)	9.9 (9.1, 10.8)	8.6 (7.9, 9.3)	3.7 (3.3, 4.1)	2.3 (2.0, 2.5)

NRCMS: new rural cooperative medical scheme, UEBMI: urban employee basic medical insurance, URBMI: urban resident basic medical insurance. For current marital status, the other category includes widowed, separated/divorced or never married individuals. For hospital tier, the other category includes tier 1, 2 or missing/unrated.

6.3.5 Sensitivity analyses

In sensitivity analyses, using a subsample of AMI admissions with available information on subtypes of AMI (n=1500), the proportions with STEMI were 52% in women and 68% in men. The women-to-men RRs of having coronary procedures were similar for STEMI and NSTEMI subtypes and were suggesting potentially smaller differences in rates of procedures between men and women for STEMI (**Figure 6.5**). The minimal effect of adjusting for socioeconomic and health system factors on the women-to-men RRs of having cardiac tests and procedures persisted for both STEMI and NSTEMI, after excluding individuals with prior CVD (**Figure 6.6**), and in analyses stratified by region (**Figure 6.7**).

After excluding individuals who died during admission for AMI, the women-to-men RRs (95% CI) of having cardiac enzyme tests, coronary angiography and coronary procedure were 1.00 (0.98, 1.03), 0.81 (0.69, 0.94), and 0.87 (0.76, 1.01). For angina, the corresponding RRs were: 0.97 (0.94, 1.00), 0.66 (0.59, 0.75) and 0.56 (0.47, 0.67), respectively, while for other IHD, they were 0.97 (0.94, 1.00), 0.87 (0.76, 0.99) and 0.61 (0.51, 0.73), respectively. These results were similar to those included in the main analyses.

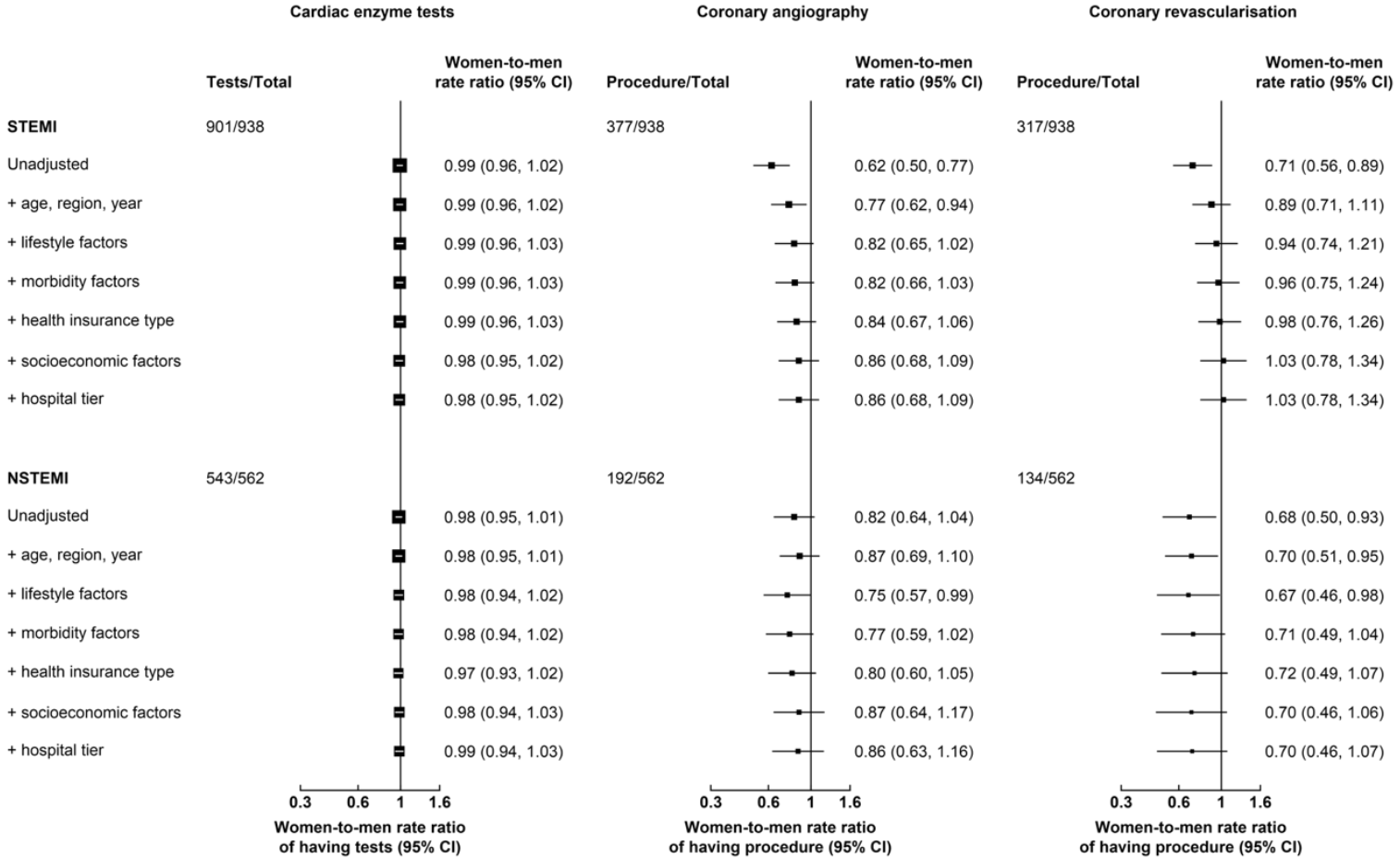
The adjusted women-to-men RRs (95% CI) of having coronary angiography among patients who received cardiac enzyme testing were: 0.80 (0.69, 0.94) for AMI, 0.67 (0.60, 0.76) for angina and 0.85 (0.74, 0.98) for other IHD. The adjusted women-to-men RRs of having coronary revascularisation among those who received cardiac enzyme testing were: 0.84 (0.71, 0.98) for AMI, 0.59 (0.49, 0.71) for angina and 0.62 (0.48, 0.79) for other IHD. These RRs were very similar to

those among all individuals, given that a majority of patients had cardiac enzyme tests.

When assuming that all individuals who had coronary revascularisation also had coronary angiography even when not explicitly recorded in their medical records (19%), the age- and region-adjusted rates of having coronary angiography for AMI rose to 39.2% (37.0, 41.3) for men and 32.3% (29.2, 35.3) for women. However, women-to-men RRs of having coronary angiography or revascularisation for AMI (0.88 [0.77, 1.00]), angina (0.63 [0.56, 0.71]) and other IHD (0.82 [0.73, 0.92]) remained similar to the main results. The adjusted women-to-men RRs of having revascularisation were similar for admissions with retrieved medical records (AMI: 0.84 [0.72, 1.00], angina: 0.56 [0.46, 0.67], other IHD: 0.66 [0.53, 0.83]) and without retrieved medical records (AMI: 0.87 [0.60, 1.24], angina: 0.72 [0.16, 3.22][1], other IHD: 0.54 [0.40, 0.73]).

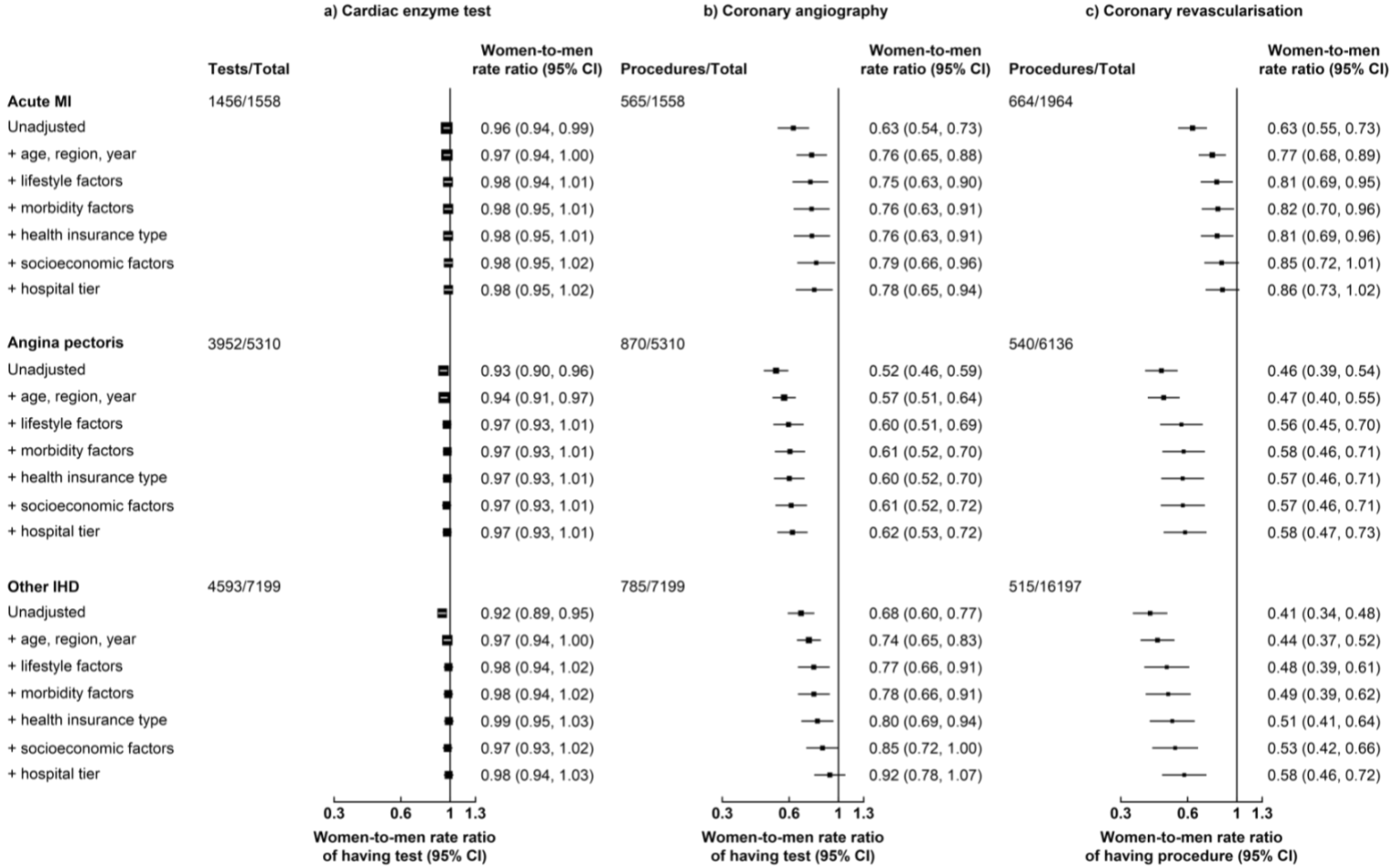
[1]OR for angina was not adjusted for regions, as otherwise the model would not converge due to a very small number of individuals who had revascularisation (n=15).

Figure 6.5 Adjusted women-to-men rate ratios of having cardiac enzyme tests, coronary angiography and coronary revascularisation for STEMI and NSTEMI, after sequential adjustment for confounding factors



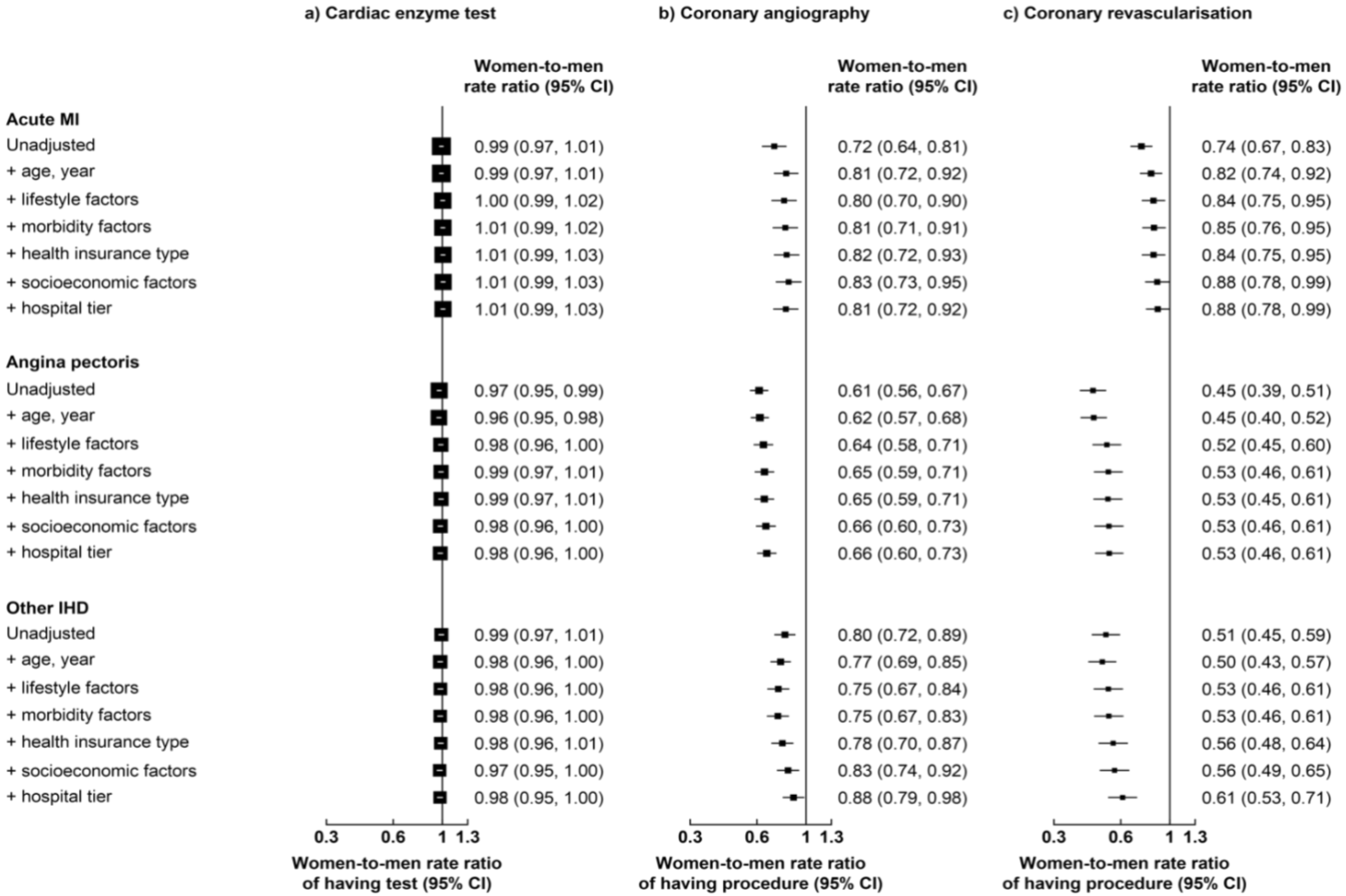
NSTEMI: non-ST segment elevation myocardial infarction, STEMI: ST segment elevation myocardial infarction myocardial infarction. The area of each square is inversely proportional to the variance.

Figure 6.6 Adjusted women-to-men rate ratios of having cardiac enzyme tests, coronary angiography and coronary revascularisation for first-ever acute MI, angina and other IHD, after sequential adjustment for confounding factors



The total number for analyses of cardiac enzyme tests and coronary angiography included first-ever admissions for participants with retrieved medical records. The total number for analyses of coronary revascularisation included all first-ever IHD admissions for participants with and without retrieved medical records. The area of each square is inversely proportional to the variance

Figure 6.7 Adjusted women-to-men rate ratios of having cardiac enzyme tests, coronary angiography and coronary revascularisation for acute MI, angina and other IHD by level of adjustment, analyses stratified by region

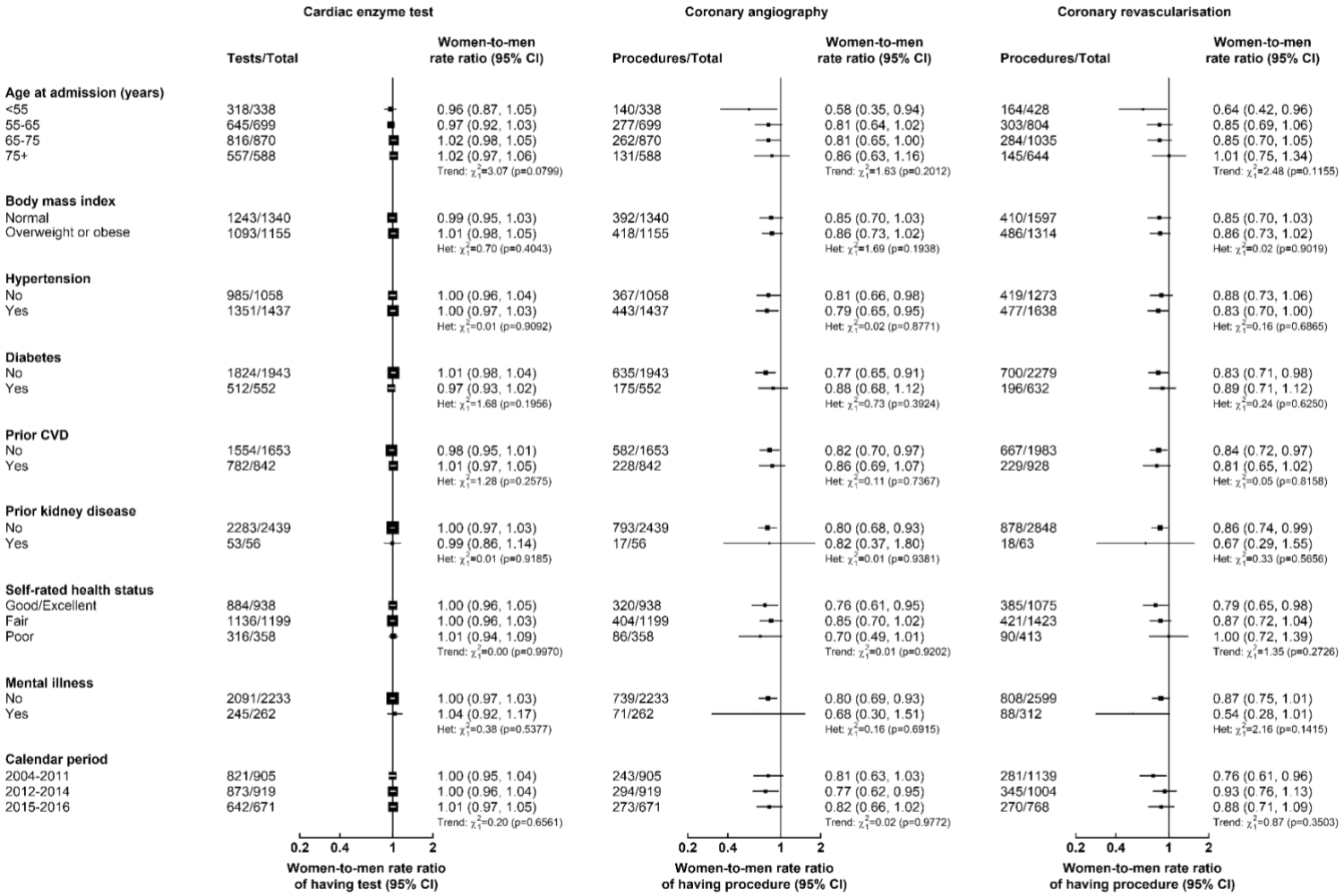


The area of each square is inversely proportional to the variance. Estimates were synthesized using the inverse-variance weighting method.

6.3.6 Further analyses

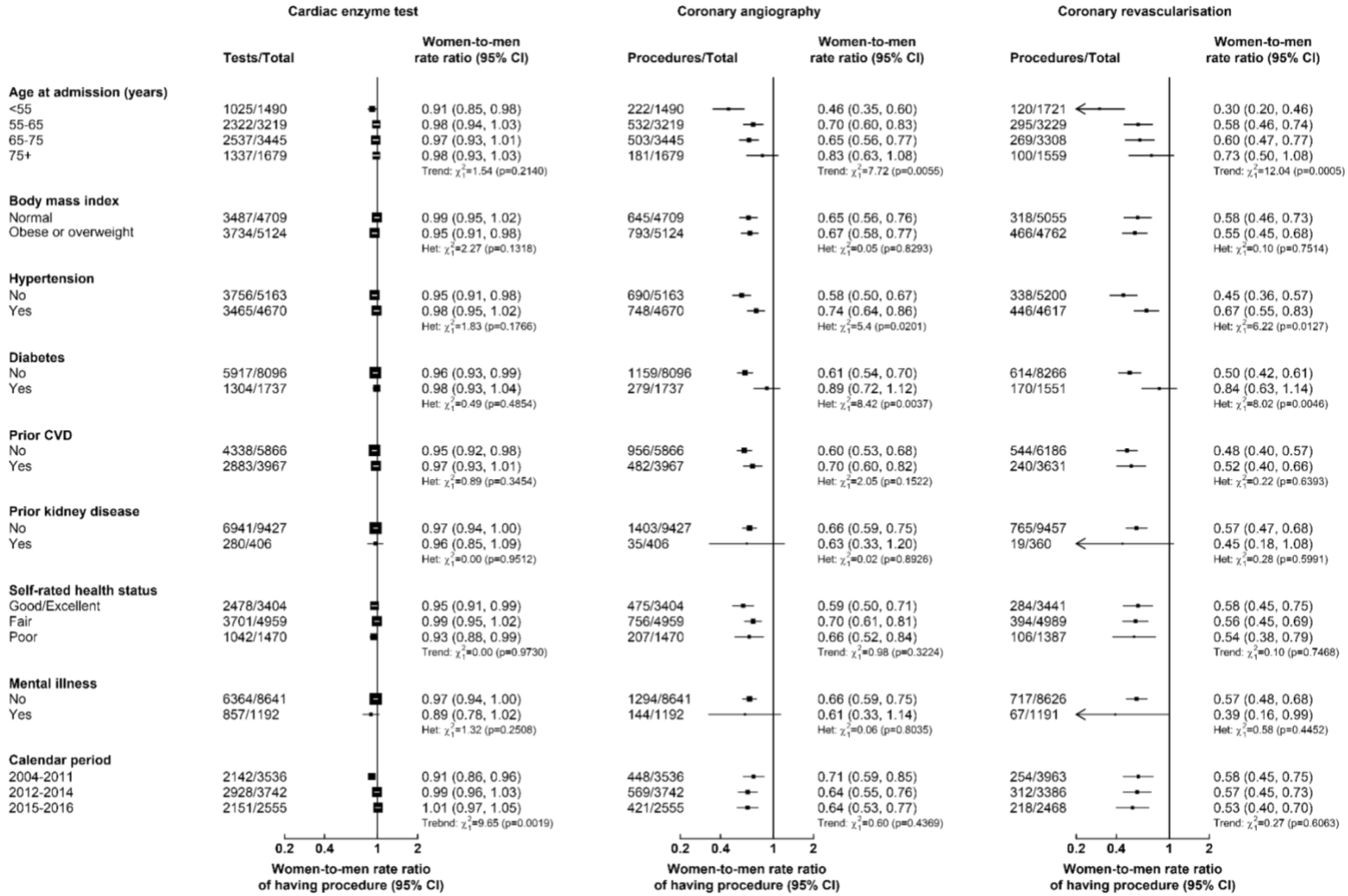
The adjusted women-to-men RRs of having coronary angiography and revascularisation for AMI did not vary by levels of established risk factors and calendar period (**Figure 6.8**). In cases with angina, the RRs of having cardiac enzyme tests for angina varied by calendar period, and the RRs of having coronary procedures varied by age, hypertension and diabetes (**Figure 6.9**). For participants with other IHD the RRs of having revascularisation varied by age and prior CVD (**Figure 6.10**)**.** The rates of having ECG, echocardiogram, Holter monitor tests and CCTA were comparable between men and women (**Table 6.5**). Among AMI admissions, the adjusted 28-day case fatality rates did not differ significantly (women-to-men RR: 0.84 [0.63, 1.11]; **Table 6.6**). A small proportion of admissions for angina and other IHD resulted in death within 28 days, albeit the case-fatality rates for other IHD were higher in men than women.

Figure 6.8 Adjusted women-to-men rate ratios of having cardiac enzyme tests, coronary angiography and coronary revascularisation for acute MI, by selected risk factors



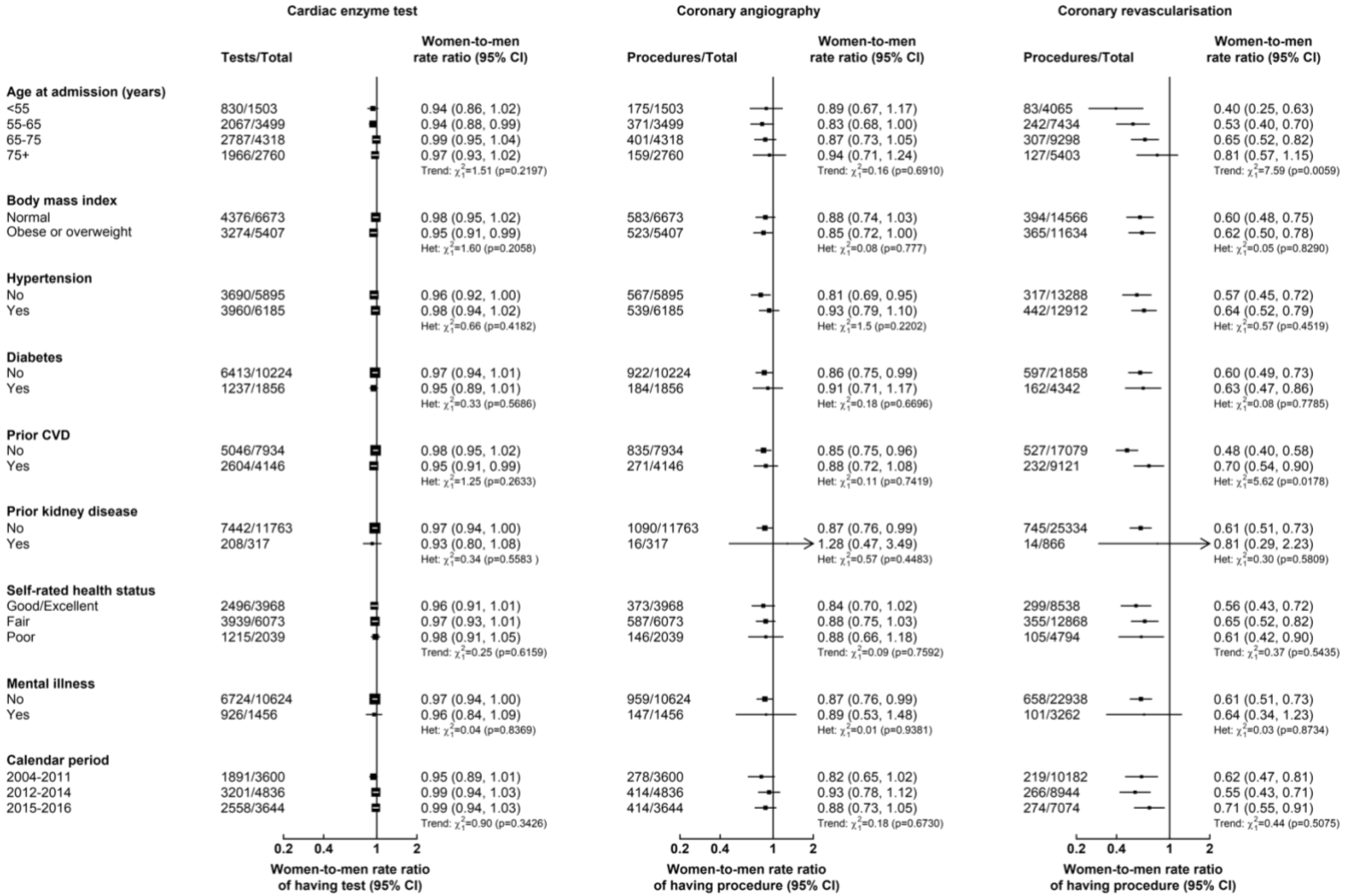
The area of each square is inversely proportional to the variance. For body mass index, the normal weight category also included underweight individuals.

Figure 6.9 Adjusted women-to-men rate ratios of having cardiac enzyme tests, coronary angiography and coronary revascularisation for angina, by selected risk factors



The area of each square is inversely proportional to the variance. For body mass index, the normal weight category also included underweight individuals.

Figure 6.10 Adjusted women-to-men rate ratios of having cardiac enzyme tests, coronary angiography and coronary revascularisation for other IHD, by selected risk factors



The area of each square is inversely proportional to the variance. For body mass index, the normal weight category also included underweight individuals.

Table 6.5 Adjusted rates (95% CI) of having other diagnostic tests per 100 admissions for acute MI, angina and other IHD, by gender

	Acute MI		Angina		Other IHD	
	Men	**Women**	**Men**	**Women**	**Men**	**Women**
ECG	98.5 (97.6, 99.5)	98.4 (97.5, 99.3)	98.1 (97.5, 98.7)	97.9 (97.4, 98.4)	96.1 (95.4, 96.9)	96.5 (96.0, 97.0)
Echocardiogram	63.2 (60.3, 66.1)	60.4 (57.3, 63.6)	67.4 (65.8, 69.0)	65.8 (64.6, 67.1)	63.5 (61.8, 65.2)	63.1 (61.9, 64.3)
Holter monitor test	24.0 (21.2, 26.9)	24.9 (21.7, 28.0)	35.8 (33.1, 38.5)	37.5 (34.9, 40.1)	33.9 (32.1, 35.6)	33.8 (32.6, 35.0)
CCTA	8.2 (6.5, 10.0)	8.5 (6.5, 10.6)	11.0 (9.8, 12.2)	9.9 (9.1, 10.8)	10.8 (9.7, 12.0)	9.8 (9.0, 10.6)

CCTA: coronary computed tomography angiography, ECG: electrocardiogram. Rates were standardised for the overall CKB participant population with AMI or other IHD in 2004-2016.

Table 6.6 Adjusted women-to-men rate ratios and rates of 28-day case fatality for acute MI and other IHD for men and women

	Rates per 100 admissions (95% CI)				Women-to-men rate ratios (95% CI)	
	Acute MI		Other IHD			
	Men (n=165)	**Women (n=123)**	**Men (n=166)**	**Women (n=147)**	**Acute MI**	**Other IHD**
Unadjusted	9.2 (7.8, 10.6)	11.1 (9.1, 13.0)	1.7 (1.5, 2.0)	0.9 (0.7, 1.0)	1.21 (0.96, 1.52)	0.51 (0.41, 0.64)
+ age, region, year	9.8 (8.3, 11.3)	10.0 (8.2, 11.7)	1.6 (1.4, 1.9)	0.9 (0.8, 1.1)	1.01 (0.80, 1.28)	0.58 (0.46, 0.72)
+ lifestyle and morbidity factors	10.7 (8.9, 10.5)	9.0 (7.2, 10.7)	1.5 (1.3, 1.8)	1.0 (0.8, 1.1)	0.84 (0.63, 1.11)	0.61 (0.46, 0.81)

Data used was from HI records supplemented by retrieved medical records. Results using data from retrieved medical records only were slightly higher. Case fatality rates for angina were not presented due to small number of 28-day case fatalities (men: 21, women: 19).

6.4 Discussion

6.4.1 Findings and interpretation of results

Summary of results

Current international and Chinese treatment guidelines for ACS recommend similar use of invasive diagnostic and therapeutic procedures in men and women.[2,18-20] However, this study of Chinese adults admitted into hospital with acute IHD demonstrated that use of invasive coronary angiography and coronary revascularisation was substantially lower in women compared to men, with greater differences in younger individuals with angina or other IHD. Gender differences in the use of diagnostic tests and procedures were similar in urban and rural areas. While women had lower socioeconomic status than men and were more likely to be admitted to lower tier hospitals, differences in socioeconomic and health system factors did not contribute to the gender differences in the use of invasive diagnostic or therapeutic procedures.

Comparison with the literature

Four studies from the literature review presented in **Chapter 3** also reported lower use of coronary angiography and revascularisation in women compared to men.[9,10,13,21] In one study, the average unadjusted use of coronary angiography for patients with STEMI in 2006-2011 was 30.3% in women (age- and region-adjusted in CKB: 27.8% for AMI) and 46.4% in men (CKB: 34.9% for AMI).[13] Across two studies, the average use of PCI in years after 2010 was 30.7% in women (CKB: 27.6% for AMI) and 37.9% in men (CKB: 32.3% for AMI).[9,13] Possible reasons for

the differences in rates are differences in disease outcomes (AMI vs STEMI), study period, model adjustments and hospital tier included (10% of all AMI admissions were in tier 1 hospitals in this study). Furthermore, when assuming that all CKB participants who had coronary revascularisation also had coronary angiography, the age- and region-adjusted rates of having coronary angiography for AMI were higher (women: 32.3% and men: 39.2%). In tier 3 hospitals only, rates of having coronary angiography (44.0%) or revascularisation (36.9%) for men with AMI in this study were similar to average rates for STEMI in the literature review, but rates were slightly higher for women with AMI (36.7% and 32.8%, respectively).

In addition to inequalities in the use of tests and procedures, a previous study reported that Chinese women were less likely to be discharged with guideline recommended medication, had a half a day shorter length of hospital stay and were more likely to be diagnosed with unstable angina pectoris than men.[21] Although this study did not report any differences in the duration of hospitalisation between men and women with acute IHD, women were also more likely to be admitted for angina. Another study reported that women with CVD were less likely than men to use guideline-directed secondary prevention medication, and those at high CVD risk were less likely to achieve blood pressure, LDL cholesterol, and body weight control.[22]

Similar to findings from Li et al (2017),[23] the rates of having coronary angiography and revascularisation were higher in urban than rural areas for men and women. Previous studies also reported higher use of coronary angiography and PCI for STEMI in tier 3 (56.8% and 42.7%, respectively) than tier 2 hospitals (27.5%, 16.3%), and in province level (75.2%, 65.7%) than prefecture (60.8%, 42.2%) and county (32.1%, 20.2%) level hospitals in 2013-2014.[24-26] Consistent with the

literature review, this study reported increased use of cardiac enzyme tests, coronary angiography and coronary procedures over time for acute IHD. Standardised rates of having cardiac enzyme tests for AMI in this study (2004-2011: 88%, 2012-2016: 93%) were similar to the average rates found in the literature review (before 2010: 91%, after 2010: 95%). Rates of having echocardiogram for AMI in this study (60-63%) were also similar to the average rates after 2010 reported in the literature review (62%).

The role of socioeconomic and health system factors

Previous studies have suggested that socioeconomic inequalities might account for some of the differences in access to healthcare services, especially for more expensive ones.[21,27] Consistent with previous findings, women in CKB had lower socioeconomic status compared to men, evidenced by lower educational attainment and household income.[6,7,21] They were more likely to be widowed, enrolled in HI types with less generous coverage, and seek care in lower tier hospitals with more limited expertise and capacity for performing complex procedures. These gender differences in socioeconomic status are likely to be exacerbated by substantial out-of-pocket (OOP) contributions to hospitalisation costs in China. The OOP payments for individuals with AMI requiring revascularisation procedures have been associated with catastrophic health expenditure, especially for individuals from lower socioeconomic groups.[28] One study reported that women's lower labour participation, especially in the formal economy, explained older women's lower HI coverage in China. While gender differences in HI coverage were more significant in individuals with low education, no gender differences were reported in those with high education.[29] In another

study, supplementary private HI coverage prevented catastrophic health expenditure for men but not for women, most likely because men were better at using the supplementary private HI than women.[30] Carlsson et al (2012) showed that husbands have a stronger influence than wives on joint household decisions in China,[30] which can also include decisions to seek care and would hinder women's healthcare seeking behaviour. They also found that the wife had a stronger influence on joint decisions in richer household and when the wife was older than her husband.[31]

While the magnitude of gender differences in the use of coronary angiography and revascularisation were similar for AMI, they were greater for coronary revascularisation than for coronary angiography among those with angina and other IHD. The differences suggest that financial affordability may influence the use of expensive procedures, particularly in less severe acute IHD cases. Nevertheless, the adjustment for socioeconomic and health system factors accounted for only a small proportion of the gender differences in the use of coronary procedures. A recent study also reported that education level was not associated with sex differences in primary or secondary CVD prevention in China.[22]

Other factors such as sex differences in clinical presentation and pathophysiology, and physician bias or concerns might have contributed more largely to the observed differences in use of invasive coronary procedures between men and women.

Differences in clinical presentation and pathophysiology

Differences in the use of invasive procedures may reflect heterogeneity in the clinical presentation and pathophysiology of IHD between men and women, as suggested by previous studies.[2,32] Women with ACS are more likely to present with atypical symptoms that, particularly at younger ages, are stress-related, which makes the diagnostic evaluation and subsequent management more challenging. In addition, women have a higher prevalence of non-occlusive coronary artery disease, microvascular dysfunction and spontaneous coronary artery dissection compared to men.

Although gender differences were assessed separately in cases with AMI, angina and other IHD, STEMI and NSTEMI cases could only be differentiated in a subsample of all AMI admissions. While the benefits of an early invasive strategy for STEMI in both men and women are well established, those for NSTEMI are more uncertain, but recent evidence advocate comparable use of coronary procedures in men and women with elevated biomarkers.[32,33] Moreover, previous studies have reported that most AMI cases in both Chinese men and women were STEMI.[12,35]

Although there were no differences in use of cardiac enzyme tests, the lack of sex-specific cardiac biomarkers thresholds may have underestimated the severity of ACS in women, resulting in greater risk of diagnosis misclassification.[36]

Similarly to this study, two studies in the literature review did not find higher rates of death, cardiac death, major adverse CVD events or major bleeding episodes in women than men after adjusting for baseline or clinical characteristics.[9,21] However,

Zheng et al (2015) found higher mortality in women than men with STEMI and a significant gender-age interaction even after adjusting for confounders.[10]

Physician bias or concerns

The differences in use of coronary artery procedures among women with AMI compared to men may reflect physician bias or concerns about the safety of such procedures in women.[3] Women have higher risks than men of bleeding and other vascular complications following PCI, which may prompt a greater reluctance to use coronary revascularisation.[37,38] Alternatively, unconscious bias or beliefs that AMI or IHD preferentially affect men could lead physicians to underestimate the severity of IHD in women and contribute to a lower use of certain invasive procedures.[1,39] Such biases may be even more extreme in younger patients due to lower incidence of IHD in younger women.[10] Xia et al (2020) also identified that younger women were at higher risk of suboptimal secondary prevention for CVD, probably reflecting bias within the healthcare system.[22] Raising awareness among physicians and women themselves about IHD in women would help tackle the general underestimation of cardiovascular risk in women, especially in young women. Improving the fair representation of women in CVD clinical trials in China might help to increase the evidence base, overcome physician's concerns and improve the appropriate guideline-indicated use of coronary tests and procedures for women.

6.4.2 Limitations

Despite the large population studied, the diversity of regions and hospitals examined, the present study had several limitations.

Case definition

The study could not differentiate AMI subtypes (STEMI or NSTEMI) in all cases, nor could it differentiate stable from unstable angina. Although IHD cases with retrieved medical records were validated by Chinese cardiologists, alternate diagnoses such as Takotsubo cardiomyopathy or spontaneous coronary artery dissection were not excluded although these are extremely rare.

Socioeconomic characteristics

Socioeconomic characteristics, except HI type, and lifestyle factors were only collected at baseline. As the study population is middle-aged and older, education is unlikely to change further. Income, however, has likely increased during the study period, though relative income or categories of income are expected to be more stable over time. In addition, income was self-reported and hence subject to misreporting, which might vary between men and women.

Data sources

Different data sources were used for different study outcomes. For the use of coronary revascularisation, 45% of acute IHD admissions did not have retrieved medical records, yet this proportion was similar for men and women. The results were unlikely to be affected by bias, because the distribution of acute IHD events between men and women and the adjusted women-to-men rates ratios of having

revascularisation were similar for admissions with and without retrieved medical records.

This study lacked information on patients' presentation symptoms, the clinical indication for revascularisation procedures, such as echocardiographic or angiographic variables or hemodynamic parameters, delay in admission from onset of acute IHD symptoms, timing of procedure following admission, or reasons for not having more invasive procedures. These factors might vary between men and women, and explain some of the observed gender differences in use of diagnostic tests and procedures.

Although CKB data did not allow us to clearly identify inter-hospital transfers, readmissions within 30 days were used as a proxy measure to examine whether women were transferred more or less often after presenting to a tier 1 hospital. Among individuals with acute IHD, only 3.3% had a 30-day readmission, and the proportion was significantly higher for men compared to women (3.9% vs 3.0%, $p<0.001$). The proportion of individuals admitted to tier 1 hospitals who had a 30-day readmission was higher for men (4.4%) than women (3.8%), but the difference was not statistically significant ($p=0.111$). For individuals with AMI, 6.3% of individuals had a 30-day readmission and the proportions of men and women with a readmission were similar. Furthermore, primary and non-primary PCI could not be differentiated. Thus, the present study could not fully exclude residual confounding.

Power

Despite the large study sample size for acute IHD overall, sample size for subgroup analysis for AMI might have been insufficient in some cases.

Generalisability of results

The CKB study was not designed to be nationally representative of the overall Chinese population, and participants were recruited from 10 diverse areas.[40] If individuals who entered the CKB study were wealthier, the differences between socioeconomic groups would be smaller than in the general population, potentially biasing results. Unfortunately, there are no data to check if the CKB cohort is representative of the underlying populations in the counties where participants were recruited. Nevertheless, the diversity of the population (e.g. socio-demographic characteristics) and hospital care setting covered is likely to make women-to-men rate ratios of having a diagnostic test or procedure generalisable to the wider Chinese population. Given the rapidly evolving field, future research should investigate contemporary use of invasive procedures for acute IHD in men and women.

6.4.3 Conclusions

Overall, this large prospective study demonstrated that Chinese women were less likely than men to have coronary angiography and revascularisation procedures following hospital admission for AMI, angina and other IHD. This is the first study to investigate the role of socioeconomic and health system factors, under-recognised risk factors, on the differences in use of tests and procedures between men and women. However, this study found that women's lower socioeconomic status and higher attendance of smaller hospitals did not contribute to these differences. It is likely that sex differences in clinical presentation and pathophysiology or physicians' bias or concerns played a larger role. Further systematic monitoring of clinical care in men and women with acute IHD is required as the reasons for differences in use of invasive coronary procedures remain unexplained.

6.5 Summary

This chapter demonstrated that the use of invasive diagnostic and therapeutic procedures for acute IHD was lower in women than men in China and that socioeconomic and health system factors did not explain these differences. The next chapter, Chapter 7, examines the influence of health insurance and socioeconomic characteristics on the choice of hospital tier for stroke and IHD.

References

1. Woodward M. Cardiovascular Disease and the Female Disadvantage. *International Journal of Environmental Research and Public Health*. 2019; **16**(7): 1165.

2. Haider A, Bengs S, Luu J, et al. Sex and gender in cardiovascular medicine: presentation and outcomes of acute coronary syndrome. *European Heart Journal*. 2019; **41**(13): 1328-36.

3. Hvelplund A, Galatius S, Madsen M, et al. Women with acute coronary syndrome are less invasively examined and subsequently less treated than men. *European Heart Journal*. 2009; **31**(6): 684-90.

4. Yip W, Fu H, Chen AT, et al. 10 years of health-care reform in China: progress and gaps in Universal Health Coverage. *The Lancet*. 2019; **394**(10204): 1192-204.

5. World Health Organisation (WHO). Global Health Expenditure Database 2019. Available from: https://apps.who.int/nha/database/ViewData/Indicators/en (Accessed: 20 January 2021).

6. Liu C, Bryson SA. Why informally employed Chinese women do not go to the doctor. *Health Promotion International*. 2015; **32**(3): 558-66.

7. Song Y, Bian Y. Gender differences in the use of health care in China: cross-sectional analysis. *International Journal for Equity in Health*. 2014; **13**: 8-.

8. Zhang C, Lei X, Strauss J, Zhao Y. Health Insurance and Health Care among the Mid-Aged and Older Chinese: Evidence from the National Baseline Survey of CHARLS. *Health Economics*. 2017; **26**(4): 431-49.

9. Hao Y, Liu J, Liu J, et al. Sex Differences in In-Hospital Management and Outcomes of Patients With Acute Coronary Syndrome. *Circulation*. 2019; **139**(15): 1776-85.

10. Zheng X, Dreyer RP, Hu S, et al. Age-specific gender differences in early mortality following ST-segment elevation myocardial infarction in China. *Heart*. 2015; **101**(5): 349.

11. Dreyer RP, Zheng X, Xu X, et al. Sex differences in health outcomes at one year following acute myocardial infarction: A report from the China Patient-Centered Evaluative Assessment of Cardiac Events prospective acute myocardial infarction study. *European Heart Journal - Acute Cardiovascular Care*. 2019; **8**(3): 273-82.

12. Chen H, Shi L, Xue M, et al. Geographic Variations in In‐Hospital Mortality and Use of Percutaneous Coronary Intervention Following Acute

Myocardial Infarction in China: A Nationwide Cross‐Sectional Analysis. *Journal of the American Heart Association*. 2018; **7**(8): e008131.

13. Du X, Spatz ES, Dreyer RP, et al. Sex Differences in Clinical Profiles and Quality of Care Among Patients With ST-Segment Elevation Myocardial Infarction From 2001 to 2011: Insights From the China Patient-Centered Evaluative Assessment of Cardiac Events (PEACE)-Retrospective Study. *Journal of the American Heart Association*. 2016; **5**(2).

14. Shaw LJ, Pepine CJ, Xie J, et al. Quality and Equitable Health Care Gaps for Women: Attributions to Sex Differences in Cardiovascular Medicine. *Journal of the American College of Cardiology*. 2017; **70**(3): 373-88.

15. Vogel B, Acevedo M, Appelman Y, et al. The Lancet women and cardiovascular disease Commission: reducing the global burden by 2030. *The Lancet*. 2021; **397**(10292): 2385-438.

16. Wang H, Xu T, Xu J. Factors Contributing to High Costs and Inequality in China's Health Care System. *JAMA*. 2007; **298**(16): 1928-30.

17. Zou G. A Modified Poisson Regression Approach to Prospective Studies with Binary Data. *American Journal of Epidemiology*. 2004; **159**(7): 702-6.

18. Cardiovascular Branch of Chinese Medical Association Editorial Board of The Chinese Journal of Cardiology. Guidelines for Diagnosis and Treatment of Acute ST-elevation Myocardial Infarction. *Chinese Journal of Cardiology*. 2015; **43**(5): 380-93.

19. Chinese Medical Association, Editorial Board of The Chinese Journal of Cardiology. Guidelines for Chinese Percutaneous Coronary Intervention. *The Chinese Journal of Cardiology*. 2016; **44**(5): 382-400.

20. Chinese Society of Cardiology. Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation. *The Chinese Journal of Cardiology*. 2012; **40**: 353–67.

21. Du X, Patel A, Li X, Wu Y, Turnbull F, Gao R. Treatment and outcomes of acute coronary syndromes in women: An analysis of a multicenter quality improvement Chinese study. *International Journal of Cardiology*. 2017; **241**: 19-24.

22. Xia S, Du X, Guo L, et al. Sex Differences in Primary and Secondary Prevention of Cardiovascular Disease in China. *Circulation*. 2020; **141**(7): 530-9.

23. Li X, Murugiah K, Li J, et al. Urban-Rural Comparisons in Hospital Admission, Treatments, and Outcomes for ST-Segment-Elevation Myocardial Infarction in China From 2001 to 2011: A Retrospective Analysis From the China PEACE Study (Patient-Centered Evaluative Assessment of

Cardiac Events). *Circulation: Cardiovascular Quality and Outcomes*. 2017; **10**(11).

24. Yang Y, Nicholas S, Li S, et al. Health care utilization for patients with stroke: a 3-year cross-sectional study of China's two urban health insurance schemes across four cities. *BMC Public Health*. 2021; **21**(1): 531.

25. Gao R, Patel A, Gao W, et al. Prospective observational study of acute coronary syndromes in China: practice patterns and outcomes. *Heart*. 2008; **94**(5): 554-60.

26. Zhang Y, Yang S, Liu X, et al. Management of ST-segment elevation myocardial infarction in predominantly rural central China: A retrospective observational study. *Medicine*. 2016; **95**(49): e5584.

27. Chen L, Standing H. Gender equity in transitional China's healthcare policy reforms. *Feminist Economics*. 2007; **13**(3-4): 189-212.

28. Fang H, Eggleston K, Hanson K, Wu M. Enhancing financial protection under China's social health insurance to achieve universal health coverage. *BMJ*. 2019; **365**: l2378.

29. Zhou M, Zhao S, Zhao Z. Gender differences in health insurance coverage in China. *International Journal for Equity in Health*. 2021; **20**(1): 52.

30. Sun J, Lyu S. The effect of medical insurance on catastrophic health expenditure: evidence from China. *Cost Effectiveness and Resource Allocation*. 2020; **18**(1): 10.

31. Carlsson F, He H, Martinsson P, Qin P, Sutter M. Household decision making in rural China: Using experiments to estimate the influences of spouses. *Journal of Economic Behavior & Organization*. 2012; **84**(2): 525-36.

32. Garcia M, Mulvagh SL, Merz CNB, Buring JE, Manson JE. Cardiovascular Disease in Women: Clinical Perspectives. *Circulation Research*. 2016; **118**(8): 1273-93.

33. Alfredsson J, Lindbäck J, Wallentin L, Swahn E. Similar outcome with an invasive strategy in men and women with non-ST-elevation acute coronary syndromes: From the Swedish Web-System for Enhancement and Development of Evidence-Based Care in Heart Disease Evaluated According to Recommended Therapies (SWEDEHEART). *European Heart Journal*. 2011; **32**(24): 3128-36.

34. O'Donoghue M, Boden WE, Braunwald E, et al. Early Invasive vs Conservative Treatment Strategies in Women and Men With Unstable Angina and Non–ST-Segment Elevation Myocardial Infarction: A Meta-analysis. *JAMA*. 2008; **300**(1): 71-80.

35. Huo Y, Zhang Y, Han Y, Yan H, Ge J. Cardiovascular diseases in China: The blue book myocardial infarction. *Cardiology Plus*. 2017; **2**(1): 39-54.

36. Sobhani K, Nieves Castro DK, Fu Q, Gottlieb RA, Van Eyk JE, Noel Bairey Merz C. Sex differences in ischemic heart disease and heart failure biomarkers. *Biology of Sex Differences*. 2018; **9**(1).

37. Kosmidou I, Leon MB, Zhang Y, et al. Long-Term Outcomes in Women and Men Following Percutaneous Coronary Intervention. *Journal of the American College of Cardiology*. 2020; **75**(14): 1631-40.

38. Lichtman JH, Wang Y, Jones SB, et al. Age and sex differences in inhospital complication rates and mortality after percutaneous coronary intervention procedures: Evidence from the NCDR(®). *American Heart Journal*. 2014; **167**(3): 376-83.

39. Bönte M, von dem Knesebeck O, Siegrist J, et al. Women and Men with Coronary Heart Disease in Three Countries: Are They Treated Differently? *Women's Health Issues*. 2008; **18**(3): 191-8.

40. Chen Z, Chen J, Collins R, et al. China Kadoorie Biobank of 0.5 million people: survey methods, baseline characteristics and long-term follow-up. *International Journal of Epidemiology*. 2011; **40**(6): 1652-66.

Chapter 7. The influence of health insurance and socioeconomic characteristics on choice of hospital tier for stroke and ischaemic heart disease

7.1 Background

In the absence of a well-developed primary care and referral system in China,[1] Chinese adults are free to choose to present at hospital of any tier or size.[2] Irrespective of the severity of their illness, patients preferentially select to access higher rather than lower tier hospitals for medical treatment.[3-8] Thus, increased demand for care in higher tier hospitals has resulted in substantial problems for the provision of healthcare, including inefficient allocation of resources, increased expenditure, worsening patient outcomes and deteriorating doctor-patient relationships.[3,8,9] These issues have been referred to as the "three longs and one short" problem: long waiting times for registration, long waiting times for payment of charges, long waiting times for appointment with a doctor, and a short appointment duration.[10]

One of the chief objectives of the healthcare reforms launched in 2009 was to improve the primary care system and divert patient admissions from higher to lower tier hospitals.[8] The government outlined a target to have at least 70% of patients choose primary care facilities for their first visit,[11] and increased subsidies for primary care from ¥19 billion in 2008 to ¥140 billion in 2015 to improve the infrastructure and workforce (including training of general practitioners).[5] The more recent phases of healthcare reforms focused on enhancing utilisation of primary

care and strengthening connections between different healthcare facilities to establish a hierarchical medical system. This system would involve a clear division of labour and responsibilities between different hospital tiers, with initial diagnosis and treatment of chronic and common diseases in tier 1 hospitals, with referral for those with acute diseases to higher tier hospitals and two-way referrals between hospital tiers.[12,13] Guidelines issued by the State Council in 2015 advocated changes to patient cost sharing, establishment of medical alliances between large hospitals and primary care providers, and registration of all patients with a family doctor.[14,15] The use of differential cost sharing by hospital tiers (lower deductibles and higher reimbursement rates in lower tiers) was adopted by local governments to encourage patients to preferentially seek care in lower tier hospitals and limit costs.[5,16]

The aims of this chapter were: (i) to summarise previous studies of factors influencing choice of healthcare facilities in China; and (ii) examine the impact of health insurance (HI) characteristics (reimbursement rates, deductibles and ceilings), and socioeconomic characteristics on choice of hospital tier (conditional on hospitalisation) for treatment of stroke, ischaemic heart disease (IHD) or any cause in 2009-2017 among China Kadoorie Biobank (CKB) participants.

7.2 Overview of studies of factors influencing choice of healthcare facilities in China

7.2.1 Methods

Although a systematic review of previous studies in **Chapter 3** highlighted differences in admissions, length of hospital stay, in-hospital mortality and use of diagnostic tests and procedures for stroke and IHD by hospital tier, none of the included studies examined factors influencing choice of hospital tier. Consequently, a rapid literature review of studies of factors influencing choice of healthcare facilities for any disease was conducted. Studies were identified using MEDLINE in addition to searching citation lists of previously identified relevant studies (**Appendix Table F.1**). The inclusion criteria were:

- English language publications in peer-reviewed journals prior to September 1, 2021
- Studies conducted in China
- Data collection period commenced after 2003
- Outcomes included choice of healthcare facility level, with at least one of the options being a hospital

Studies focusing on specific population groups (e.g. pregnant women, migrant workers), types of care (e.g. dental care) or occupational diseases (e.g. pneumoconiosis), and comparing public and private healthcare providers were excluded. When studies used the same dataset during identical years, only the study providing the maximum information was retained, unless different variables were studied.

A total of 22 studies were identified and except for one study,[17] all studies used individual-level data. Only two studies used preferences derived from experimental design studies (i.e. stated preference data) rather than individuals' actual choices (i.e. revealed preference data). Eight studies (36%) examined choice of healthcare facilities for outpatient care only, four studies (18%) focused on inpatient care, and ten studies (46%) did not specify if inpatient or outpatient care was used. The details of the data extracted are provided in **Appendix Table F.2** and **Table F.3**. Since the terminology for similar healthcare facilities differs between studies, tier 1 hospitals (or healthcare facilities) included primary care facilities, such as community health centres (CHCs) and stations in urban areas or township health centres (THCs) and village clinics in rural areas.

7.2.2 Cost sharing mechanisms

Among the included studies, cost sharing mechanisms were reflected by enrolment in new or different HI schemes, expansion of HI coverage, or changes in HI characteristics.

Rural areas

With the introduction of the New Rural Cooperative Medical Scheme (NRCMS) in 2003, several studies examined the impact of expanding NRCMS on individuals' health seeking behaviours.[18-20] Babiarz et al (2010) reported no significant effects of reimbursement rates on the probability of using THCs or hospitals, compared to village clinics.[18] Similarly, in a study of patients with diabetes in rural areas, changes in reimbursement rates did not affect outpatient care utilisation in different types of healthcare facilities.[21] Brown and Theoharides (2009) demonstrated that

conditional on seeking treatment, the deductible and average daily expenditure for inpatient care had an adverse effect and a higher reimbursement ceiling had a positive effect on health seeking behaviours.[20] According to Qian et al (2009), price was an important determinant of choice of healthcare facility for outpatient care in less affluent rural areas, with higher elasticity (i.e. larger change in choice probability in response to a change in price) for low-income than high-income groups and for county hospitals than THCs or village clinics.[22] Hou et al (2014) reported that NRCMS enrollees were more likely to choose providers with higher rather than lower reimbursement rates for inpatient care.[19]

Urban areas

One study in Shanghai reported that being enrolled in HI (vs uninsured) had no effect on healthcare seeking behaviour.[23] Another study examining the choice of private clinics[1], CHCs or city hospitals compared to self-treatment in urban areas reported that NRCMS enrollees with upper respiratory tract infections (URTI) were less likely to use private clinics and more likely to use CHCs, while the choice of provider did not vary significantly for Urban Employee Basic Medical Insurance (UEBMI) enrollees.[1]

Urban and rural areas

Xiong et al (2018) reported that patients enrolled in UEBMI, Urban Resident Basic Medical Insurance (URBMI) and NRCMS were more likely to choose inpatient services in tier 3 hospitals, tier 2 hospitals, and township or tier 1 hospitals, respectively.[17] For all HI enrollees, trends in the choice of tier 3 hospitals increased

[1]Private clinics are similar to CHCs except that they are privately owned and that they mostly provide curative services, while CHCs also provide health promotion education, disease prevention, family planning and other public health services.

in 2008-2014, but trends decreased for the choice of tier 1 and 2 for UEBMI patients, tier 2 for URBMI patients, and township hospitals for NRCMS patients.[17] Compared to the uninsured, UEBMI enrollees were more likely to choose higher tier facilities, yet NRCMS enrollees were less likely to do so across 29 regions in China.[24] Similarly, the proportions of outpatient and inpatient visits in general hospitals (vs specialised hospitals and primary care facilities) were higher for middle-aged and older Chinese enrolled in UEBMI and URBMI than those enrolled in NRCMS, other HI (e.g. government or private HI) or the uninsured.[25] Jin et al (2020) reported that increasing both HI average reimbursement rates and physician density at primary care facilities were associated with a greater likelihood of visiting primary care facilities and a lower probability of visiting county and higher-level hospitals.[26] Zhou et al (2021) reported that the nationwide implementation of a hierarchical medical system[2] had a significantly positive effect on the probability of urban residents using primary care facilities, but the effect was not significant for rural residents.[12] They also reported that insured urban and rural residents were more likely than uninsured residents to choose primary care facilities, indicating that social HI had a significant influence on guiding patients to primary care facilities.[12]

[2]The hierarchical medical system introduced gradient reimbursement and referral reforms, and different supply-side strategies (i.e. increased subsidies in the infrastructure and workforce of the primary care system) to alleviate the unbalanced distribution of medical resources and divert patient flow to primary care facilities.

7.2.3 Patient characteristics

The effect of age on the choice of healthcare facility was inconsistent across studies, with some studies reporting that older individuals were more likely to choose primary care facilities,[23,27,28] yet other studies reported that middle-aged (40-60 years) and older individuals were more likely to choose higher tier hospitals for outpatient care or municipal-level hospitals for any type of care.[28-30] One study reported different effects by urban and rural areas, with older adults in urban areas being more likely to directly access higher tier hospitals for outpatient care, while in rural areas this was true for middle-aged rather than older adults.[29] While most studies did not report a significant effect of sex (or gender) on choice of healthcare facility,[1,20,27,29-32] two studies reported that men were more likely than women to choose higher tier hospitals than village-level hospitals or community health stations.[24,28] In contrast, Yu et al (2017) reported that among individuals with mild diseases, men were more likely to choose a community health facility, and that among individuals with chronic diseases, men were more likely to choose a drug store and less likely to choose a specialty rather than a general hospital.[23]

Three studies showed that rural patients were more likely than urban patients to choose primary care facilities than higher-level facilities.[27,29,30] Several studies reported that individuals with higher levels of education or income were more likely to choose higher level facilities than primary care facilities for inpatient and outpatient care.[23-25,27-30,32]

Individuals with less severe diseases were more likely to choose lower level facilities, while those with more severe conditions, chronic diseases, poor self-assessed health or who experienced hospitalisation in the past 12 months were

more likely to choose higher level facilities than healthier individuals.[1,12,23,25,27,29,30,32]

Other patient characteristics that were associated with a higher probability of choosing higher tier (i.e. municipal-level but not county-level hospitals) than lower tier facilities were internet usage,[30] and high (vs low) level of anxiety before seeing a doctor.[33]

7.2.4 Supply-side factors

Zhou et al (2021) reported that the availability of primary care facilities in the medical system had a positive effect on the likelihood of using primary care facilities for urban and rural residents.[12] As previously mentioned, increasing physician density at primary healthcare facilities together with higher average reimbursement rate was associated with a higher likelihood of choosing these facilities (vs higher tier hospitals) for inpatient and outpatient care, and these effects were attenuated in 2013 compared to 2008.[26] The lower use of primary care facilities for outpatient care over time was associated with a higher density of hospitals and medical doctors.[32] In another study, the larger the city, the more likely patients with URTI were to use city hospitals for outpatient care, probably reflecting the concentration of these hospitals in large urban areas.[1] In a mixed-method study in urban areas, participants who rated quality of medical equipment, reputation of facilities, and expertise of doctors as important were significantly more likely to choose hospital services than community health services.[31] Patients dissatisfied with medical care or those with low degree of trust in doctors were more likely to choose higher-level medical institutions.[24,28]

While Brown and Theoharides (2009) reported a non-significant effect of travel costs on choice of providers in rural areas,[20] distance, public transportation convenience or medical accessibility had a significant influence in four other studies.[22,27-29] More precisely, when individuals in rural Gansu were concerned about provider quality or reputation, or when their health status was poor, distance tended to matter less.[22] In Yu et al's study (2017), lower tier facilities were more likely to be selected by patients' with no preference for facilities or advanced medical technology, concern about distances to facilities and waiting times, or those seeking low medical costs. Patients with the opposite preferences were more likely to choose general hospitals.[23]

In two discrete choice experiments (DCE), the impact of facility attributes on choice of healthcare facilities for first-contact care varied by the perceived severity of illness.[11,34] For conditions regarded as minor, urban respondents rated visit time, quality of equipment and expertise of medical staff as important, while for conditions regarded as severe, respondents rated quality of equipment, travel time and facility size as important.[11] Regardless of perceived disease severity, rural residents highly valued availability and affordability of a healthcare facility, including visit time, travel time, and out-of-pocket cost.[34]

7.2.5 Gaps in the literature in China

Even though studies published in Chinese language were excluded, the number of studies assessing the choice of healthcare provider in China has increased since the implementation of social HI schemes. Nonetheless, the available evidence remains limited. Included studies have mainly focused on the choice of healthcare

provider for outpatient care or did not distinguish between inpatient and outpatient care.[1,12,21] The few studies that examined healthcare seeking behaviour for specific diseases, focused on patients with URTI (outpatient care), chronic conditions, and type 2 diabetes (outpatient care).[1,21,24] The main factors studied were price through HI status, HI type and OOP payments, distance from home to healthcare facility, health status and demographic and socioeconomic characteristics. Three studies examined the direct effect of reimbursement rates or deductibles on choice of healthcare facilities.[19,20,26] Few studies examined the impact of quality of care on patients' choice, as well as the trade-offs between price, distance and quality. The effect of quality was mostly studied qualitatively or through measures perceived to be correlated with quality, such as health workforce, equipment, medical skill and facility size.[1,26,31] In most studies, data on choice of healthcare provider was self-reported from survey (e.g. China National Health Services Survey, China Family Panel Studies and the China Health and Retirement Longitudinal Survey) or from questionnaires in a single region or city, thus prone to recall and selection bias.[23] Only three studies compared choice of healthcare facility between urban and rural areas, and these focused on outpatient or unspecified care.[12,29,32] The present study was the first study to analyse the choice of tier 1, 2 or tier 3 hospitals for inpatient care in urban and rural areas, using revealed preference data from HI claims rather than from surveys.

7.3 Methods

7.3.1 Participants and follow-up

All CKB participants alive on January 1, 2009 and admitted to hospital in the period 2009-2017 were included in the main analyses. The study period was restricted to hospital admissions after 2009, because recruitment to the CKB was completed on July 15, 2008, and completed data from HI records were available from January 1, 2009. The analyses were based on release 17 of the CKB data.

7.3.2 Hospital tier choice variable

The dependent variable was choice of one of the three hospital tiers for first admissions for either stroke, IHD or any cause (tier 1, tier 2 and tier 3 hospitals). Although the main focus was on choice of hospital tier for stroke and IHD, analyses were performed for first admissions for any cause for comparison as these were more likely to be sensitive to changes in HI characteristics given the wider range of conditions. The study focused on first admissions because these were less likely to be influenced by previous healthcare experiences than recurrent admissions. The proportion of participants with stroke or IHD who had more than one hospital admission for the same disease in 2009-2017 was around 11-15%. Both public and private hospitals were included. To reduce the proportions of hospitals with unspecified or missing tiers, information on the number of beds recorded by CKB staff when checking hospital tier information was used to allocate tier status. This reduced the proportion of admissions with missing tier information from 7% to 2%

for stroke and IHD, and from 11% to 5% for any cause. Individuals admitted in hospitals with remaining missing hospital tier information were excluded.

7.3.3 Factors influencing hospital tier choice

Health insurance characteristics

A questionnaire was designed and circulated to each of the 10 CKB centres to collect data on HI characteristics (see **Chapter 4**), including reimbursement rates (%), deductibles (in Yuan) per visit, and reimbursement ceiling (in Yuan) per year for inpatient care. Data for deductibles and reimbursement ceilings were standardised to 2017 values using urban/rural-specific consumer prices indices from the China statistical yearbooks.[35] The HI characteristics varied by CKB centre, HI scheme, year, and (except ceiling) hospital tier. In addition, in some CKB centres, reimbursement rates varied by hospitalisation costs (and disease types) and for the UEBMI scheme by retirement level. Consequently, there were natural exogenous variations in cost sharing between and within CKB centres. The study used the differences in tiered reimbursement rates and deductibles (i.e. higher reimbursement rates and lower deductibles in lower hospital tiers) across CKB centres in the analyses. Uninsured participants or those with missing HI type were excluded from all analyses as they could not be matched to HI characteristics.

In sensitivity analysis, to combine reimbursement rates and deductibles in a single measure, out-of-pocket (OOP) payments and actual reimbursement rates (ARR) were approximated using annual data on medical expenses of discharged patients with stroke or IHD by hospital grade at the national level from China's health statistics yearbooks (**Appendix Table F.3**). Medical expenses in county hospitals,

county-level municipal hospitals and prefecture level hospitals were used as proxies for expenses in tier 1, tier 2 and tier 3 hospitals, respectively. Average medical expenses for acute myocardial infarction (AMI) were used as a proxy for IHD as data on hospitalisation costs for IHD were not available. OOP payments (Yuan per admission) and ARR (%) were calculated using the following formulas:

$$OOP_{irft} = Deductible_{irft} +$$

$$(1 - Reimbursement\ rate_{irft}) * (Cost_{ft} - Deductible_{irft})$$

$$ARR_{irft} = 1 - \frac{OOP_{irft}}{Cost_{ft}}$$

i: individual, r: region, f: calendar year, t: hospital tier

The reimbursement ceiling was ignored when calculating OOP payments, because it was assumed that patients rarely exhaust the reimbursement ceiling, and this is even less likely when considering patients' first stroke or IHD admission.[36] Hospitalisation costs were inflated to 2017 values using consumer price indices, thus OOP payments and ARR were also adjusted for inflation.[35]

Patient characteristics

The patient characteristics assessed for influence on the choice of hospital tiers included demographic, socioeconomic, lifestyle and morbidity factors. These characteristics did not vary by hospital tier. Demographic variables included age at admission and sex. Socioeconomic variables included marital status, household size, highest level of education attained (no formal school, primary or middle school, high school or above), annual household income in Yuan (<10 000, 10 000-19 999, 20 000-34 999, ≥35 000). Lifestyle factors included smoking and alcohol consumption, body mass index, physical activity assessed using metabolic

equivalents of task, and self-rated health status. Socioeconomic and lifestyle factors were restricted to information collected at entry into the study (2004-2008). Morbidity factors included history of major diseases as defined in **Chapter 4**, in addition to stroke type (lacunar ischaemic stroke [IS], non-lacunar IS, and haemorrhagic stroke [HS]) or IHD type (AMI or angina, and other IHD) at presentation.

Region-level fixed effects and year fixed effects were included in the regression analyses to capture fixed differences across CKB areas in unobserved characteristics, such as healthcare system characteristics at the local government level, other HI differences, and secular time trends common to all areas.

7.3.4 Statistical analysis

Main analysis

The strategy used to examine associations between HI and patient characteristics on choice of hospital tier relied on McFadden's choice model (or multinomial logit model [MNL], also sometimes referred to as conditional logit).[37]

The choice of hospital tier was assumed to maximise an individual's utility (U). That is, an individual, n, will only choose alternative i if $U_{n,i} > U_{n,j}\ \forall\ j\ \neq\ i$. Utility was further decomposed to include a deterministic component $V_{n,i}$ and a random component $\varepsilon_{n,i}$ (error term): $U_{n,i} = V_{n,i} + \varepsilon_{n,i}$. The error term ε_{ni} measured deviation from modelled utility for alternative i and individual n, and captured all factors not included in $V_{n,i}$.

Thus, the probability that decision maker n chose alternative i was given by:

$$P_{n,i} = Prob\left(V_{n,i} + \varepsilon_{n,i} > V_{n,j} + \varepsilon_{n,j}\right)\ \forall\ j \neq i.$$

The deterministic component $V_{n,i}$ captured the role of the characteristics of the alternatives, decision maker and choice setting. In very general terms, $V_{n,i} = \delta_i + f(x_{n,i}, z_n, \beta)$. $x_{n,i}$ were characteristics of alternative i as faced by decision maker n, also called alternative-specific variables. z_n were characteristics of decision maker n, also called case-specific variables. β was a vector of estimated parameters. δ_i were alternative-specific constants capturing the mean of the error terms across alternatives. The average effect on utility of all factors not included in the model were captured by the alternative-specific constants.

Assuming that each ε_{ni} for all alternatives i is distributed independently and identically in accordance with the extreme value distribution, the probability that a patient will choose alternative i was given by:

$$P_{n,i} = \frac{e^{V_{n,i}}}{\sum_{j=1}^{J} e^{V_{n,j}}}$$

The parameters of this model were estimated using maximum-likelihood estimation.

Alternative-specific variables were variables that varied by hospital tier: reimbursement rates and deductibles. These two variables were interacted with hospital tier to obtain tier-specific effects of reimbursement rates and deductibles on choice of hospital tier. Case-specific variables were variables that did not vary by hospital tier: demographic, socioeconomic, lifestyle and morbidity factors, reimbursement ceiling, and year and area fixed effects. These variables were interacted with the alternative-specific constants. Given the large differences in healthcare organisation, delivery, and financing, as well as population characteristics between urban and rural areas in China, analyses were performed

separately in urban and rural areas. This allowed the examination of differences in health seeking behaviours between urban and rural areas.

The MNL requires the "independence of irrelevant alternatives" (IIA, proportional substitution pattern) assumption to be satisfied. The IIA implies that the choice between any two alternatives does not depend upon a third one, namely the ratio of choice probabilities for alternatives i and j does not depend on characteristics of other alternatives. A Hausman test was performed to compare estimated coefficients from the full model with all choice alternatives with estimated coefficients from a reduced model excluding an alternative. A test of whether cross-alternative-specific variables significantly entered the model was also applied to test for the IIA assumption.[38] This consisted in re-estimating the model with alternative-specific variables from one alternative entering the utility of another alternative. A third method to test the IIA assumption is model-based testing. This involved estimating a nested logit model, which relaxes the IIA assumption by allowing for correlated errors between the "nests" of a model. The nested logit collapses to the MNL if the dissimilarity parameter or the measure of the degree of independence in unobserved utility among the alternatives within a nest is equal to one, implying no correlation among alternatives in a nest. Nested logit models with tiers 1 and 2 hospitals or tiers 2 or 3 hospitals nested together were estimated. Mixed MNL models, which relax the IIA, were also estimated.

Post-estimation analyses

Using the estimates from the main analyses, the predicted probabilities of choosing hospital tier were estimated overall and by key patient characteristics using the "sample enumeration" technique.[39] To understand the importance of

reimbursement rates and deductibles for choice of hospital tier, a number of different policy scenarios were simulated. The values of the reimbursement rates or deductibles were varied separately and together while holding all other variables constant, new probabilities were predicted for each individual and averaged over the sample. Policy scenarios were only performed for effects of reimbursement rates or deductibles that were statistically significant and in the expected direction based on economic theory (i.e. positive effect of reimbursement rates and negative effect of deductibles). The different policy scenarios were chosen based on observed variations in the HI characteristics data between 2009 and 2017. Hypothetical changes in HI characteristics leading to increased choice of tier 1 or 2 hospitals and decreased choice of tier 3 hospitals (desired outcomes) were also simulated in urban and rural areas. Own and cross-elasticities of choice were also estimated. Own elasticities of choice reflect how the probability of choosing a given hospital tier changes following a 1% change in reimbursement rates or deductibles in the same tier. Cross-elasticities of choice reflect how the probability of choosing a given tier changes following a 1% change in reimbursement rates or deductibles in another hospital tier. Own and cross-elasticities were also estimated using co-insurance rates. Confidence intervals (CI) were estimated using 10 000 runs of the prediction on sets of random draws of model coefficients, and then taking the 2.5th and 97.5th percentiles for the 95% confidence interval.[40]

Sensitivity analyses

Analyses were performed to assess the sensitivity of the estimated associations between HI and socioeconomic characteristics and choice of hospital tier to the methodological assumptions.

Effect of HI characteristics

Analyses were repeated limiting adjustments to age, sex, year and region fixed effects only (minimally-adjusted models), to study the effect of adjusting for socioeconomic, lifestyle and morbidity factors on the coefficients for reimbursement rates and deductibles by comparing fully-adjusted and minimally-adjusted models. The effects of reimbursement rates and deductibles on choice of hospital tier were also examined by including each variable separately rather than together (to acknowledge correlation between them), and without adjusting for ceiling. MNL models were also estimated without tier-specific effects for reimbursement rates and deductibles but with a single coefficient for reimbursement rates and for deductibles across tiers. To explore heterogeneity in the effect of HI characteristics by socioeconomic status, MNL models were estimated with an interaction between reimbursement rates and, separately, deductibles, and income or education. In these analyses, admissions for stroke and IHD were combined to avoid issues with small numbers and because results from separate models for stroke and IHD admissions were similar. Furthermore, models were estimated with OOP payments or ARR (alternative-specific variables) instead of reimbursement rates and deductibles.

Effect of socioeconomic characteristics

To more fully capture effects of socioeconomic factors, the analyses were repeated without adjustments for lifestyle and morbidity factors that may be considered on the causal pathways between socioeconomic factors and choice of hospital tier. To check if the effect of income on choice of hospital tier was sensitive to the type of income measure used, models were repeated using quartiles of approximated equivalent income instead of the original CKB income categories.

Effect of supply-side factors

To examine the effect of supply-side factors on the choice of hospital tier as well as on the effect of HI characteristics, MNL models were estimated with further adjustments for the number of doctors (per 10 000 persons, case-specific variable) and the number of beds by hospital tier (per 10 000, alternative-specific variable) at the province level of corresponding CKB centres. Data for these supply-side factors were extracted from the China health statistical yearbooks.

7.4 Results

7.4.1 Participant characteristics and outcomes

Among the 42 755 participants with first stroke admissions in the CKB between January 1, 2009, and December 31, 2017, 793 (1.9%) had missing hospital tier information and 583 (1.4%) had missing HI type information or were uninsured. Among the 38 213 participants with first IHD admissions, 649 (1.7%) had missing hospital tier information and 417 (1.1%) had missing HI type information or were uninsured. Among the 224 850 participants with first admissions for any cause, 12 790 (5.2%) had missing hospital tier information and 2370 (1.0%) had missing HI type information or were uninsured. After excluding participants with missing data, 41 432 (urban: 20 302, rural: 21 130) participants with stroke, 37 173 (urban: 19 283, rural: 17 890) participants with IHD, and 230 005 (urban: 97 315, rural: 132 690) participants with any cause contributed to the present analyses.

Among participants with stroke and IHD in urban and rural areas, the mean age was 65-66 years and the majority of participants were women, with a slightly greater proportion in urban than rural areas (**Table 7.1**). The proportions of participants who had completed high school education and those with an annual household income above ¥35 000 were both greater among participants living in urban than in rural areas. In rural areas, approximately 90% of individuals were enrolled in URBMI or NRCMS, while in urban areas between 82-88% of individuals were enrolled in UEBMI. The proportions of individuals enrolled in each HI type also varied within urban and rural CKB centres (**Appendix Table F.5**).

The proportions of men who were current smokers were higher in rural than in urban areas, while the proportion of men who were regular alcohol drinkers were higher in urban than rural areas. The mean levels of physical activity were higher in rural than in urban areas, and the proportions of individuals who were overweight or obese were higher in urban than rural areas. The proportions of individuals who reported poor self-rated health were higher in rural than in urban areas.

Among participants with stroke in urban areas, 71.3% had non-lacunar IS, 20.9% had lacunar IS and 7.8% had HS. In rural areas, 76.7% had non-lacunar IS, 7.0% had lacunar IS and 16.3% had HS. Among participants with IHD in urban areas, 8.7% had AMI or angina and 91.3% had other IHD, while in rural areas 9.7% had AMI or angina and 90.3% had other IHD. Selected baseline characteristics of individuals with first admission for any cause are presented in **Appendix Table F.6**. Selected baseline characteristics of participants in urban and rural areas by hospital tier are presented in **Appendix Table F.7**, **Table F.8** and **Table F.9**.

In 2009-2017, the proportions of admissions for stroke in tier 1, tier 2 and tier 3 hospitals were: 6.0%, 30.4% and 63.5% in urban areas, and 29.9%, 40.7%, and 29.4% in rural areas, respectively. The corresponding proportions for IHD admissions were 5.9%, 25.8% 68.3% in urban areas, and 47.3%, 26.0% and 26.7% in rural areas. The corresponding proportions for admissions for any cause were 8.4%, 26.3% and 65.3% in urban areas, and 38.2%, 30.3% and 31.5% in rural areas.

Between 2009 and 2017 in urban areas, the proportion of admissions in tier 1 hospitals increased by 50% for stroke, 39.2% for IHD and 13.6% for any cause, the proportion of admissions in tier 2 increased by 12.9% for stroke, 16.4% for IHD and 3.3% for any cause, and the proportion of admissions in tier 3 decreased by

9.2% for stroke, 8.9% for IHD and 2.7% for any cause (**Table 7.2**, **Appendix Figure F.1**). In rural areas, the proportion of admissions in tier 1 hospitals decreased by 32.8% for stroke, 20.9% for IHD and 5.1% for any cause, the proportion of admissions in tier 2 decreased by 4.2% for stroke, 11.3% for IHD and 7.4% for any cause, and the proportion of admissions in tier 3 increased by 68.1% for stroke, 64.1% for IHD and 16.5% for any cause in 2009-2017.

In urban areas, the proportions of stroke and IHD admissions in tier 3 hospitals were higher for individuals enrolled in UEBMI than those enrolled in URBMI or NRCMS (stroke: 67% vs 47%, IHD: 70% vs 54%) (**Appendix Table F.10**). In rural areas, the proportions of stroke and IHD admissions in tier 1 hospitals for UEBMI enrollees were around half those for URBMI or NRCMS enrollees (stroke: 12% vs 32%, IHD: 26% vs 50%).

Table 7.1 Selected characteristics of individuals with first stroke and IHD admissions in urban and rural areas in 2009-2017

	Stroke		IHD	
	Urban (n=20302)	Rural (n=21130)	Urban (n=19283)	Rural (n=17890)
Demographic characteristics				
Age (years) at admission, Mean (SD)	66.4 (9.8)	65.0 (9.7)	65.3 (9.9)	65.7 (10.0)
Women, %	56.6	54.5	62.1	59.6
Socioeconomic characteristics				
Married, %	85.3	87.3	86.1	86.5
Household size, Mean (SD)	3.1 (1.4)	4.2 (1.7)	3.0 (1.3)	4.1 (1.8)
Highest level of education attained, %				
No formal school	14.2	28.5	10.8	26.7
Primary/middle school	50.9	64.3	51.2	66.3
High school or above	34.9	7.2	38.1	7.1
Annual household income (¥), %				
<10 000	17.1	45.6	14.1	44.9
10 000-19 999	33.2	30.7	33.3	30.3
20 000-34 999	28.6	15.5	31.0	16.3
≥35 000	21.1	8.2	21.6	8.4
Health insurance type at admission, %				
URBMI or NRCMS	18.4	91.4	12.0	89.4
UEBMI	81.6	8.6	88.0	10.6
Lifestyle characteristics				
Current smoker, %				
Women	4.2	3.5	3.9	4.6
Men	50.4	65.0	51.3	65.8
Regular alcohol drinker, %				
Women	4.9	3.6	5.9	3.9
Men	50.3	38.7	50.0	38.4
Physical activity (MET-h/day), Mean (SD)	14.1 (10.7)	19.0 (13.5)	13.8 (9.8)	18.0 (12.6)
Overweight or obese, %	46.6	33.7	50.7	34.0
Morbidity factors, %				
Poor self-rated health	9.8	14.0	10.1	17.2
Disease type at admission				
Haemorrhagic stroke	7.8	16.3		
Non-lacunar ischaemic stroke	71.3	76.7		
Lacunar ischaemic stroke	20.9	7.0		
AMI or angina			8.7	9.7
Other IHD			91.3	90.3

All characteristics were measured at baseline unless otherwise specified. AMI: acute myocardial infarction, IHD: ischaemic heart disease, MET: metabolic equivalents of task, NRCMS: new rural cooperative medical scheme, SD: standard deviation, UEBMI: urban employee basic medical insurance, URBMI: urban resident basic medical insurance.

Table 7.2 Proportions of admissions for stroke and IHD, reimbursement rates (RR) and deductibles (DD) by hospital tier in 2009 and 2017

	2009				2017				% change between 2009 and 2017			
	Proportions of admissions (%)		Average RR (%)	Average DD (¥)	Proportions of admissions (%)		Average RR (%)	Average DD (¥)	Proportions of admissions (%)		Average RR	Average DD
	Stroke	IHD			Stroke	IHD			Stroke	IHD		
Urban areas												
Tier 1	5.0	6.5	90	509	7.5	9.1	91	325	50.0	39.2	1.2	-36.1
Tier 2	28.2	22.7	88	685	31.8	26.4	88	545	12.9	16.4	0.0	-20.4
Tier 3	66.8	70.8	86	872	60.7	64.5	86	738	-9.2	-8.9	-0.1	-15.4
Rural areas												
Tier 1	39.4	48.1	77	253	26.5	38.0	87	198	-32.8	-20.9	13.2	-21.7
Tier 2	39.2	30.8	66	539	37.5	27.3	77	416	-4.2	-11.3	15.6	-22.8
Tier 3	21.4	21.1	59	835	36.0	34.6	67	797	68.1	64.1	13.0	-4.6

HI characteristics for stroke presented in table; HI characteristics for IHD (not presented) were similar. Reimbursement rates and deductibles were averaged across health insurance schemes and regions, within urban and rural areas. The averages were weighted by the proportion of CKB participants with first stroke enrolled in each scheme in urban and rural areas. Deductibles in 2009 were inflated to 2017 values.

7.4.2 Health insurance characteristics

As average HI characteristics values and trends differed only marginally by disease types (i.e. stroke, IHD, any cause), only the HI characteristics for stroke were reported.

Urban areas

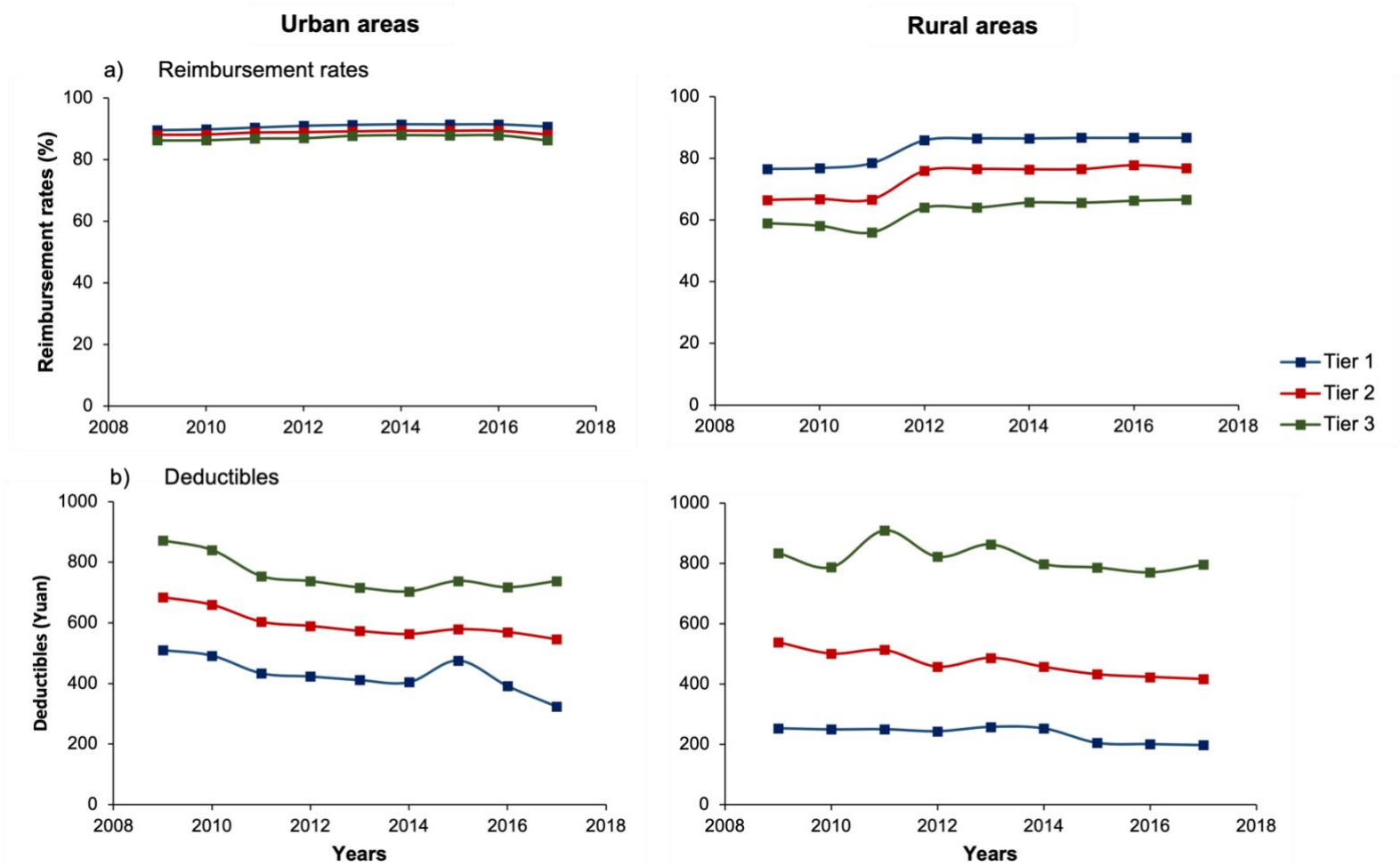
In urban CKB centres, the average reimbursement rates remained stable over time and did not differ appreciably between hospital tiers (tier 1: 91%, tier 2: 89%, tier 3: 88%, **Figure 7.1**). Qingdao had the highest reimbursement rates and Suzhou had the lowest rates (**Table 7.3**). The average levels of deductibles were highest in tier 3 (872¥ in 2009), then tier 2 (685¥) and tier 1 hospitals (509¥). In 2009-2017, the average deductibles decreased by 4.9%, 2.8% and 2.0% per year in tier 1, 2 and 3 hospitals, respectively. While some urban centres had the same reimbursement rates and deductibles across tiers in 2009, an increasing number of centres implemented differential cost sharing by hospital tier by 2017. The average reimbursement ceiling increased over time from 174 712¥ in 2009 to 241 401¥ in 2017, or by approximately 4.2% per year.

Rural areas

In rural CKB centres, the average reimbursement rates were highest in tier 1 (77% in 2009), then tier 2 (66%) and tier 3 (59%) hospitals in 2009-2017 (**Figure 7.1**). The average reimbursement rates increased by 1.6%, 1.9% and 1.7% per year in tier 1, tier 2 and tier 3 hospitals, respectively. While Sichuan had the highest reimbursement rates, Hunan had the lowest rates (**Table 7.3**). The average levels of deductibles were highest in tier 3 hospitals (835¥ in 2009), then tier 2 (539¥) and lowest in tier 1 (253¥). In 2009-2017, the average deductibles decreased by

2.8%, 3.0% and 0.3% per year in tier 1, tier 2 and tier 3 hospitals. On average, the reimbursement ceiling increased from 53 001¥ in 2009 to 133 607¥ in 2017 or by about 13% per year. Trends in actual reimbursement rates and OOP payments by hospital tier in urban and rural CKB centres in 2009-2017 are described in **Appendix Figure F.2**.

Figure 7.1 Average reimbursement rates and deductibles by hospital tier in urban and rural CKB centres, between 2009 and 2017



Reimbursement rates and deductibles were averaged across HI schemes and regions, within urban and rural areas. The averages were weighted by the proportion of CKB participants with first stroke enrolled in each scheme in urban and rural areas. Deductibles were inflated to 2017 values.

Table 7.3 Example of variations in health insurance characteristics in CKB centres* in 2009 and 2017

	2009							2017						
	Reimb. rate (%)			Deductible (¥/visit)			Ceiling	Reimb. rate (%)			Deductible (¥/visit)			Ceiling
	Tier 1	Tier 2	Tier 3	Tier 1	Tier 2	Tier 3	(¥/year)	Tier 1	Tier 2	Tier 3	Tier 1	Tier 2	Tier 3	(¥/year)
Urban areas														
Qingdao	95	95	95	500	670	840	200 000	90	88	86	200	500	800	200 000
Harbin	90	90	90	240	480	720	150 000	90	90	90	240	480	720	250 000
Haikou	88	88	85	800	800	800	230 000	88	85	82	300	600	800	260 000
Suzhou	70	70	70	400	600	800	100 000	75	75	50	200	400	800	150 000
Liuzhou	92	87	82	400	600	800	67 290	92	87	82	400	600	800	325 338
Rural areas														
Sichuan	92	90	85	200	400	800	98 764	92	90	85	200	400	800	367 980
Gansu	80	60	55	100	500	700	30 000	85	75	65	100	300	800	40 000
Henan	65	55	40	80	300	800	40 000	90	75	72	200	500	900	150 000
Zhejiang	55	55	55	300	300	300	70 000	85	75	65	300	500	800	150 000
Hunan	80	65	55	100	300	500	60 000	85	70	50	200	500	800	150 000

Reimb. rate: reimbursement rate. *In each centre, the health insurance characteristics shown are for the scheme in which the majority of participants were enrolled in: NRCMS in all rural areas and UEBMI in urban areas except in Suzhou (URBMI/NRCMS). Raw data are presented, and deductibles and ceilings were not adjusted for inflation.

7.4.3 Selection of choice model

The results of the Hausman tests differed between models, depending on which hospital tier was omitted. Some of the Chi-squared statistics for the Hausman tests were negative, which might be interpreted as evidence that the null hypothesis (i.e. the choice between any two alternative does not depend upon a third one) cannot be rejected,[41] but could also lead to invalid statistical inference.[42] Thus, results from other tests were more reliable for testing the IIA assumption. When applying the “cross-alternative” method to test for the IIA assumption, results were mixed, namely the significance of the effect of cross-alternative variables varied with the cross-alternative variables entered. Using the model-testing method, in both urban and rural areas, the dissimilarity parameter in some of the nested logit models were much larger than one, indicating potential optimisation issues and unreliable results. One option could have been to restrict the dissimilarity parameter to be between 0 and 1, but this is not recommended because it could mask other underlying issues.[40] Mixed MNL models resulted in optimisation issues when including HI characteristics simultaneously and adding patient characteristics. However, in mixed MNL models with reimbursement rates and deductibles entered separately, the standard deviations of the distribution of these attributes were typically non-significant, so the null hypothesis of no random heterogeneity could not be rejected. The results of the different tests were inconclusive and there was no evidence that the IIA assumption was violated.

Previous work indicated that IIA assumption was not realistic in many situations and that IIA assumption in the MNL was not as restrictive as perceived.[43] Cheng and Long (2007) presented evidence that IIA tests often rejected the IIA

assumption even when alternatives were distinct and did not reject it when alternatives were close substitutes, concluding that choice set partitioning tests of IIA were not appropriate for applied work.[44] In summary, these analyses demonstrated that the choice of alternatives was considered to be plausibly distinct and weighed independently by each decision maker, and the MNL model was deemed appropriate.

7.4.4 Main analysis

The results of the multinomial analyses of choice of hospital tiers are presented separately for urban areas and rural areas. For ease of interpretation, alternative and case-specific variables are reported separately in Figures and Tables, as the interpretation of the respective coefficients differs. For alternative-specific variables, reimbursement rates and deductibles, a positive coefficient or an odds ratio (OR) greater than one means that if the regressor increases for one hospital tier, then this hospital tier is chosen more and other tiers are chosen less; and vice versa for a negative coefficient or an OR less than one. For case-specific variables, coefficients or relative risk ratios (RRRs) are interpreted as parameters of a logistic model against the reference group “tier 3 hospital”.

Urban areas

Health insurance characteristics

Among participants with admissions for stroke, IHD and any cause, higher reimbursement rates in all tiers were associated with a higher use of the corresponding hospital tier (**Figure 7.2**). For stroke admissions, a 1% point higher

reimbursement rate was associated with a 4% (OR: 1.04, 95% CI [1.02, 1.06]), 5% (OR: 1.05 [1.04, 1.07]) and 4% (OR: 1.04 [1.03, 1.06]) higher odds of choosing tier 1, tier 2 and tier 3 hospitals, respectively. For IHD admissions, a 1% point higher reimbursement rate was associated with 3% higher odds of choosing any hospital tier. For any cause, a 1% point higher reimbursement rate was associated with a 2% (OR 1.02 [1.01, 1.03]), 3% (OR 1.03 [1.03, 1.04]) and 3% (OR 1.03 [1.02, 1.04]) higher odds of choosing tier 1, tier 2 and tier 3 hospitals, respectively.

While the level of deductible was not statistically significantly associated with the choice of hospital tier 1 and 2 for stroke and IHD, a 100¥ higher deductible in tier 3 was associated with 14% (OR: 0.86 [0.83, 0.89]) and 9% (OR: 0.91 [0.87, 0.95]) lower odds of choosing tier 3 hospitals for stroke and IHD, respectively. For any cause, a 100¥ higher deductible was associated with a 9% (OR: 0.91 [0.87, 0.95]), 7% (0.93 [0.91, 0.96]), and 14% (0.86 [0.85, 0.88]) lower odds of choosing tier 1, tier 2, and tier 3 hospitals, respectively.

A 10% higher ceiling was associated with 0.47% (RRR for logged ceiling: 0.77 [0.68, 0.86])[3] and 0.13% (RRR for logged ceiling: 0.93 [0.89, 0.98]) lower use of tier 2 compared to tier 3 hospitals for stroke and any cause, respectively (**Appendix Table F.11** and **Table F.12**). However, ceiling did not have a significant effect for choice of hospital tier in the case of IHD admissions (**Appendix Table F.13**).

Patient characteristics

Stroke patients aged between 65-74 years and above 75 years were more likely to choose tier 1 and 2 (vs tier 3) hospitals than those aged below 55 years (**Figure**

[3]The corresponding RRRs associated with a 10% higher ceiling are: exp(log(0.77)*log(1.1))=0.995 for stroke and exp(log(0.93)*log(1.1))=0.999 for any cause.

7.3). Individuals aged 55-64 years were more likely to choose tier 2 (vs tier 3) hospitals than those aged below 55 years. Older individuals accessing hospital for any cause were more likely to choose tier 1 or tier 2 (vs tier 3) hospitals than those aged below 55 years old (**Figure 7.4**). Women were less likely than men to choose tier 2 (vs tier 3) for stroke and more likely to choose tier 1 or 2 (vs tier 3) hospitals for IHD (**Figure 7.5**). A higher household size was associated with a higher use of tier 2 (vs tier 3) for stroke, tier 1 (vs tier 3) for IHD, and both tier 1 and 2 (vs tier 3) for any cause.

Compared to participants with primary or middle school, those with high school and above were less likely to use tier 2 (vs tier 3) for stroke, IHD and any cause, and those with no formal school were more likely to choose tier 1 and 2 hospitals (vs tier 3) for any cause. Individuals with income levels higher than those in the 2nd income group (10 000-20 000¥/year) were less likely to choose tier 1 or 2 hospitals (vs tier 3) for stroke, IHD and any cause. While individuals in the lowest income group were more likely to choose tier 1 or 2 hospitals (vs tier 3) than those in the 2nd income group for stroke.

Compared to patients with non-lacunar IS, those with lacunar IS were more likely to choose tier 1 (4.20 [3.55, 4.96]) or 2 (2.02 [1.84, 2.21]) hospitals (vs tier 3), while those with HS were less likely to choose tier 1 (0.18 [0.12, 0.26]) or 2 (0.54 [0.47, 0.61]) hospitals (vs tier 3). Individuals with other IHD were more likely to choose tier 1 (1.70 [1.28, 2.25] or tier 2 (1.34 [1.17, 1.53)] hospitals than those with AMI or angina.

Results for the effects of lifestyle and morbidity factors on the choice of hospital tier for stroke, any cause and IHD admissions in urban areas are presented in **Appendix Table F.11**, **Table F.12**, and **Table F.13**, respectively.

Rural areas

Health insurance characteristics

In rural areas, a 1% point higher reimbursement rate in tier 3 was associated with a 2% (1.02 [1.01, 1.02]), and 1% (1.01 [1.00, 1.02]) higher use of corresponding hospitals for individuals with stroke and IHD, respectively (**Figure 7.2**). For individuals admitted with IHD, a 1% point increase in reimbursement rate in tier 1 was associated with lower use of tier 1 hospitals (0.98 [0.97, 1.00]). For any cause, a 1% point higher reimbursement rate was associated with a 1% (OR: 0.99 [0.99, 1.00]) lower odds of choosing tier 1 hospitals, and a 0.5% (1.005 [1.002, 1.007]) and 1% (1.01 [1.01, 1.01]) higher odds of choosing tier 2 and 3 hospitals, respectively.

A 100¥ increase in deductibles in tier 1 was associated with 13% (0.87 [0.81, 0.94]), 6% (0.94 [0.88, 1.02]) and 3% (OR: 0.97 [0.95, 0.99]) lower odds of choosing tier 1 hospitals for stroke, IHD and any cause, respectively. In addition, higher deductibles in tier 2 or 3 hospitals were associated with higher use of these hospitals for stroke and IHD, and in tier 2 only for any cause.

A 10% higher ceiling was associated with a 0.40% higher use of tier 1 (RRR for logged ceiling: 1.25 [1.05, 1.49]) and a 0.50% higher use of tier 2 (1.32 [1.12, 1.55]) compared to tier 3 hospitals for stroke (**Appendix Table F.11**). For any cause, a 10% higher reimbursement ceiling was associated with a 0.74% lower use of tier 1 hospitals (RRR for logged ceiling: 0.66 [0.62, 0.70]) compared to tier 3 hospitals (**Appendix Table F.12**).

Patient characteristics

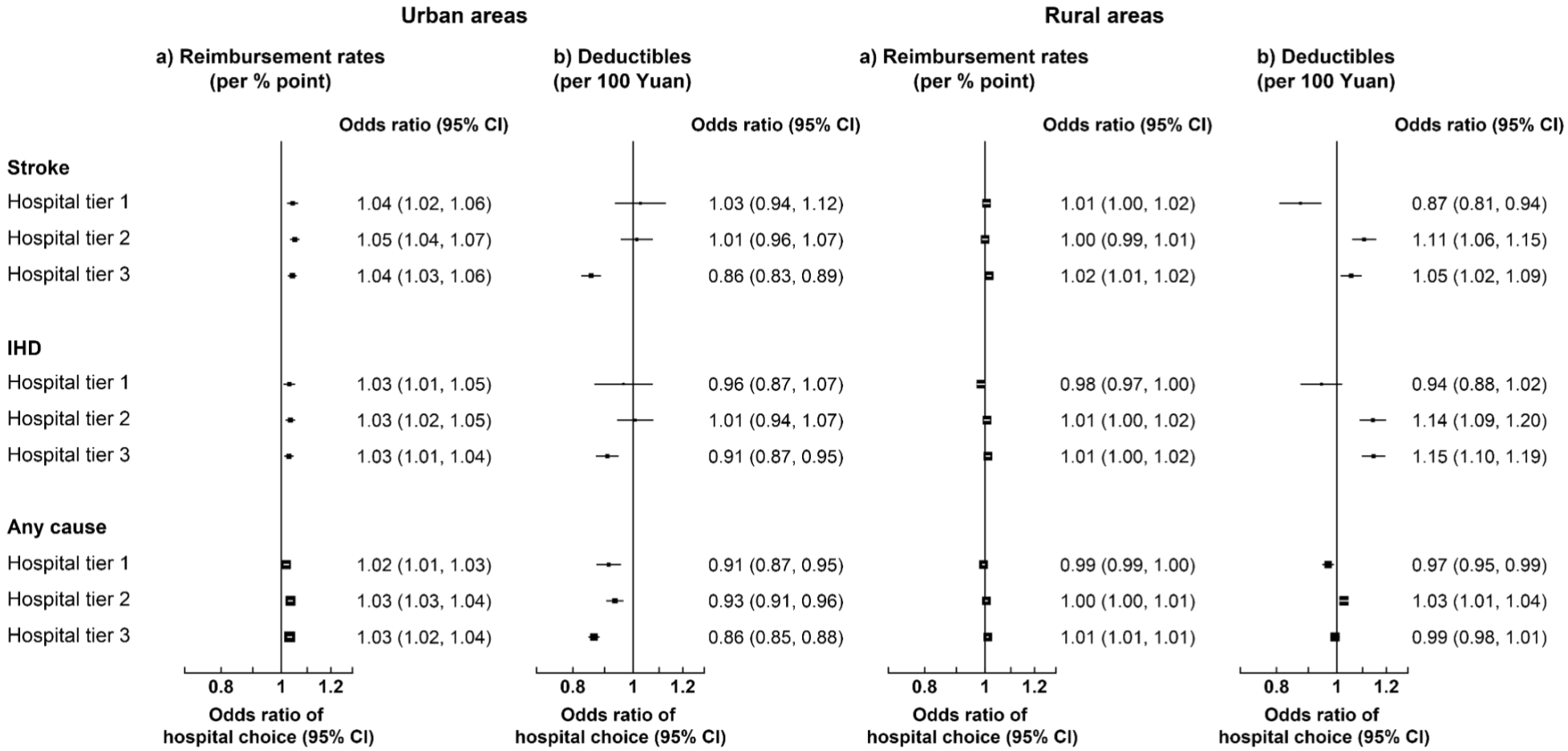
Individuals with stroke and any cause aged above 75 years were more likely to choose tier 1 or tier 2 (vs tier 3) than those aged below 55 years (**Figure 7.3** and

Figure 7.4). Individuals with IHD aged between 55-64 years were less likely to choose tier 1 hospitals and those aged above 75 years were more likely to choose tier 2 (vs tier 3) hospitals (**Figure 7.5**). Women were more likely to choose tier 1 or 2 (vs tier 3) for IHD, and tier 1 (vs tier 3) for any cause. Individuals who were not married were more likely than married individuals to choose tier 1 (vs tier 3) for stroke and IHD, and tier 1 or 2 (vs tier 3) hospitals for any cause. A higher household size was associated with a higher use of tier 1 (vs tier 3) hospitals for IHD admissions. Compared to participants with primary or middle school, those with high school and above were less likely to use tier 1 or 2 (vs tier 3) for all three conditions and those with no formal schooling were more likely to use tier 1 or 2 (vs tier 3) hospitals for IHD and any cause. Individuals in the highest income group were less likely than those in the 2nd income group to choose tier 1 or 2 (vs tier 3) hospitals for stroke, IHD and any cause. Individuals in the 2nd highest income group also were less likely to choose tier 1 (vs tier 3) hospitals for stroke and any cause. Individuals in the lowest income group were more likely than those in the 2nd income group to choose tier 1 or 2 (vs tier 3) hospitals for any cause.

Compared to patients with non-lacunar IS, those with lacunar IS were more likely to choose tier 1 (1.64 [1.40, 1.93]) or tier 2 (1.65 [1.43, 1.89]) (vs tier 3) hospitals, while those with HS were less likely to choose tier 1 (0.50 [0.44, 0.55]) or tier 2 (0.68 [0.62, 0.74]) (vs tier 3) hospitals. For IHD, individuals with other IHD were more likely to choose tier 1 (1.85 [1.62, 2.11]) or tier 2 (1.39 [1.21, 1.59]) (vs tier 3) hospitals than those with AMI or angina.

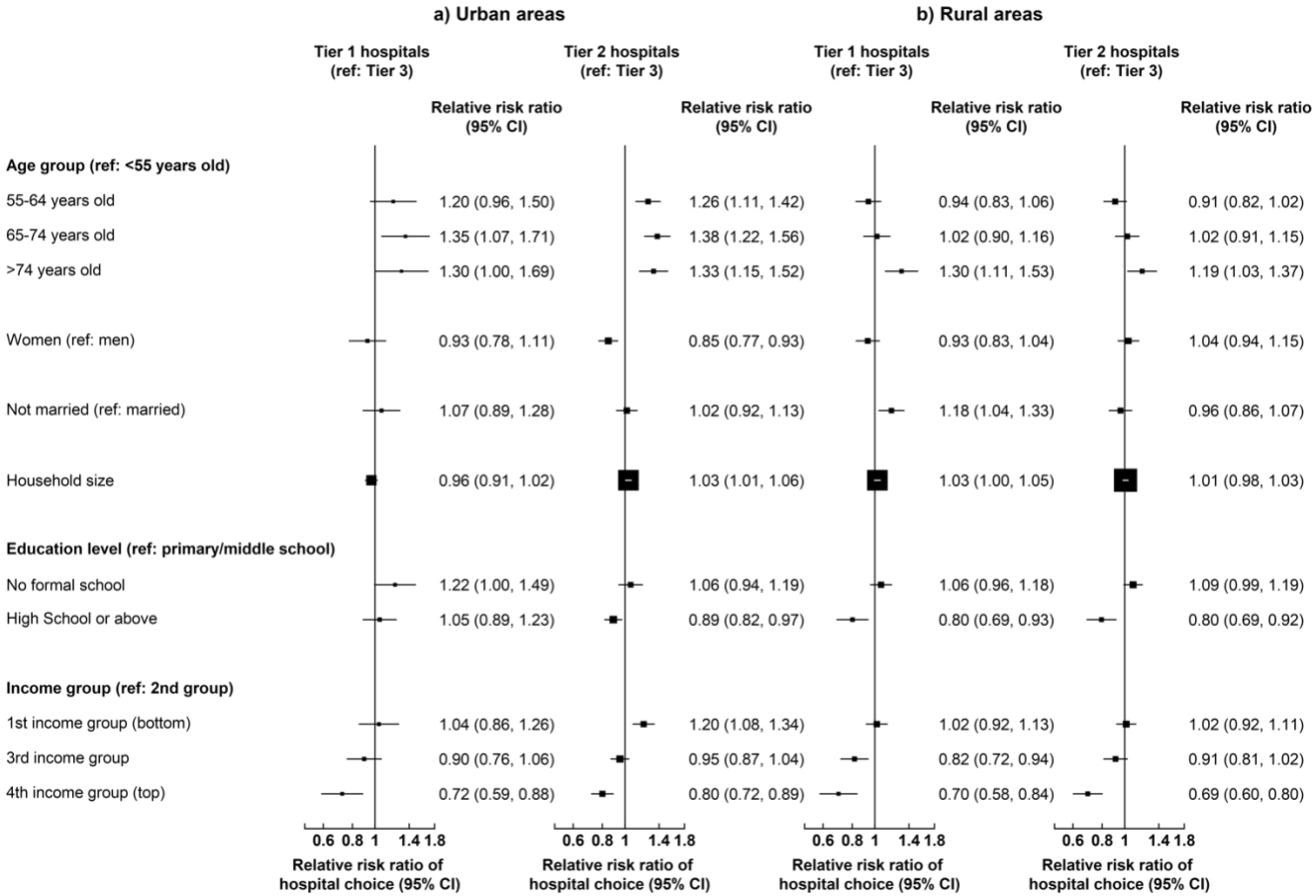
Results for the effects of lifestyle and morbidity factors on the choice of hospital tier for stroke, any cause and IHD admissions in rural areas are presented in **Appendix Table F.11**, **Table F.12**, and **Table F.13**.

Figure 7.2 Effects of higher reimbursement rates or deductibles on choice of hospital tier for stroke, IHD and any cause admissions in urban and rural areas



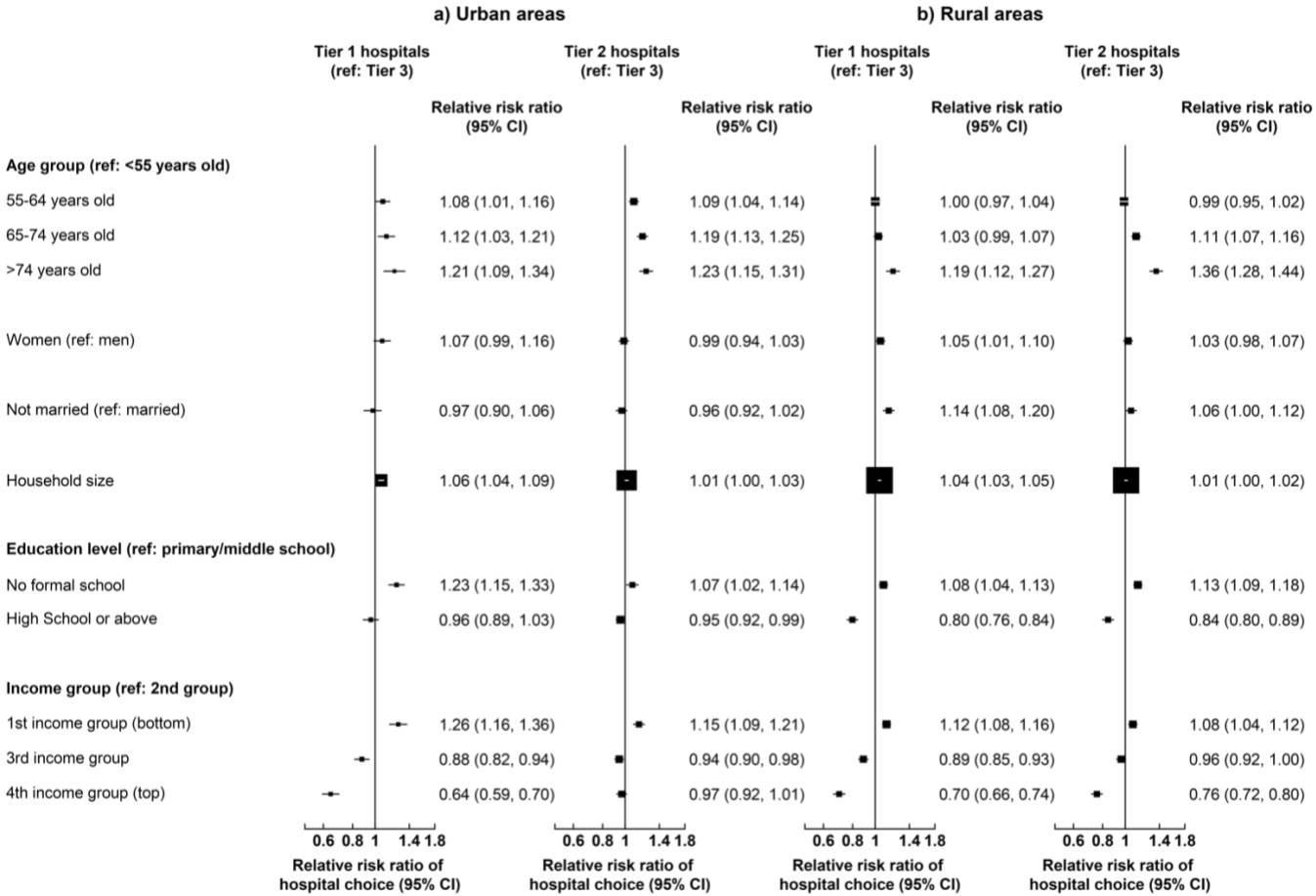
Results are from multinomial logit models with as alternative-specific variables: interactions between tier and, reimbursement rate and deductible. Only alternative-specific ORs are presented and interpreted as follows: an OR>1 means that if the regressor increases for one hospital tier, then that tier is chosen more; and vice versa for an OR<1. Case-specific RRRs from these models are presented in **Appendix Table F.11**, **Table F.12**, and **Table F.13**.

Figure 7.3 Effects of demographic and socioeconomic characteristics on choice of hospital tier for stroke admissions in urban and rural areas



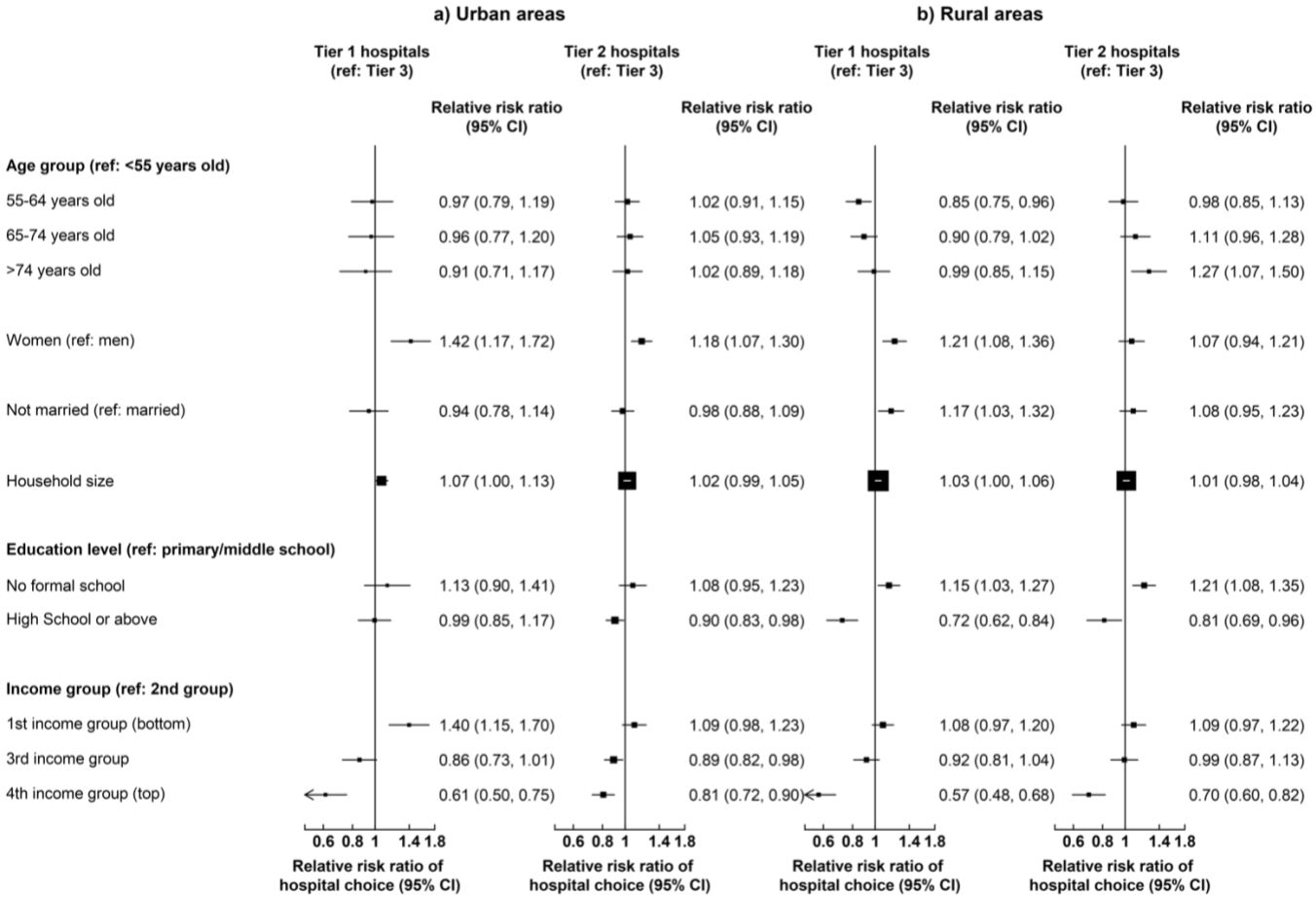
Results are from multinomial logit models with as alternative-specific variables: interactions between tier and, reimbursement rate and deductible. Only selected case-specific RRRs are presented and interpreted as parameters of a binary logit model against the base category “Tier 3 hospital”. Alternative-specific ORs from these models are presented in **Figure 7.2** and other included case-specific variables, including lifestyle and morbidity factors, are presented in **Appendix Table F.11**.

Figure 7.4 Effects of demographic and socioeconomic characteristics on choice of hospital tier for admissions for any cause in urban and rural areas



Results are from a multinomial logit model with as alternative-specific variables: interactions between tier and, reimbursement rate and deductible. Only selected case-specific RRRs are presented and interpreted as parameters of a binary logit model against the base category “Tier 3 hospital”. Alternative specific ORs from these models are presented in **Figure 7.2** and other included case-specific variables, including lifestyle and morbidity factors, are presented in **Appendix Table F.12**.

Figure 7.5 Effects of demographic and socioeconomic characteristics on choice of hospital tier for IHD admissions in urban and rural areas



Results are from multinomial logit models with as alternative-specific variables: interactions between tier and, reimbursement rate and deductible. Only selected case-specific RRRs are presented and interpreted as parameters of a binary logit model against the base category “Tier 3 hospital”. Alternative specific ORs from these models are presented in **Figure 7.2** and other included case-specific variables, including lifestyle and morbidity factors, are presented in **Appendix Table F.13**.

7.4.5 Post-estimation analyses

Urban areas

Among all stroke and IHD types, tier 3 hospitals had the highest probability of being selected, with higher probabilities for more severe types of disease (HS and AMI or angina) (**Appendix Figure 7.3**). The probability of choosing a hospital tier varied between urban CKB centres, with a higher probability of choosing tier 2 than 3 hospitals in Suzhou and Liuzhou (**Appendix Figure 7.4**).

For stroke, a 20% reduction in reimbursement rates in tier 3[4] was associated with a decline of 13.45% points in the predicted probability of using tier 3, and an increase of 2.06% and 11.39% points in the probability of using tier 1 and tier 2, respectively (**Table 7.4**). The corresponding probabilities for IHD were a decline of 9.54% points in tier 3, and a 1.77% and 7.77% points increase in tier 1 and 2, respectively. A 50% higher deductible in tier 3[5] was associated with a decrease in the probability of seeking care in tier 3 hospitals by 10.02% points for stroke and 6.31% points for IHD, and an increase in the probability of using tier 1 and 2 by 1.52% and 8.51% points for stroke, and 1.16% and 5.16% points for IHD, respectively. A 1% proportional increase in the reimbursement rate in tier 1 and 2 hospitals was associated with a greater change in own choice probabilities for stroke (3.13% and 2.55%, respectively) and IHD (2.34% and 1.91%) (i.e. elastic), yet the increase in the probability of choosing tier 3 for IHD (0.66%) was smaller than the 1% proportional increase in reimbursement rate in tier 3 (i.e. inelastic)

[4]On average across all urban participants in 2009-2017, this corresponds to a reduction in tier 3 reimbursement rates from 86% to 69%.

[5]On average across all urban participants in 2009-2017, this corresponds to an increase in tier 3 deductibles (inflated to 2017 values) from 624¥ to 936¥.

(**Table 7.5**). For stroke, cross changes in choice probabilities were smaller than the change in reimbursement rates in tier 1 (tier 2: -0.28%, tier 3: -0.17%), but greater than the change in reimbursement rates in tier 2 (tier 1: -1.64%, tier 3: -1.09%) and tier 3 (tier 1: -1.68%, tier 2: -1.79%). For IHD, cross changes in choice probabilities were smaller than the change in reimbursement rates in tier 1 (tier 2: -0.18%, tier 3: -0.14%) and tier 2 (tier 1: -0.85%, tier 3: -0.66%), but greater than the change in reimbursement rates in tier 3 (tier 1: -1.43%, tier 2: -1.43%). Elasticities using co-insurance rates are presented in **Appendix Table F.14Table F.14 Own and cross elasticities (95% CI) of choice of hospital tier in terms of co-insurance rate for stroke and IHD in urban and rural areas**. The own and cross changes in choice probabilities were smaller than the change in tier 3 deductibles for stroke and IHD.

Rural areas

The probability of choosing tier 3 hospitals was higher for individuals with the most severe stroke or IHD type, while the probability of choosing tier 1 was higher for those with the least severe disease type (**Appendix Figure F.3**). For patients with HS, the probabilities of choosing tier 2 and 3 were both about 40%, while the probability of choosing tier 2 was highest for those with lacunar and non-lacunar IS. For both IHD types, tier 1 hospitals had the highest probability of being chosen. The probabilities of choice of hospital tier varied between rural CKB centres, with a much greater probability of choosing tier 1 hospitals for patients in Henan. The probabilities of choosing tier 1 hospitals were generally higher for IHD than for stroke admissions (**Appendix Figure F.4**).

For stroke, a 15% increase in reimbursement rates in tier 3[6] was associated with an increase of 2.58% points in the predicted probability of attending tier 3, and a decrease of 0.99% and 1.58% points in the probability of attending tier 1 and tier 2, respectively (**Table 7.6**). The corresponding probabilities for IHD were an increase of 1.78% points in tier 3, and a 1.03% and 0.75% points decrease in tier 1 and 2, respectively. A 50% lower deductible in tier 1 hospitals[7] was associated with 2.02% points higher predicted probability of choosing tier 1 rather than tier 2 or 3 for stroke (**Table 7.6**). Completely removing the deductible in tier 1 was associated with a 4.15% points higher probability of choosing tier 1 hospitals for stroke. For stroke, a 1% proportional increase in reimbursement rates in tier 3 hospitals was associated with a 0.22% and 0.26% decrease in the probability of choosing tier 1 and 2, respectively, and a 0.57% increase in the probability of choosing tier 3 (**Table 7.7**). Own and cross changes in choice probabilities were smaller than the change in deductibles across all hospital tiers. For IHD, own and cross changes in choice probabilities were smaller than the change in reimbursement rates in tier 1 and 3, and in deductibles in tier 2 and 3 hospitals. Elasticities using co-insurance rates are presented in **Appendix Table F.14**.

[6]On average across all rural participants in 2009-2017, this corresponds to an increase in tier 3 reimbursement rates from 63% to 73%.
[7]On average across all rural participants in 2009-2017, this corresponds to a decrease in tier 1 deductibles (inflated to 2017 values) from 286¥ to 143¥.

Table 7.4 Effects (95% CI) of changes in reimbursement rates and deductibles on probabilities of hospital tier choice for stroke and IHD in urban areas

	Stoke			IHD		
	Tier 1	**Tier 2**	**Tier 3**	**Tier 1**	**Tier 2**	**Tier 3**
Baseline probabilities (%)	6.03 (0.34, 24.62)	30.44 (5.69, 64.82)	63.53 (22.75, 93.55)	5.89 (0.10, 23.41)	25.82 (6.75, 59.03)	68.29 (31.49, 92.78)
Difference between simulated and baseline probabilities (%)						
Changes in reimbursement rates						
Tier 1: 5% increase	1.01 (0.06, 3.61)	-0.44 (-2.13, -0.00)	-0.57 (-1.87, -0.05)	0.72 (0.01, 2.57)	-0.24 (-1.17, 0)	-0.48 (-1.59, -0.01)
Tier 2: 5% increase	-0.49 (-2.36, -0.01)	4.01 (1.19, 6.72)	-3.52 (-5.96, -1.15)	-0.25 (-1.22, 0)	2.53 (0.78, 4.79)	-2.28 (-4.36, -0.75)
Tier 3: 5% increase	-0.49 (-1.61, -0.04)	-2.64 (-4.72, -0.78)	3.14 (0.90, 5.53)	-0.41 (-1.27, -0.01)	-1.79 (-3.55, -0.54)	2.20 (0.61, 4.15)
Tier 3: 20% decrease	2.06 (0.21, 6.37)	11.39 (3.98, 18.98)	-13.45 (-22.31, -4.85)	1.77 (0.05, 5.29)	7.77 (2.42, 14.35)	-9.54 (-17.36, -2.83)
Changes in deductibles						
Tier 3: 5% increase	0.15 (0.00, 0.52)	0.82 (0.00, 1.48)	-0.97 (-1.76, 0.00)	0.11 (0.00, 0.38)	0.49 (0.00, 0.94)	-0.60 (-1.17, 0.00)
Tier 3: 50% increase	1.52 (0.00, 4.99)	8.51 (0.00, 14.94)	-10.02 (-17.45, 0.00)	1.16 (0.00, 3.83)	5.16 (0.00, 9.77)	-6.31 (-12.09, 0.00)
Changes in reimbursement rates (RR) and deductibles (DD)						
Tier 3: RR 5% decrease and DD 5% increase	0.66 (0.06, 2.06)	3.59 (1.07, 5.81)	-4.25 (-6.93, -1.29)	0.54 (0.01, 1.60)	2.37 (0.78, 4.25)	-2.91 (-5.09, -0.91)

Simulated probabilities were only computed for significant effects of the reimbursement rates and deductibles on choice of hospital tier (c.f. **Figure 7.2**).

Table 7.5 Own and cross elasticities (95% CI) of choice of hospital tier for stroke and IHD in urban areas

	Stroke			IHD		
With respect to:	**Tier 1**	**Tier 2**	**Tier 3**	**Tier 1**	**Tier 2**	**Tier 3**
Reimbursement rates						
Tier 1	3.13 (1.61, 4.62)	-0.28 (-0.42, -0.14)	-0.17 (-0.26, -0.09)	2.34 (0.73, 3.95)	-0.18 (-0.31, -0.06)	-0.1 (-0.24, -0.04)
Tier 2	-1.64 (-2.17, -1.10)	2.55 (1.73, 3.37)	-1.09 (-1.45, -0.74)	-0.85 (-1.27, -0.42)	1.91 (0.96, 2.84)	-0.66 (-0.99, -0.33)
Tier 3	-1.68 (-2.29, -1.06)	-1.79 (-2.43, -1.13)	1.00 (0.64, 1.36)	-1.43 (-2.20, -0.63)	-1.43 (-2.20, -0.63)	0.66 (0.29, 1.01)
Deductibles						
Tier 1	0.06 (-0.16, 0.28)	-0.01 (-0.03, 0.01)	0.00 (-0.01, 0.01)	-0.08 (-0.33, 0.17)	0.01 (-0.01, 0.03)	0.01 (-0.01, 0.02)
Tier 2	-0.03 (-0.13, 0.09)	0.04 (-0.13, 0.20)	-0.02 (-0.08, 0.06)	-0.01 (-0.10, 0.08)	0.02 (-0.18, 0.23)	-0.01 (-0.08, 0.06)
Tier 3	0.50 (0.38, 0.62)	0.54 (0.42, 0.66)	-0.31 (-0.38, -0.24)	0.38 (0.21, 0.54)	0.38 (0.21, 0.55)	-0.18 (-0.26, -0.10)

Elasticities were based on the effects of the reimbursement rates and deductibles on choice of hospital tier estimated in the main analysis (c.f. **Figure 7.2**). Example for stroke: a 1% increase in the reimbursement rate in tier 3 is associated with: a 1.00% increase in the probability of choosing tier 3 hospitals (own elasticity), a 1.68% and 1.79% decrease in the probability of choosing tier 1 and 2 hospitals, respectively (cross elasticities). Choice elasticity is elastic when |elasticity|>1 and inelastic when |elasticity|<1.

Table 7.6 Effects (95% CI) of changes in reimbursement rates and deductibles on probabilities of hospital tier choice for stroke and IHD in rural areas

	Stroke			IHD		
	Tier 1	**Tier 2**	**Tier 3**	**Tier 1**	**Tier 2**	**Tier 3**
Baseline probabilities (%)	29.92 (6.19, 70.00)	40.65 (18.58, 74.36)	29.42 (9.87, 62.34)	47.29 (4.98, 77.75)	25.98 (8.74, 52.65)	26.72 (9.87, 62.07)
Difference between simulated and baseline probabilities (%)						
Changes in reimbursement rates						
Tier 3: 5% increase	-0.33 (-0.78, -0.05)	-0.52 (-1.26, -0.07)	0.85 (0.27, 1.67)	-0.34 (-0.83, -0.06)	-0.25 (-0.90, -0.03)	0.59 (0.16, 1.33)
Tier 3: 15% increase	-0.99 (-2.42, -0.15)	-1.58 (-3.80, -0.20)	2.58 (0.83, 5.03)	-1.03 (-2.53, -0.19)	-0.75 (-2.70, -0.08)	1.78 (0.47, 4.01)
Changes in deductibles						
Tier 1: 5% decrease	0.20 (0.05, 0.50)	-0.12 (-0.30, -0.02)	-0.08 (-0.22, -0.01)	0.10 (-0.04, 0.33)	-0.05 (-0.18, 0.02)	-0.05 (-0.18, 0.02)
Tier 1: 50% decrease	2.02 (0.47, 5.04)	-1.20 (-3.02, -0.17)	-0.82 (-2.28, -0.15)	1.05 (-0.41, 3.30)	-0.52 (-1.83, 0.20)	-0.53 (-1.81, 0.20)
Tier 1: No deductible	4.15 (0.95, 10.35)	-2.46 (-6.21, -0.36)	-1.60 (-4.74, -0.31)	2.79 (-0.81, 6.63)	-1.05 (-3.68, 0.39)	-1.06 (-3.64, 0.40)
Changes in reimbursement rates (RR) and deductibles (DD)						
RR: Tier 3: +15% and DD: Tier 1: -20%	-0.21 (-1.46, 0.94)	-2.02 (-4.12, -0.57)	2.24 (0.59, 4.68)	-0.61 (-2.23, -0.64)	-0.95 (-2.86, -0.16)	1.56 (0.20, 3.81)

Simulated probabilities were only computed for significant effects of the reimbursement rates and deductibles on choice of hospital tier (c.f. **Figure 7.2**).

Table 7.7 Own and cross elasticities (95% CI) of choice of hospital tier for stroke and IHD in rural areas

	Stroke			IHD		
With respect to:	**Tier 1**	**Tier 2**	**Tier 3**	**Tier 1**	**Tier 2**	**Tier 3**
Reimbursement rates						
Tier 1	0.27 (-0.22, 0.76)	-0.12 (-0.33, 0.09)	-0.11 (-0.32, 0.09)	-0.58 (-1.07, -0.09)	0.53 (0.08, 0.95)	0.51 (0.08, 0.93)
Tier 2	-0.01 (-0.21, 0.19)	0.01 (-0.30, 0.34)	-0.01 (-0.25, 0.23)	-0.11 (-0.25, 0.03)	0.33 (-0.10, 0.78)	-0.14 (-0.32, 0.04)
Tier 3	-0.22 (-0.30, -0.13)	-0.26 (-0.36, -0.15)	0.57 (0.34, 0.80)	-0.14 (-0.23, -0.06)	-0.19 (-0.31, -0.07)	0.44 (0.17, 0.70)
Deductibles						
Tier 1	-0.13 (-0.21, -0.05)	0.06 (0.02, 0.09)	0.05 (0.02, 0.09)	-0.04 (-0.11, 0.02)	0.04 (-0.02, 0.10)	0.04 (-0.02, 0.10)
Tier 2	-0.15 (-0.21, -0.08)	0.23 (0.13, 0.33)	-0.17 (-0.24, -0.10)	-0.12 (-0.16, -0.08)	0.40 (0.27, 0.53)	-0.17 (-0.23, -0.11)
Tier 3	-0.10 (-0.17, -0.03)	-0.12 (-0.20, -0.03)	0.26 (0.07, 0.44)	-0.23 (-0.30, -0.16)	-0.31 (-0.41, -0.22)	0.71 (0.49, 0.92)

Elasticities were based on the effects of the reimbursement rates and deductibles on choice of hospital tier estimated in the main analysis (c.f. **Figure 7.2**). Example for stroke: a 1% increase in the reimbursement rate in tier 3 is associated with: a 0.57% increase in the probability of choosing tier 3 hospitals (own elasticity), a 0.22% and 0.26% decrease in the probability of choosing tier 1 and 2 hospitals, respectively (cross elasticities). Choice elasticity is elastic when |elasticity|>1 and inelastic when |elasticity|<1.

7.4.6 Sensitivity analyses

Effect of HI characteristics

The effects of reimbursement rates and deductibles in minimally-adjusted models were similar to their effects in fully-adjusted models for stroke, IHD and any cause in both urban and rural areas (**Table 7.8**).

When including reimbursement rates and deductibles separately rather than together in MNL models in urban areas, the effects of reimbursement rates on choice of hospital tier for stroke were attenuated (effect no longer significant in tier 1) and the effects of deductibles were stronger and significant across all tiers for stroke and any cause (**Table 7.9**). For admissions for IHD in urban areas, effects were similar to the ones in the main analysis. In rural areas, effects of reimbursement rates and deductibles were also broadly similar to the ones in the main analysis for stroke and IHD, with a significant effect of tier 1 deductible for IHD. The effect of deductible in tier 1 was stronger for any cause while the effects of deductibles in tier 2 and 3 were no longer significant. Excluding the reimbursement ceiling from MNL models did not affect results for reimbursement rates and deductibles (**Appendix Table F.15**).

In urban and rural areas, MNL models for stroke, IHD and any cause with a single effect of reimbursement rates and deductibles had worse model fit than those with tier-specific HI characteristics (**Appendix Table F.16**).

For admissions for stroke and IHD combined, the negative effect of deductibles in tier 3 hospitals was higher for individuals with lower income (ORs bottom vs top income group: 0.81 [0.77, 0.86] vs 0.94 [0.89, 0.99]) and education levels (ORs no formal school vs high school and above: 0.77 [0.72, 0.82] vs 0.89 [0.85, 0.94]) in

urban areas (**Table 7.10**). In rural areas, the effect of reimbursement rates in tier 3 hospitals was higher for individuals with high school and above (OR: 1.03 [1.02, 1.04]) than those with primary or middle school (OR: 1.01 [1.01, 1.02]). The effect of deductible in tier 1 hospitals was higher for individuals in lower income groups (ORs bottom vs top income group: 0.80 [0.73, 0.88] vs 1.01 [0.92, 1.10]; **Table 7.11**). Similar results for any cause are presented in **Appendix Table F.17** and **Table F.18**.

In urban areas, higher OOP payments in tier 2 and 3 were associated with lower use of corresponding hospital tiers for stroke and IHD admissions (**Table 7.12**). Higher ARR were associated with higher use of tier 2 and 3 for stroke admissions only. In rural areas, higher OOP payments were associated with lower use of tier 3 hospitals for stroke admissions, and lower use of tier 2 and tier 3 hospitals for IHD admissions (**Table 7.12**). Higher ARR was associated with higher use of tier 3 hospitals for stroke, and higher use of tier 2 and tier 3 hospitals for IHD.

Effect of socioeconomic characteristics

The effects of socioeconomic factors on the choice of hospital tier did not change after excluding adjustments for lifestyle and morbidity factors for stroke, IHD and any cause in urban and rural areas (**Appendix Table F.19**, **Table F.20**, and **Table F.21**). The effects of quartiles of approximated equivalent income on choice of hospital tier for stroke and IHD were similar to the effects of the original CKB income categories (**Appendix Table F.22**).

Effect of supply-side factors

Likewise, the effects of adjusting for supply-side factors on the choice of hospital tiers did not significantly affect coefficients for reimbursement rates and deductibles in models for stroke and IHD (**Appendix Table F.23**). The number of beds was not significantly associated with choice of hospital tier. In urban areas, a higher density of doctors was associated with a lower relative risk of choosing tier 1 or 2 (vs tier 3) hospitals for stroke (RRRs: 0.51 [0.33, 0.80] and 0.76 [0.63, 0.92], respectively) and IHD (0.19 [0.11, 0.35], 0.47 [0.36, 0.60]). In rural areas, a higher density of doctors was associated with a lower relative risk of choosing tier 2 (vs tier 3) hospitals for stroke (RRR: 0.35 [0.21, 0.59]).

Table 7.8 Effects (Odds Ratios [95% CI]) of reimbursement rates and deductibles on choice of hospital tier for admissions for stroke, IHD and any cause in minimally-adjusted models

	Stroke		IHD		Any cause	
	Reimbursement rate (per % point)	**Deductible (per 100¥)**	**Reimbursement rate (per % point)**	**Deductible (per 100¥)**	**Reimbursement rate (per % point)**	**Deductible (per 100¥)**
Urban areas						
Tier 1	1.05 (1.03, 1.06)	1.02 (0.94, 1.11)	1.03 (1.00, 1.05)	0.95 (0.85, 1.05)	1.01 (1.01, 1.02)	0.87 (0.84, 0.92)
Tier 2	1.05 (1.04, 1.07)	0.98 (0.93, 1.03)	1.04 (1.02, 1.05)	1.00 (0.94, 1.06)	1.03 (1.03, 1.04)	0.90 (0.88, 0.93)
Tier 3	1.05 (1.03, 1.06)	0.85 (0.82, 0.88)	1.03 (1.02, 1.05)	0.90 (0.86, 0.93)	1.03 (1.03, 1.04)	0.83 (0.82, 0.85)
Rural areas						
Tier 1	1.00 (0.99, 1.01)	0.87 (0.80, 0.93)	0.99 (0.98, 1.00)	0.91 (0.84, 0.98)	0.99 (0.99, 0.99)	0.96 (0.94, 0.98)
Tier 2	1.00 (0.99, 1.01)	1.12 (1.08, 1.17)	1.00 (1.00, 1.01)	1.12 (1.07, 1.17)	1.01 (1.01, 1.01)	1.05 (1.04, 1.07)
Tier 3	1.01 (1.01, 1.02)	1.06 (1.02, 1.10)	1.01 (1.01, 1.02)	1.14 (1.09, 1.19)	1.02 (1.01, 1.02)	1.03 (1.01, 1.04)

Results are from multinomial logit models with as alternative-specific variables: interactions between tier and, reimbursement rate and deductible, and as case-specific variables: age, sex, years and regions. Only alternative-specific ORs are presented and interpreted as follows: an OR>1 means that if the regressor increases for one hospital tier, then that hospital tier is chosen more; and vice versa for an OR<1.

Table 7.9 Effects (Odds Ratios [95% CI]) of reimbursement rates and deductibles included separately in models on choice of hospital tier for admissions for stroke, IHD and any cause

	Stroke		IHD		Any cause	
	Reimbursement rate (per % point)	**Deductible (per 100¥)**	**Reimbursement rate (per % point)**	**Deductible (per 100¥)**	**Reimbursement rate (per % point)**	**Deductible (per 100¥)**
Urban areas						
Tier 1	1.01 (1.00, 1.03)	0.91 (0.84, 0.98)	1.00 (0.99, 1.02)	0.90 (0.82, 1.00)	1.02 (1.01, 1.02)	0.88 (0.85, 0.91)
Tier 2	1.02 (1.01, 1.04)	0.94 (0.89, 0.99)	1.01 (1.00, 1.02)	0.97 (0.91, 1.03)	1.03 (1.02, 1.04)	0.88 (0.85, 0.90)
Tier 3	1.02 (1.01, 1.03)	0.83 (0.80, 0.85)	1.01 (0.99, 1.02)	0.90 (0.86, 0.93)	1.03 (1.02, 1.04)	0.84 (0.82, 0.85)
Rural areas						
Tier 1	1.00 (0.99, 1.01)	0.84 (0.78, 0.90)	0.99 (0.98, 1.00)	0.85 (0.80, 0.91)	0.99 (0.99, 1.00)	0.93 (0.91, 0.95)
Tier 2	1.01 (1.00, 1.02)	1.08 (1.04, 1.13)	1.02 (1.01, 1.02)	1.12 (1.07, 1.17)	1.01 (1.00, 1.01)	1.01 (1.00, 1.02)
Tier 3	1.02 (1.01, 1.03)	1.09 (1.06, 1.13)	1.02 (1.01, 1.03)	1.16 (1.12, 1.20)	1.01 (1.01, 1.01)	1.01 (0.99, 1.02)

Results are from multinomial logit models with as alternative-specific variables: interactions between tier and, reimbursement rate or deductible, and as case-specific variables: age, sex, years and regions. Only alternative-specific ORs are presented and interpreted as follows: an OR>1 means that if the regressor increases for one hospital tier, then that hospital tier is chosen more; and vice versa for an OR<1.

Table 7.10 Effect (Odds Ratios [95% CI]) of reimbursement rates and deductibles on choice of hospital tier for admissions for stroke and IHD combined in urban areas, by income and education level

	Reimbursement rates (per % point)			Deductibles (per 100¥)		
	Tier 1	**Tier 2**	**Tier 3**	**Tier 1**	**Tier 2**	**Tier 3**
Income group						
1st (bottom)	1.03 (1.01, 1.05)	1.04 (1.03, 1.06)	1.04 (1.02, 1.05)	1.14 (1.03, 1.26)	0.97 (0.90, 1.05)	0.81 (0.77, 0.86)
2nd	1.03 (1.01, 1.05)	1.04 (1.02, 1.05)	1.03 (1.02, 1.04)	0.99 (0.90, 1.10)	0.93 (0.87, 1.00)	0.84 (0.81, 0.88)
3rd	1.02 (1.00, 1.04)	1.02 (1.01, 1.04)	1.02 (1.00, 1.03)	0.89 (0.79, 0.99)	0.94 (0.87, 1.01)	0.86 (0.82, 0.90)
4th (top)	1.05 (1.03, 1.07)	1.06 (1.03, 1.08)	1.05 (1.03, 1.07)	1.03 (0.91, 1.16)	1.08 (1.00, 1.17)	0.94 (0.89, 0.99)
Education						
No formal school	1.02 (1.01, 1.04)	1.04 (1.02, 1.05)	1.03 (1.02, 1.05)	1.17 (1.06, 1.30)	0.92 (0.84, 1.01)	0.77 (0.72, 0.82)
Primary/middle school	1.03 (1.01, 1.04)	1.03 (1.02, 1.05)	1.02 (1.01, 1.04)	0.96 (0.88, 1.04)	0.91 (0.86, 0.97)	0.82 (0.79, 0.86)
High school and above	1.03 (1.01, 1.05)	1.02 (1.01, 1.04)	1.01 (1.00, 1.03)	0.82 (0.72, 0.94)	0.98 (0.92, 1.05)	0.89 (0.85, 0.94)

Results are from multinomial logit models with as alternative-specific variables: triple interactions between tier and, reimbursement rate and deductible, and income or education. Case-specific variables included demographic, socioeconomic (excluding income or education), lifestyle and morbidity factors, and log reimbursement ceiling. Only alternative-specific ORs are presented and interpreted as follows: an OR>1 means that if the regressor increases for one hospital tier, then that hospital tier is chosen more; and vice versa for an OR<1. Income groups are: 1st: <10 000¥, 2nd: 10 000-19 999¥, 3rd: 20 000-34 999¥, 4th: ≥35 000¥.

Table 7.11 Effect (Odds Ratios [95% CI]) of reimbursement rates and deductibles on choice of hospital tier for admissions for stroke and IHD combined in rural areas, by income and education level

	Reimbursement rates (per % point)			Deductibles (per 100¥)		
	Tier 1	**Tier 2**	**Tier 3**	**Tier 1**	**Tier 2**	**Tier 3**
Income group						
1st (bottom)	1.00 (0.99, 1.00)	1.01 (1.00, 1.01)	1.01 (1.01, 1.02)	0.80 (0.73, 0.88)	1.15 (1.10, 1.20)	1.10 (1.06, 1.14)
2nd	0.99 (0.98, 1.00)	1.00 (0.99, 1.01)	1.01 (1.00, 1.02)	0.83 (0.77, 0.90)	1.10 (1.05, 1.15)	1.10 (1.05, 1.15)
3rd	0.98 (0.97, 0.99)	1.00 (0.99, 1.01)	1.01 (1.00, 1.02)	0.91 (0.84, 0.99)	1.07 (1.01, 1.13)	1.07 (1.01, 1.13)
4th (top)	0.97 (0.96, 0.98)	0.99 (0.98, 1.00)	1.01 (1.00, 1.02)	1.01 (0.92, 1.10)	1.04 (0.96, 1.12)	0.96 (0.88, 1.04)
Education						
No formal school	0.99 (0.98, 1.00)	1.01 (1.00, 1.01)	1.01 (1.01, 1.02)	0.97 (0.89, 1.05)	1.14 (1.09, 1.19)	1.09 (1.05, 1.14)
Primary/middle school	0.98 (0.98, 0.99)	1.00 (0.99, 1.01)	1.01 (1.00, 1.02)	0.91 (0.86, 0.97)	1.12 (1.08, 1.16)	1.09 (1.06, 1.12)
High school and above	0.99 (0.98, 1.00)	1.01 (1.00, 1.03)	1.03 (1.02, 1.04)	0.91 (0.81, 1.02)	1.06 (0.98, 1.15)	1.06 (0.99, 1.13)

Results are from multinomial logit models with as alternative-specific variables: triple interactions between tier and, reimbursement rate and deductible, and income or education. Case-specific variables included demographic, socioeconomic (excluding income or education), lifestyle and morbidity factors, and log reimbursement ceiling. Only alternative-specific ORs are presented and interpreted as follows: an OR>1 means that if the regressor increases for one hospital tier, then that hospital tier is chosen more; and vice versa for an OR<1. Income groups are: 1st: <10 000¥, 2nd: 10 000-19 999¥, 3rd: 20 000-34 999¥, 4th: ≥35 000¥.

Table 7.12 Effect (Odds Ratios [95% CI]) of out-of-pocket (OOP) payments and actual reimbursement rates (ARR) on choice of hospital tier for admissions for stroke and IHD

	Stroke		IHD	
	OOP payments (per 100¥)	**ARR (per % point)**	**OOP payments (per 100¥)**	**ARR (per % point)**
Urban areas				
Tier 1	0.99 (0.97, 1.01)	1.01 (0.99, 1.02)	0.99 (0.97, 1.00)	1.00 (0.98, 1.01)
Tier 2	0.98 (0.97, 0.99)	1.02 (1.01, 1.03)	0.99 (0.98, 1.00)	1.01 (0.99, 1.02)
Tier 3	0.98 (0.98, 0.99)	1.02 (1.01, 1.03)	1.00 (0.99, 1.00)	1.00 (0.99, 1.02)
Rural areas				
Tier 1	1.00 (0.99, 1.02)	1.01 (1.00, 1.02)	1.01 (1.00, 1.03)	0.99 (0.98, 1.01)
Tier 2	1.00 (0.99, 1.00)	1.00 (1.00, 1.01)	0.99 (0.99, 1.00)	1.02 (1.01, 1.02)
Tier 3	0.99 (0.98, 0.99)	1.02 (1.02, 1.03)	0.99 (0.99, 0.99)	1.02 (1.02, 1.03)

Models for OOP and ARR are different regressions. Results are from multinomial logit models with as alternative-specific variables: interactions between tier and OOP payments or ARR, and as case-specific variables: demographic, socioeconomic, lifestyle and morbidity factors and log reimbursement ceiling. Only alternative-specific ORs are presented and interpreted as follows: an OR>1 means that if the regressor increases for one hospital tier, then that hospital tier is chosen more; and vice versa for an OR<1.

7.5 Discussion

7.5.1 Findings and interpretation

Summary of results

In 2009-2017, about 60% of participants admitted to hospital for a first stroke or IHD selected tier 3 hospitals in urban areas, but only about 30% of participants in rural areas selected tier 3 hospitals. Urban residents were increasingly choosing tier 1 or 2 hospitals over time, while rural residents were increasingly choosing tier 3 hospitals. The effect of cost sharing mechanisms on the choice of hospital tiers for stroke and IHD differed between urban and rural areas. In urban areas, a 1% point increase in the reimbursement rate was associated with 3-5% higher odds of selection of a given hospital tier for stroke and IHD, and a 100¥ increase in deductibles in tier 3 was associated with an 9-14% lower odds of selection of such hospitals. In rural areas, a 1% point higher reimbursement rate in tier 3 was associated with 1-2% higher odds of selection of these hospitals for stroke and IHD, and a 100¥ higher deductible in tier 1 was associated a 13% lower odds of selection of these hospitals for stroke. However, higher deductibles in tier 2 and 3 hospitals were associated with a higher likelihood of choosing these hospital tiers. For patients with stroke, a higher reimbursement ceiling was associated with a lower use of tier 2 (vs tier 3) in urban areas, but a higher use of tier 1 and 2 (vs tier 3) hospitals in rural areas. In both urban and rural areas, higher socioeconomic groups as defined by higher educational or income level, were less likely than lower socioeconomic groups to choose tier 1 or 2 hospitals (vs tier 3) for stroke and IHD. Women with IHD were more likely than men to choose tier 1 or 2 (vs tier 3)

hospitals in urban and rural areas. In rural areas, the oldest patients were more likely to choose tier 1 or 2 (vs tier 3) compared to the youngest patients and individuals not currently married (vs married) were more likely to choose tier 1 (vs tier 3) hospitals for all conditions. Urban individuals living in larger households were more likely to choose tier 2 for stroke and tier 1 (vs tier 3) hospitals for IHD. Rural individuals living in larger households were more likely to choose tier 1 (vs tier 3) hospitals for IHD. Individuals with less severe stroke or IHD types were more likely to choose tier 1 or 2 hospitals (vs tier 3) than those with more severe disease types. The results for first admissions for any cause were broadly similar to those for stroke and IHD.

Heterogeneity in choice of hospital tier

The higher probabilities of choosing tier 3 hospitals in urban areas, and tier 1 or 2 hospitals in rural areas were consistent with results from two DCE studies suggesting that for conditions perceived as severe, urban residents preferred large hospitals, while rural residents preferentially sought care in medium-sized hospitals.[11,34]

Despite higher OOP payments in higher tier hospitals, the higher use of tier 3 hospitals in urban areas might reflect the higher concentration of these hospitals in large cities, easier access, low travel costs and perceived low quality of care in lower tier hospitals.[29,31] As income was higher and OOP payments were lower in urban than rural areas in this study, urban residents were more likely to be able to afford healthcare in tier 3 hospitals. The increase in use of tier 1 and 2 hospitals in urban areas in 2009-2017, especially for stroke, might be related to the higher annual reduction in average deductibles in tier 1 (4.9%) and 2 (2.8%) than tier 3

hospitals (2.0%) or a stricter implementation of a referral system and medical alliances between tiers.[12,45] In addition, following the healthcare reforms, investment in healthcare infrastructure and workforce increased, and a zero mark-up drug policy was implemented in tier 1 hospitals, potentially rising their attractiveness.[7] Although the probability of choosing tier 1 hospitals for stroke and IHD increased over time, it remained low (8-9%) in 2017.

In rural areas, probabilities of choosing each hospital tier for any cause were similar to those reported in a previous study (township hospital/tier 1: 39%, county hospital/tier 2: 34% prefectural/provincial hospital/tier 3: 27%).[20] The majority of patients chose tier 1 or 2 hospitals, likely reflecting the concentration of these hospitals and the lack of tier 3 hospitals in rural areas, financial constraints, and distance being a greater obstacle.[29,46] Results from a DCE in rural areas also found that choosing a large-size hospital was never patients' preferred choice for first-contact care, even for severe diseases.[34] Liu et al (2018) reported that rural residents usually found it difficult to seek help in tier 3 hospitals and that consultation periods were very short in these hospitals.[47] Despite higher deductibles in tier 3 hospitals in rural areas in 2009-2017, individuals increasingly chose tier 3 hospitals over time. Potential reasons for this trend might include increasing reimbursement rates and improved access to more expensive care.

Urban and rural residents enrolled in UEBMI had a higher proportion of admissions in tier 3 hospitals than those enrolled in URBMI or NRCMS, likely highlighting the higher HI benefits of UEBMI. Previous studies reported similar results and suggested that URBMI and NRCMS enrollees were more sensitive to price of health services.[17,24] In contrast to the present study, one study reported that individuals enrolled in UEBMI, URBMI and NRCMS increasingly chose tier 3

hospitals in 2008-2014.[17] This difference might be explained by the use of aggregate national level data of hospital care use rather than individual-level data by urban or rural area like in the CKB study and by a shorter time period.

Effect of HI characteristics on choice of hospital tier

The positive effect of reimbursement rates on choice of a given hospital tier was also reported in one previous study.[19] In urban areas, only deductibles in tier 3 were associated with the choice of hospital tier, which might reflect the wide variations in tier 1 and 2 deductibles across urban centres and their low value. The negative effect of the deductible in tier 3 in urban areas and in tier 1 hospitals in rural areas was consistent with the negative effect found by Brown and Theoharides (2009).[20] The stronger effect of cost sharing, especially reimbursement rates, on choice of hospital tier in urban than rural areas echoed results from Zhou et al (2021) that the implementation of the hierarchical medical system only had a significantly positive effect on the choice of primary care facilities for urban residents.[12] Urban residents, particularly urban workers, are likely to be more familiar with the concept of insurance and better informed about the reimbursement policies than rural residents, as policies have been in operation for a longer time. In rural areas, the complexity of NRCMS cost sharing arrangements may cause confusion among insured about what can and cannot be reimbursed, and how much will be reimbursed.[48]

The positive effect of tier 2 and 3 deductibles on choice of hospital tier for stroke and IHD in rural areas, might be due to the hospital tier being a proxy for quality of medical care for rural residents.[49] Rural residents may be willing to pay a higher price to attend higher tier hospitals, because they perceive them to provide higher

quality services,[50] or because their health need is considerable enough to override larger deductibles. Similarly, the negative effect of tier 1 reimbursement rates for IHD admissions might be explained by the perceived low quality of care and higher long-term risks in tier 1 hospitals, overriding the lower costs of these hospitals. It is also possible that lower and higher tier hospitals are not true substitutes and that for conditions such as stroke and IHD, patients may have less choice but to seek treatment at tier 2 or 3 hospitals. Tier 1 hospitals may not be able to treat severe cases of stroke and IHD due to the lack of advanced diagnostic and treatment methods (e.g. magnetic resonance imaging and coronary revascularisation), especially in rural areas, which might partly explain the negative effect of reimbursement rates and positive effect of deductibles in rural areas.

Furthermore, Baicker and Goldman (2011) highlighted the complexity of multiple cost sharing arrangements, the difficulty in understanding which design feature (e.g. reimbursement rate or deductible) individuals consider when choosing a hospital tier.[51] When combining reimbursement rates and deductibles into a single measure (OOP payments and ARR), the effects of cost sharing were more frequently in the expected direction (negative for OOP payments and positive for ARR). The effect of reimbursement ceiling of the choice of hospital tier was generally weak, potentially reflecting that the ceiling is rarely reached.[36] Moreover, for conditions like stroke and IHD, reimbursement ceilings for URBMI and NRCMS enrollees in some areas are increased by the critical illness insurance.[52] Previous studies reported that an increase in the ceiling for outpatient care under NRCMS increased outpatient care utilisation,[21] and that higher ceiling led household with more elderly members to increasingly choose higher tier hospitals.[20]

Although reducing reimbursement rates and increasing deductibles in tier 3 hospitals in urban areas could divert patients from tier 3 to lower tier hospitals to contain costs, this might negatively affect health outcomes by reducing the use of required healthcare. This highlights the need for a general practitioner referring system based on medical needs to guide choice of hospitals for individual diseases.

Effect of patient characteristics on choice of hospital tier

Older patients with stroke and IHD in rural areas, and in all areas for any cause were more likely to choose tier 1 or 2 (vs tier 3) hospitals compared to young patients, which might reflect older patients' lower socioeconomic status, preference for shorter travel distances and waiting time or the higher provision of rehabilitation services in lower tier hospitals. Studies in the literature review that reported similar results suggested reasons related to finance or ease of access.[22,24] The preference for tier 3 hospitals by individuals in higher socioeconomic groups and for tier 1 hospitals by individuals in the lowest socioeconomic groups was consistent with findings from previous studies and suggested that lower socioeconomic groups were more price-sensitive. A previous report indicated that distrust in primary care facilities was greater among patients with higher education.[53] The preference for tier 3 hospitals for patients with more severe disease types, and worse lifestyle factors was consistent with findings from previous studies, reflecting these hospitals' better capacity to treat acute diseases or increased risk aversion among people with more severe conditions.[22,34] Overall, the different effects of socioeconomic characteristics on the choice of hospital tier highlighted persistent inequalities in access to different hospital tiers in China.

7.5.2 Limitations

The chief strengths of the present study included detailed data on HI characteristics, the use of HI claims data for choice of all three hospital tiers, the diversity in regions included, and the extensive data collected on individual participants. However, the study also had several limitations.

Hospital tier data

The use of HI claims data to assess choice of hospital tier, meant that only data for hospitalised patients were available and patients' decision to seek inpatient treatment in hospital (versus not seek care or seek care elsewhere and not reach hospital) could not be modelled. As Chinese hospitals' tier status is reviewed annually, it is possible that some tier information in the CKB study was outdated resulting in some misclassification. This study was unable to distinguish between emergency and non-emergency admissions. Although emergency patients may not have considered HI characteristics to the same extent as non-emergency patients, the direction of the bias could not be identified as it may depend on the proportion of emergency and non-emergency admissions in the study.

Health insurance characteristics

HI characteristics were used as a proxy for OOP payments or hospitalisation costs which were not available in the CKB study. Although the data collected on HI characteristics were checked, several assumptions had to be made due to data availability and to match HI characteristics to the CKB participants' hospital admission data. For instance, when HI characteristics in the CKB recruitment

city/county or for a given year were not found, data for a higher administrative level or for the previous year (assuming no changes) were used instead. In four CKB centres where deductibles varied with the number of admissions per year, the deductible for the first admission was used. However, it is possible that participants' first stroke or IHD admission was not their first admission in the year. Nevertheless, first admissions for any cause were also first admissions in each year. The use of national medical expenses data as a proxy for individual expenses, and expenses for AMI as a proxy for other IHD to match reimbursement rates in seven CKB centres, might have led to mismatches. Further details on additional assumptions made for HI characteristics are provided in **Appendix C.4**. Thus, not all heterogeneity in HI characteristics was captured, which likely added noise to the data. Having reimbursement rates expressed in the relative scale and deductibles in the absolute scale limited the comparison of their effects on choice of hospital tier. Derived OOP payments and ARR did not take into account variation in medical expenses between urban and rural areas and across regions, as this data was not publicly available. As information on participants' enrolment in the critical illness insurance, the medical financial assistance programme or private HI was not available in the CKB study, HI benefits for individuals benefiting from these schemes might have been underestimated. In contrast, the actual percentages of total medical expenses reimbursed by HI might have been lower than the reimbursement rates used in this study because not all services are covered by HI.

Endogeneity bias

Analyses were likely to be biased due to missing hospital tier attributes, including distance or travel time from participants' home to hospitals of each tier and

indicators for perceived quality of hospital care in different tiers. The omission of distance in models for urban areas was unlikely to materially affect the results, as hospitals from all tiers were generally easily accessible and the differences in travel time and costs between tiers were likely to be minimal.[54,55] In rural areas, the proportion of admissions for stroke and IHD that occurred in hospitals located in the same county as the county where participants had been recruited was almost 100% for tier 1, 96-97% for tier 2 and 77-82% for tier 3 hospitals. These findings suggest that the distances between participants' home and hospital were greater for patients attending higher tier hospitals in rural areas. Travel distance may have been an important factor influencing choice of hospital tiers as suggested by the rapid literature review, and potentially contributed to the observed differences in choice of hospital tiers between urban and rural areas. However, the transportation system in rural areas has substantially improved in recent years, reducing travel time and costs to attend higher tier hospitals.

Although indicators of quality of care in different hospital tiers were not available in this study, quality of care tends to be higher in higher tier hospitals.[55,56] Previous literature suggested that the quality of tier 1 hospitals or primary care facilities was generally low, especially in rural China.[57,58] Thus, the tier of a given hospital could be considered as a signal for perceived quality of care provided. In view of trade-offs between price (proxied by HI characteristics), quality of care and distance, inability to include quality of care and distance in the utility function may have introduced endogeneity bias. A control function approach to correct for potential endogeneity bias was attempted, though the models could not be fitted.[59,60] Other omitted variables included level of trust in different hospital tiers,[53] and risk attitude or aversion.[36]

Supply-side factors

As indicated in the rapid review, supply-side factors also shape individuals' healthcare provider choices. One would expect a higher probability of choosing higher tier hospitals in areas with a higher proportion of higher tier hospitals (i.e. urban areas), and vice versa for lower tier hospitals. Thus, differences in supply-side factors, such as the distribution of hospital tiers in urban and rural areas, might partly explain observed differences in probabilities of choosing each hospital tier between and within urban and rural areas. Although the study adjusted for supply-side factors in sensitivity analyses, these factors were not specific to the CKB recruitment areas and might have introduced measurement error in the results.

Choice modelling issues

Based on the adjusted Rho-squared, a goodness of fit statistic for choice models, estimated effects from MNL models in rural areas (adjusted rho-squared: 0.14) were less likely to be reliable than those in urban areas (0.37).[61] One key limitation of using the MNL model was that random taste heterogeneity was not modelled. Before selecting the MNL model, heteroskedastic MNL, latent class and mixed MNL models were attempted, but several optimisation issues were encountered. Thus, a simple MNL model was the only specification which allowed models with tier-specific reimbursement rates and deductibles included together with a range of patient characteristics to be reliably estimated.

Generalisability of results

The CKB study is not representative of the entire Chinese population, so effects of reimbursement rates and deductibles on choice of hospital tier might not be generalisable to the rest of China and should be interpreted with caution. However, the diversity of regions included in urban and rural areas, is such that trends in HI characteristics and probabilities of choosing different tiers are expected to be more generalisable to urban and rural Chinese populations. Given that present analyses focused on first inpatient admissions only rather than all admissions, generalising the effect of HI characteristics on choice of hospital tier to recurrent admissions or other types of care (e.g. outpatient) requires further investigation. However, one study mentioned that after a first-visit to higher tier hospitals, follow-up visits to lower tier hospitals still remained uncommon in China.[47] The effect of HI characteristics on choice of hospital tier for stroke and IHD might not be generalisable to other diseases, as these are severe diseases with potentially limited trade-off behaviour. Nevertheless, results for any cause were broadly similar to those for stroke and IHD, suggesting relevance for other diseases.

Evaluation of healthcare reforms

This study lacked data (e.g. content, timing) on the specific health policy changes aimed at changing patients' health seeking behaviour, that were implemented in different CKB centres. Indeed, pilot studies of such policies were initiated in 2014-2015, with full implementation occurring in the following years.[12] Another analytical approach, such as difference-in-difference, might have been more appropriate to elucidate the causal effects of the implementation of the hierarchical medical system. Furthermore, a longer follow-up period would be needed, as changing

patients' healthcare seeking behaviour is typically a long-term process, which involves changing habits.[6,62]

7.5.3 Conclusions

In this large prospective study, urban residents with stroke and IHD had a higher probability of using tier 3 hospitals, though the choice of tier 1 and 2 hospitals increased between 2009 and 2017. While rural residents had a higher probability of using tier 1 or 2 hospitals, the choice of tier 3 hospitals increased over time. The effect of cost sharing on choice of hospital tier differed between urban and rural areas. In urban areas, higher reimbursement rates in all tiers were associated with a higher use of the corresponding hospitals, and higher deductibles in tier 3 were associated with a lower use of tier 3 hospitals. In rural areas, higher reimbursement rates in tier 3 were associated with a higher use of tier 3 hospitals, and higher deductibles in tier 1 were associated with a lower use of tier 1 hospitals. However, omitted variable bias might have led to biases, as was likely the case with the positive effects of tier 2 and 3 deductibles in rural areas. In both urban and rural areas, patients with higher socioeconomic groups or more severe disease types were more likely to choose tier 3 than tier 1 or 2 hospitals. Future studies should include better measurements of distance between participants' home and hospitals, quality of care, and supply-side factors to more reliably estimate the effects of HI characteristics on choice of hospital tier.

7.6 Summary

This chapter provides novel evidence on the effects of tiered reimbursement rates and deductibles and socioeconomic characteristics on the choice of hospital tier for patients with stroke and IHD in urban and rural areas. Chapter 8 summarises the research presented in this thesis, discusses the policy implications, in addition to making recommendations for future research.

References

1. Qian D, Lucas H, Chen J, Xu L, Zhang Y. Determinants of the use of different types of health care provider in urban China: A tracer illness study of URTI. *Health Policy*. 2010; **98**(2): 227-35.

2. Eggleston KN. Health Care for 1.3 Billion: An Overview of China's Health System. Stanford Asia Health Policy Program Working Paper 28; 2012.

3. Yip W, Hsiao W. Harnessing the privatisation of China's fragmented health-care delivery. *The Lancet*. 2014; **384**(9945): 805-18.

4. Wu D, Lam TP. Underuse of Primary Care in China: The Scale, Causes, and Solutions. *Journal of the American Board of Family Medicine*. 2016; **29**(2): 240-7.

5. Li X, Lu J, Hu S, et al. The primary health-care system in China. *The Lancet*. 2017; **390**(10112): 2584-94.

6. Li L, Fu H. China's health care system reform: Progress and prospects. *The International Journal of Health Planning and Management*. 2017; **32**(3): 240-53.

7. Yip W, Fu H, Chen AT, et al. 10 years of health-care reform in China: progress and gaps in Universal Health Coverage. *The Lancet*. 2019; **394**(10204): 1192-204.

8. Liu GG, Vortherms SA, Hong X. China's Health Reform Update. *Annual Review of Public Health*. 2017; **38**(1): 431-48.

9. Zhang L, Cheng G, Song S, et al. Efficiency performance of China's health care delivery system. *The International Journal of Health Planning and Management*. 2017; **32**(3): 254-63.

10. Hu Y, Zhang Z. Skilled doctors in tertiary hospitals are already overworked in China. *The Lancet Global Health*. 2015; **3**(12): e737.

11. Liu Y, Kong Q, Wang S, Zhong L, van de Klundert J. The impact of hospital attributes on patient choice for first visit: evidence from a discrete choice experiment in Shanghai, China. *Health Policy and Planning*. 2019; **35**(3): 267-78.

12. Zhou Z, Zhao Y, Shen C, Lai S, Nawaz R, Gao J. Evaluating the effect of hierarchical medical system on health seeking behavior: A difference-in-differences analysis in China. *Social Science & Medicine*. 2021; **268**: 113372.

13. Shen X, Yang W, Sun S. Analysis of the Impact of China's Hierarchical Medical System and Online Appointment Diagnosis System on the

Sustainable Development of Public Health: A Case Study of Shanghai. *Sustainability*. 2019; **11**(23): 6564.

14. State Council. Implementation opinions of the State Council on comprehensively promoting the comprehensive reform of all public hospitals at the county level 2015. Available from: http://www.gov.cn/zhengce/content/2015-05/08/content_9710.htm (Accessed: 27 October 2021).

15. State Council. Guiding opinions of the general office of the state council on urban public hospital comprehensive reform pilot 2015. Available from: http://www.gov.cn/zhengce/content/2015-05/17/content_9776.htm (Accessed: 27 October 2021).

16. Meng Q, Fang H, Liu X, Yuan B, Xu J. Consolidating the social health insurance schemes in China: towards an equitable and efficient health system. *The Lancet*. 2015; **386**(10002): 1484-92.

17. Xiong X, Zhang Z, Ren J, et al. Impact of universal medical insurance system on the accessibility of medical service supply and affordability of patients in China. *PLOS One*. 2018; **13**(3): e0193273.

18. Babiarz KS, Miller G, Yi H, Zhang L, Rozelle S. New evidence on the impact of China's New Rural Cooperative Medical Scheme and its implications for rural primary healthcare: multivariate difference-in-difference analysis. *BMJ*. 2010; **341**: c5617.

19. Hou Z, Poel E, Doorslaer E, Yu B, Meng Q. Effects of NCMS on Access to Care and Financial Protection in China. *Health economics*. 2014; **23**(8): 917-34.

20. Brown PH, Theoharides C. Health-seeking behavior and hospital choice in China's New Cooperative Medical System. *Health Economics*. 2009; **18**(S2): S47-S64.

21. Zhang L, Wang Z, Qian D, Ni J. Effects of changes in health insurance reimbursement level on outpatient service utilization of rural diabetics: evidence from Jiangsu Province, China. *BMC Health Services Research*. 2014; **14**: 185-.

22. Qian D, Pong RW, Yin A, Nagarajan KV, Meng Q. Determinants of health care demand in poor, rural China: the case of Gansu Province. *Health Policy and Planning*. 2009; **24**(5): 324-34.

23. Yu W, Li M, Ye F, Xue C, Zhang L. Patient preference and choice of healthcare providers in Shanghai, China: a cross-sectional study. *BMJ Open*. 2017; **7**(10): e016418.

24. Shu Z, Han Y, Xiao J, Li J. Effect of medical insurance and family financial risk on healthcare utilisation by patients with chronic diseases in China: a cross-sectional study. *BMJ Open*. 2019; **9**(11): e030799-e.

25. Zhang C, Lei X, Strauss J, Zhao Y. Health Insurance and Health Care among the Mid-Aged and Older Chinese: Evidence from the National Baseline Survey of CHARLS. *Health Economics*. 2017; **26**(4): 431-49.

26. Jin Y, Xu J, Zhu W, Zhang Y, Xu L, Meng Q. Synergy of policies to strengthen primary care: evidence from a national repeated cross-sectional study. *BMC Health Services Research*. 2020; **20**(1): 865.

27. Li X, Zhang L, Li Z, Tang W. Patient Choice and Willingness Toward Gatekeepers as First-Contact Medical Institutions in Chinese Tiered Healthcare Delivery System: A Cross-Sectional Study. *Frontiers in Public Health*. 2021; **9**: 665282-.

28. Cao Y, Zhen F, Wu H. Public Transportation Environment and Medical Choice for Chronic Disease: A Case Study of Gaoyou, China. *International Journal of Environmental Research and Public Health*. 2019; **16**(9): 1612.

29. Li C, Chen Z, Khan MM. Bypassing primary care facilities: health-seeking behavior of middle age and older adults in China. *BMC Health Services Research*. 2021; **21**(1): 895.

30. Ma Q, Sun D, Cui F, et al. Impact of the Internet on Medical Decisions of Chinese Adults: Longitudinal Data Analysis. *Journal of Medical Internet Research*. 2020; **22**(9): e18481-e.

31. Wu D, Lam TP, Lam KF, Zhou XD, Sun KS. Health reforms in china: the public's choices for first-contact care in urban areas. *Family Practice*. 2017; **34**(2): 194-200.

32. Zhang A, Nikoloski Z, Albala S, Yip W, Xu J, Mossialos E. Patient Choice of Health Care Providers in China: Primary Care Facilities versus Hospitals. *Health Systems & Reform*. 2020; **6**.

33. Tang L. The patient's anxiety before seeing a doctor and her/his hospital choice behavior in China. *BMC Public Health*. 2012; **12**(1): 1121.

34. Liu Y, Kong Q, de Bekker-Grob EW. Public preferences for health care facilities in rural China: A discrete choice experiment. *Social Science & Medicine*. 2019; **237**: 112396.

35. National Bureau of Statistics of China. China Statistical Yearbook 2018. Available from: http://www.stats.gov.cn/english/Statisticaldata/AnnualData (Accessed: 27 July 2019).

36. Julie Shi XW, and Castiel Chen Zhuang. Understanding Deductible and Reimbursement Maximum: A Study of Rural China's Tiered Medical System. 2021.

37. McFadden D. Conditional logit analysis of qualitative choice behaviour. *Frontiers in Econometrics*. 1974: pp. 105-42.

38. Train K. Discrete Choice Methods With Simulation. 2nd ed: Cambridge University Press; 2009.

39. Hensher DA, Rose JM, Greene WH. Applied Choice Analysis. 2nd ed. Cambridge: Cambridge University Press; 2015.

40. Palma SHD. Apollo: a flexible, powerful and customisable freeware package for choice model estimation and application. Choice Modelling Centre, University of Leeds; 2021.

41. Stata. hausman - Hausman specification test. Available from: https://www.stata.com/manuals/rhausman.pdf (Accessed: 4 November 2021).

42. Vijverberg W. Testing for IIA with the Hausman-Mcfadden Test. *SSRN Electronic Journal*. 2011.

43. Train KE. Qualitative Choice Analysis: Theory Econometrics, and an Application to Automobile Demand: MIT Press; 1986.

44. Cheng S, Long JS. Testing for IIA in the Multinomial Logit Model. *Sociological Methods & Research*. 2007; **35**(4): 583-600.

45. Zhu J, Li J, Zhang Z, Li H, Cai L. Exploring determinants of health provider choice and heterogeneity in preference among outpatients in Beijing: a labelled discrete choice experiment. *BMJ Open*. 2019; **9**(4): e023363-e.

46. Liu Y, Kong Q, Yuan S, van de Klundert J. Factors influencing choice of health system access level in China: A systematic review. *PLOS One*. 2018; **13**(8): e0201887.

47. Liu Y, Zhong L, Yuan S, van de Klundert J. Why patients prefer high-level healthcare facilities: a qualitative study using focus groups in rural and urban China. *BMJ Global Health*. 2018; **3**(5): e000854-e.

48. Lei X, Lin W. The New Cooperative Medical Scheme in rural China: does more coverage mean more service and better health? *Health Economics*. 2009; **18 Suppl 2**: S25-46.

49. Sinaiko AD, Rosenthal MB. Increased Price Transparency in Health Care — Challenges and Potential Effects. *New England Journal of Medicine*. 2011; **364**(10): 891-4.

50. Eggleston K, Ling L, Qingyue M, Lindelow M, Wagstaff A. Health service delivery in China: a literature review. *Health Economics*. 2008; **17**(2): 149-65.

51. Baicker K, Goldman D. Patient Cost-Sharing and Healthcare Spending Growth. *Journal of Economic Perspectives*. 2011; **25**(2): 47-68.

52. Fang P, Pan Z, Zhang X, Bai X, Gong Y, Yin X. The effect of critical illness insurance in China. *Medicine*. 2018; **97**(27): e11362-e.

53. Duckett J, Hunt K, Munro N, Sutton M. Does distrust in providers affect health-care utilization in China? *Health Policy and Planning*. 2016; **31**(8): 1001-9.

54. Chen Y, Yin Z, Xie Q. Suggestions to ameliorate the inequity in urban/rural allocation of healthcare resources in China. *International Journal for Equity in Health*. 2014; **13**(1): 34.

55. Cai M, Liu E, Li W. Rural versus urban patients: Benchmarking the outcomes of patients with acute myocardial infarction in Shanxi, China from 2013 to 2017. *International Journal of Environmental Research and Public Health*. 2018; **15**(9): 1930.

56. Shi H, Fan M, Zhang H, et al. Perceived health-care quality in China: a comparison of second- and third-tier hospitals. *International Journal for Quality in Health Care*. 2021; **33**(1).

57. Sylvia S, Xue H, Zhou C, et al. Tuberculosis detection and the challenges of integrated care in rural China: A cross-sectional standardized patient study. *PLOS Medicine*. 2017; **14**(10): e1002405.

58. Li X, Krumholz HM, Yip W, et al. Quality of primary health care in China: challenges and recommendations. *The Lancet*. 2020; **395**(10239): 1802-12.

59. Guevara C. Critical Assessment of Five Methods to Correct for Endogeneity in Discrete-Choice Models. *Transportation Research Part A Policy and Practice*. 2015; **82**: 240-54.

60. Guevara CA, Ben-Akiva M. Endogeneity in Residential Location Choice Models. *Transportation Research Record*. 2006; **1977**(1): 60-6.

61. Mokhtarian P. Discrete choice models' ρ2: A reintroduction to an old friend. *Journal of Choice Modelling*. 2016; **21**(C): 60-5.

62. Powell-Jackson T, Yip WC-M, Han W. Realigning Demand and Supply Side Incentives to Improve Primary Health Care Seeking in Rural China. *Health Economics*. 2015; **24**(6): 755-72.

Chapter 8. Discussion

This thesis examined the trends and differences in use of hospital care for stroke and ischaemic heart disease (IHD) across urban and rural areas, socioeconomic groups, gender, and health insurance (HI) characteristics following expansion of HI coverage and during a period of healthcare reforms in China, aiming to inform policies to reduce these differences.

8.1 Findings and interpretation

Since 2004, the use of hospital care for stroke and acute myocardial infarction (AMI) has increased, length of stay (LOS) for stroke decreased, in-hospital mortality rates decreased for both stroke and AMI, and the use of diagnostic tests and procedures increased for patients with stroke and AMI. However, these results varied by disease subtypes, sex, urban or rural areas, HI type and hospital tiers (**Chapter 3**). Previous studies focused on urban areas or higher tier hospitals, and lacked follow-up data or linked data to mortality registers. In addition, as most studies used data from hospital discharge records, studying differences in hospital care use by socioeconomic characteristics was limited. Most studies on health seeking behaviour in China used self-reported data and examined choice of provider for healthcare overall.

In order to address these issues, data from over 0.5 million Chinese adults from the China Kadoorie Biobank (CKB), who were followed up for at least 8 years, were used to study trends in annual rates of hospitalisation, case fatality rates and LOS for stroke and IHD overall and across different socioeconomic groups (**Chapter 5**),

gender differences in use of diagnostic tests and procedures for patients with acute IHD and the role of socioeconomic and health system factors (**Chapter 6**), and the influence of HI and socioeconomic characteristics on the choice of hospital tiers for stroke and IHD (**Chapter 7**).

Chapter 5 demonstrated that between 2009 and 2016, admissions to hospital for stroke and IHD increased by approximately 4-5% per year after controlling for demographic, socioeconomic, lifestyle and morbidity factors. Although hospital admission rates were higher among individuals living in urban areas and those enrolled in Urban Employee Basic Medical Insurance (UEBMI), annual proportional increases in hospitalisation rates for stroke and IHD were greater among individuals living in rural than urban areas (stroke: 4.5% vs 3.3%, IHD: 8.4% vs 3.6%), those with lower than higher levels of education (bottom: 7.1-8.2% vs top: 2.9-3.3%) or income (bottom: 7.0-9.8% vs top: 2.0-3.2%), and those enrolled in Urban Resident Basic Medical Insurance (URBMI) or New Rural Cooperative Medical Scheme (NRCMS) compared to the UEBMI (stroke: 4.2% vs 2.5%, IHD: 7.4% vs 3.6%). Case fatality rates for stroke and IHD decreased by 12.0-14.5% per year in 2009-2016. While case fatality rates were higher in lower than higher socioeconomic groups, annual reductions in case fatality rates were greater in the lower socioeconomic groups (rural vs urban: 11.9% vs 6.4% for stroke, 16.7% vs 8.3% for IHD). In 2009-2016, the average length of stay (ALOS) decreased by around 2% per year for stroke, IHD, and any cause. ALOS were longer in higher socioeconomic groups, but also decreased to a greater extent in these populations (rural vs urban: ≤1% vs 2.5% for stroke and IHD). For rates of hospitalisation for stroke and IHD, only absolute differences between HI types decreased, while for case fatality and ALOS differences between urban and rural areas, and HI types

decreased over time. Overall, these trends indicated modest improvements in utilisation, quality and efficiency of hospital care use for stroke and IHD, and some attenuations in differences across socioeconomic groups in China.

Chapter 6 examined gender differences in the management of acute IHD for Chinese adults admitted into hospital in 2004-2016. The results demonstrated that compared to men, women with AMI, angina or other IHD had 20%, 34% and 13% lower rates of having coronary angiography and 15%, 46% and 39% lower odds of having revascularisation, respectively. While women had lower socioeconomic status than men and were more likely to be admitted to lower tier hospitals, differences in socioeconomic and health system factors did not contribute to the gender differences in the use of invasive diagnostic or therapeutic procedures. Women-to-men rate ratios of having these procedures were similar across urban and rural areas and most categories of marital status, HI type, education, and income. For both men and women with acute IHD, the rates of having these procedures increased over time, but the women-to-men rate ratios remained similar across calendar periods. It is likely that differences in clinical presentation and pathophysiology or physicians' bias or concerns contributed to differences in the use of IHD tests and procedures between men and women.

Chapter 7 examined differences in choice of hospital tiers for stroke and IHD in urban and rural areas, and the influence of health insurance (HI) and socioeconomic characteristics. The results demonstrated that over 60% of participants with first admissions for stroke and IHD in 2009-2017 chose tier 3 hospitals in urban areas and only around 30% of participants chose tier 3 hospitals in rural areas. Using the wide heterogeneity in the design of HI characteristics, the effects of tiered reimbursement rates and deductibles on choice of hospital tiers

differed between urban and rural areas. In urban areas, a 1% point higher reimbursement rate was associated with 3-5% higher odds of choosing a given hospital tier, and a 100¥ higher deductible in tier 3 was associated with 9-13% lower odds of choosing tier 3 hospitals. In rural areas, a 1% point higher reimbursement rate in tier 3 was associated with a 1-2% higher odds of choosing tier 3 hospitals for stroke and IHD, and a 100¥ higher deductible in tier 1 was associated with a 13% lower odds of choosing tier 1 hospitals for stroke. However, higher deductibles in tier 2 and 3 hospitals were associated with a higher likelihood of choosing these hospitals. The reimbursement ceiling had only a modest effect on choice of hospital tiers. In both urban and rural areas, individuals with higher educational or income level were less likely than those with lower educational or income level to choose tier 1 or 2 hospitals (vs tier 3) for stroke and IHD. Individuals with less severe stroke or IHD types were more likely to choose tier 1 or 2 hospitals (vs tier 3) than those with more severe disease types. The results for first admissions for any cause were broadly similar to those for stroke and IHD.

8.2 Implications of results

8.2.1 Overview

Despite improvements in the coverage and delivery of hospital care in China, especially for lower socioeconomic groups, and favourable trends in the use of higher tier hospitals for rural residents, socioeconomic differences in utilisation of hospital care services, health outcomes, and choice of hospital tiers have persisted. The results of this thesis reinforce the need for further investment in HI schemes to support lower socioeconomic groups and reduce urban-rural differences in healthcare use. The results for trends in rates of hospitalisation, case fatality, LOS, use of tests and procedures, and choice of hospital tiers for stroke and IHD in urban and rural areas could inform the development of health policies by government, HI agencies, or healthcare providers to ameliorate some of the reported differences. Detailed results for stroke and IHD should aid policy-makers to target policies and interventions for the most common causes of mortality and morbidity in China. In addition, as the results for stroke and IHD were typically comparable to those for any cause, results in this thesis may be generalised to other conditions. Evidence on the impact of near universal HI insurance from China could also inform countries implementing universal health coverage and reinforce the need for a strong gate-keeping and primary care system.

8.2.2 Health insurance reforms

The thesis demonstrated that the expansion of HI coverage in China was followed by increasing use of hospital care services for individuals with stroke and IHD and

to a greater extent in those from lower socioeconomic groups. It is likely that these groups are catching up on previously unmet hospitalisation needs due to a lack of HI coverage in the early 2000s and high healthcare costs. However, socioeconomic or gender-related differences in hospital care utilisation, outcomes, use of diagnostic tests and procedures and the choice of hospital tiers have persisted among Chinese adults in 2009-2017. The HI system which provides more generous coverage for individuals enrolled in UEBMI than for those enrolled in URBMI or NRCMS contributes to these healthcare disparities. The results in Chapters 5, 6 and 7 demonstrated that individuals enrolled in URBMI or NRCMS had lower rates of hospitalisations, higher case fatality rates, lower ALOS, lower rates of having cardiac enzyme test and coronary angiography, and lower probabilities of choosing tier 3 hospitals than individuals enrolled in UEBMI. Hospital care disparities between HI types partly reflected disparities between urban and rural areas, as enrolment in a social HI scheme depends on an individual's employment status, household registration status (hukou) and place of residence. Although China has achieved near universal HI coverage since 2011,[1] the depth of HI coverage (i.e. percentage of health costs covered) still requires further improvements, especially for URBMI and NRCMS enrollees who may experience substantial out-of-pocket payments for severe diseases like stroke and IHD.[2,3] Based on official HI characteristics data collected in CKB centres, reimbursement rates and ceilings in URBMI and NRCMS could still be increased, and deductibles in tier 3 hospitals reduced in order to minimise the gap in benefits with UEBMI. In recent years, the government has started to merge the URBMI and NRCMS, as was observed in four CKB centres, to establish a unified system of HI (e.g. coverage, financing policy) for urban and rural residents.[4] Recent studies

have reported that integration of the two HI schemes has improved healthcare utilisation and financial risk protection of rural residents, albeit the effects on health outcomes and for urban residents have not been consistent.[5-8] In 2018, China also established the National Healthcare Security Administration to unify the management of all social HI schemes. In the future, the three social HI schemes should merge their pooling funds at the provincial or country level, to improve equity in access to and utilisation of hospital care services, and in the choice of hospital tiers between HI types and urban and rural areas.

The estimated effects of reimbursement rates and deductibles on choice of hospital tiers in urban and rural areas in **Chapter 7**, can help HI agencies to modify and adapt HI schemes to promote greater use of lower tier hospitals where appropriate. Greater differences in reimbursement rates and deductibles between hospital tiers, especially in urban areas, could enhance the use of lower tier hospitals for stroke and IHD patients. Increasing the deductibles in tier 3 hospitals in urban areas, might also foster greater use of lower tier hospitals, particularly for those with less severe diseases. A recent study reported that increasing deductibles moderately for all hospital tiers together with a modest increase in the reimbursement ceiling could lead to improvement in social welfare.[9] Furthermore, China could implement differentiated reimbursement rates by disease type, with higher reimbursement rates for minor diseases in lower tier hospitals and lower reimbursement rates for minor diseases in higher tier hospitals. Increasing HI coverage for outpatient care, which remains lower than for inpatient care,[10] could limit the use of expensive inpatient care and reduce healthcare costs, by redirecting patients with less severe diseases to outpatient care.

More generous HI coverage should be provided to lower socioeconomic groups, by linking HI cost sharing to household income, and expanding the breadth and depth of coverage of the critical illness insurance and the medical financial assistance programme.[11] Indeed, previous studies have suggested that these two supplementary schemes have a limited effect on reducing the incidence of catastrophic health expenditure.[12,13] Currently, China's social HI does not cover rehabilitation services or nursing care, which could lead to further socioeconomic differences in healthcare use and outcomes, as higher socioeconomic groups will have a higher ability to pay for these services.[14] Moreover, local governments need to educate individuals about their HI benefits, especially in rural areas and among lower socioeconomic groups who have limited access to this information or have higher levels of mistrust of the HI schemes.[15]

8.2.3 Healthcare delivery

The analyses of choice of hospital tiers in urban and rural areas highlighted the imbalance in medical resources in China, with a concentration of tier 3 hospitals in urban areas. To reduce differences in choice of hospital tiers, access to more specialised care in rural areas needs to be improved, and skilled human and technological resources need to be more equitably allocated between urban and rural areas.[16] Since 2011, the Chinese government initiated a special education program which financially supports the studies of medical students if they work in primary care facilities and remote rural areas for a time period to address the shortage of health workforce in these areas.[17]

To encourage patients with less severe cardiovascular disease types to use lower tier hospitals and contain hospital care costs, the quality of services provided in these hospitals needs to be improved. This implies recruiting more skilled physicians and nurses and implementing more efficient transfers or referrals to tier 3 hospitals when highly specialised services are required.[18] Lower socioeconomic groups would benefit to a greater extent from higher quality of care in lower tier hospitals and have better health outcomes. Improved quality of care in lower tier facilities will also help build the Chinese population's trust in primary healthcare.[19] Strengthening lower tier hospitals and referral systems will simultaneously enhance the primary and secondary prevention of CVD and both of these should occur in primary care settings.

While substantial improvements in the quality of medical care for stroke and acute IHD have occurred in recent decades, China still lacks optimal rehabilitation care.[20] One study reported that only 59% of patients with stroke received rehabilitation assessment during hospital admission and only half of these were assessed by a rehabilitation therapist.[14] This might reflect the greater LOS in China than in member countries of the Organisation for Economic Co-operation and Development observed in **Chapter 5**,[21] and among higher socioeconomic groups who can afford to stay longer in hospital. Hence, there is a pressing need to improve rehabilitation services and technology to enhance recovery of functional status after acute stroke or IHD, and reduce hospitalisations and costs.[22] Moreover, effective coordination between primary care, hospital care, and rehabilitation care is needed to ensure the continuity of care for patients with CVD at different levels of the health system.

8.2.4 Health promotion

The finding that socioeconomic differences between men and women in China did not explain the gender differences in the use of diagnostic tests and procedures for acute IHD highlights the fact that inequalities in use of hospital care services are not exclusively related to ability to pay. Consequently, greater efforts are required to promote cardiovascular health among Chinese adults and healthcare professionals. Consistent with China's medium-to long-term plan for the prevention and treatment of chronic diseases (2017-2025),[23] China should invest in promoting greater awareness of cardiovascular risk and risk factors, and emphasise that CVD is not restricted to men but also occurs in women. Likewise, it is important to educate physicians about the differences in the use of diagnostic tests and procedures between men and women, and the guideline-recommended treatments for acute IHD. Implementing cost-effective interventions and population-level strategies for CVD prevention and control of CVD risk factors is crucial to reduce the incidence of stroke and IHD and minimise hospital care use. As China represent one-fifth of the world total population, reducing the incidence of CVD in this country could have a major impact on global health and in achieving the Sustainable Development Goal of a one-third reduction in premature deaths from non-communicable diseases worldwide by 2030.[24]

8.3 Strengths and limitations

8.3.1 Strengths

Health services research in the CKB

This was the first study on the use of healthcare services in the CKB. The thesis contributed to an expansion of the CKB data, including the use of novel data on HI types, diagnostic tests and procedures for IHD and hospital tiers. Additional data on HI characteristics in each CKB centre were collected and could inform further health policy questions in this population.

Long follow-up period and large sample size

This was the first study to use data from a prospective cohort with linked data to HI records, disease and death registries in Chinese adults to examine trends in healthcare use and health seeking behaviours. Compared to previous studies, this thesis included a longer duration of follow-up for the same population since the launch of the healthcare reforms in 2009. Data on hospital care use were largely complete, and the accuracy of overall stroke and IHD and their relevant subtypes was high. With participants recruited from 10 diverse areas in China, including five urban and five rural areas, differences across socioeconomic groups could be reliably investigated. As the CKB study recruited more than 0.5 million participants, of which several thousand had stroke or IHD admissions during follow-up, it had good statistical power overall and in population subgroups.

Data on HI characteristics

This thesis had updated data on participants' HI scheme since 2012, including all three social HI schemes in China. Previous studies typically focused on a single HI type or compared healthcare utilisation between the two urban HI scheme (i.e. UEBMI and URBMI), because HI claims for these schemes are managed by the same government agency and are more readily accessible. In each chapter, the study outcomes were compared between HI types. In addition, the effect of HI characteristics on the choice of hospital tiers was evaluated by collecting detailed data on official reimbursement rates, deductibles and ceilings, which are difficult to obtain and have not routinely been examined in previous studies.

Patient characteristics

Compared to previous studies relying on data from routine medical records or HI claims, the present thesis was able to control for a wide range of patient characteristics recorded as part of the CKB study. Although most patient characteristics were collected at baseline only, these included socioeconomic, lifestyle and morbidity factors.

Focus on specific diseases

Most studies on healthcare utilisation and health seeking behaviour in China focused on healthcare overall, and did not distinguish between different diseases or between inpatient and outpatient care. In contrast, the present thesis focused on inpatient hospital care for specific diseases, namely stroke and IHD which account for the most causes of death in China. This allowed more in depth

controlling for and investigation of role of disease characteristics, including disease severity, while also generating broadly generalisable results for these conditions.

8.3.2 Limitations

Partial healthcare services use data

The CKB data only captured participants with stroke and IHD that sought inpatient hospital care services or died, and could not measure unmet hospitalisation need. While outpatient or rehabilitation care for such diseases can be used to supplement inpatient care, analyses in this thesis were restricted to inpatient care data. Data on the use of other types of healthcare services by CKB participants with stroke and IHD would have enabled a more detailed understanding of differences in inpatient care use and choice of hospital tiers across socioeconomic groups. For instance, the increasing use of tier 1 hospitals in recent years in urban areas might be related to the greater provision of rehabilitation services in these hospitals. Distinguishing emergency from non-emergency admissions could have provided useful information on the severity and appropriateness of hospital use, especially in higher tier hospitals. However, data on outpatient care were only available in some CKB centres and years, and rehabilitation and emergency care data were not provided in HI claims. Medical records for outpatient attendances are still typically managed by patients themselves, and reimbursement rates and ceilings for outpatient care remain low, especially for URBMI and NRCMS.[25,26]

Lack of healthcare quality measures

Although the estimated case fatality rates in **Chapter 5** and use of coronary angiography and revascularisation in **Chapter 6** could be considered as proxy measures for quality of hospital care, the CKB study did not include more detailed measures of quality of hospital care. In previous studies in China, quality of care measures included use of in-hospital treatments, such as aspirin, clopidogrel, beta blocker, angiotensin-converting enzyme inhibitor/angiotensin II receptor blocker, statin, reperfusion therapies and procedures.[27,28] While higher hospital tier generally reflects higher quality of care, the lack of adjustment for indicators of objective or subjective quality of care in different hospital tiers might have affected results in **Chapter 7**.

Lack of healthcare payments

Healthcare costs are typically considered an aggregate measure of individual financial burden. One of the key limitations of this thesis is the lack of linked data on actual inpatient hospitalisation payments. Since this data was not collected as part of the CKB study, data on HI characteristics were collected as a proxy for healthcare payments in **Chapter 7**. Thus, trends and differences in financial protection and catastrophic health expenditure for stroke and IHD over time and across demographic and socioeconomic groups, and hospital tiers could not be reliably estimated. Studies included in the literature review estimated hospitalisation costs using data from HI claims (discharge records) or more rarely through telephone interviews.[2,3,29-31]

Limitations of observational data

The observational analyses included in this thesis were constrained by potential bias and residual confounding, including age, pre-existing disease, comorbidities, and improved living conditions. Although the socioeconomic status (i.e. education and income level) of CKB participants was unlikely to change over time, information on lifestyle factors were only collected at baseline and could have changed during follow-up. Unknown or unmeasured variables could also account for confounding of some of the associations. Nevertheless, detailed adjustments for confounders (e.g. flexible age adjustments) and data exclusions were implemented in both the main and sensitivity analyses to minimise the impact of these potential sources of bias.

The causal relevance of the healthcare reforms cannot be reliably estimated using observational data. Although the study period used in the thesis covered major healthcare reforms, trends and differences in hospital care use and choice of hospital tiers could not be causally attributed to specific changes in health policy. This study lacked reliable data prior to 2009, as the recruitment period ended and linkage to HI claims was fully established in 2008.

8.4 Future research

While the work presented in this thesis has addressed some important knowledge gaps, it also prompted additional questions to be answered in future studies, including appropriateness of hospital care use, other measures of inequalities, causes of trends in healthcare utilisation and health seeking behaviour, and the role of supply-side factors.

8.4.1 Appropriateness of hospital care use

This thesis has demonstrated increased rates of hospitalisation for stroke and IHD over time, with high probabilities of choosing tier 3 hospitals in urban areas. However, based on the data available, it was not possible to identify whether all admissions were necessary and if hospital admissions in a given tier were adequate given the severity of the stroke or IHD type. A few studies in China have previously examined avoidable or inappropriate hospital admissions and their determinants,[32-35] including one study reporting inappropriate admission rates of 35% in a cardiology department of a tier 3 hospital in Shanghai in 2013-2014.[36] Similarly, some of the use of coronary angiography and revascularisation for patients with angina or other IHD in **Chapter 6** might have been unnecessary. Indeed, as a result of the increasing incidence of AMI, fee-for-service payment method, higher profit margins for advanced technologies (e.g. stents), and marketing from stent companies, the number of percutaneous coronary intervention (PCI) has rapidly increased in China.[37] A previous study also showed that acute coronary syndrome patients at low risk had a higher likelihood of having

PCI that those at high risk.[38] This finding is consistent with the inverse care law proposed by Julian Tudor Hart which suggested that the accessibility of good medical care tends to vary inversely with the needs for the population served and that those with least need of healthcare tend to use health services more (and more effectively).[39] Future research should explore the proportion of potentially avoidable hospital admissions and use of diagnostic tests and procedures to measure inefficiencies in the hospital care system.

8.4.2 Other measures of inequalities

Descriptive methods were used in this thesis to measure socioeconomic differences in hospital care utilisation and health outcomes. Future work could investigate further measures for socioeconomic-related healthcare inequalities, including standard (relative inequality) and generalised (absolute inequality) concentration indices and curves.[40] Future research could also examine in more detail socioeconomic inequalities in hospital care use within urban and rural areas, regional inequalities between individuals enrolled in the same HI scheme, and socioeconomic differences in the use of public versus private hospitals.

8.4.3 Causes of trends in healthcare utilisation and health seeking behaviour

In this thesis, trends and differences in hospital care use and choice of hospital tiers were described, and some of the potential contributing factors were investigated. However, there is a good scope for further studies of the reasons for such differences. Future research could investigate the contribution of

epidemiologic transition, improvements in income and greater HI coverage to the observed increasing trends in hospital care utilisation. For example, higher HI coverage might have reduced incentives for individuals to invest in preventive behaviours, leading to moral hazard.[41]

Collection of additional data on the content and timing of specific health policy changes that occurred in CKB areas in 2009-2017 could enable a better understanding of their contribution to changes in hospital care utilisation, health outcomes and hospital choice. Qualitative methods such as interviews and focus group methods with HI agencies, healthcare providers or local health-policy makers could be used to collect these data. The long-term effects of the Chinese healthcare reforms as well as the effects of the third phase (2016-2020) of the reforms could be evaluated using future follow-up data from the CKB.

8.4.4 The role of supply-side factors

While this thesis mostly focused on the effect of demand-side factors on hospital care utilisation and health seeking behaviour, supply-side factors should be investigated in greater detail in future research. It is possible that these may have a greater impact than demand-side factors and HI characteristics. Data on quality indicators of hospital care, distance between patient's home and healthcare facility, as well as the number of hospitals of each tier in CKB centres could be collected during future resurveys and controlled for in future analyses to reduce potential bias.

The contribution of supply induced demand to the increasing trends in hospital care utilisation for stroke and IHD should also be investigated, especially when the

number of inpatients is one of the key performance indicators for hospitals in China.[9] China's dominant fee-for-service hospital payment method, as well as increased HI coverage might incentivise healthcare providers to prescribe more hospital services than required, including diagnostic tests and procedures.

As part of the healthcare reforms, the fee-for-service method was gradually replaced by new prospective payment methods (e.g. diagnostic related groups, global budget, capitation).[42] A few studies have reported that these payment reforms were associated with decreased total medical expenditure, out-of-pocket payments and LOS, but evidence on the effects on quality of care was insufficient and inconsistent.[43,44] Additional research is needed to evaluate the effect of changes in provider payment methods on hospital care use and health outcomes for CVD.

8.5 Conclusions

Using data from the CKB, a prospective cohort study of 0.5 million Chinese adults, this thesis demonstrated that hospital care utilisation, health outcomes and the distribution of admissions across tiers for stroke and IHD improved over time and to a greater extent in rural than in urban areas and for lower than higher socioeconomic groups. In addition to socioeconomic and need factors, HI reimbursement rates and deductibles were important factors influencing the choice of hospital tiers in urban and rural areas. However, even after the expansion of HI coverage, socioeconomic and/or gender differences in the utilisation of hospital care, health outcomes, the use of diagnostic tests and procedures and the choice of hospital tiers for stroke and IHD have persisted in 2004-2017. The HI system, which provides more generous coverage for individuals enrolled in UEBMI than those enrolled in URBMI or NRCMS, and the concentration of higher tier hospitals in urban areas contribute to some of these healthcare disparities.

The results of this thesis provide novel evidence on differences in hospital care utilisation and choice of hospital tiers for stroke and IHD across socioeconomic groups. Although the generalisability of results to the Chinese population is limited, the findings can still inform national and local governments, HI agencies, and healthcare providers in their investment and prioritisation decisions, and guide the design of ongoing and future healthcare reforms.

In addition, the results reinforce the need to consolidate the different social HI schemes, enhance investments in healthcare resources in rural areas, improve quality of care in lower tier hospitals and prioritise prevention, in order to reduce

socioeconomic disparities in healthcare use and curtail excessive demand for healthcare in higher tier hospitals.

References

1. Yu H. Universal health insurance coverage for 1.3 billion people: What accounts for China's success? *Health Policy*. 2015; **119**(9): 1145-52.

2. Ding JM, Zhang XZ, Hu XJ, Chen HL, Yu M. Analysis of hospitalization expenditures and influencing factors for inpatients with coronary heart disease in a tier-3 hospital in Xi'an, China A retrospective study. *Medicine*. 2017; **96**(51): e9341.

3. Zhang H, Yin Y, Zhang C, Zhang D. Costs of hospitalization for stroke from two urban health insurance claims data in Guangzhou City, southern China. *BMC Health Services Research*. 2019; **19**(1): 671.

4. Sun J, Lyu S. The effect of medical insurance on catastrophic health expenditure: evidence from China. *Cost Effectiveness and Resource Allocation*. 2020; **18**(1): 10.

5. Zhou Q, He Q, Eggleston K, Liu GG. Urban-rural health insurance integration in china: impact on health care utilization, financial risk protection, and health status. *Applied Economics*. 2021: 1-19.

6. Huang X, Wu B. Impact of urban-rural health insurance integration on health care: Evidence from rural China. *China Economic Review*. 2020; **64**: 101543.

7. Li C, Tang C, Wang H. Effects of health insurance integration on health care utilization and its equity among the mid-aged and elderly: evidence from China. *International Journal for Equity in Health*. 2019; **18**(1): 166.

8. Liu P, Guo W, Liu H, Hua W, Xiong L. The integration of urban and rural medical insurance to reduce the rural medical burden in China: a case study of a county in Baoji City. *BMC Health Services Research*. 2018; **18**(1): 796.

9. Julie Shi XW, and Castiel Chen Zhuang. Understanding Deductible and Reimbursement Maximum: A Study of Rural China’s Tiered Medical System. 2021.

10. Meng Q, Xu L, Zhang Y, et al. Trends in access to health services and financial protection in China between 2003 and 2011: a cross-sectional study. *The Lancet*. 2012; **379**(9818): 805-14.

11. Li A, Shi Y, Yang X, Wang Z. Effect of Critical Illness Insurance on Household Catastrophic Health Expenditure: The Latest Evidence from the National Health Service Survey in China. *International Journal of Environmental Research and Public Health*. 2019; **16**(24): 5086.

12. Fang P, Pan Z, Zhang X, Bai X, Gong Y, Yin X. The effect of critical illness insurance in China. *Medicine*. 2018; **97**(27): e11362-e.

13. Liu K, Yang J, Lu C. Is the medical financial assistance program an effective supplement to social health insurance for low-income households in China? A cross-sectional study. *International Journal for Equity in Health*. 2017; **16**(1): 138.

14. Bettger JP, Li Z, Xian Y, et al. Assessment and provision of rehabilitation among patients hospitalized with acute ischemic stroke in China: Findings from the China National Stroke Registry II. *International Journal of Stroke*. 2017; **12**(3): 254-63.

15. Lei X, Lin W. The New Cooperative Medical Scheme in rural China: does more coverage mean more service and better health? *Health Economics*. 2009; **18 Suppl 2**: S25-46.

16. Chen Y, Yin Z, Xie Q. Suggestions to ameliorate the inequity in urban/rural allocation of healthcare resources in China. *International Journal for Equity in Health*. 2014; **13**(1): 34.

17. Jin Y, Zhu W, Yuan B, Meng Q. Impact of health workforce availability on health care seeking behavior of patients with diabetes mellitus in China. *International Journal for Equity in Health*. 2017; **16**(1): 80.

18. Qian D, Lucas H, Chen J, Xu L, Zhang Y. Determinants of the use of different types of health care provider in urban China: A tracer illness study of URTI. *Health Policy*. 2010; **98**(2): 227-35.

19. Li X, Krumholz HM, Yip W, et al. Quality of primary health care in China: challenges and recommendations. *The Lancet*. 2020; **395**(10239): 1802-12.

20. Wang Y, Li Z, Zhao X, et al. Stroke care quality in China: Substantial improvement, and a huge challenge and opportunity. *International Journal of Stroke*. 2017; **12**(3): 229-35.

21. OECD. Health at a Glance 2017: OECD Indicators. Paris; 2017.

22. Asakawa T, Zong L, Wang L, Xia Y, Namba H. Unmet challenges for rehabilitation after stroke in China. *The Lancet*. 2017; **390**(10090): 121-2.

23. Kong L-Z. China's Medium-to-Long Term Plan for the Prevention and Treatment of Chronic Diseases (2017-2025) under the Healthy China Initiative. *Chronic Diseases and Translational Medicine*. 2017; **3**(3): 135-7.

24. United Nations. Goal 3: Ensure healthy lives and promote well-being for all at all ages. Available from: https://sdgs.un.org/goals/goal3 (Accessed: 13 December 2021).

25. Chen Y, Pine K. When Medical Expertise Meets Record Expertise: The Practices of Patient Accessible Medical Records in China. In: Rossitto C, Ciolfi L, Martin D, Conein B, editors. COOP 2014 - Proceedings of the 11th

International Conference on the Design of Cooperative Systems: Springer; 2014. p. 409-26.

26. Milcent C. Healthcare reform in China: From violence to digital healthcare: Palgrave Pivot, Cham; 2018.

27. Du X, Spatz ES, Dreyer RP, et al. Sex Differences in Clinical Profiles and Quality of Care Among Patients With ST-Segment Elevation Myocardial Infarction From 2001 to 2011: Insights From the China Patient-Centered Evaluative Assessment of Cardiac Events (PEACE)-Retrospective Study. *Journal of the American Heart Association*. 2016; **5**(2).

28. Jian W, Figueroa J, Woskie L, et al. Quality of care in large Chinese hospitals: an observational study. *BMJ Quality & Safety*. 2019; **28**(12): 963-70.

29. Wang Q, Zhang S, Wang Y, Zhang X, Zhang Y. Factors Associated With Hospitalization Costs of Coronary Heart Disease in Township Hospitals in Rural China. *Inquiry*. 2019; **56**: 46958019886958.

30. Wei JW, Heeley EL, Jan S, et al. Variations and determinants of hospital costs for acute stroke in China. *PLOS One*. 2010; **5**(9): e13041.

31. Huo X, Jiang B, Chen Z, et al. Difference of hospital charges for stroke inpatients between hospitals with different levels and therapeutic modes in Beijing, China. *The International Journal of Neuroscience*. 2017; **127**(9): 752-61.

32. Quan J, Zhang H, Pang D, et al. Avoidable Hospital Admissions From Diabetes Complications In Japan, Singapore, Hong Kong, And Communities Outside Beijing. *Health Affairs*. 2017; **36**(11): 1896-903.

33. Chang J-j, Chen Y-c, Gao H-x, et al. Effect of inappropriate admissions on hospitalization performance in county hospitals: a cross-sectional study in rural China. *Cost Effectiveness and Resource Allocation*. 2019; **17**(1): 8.

34. Hu X, Gao H, Zhang Y, et al. Determinants of inappropriate admission of elderly people in county-level hospitals: a cross-sectional study in rural China. *BMJ Open*. 2019; **9**(4): e026443.

35. Zhang Y, Zhang L, Li H, Chen Y. Determinants of Inappropriate Admissions in County Hospitals in Rural China: A Cross-Sectional Study. *International Journal of Environmental Research and Public Health*. 2018; **15**(6): 1050.

36. Liu W, Yuan S, Wei F, Yang J, Ma J. Inappropriate admissions of the cardiology and orthopedics departments of a tertiary hospital in Shanghai, China. *PLOS One*. 2018; **13**(12): e0208146.

37. Wu Y, Benjamin EJ, MacMahon S. Prevention and Control of Cardiovascular Disease in the Rapidly Changing Economy of China. *Circulation*. 2016; **133**(24): 2545-60.

38. Gao R, Patel A, Gao W, et al. Prospective observational study of acute coronary syndromes in China: practice patterns and outcomes. *Heart*. 2008; **94**(5): 554-60.

39. Hart JT. The inverse care law. *The Lancet*. 1971; **297**(7696): 405-12.

40. O'Donnell O, Van Doorslaer E, Wagstaff A, Lindelow M. Analyzing Health Equity Using Household Survey Data: : A Guide to Techniques and Their Implementation. Washington DC: The World Bank; 2008.

41. Arrow KJ. Uncertainty and the Welfare Economics of Medical Care. *The American Economic Review*. 1963; **53**(5): 941-73.

42. General Office of the State Council. Guidance of the General Office of the State Council on further deepening the basic medical insurance payment reform 2017. Available from: http://www.gov.cn/zhengce/content/2017-06/28/content_5206315.htm (Accessed: 15 December 2021).

43. Jian W, Lu M, Liu G, Chan KY, Poon AN. Beijing's diagnosis-related group payment reform pilot: Impact on quality of acute myocardial infarction care. *Social Science & Medicine*. 2019; **243**: 112590.

44. Yip W, Fu H, Chen AT, et al. 10 years of health-care reform in China: progress and gaps in Universal Health Coverage. *The Lancet*. 2019; **394**(10204): 1192-204.

Appendices

A. List of presentations related to this thesis

Oral presentations

Levy M et al. Impact of health insurance coverage on choice of hospital tier for stroke and ischaemic heart disease in Chinese adults. *Health Economics Seminar, University of Oxford, Online, June 2021.*

Levy M et al. Gender differences in the use of diagnostic tests and procedures for ischaemic heart disease in Chinese adults. *China Kadoorie Biobank Seminar, University of Oxford, Online, May 2020.*

Levy M et al. Declining socioeconomic inequalities in hospital utilisation for stroke and ischaemic heart disease in China during the implementation of healthcare reforms. *China Kadoorie Biobank Seminar, University of Oxford, Oxford, July 2019.*

Levy M et al. Trends in hospital utilisation for cardiovascular diseases during healthcare reforms in China: an 8-year follow-up of 0.5 million adults in the China Kadoorie Biobank. *International Health Economics Association, University of Basel, Basel, July 2019.*

Levy M et al. Trends in hospital care use for cardiovascular diseases following the implementation of major healthcare reforms in China. *Oxford Health Economics Workshop, University of Oxford, Oxford, May 2019.*

Levy M et al. Trends in hospital admissions for stroke and any cause following the implementation of major healthcare reforms in China. *China Kadoorie Biobank Symposium, University of Oxford, Oxford, November 2018.*

Levy M et al. Trends in hospital admissions for stroke and all causes following the introduction of universal health insurance in China. *China Kadoorie Biobank Seminar, University of Oxford, Oxford, July 2018.*

Levy M et al. Trends in hospital admissions for stroke and any cause following the introduction of universal health insurance in China. *UK-China workshop on health economics analyses in large medical databases, Peking University, Beijing, August 2018.*

Levy M et al. Trends in hospital care use in Harbin (2008-2016), using data from the China Kadoorie Biobank. *Nuffield Department of Population Health Symposium, University of Oxford, Oxford, January 2018.*

Poster presentations

Levy M et al. Impact of health insurance coverage on choice of hospital tier for stroke and ischaemic heart disease in China. *Health Economics Study Group, University of Cambridge, Online, July 2021.*

Levy M et al. Impact of health insurance coverage on choice of hospital tier for stroke and ischaemic heart disease in China. *International Health Economics Association, Online, July 2021.*

Levy M et al. Trends in hospital admissions for stroke and any cause following the introduction of universal health insurance. *Crossing Boundaries - A Conference on Global Health Systems Research, University of Oxford, Oxford, December 2018.*

Levy M et al. Trends in hospital admissions for stroke and any cause following the introduction of universal health insurance in China. *British Heart Foundation CRE Annual Symposium, University of Oxford, Oxford, November 2018.*

B. Literature review

Table B.1 MEDLINE key words and MeSH terms

1	exp Hospitalization/
2	exp Hospitals/
3	hospitali?ation.ti,ab.
4	admission*.ti,ab.
5	hospital*.ti,ab.
6	*Inpatients/
7	*Outpatients/
8	hospital system.ti,ab.
9	*Health Services/
10	*"Delivery of Health Care"/
11	*Health Services Research/
12	*Primary Health Care/
13	Community Health Centers/
14	"Referral and Consultation"/
15	Health Care Surveys/
16	*Ambulatory Care/
17	*Hospital Administration/
18	*Health Facility Administration/
19	*Diagnostic Imaging/
20	*Technology, High-Cost/
21	*Public Health Administration/
22	exp Health Surveys/
23	exp epidemiologic studies/
24	exp meta-analysis/
25	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or19 or 20 or 21 or 22 or 23 or 24
26	utili?ation.ti,ab.
27	"use".ti,ab.
28	usage.ti,ab.
29	Health Services Misuse/
30	*Utilization Review/
31	exp Probability/
32	trend.ti,ab.
33	"Length of Stay"/ or Length Of Stay/
34	exp Health Care Costs/
35	*Fees, Medical/
36	exp *"Costs and Cost Analysis"/
37	exp health services accessibility/ or exp healthcare disparities/
38	exp "Quality of Health Care"/
39	exp Economics, Hospital/

40 inequalit*.ti,ab.
41 inequit*.ti,ab.
42 Mortality/ or case fatality.mp.
43 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42
44 *Health Care Reform/
45 healthcare reform.ti,ab.
46 health care reform.ti,ab.
47 medical scheme.ti,ab.
48 exp insurance/ or exp insurance, health, reimbursement/
49 health insurance.ti,ab.
50 *Medical Assistance/
51 socioeconomic.ti,ab.
52 socio-economic.ti,ab.
53 exp socioeconomic factors/
54 "hospital type".mp.
55 *Bed Occupancy/
56 *health status disparities/
57 health system reform.ti,ab.
58 *National Health Programs/
59 *Fee-for-Service Plans/
60 provider payment.mp.
61 *Financial Management, Hospital/
62 *Physician Incentive Plans/
63 *Financing, Government/
64 *Personnel Administration, Hospital/
65 *Practice Guidelines/
66 *Ownership/
67 Middle Aged.mp.
68 *Adult/
69 *Urban Population/
70 Rural Population/
71 *Demography/
72 *Chronic Disease/
73 epidemiologic factors/ or exp age factors/
74 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 63 or 64 or 65 or 66 or 67 or 68 or 69 or 70 or 71 or 72 or 73
75 exp STROKE/
76 exp Heart Diseases/ or Myocardial Infarction/
77 75 or 76
78 exp CHINA/
79 (china or chinese).ti,ab.
80 exp TAIWAN/
81 exp Hong Kong/
82 (78 or 79) not (80 or 81)

83	25 and 43 and 74 and 77 and 82
84	limit 87 to english language
85	limit 88 to (clinical study or government publications or journal article or meta-analysis or multicenter study or observational study or systematic reviews)

Colour code: Outcome, outcome measure, exposures, medical conditions of interest, location

Table B.2 EMBASE key words and MeSH terms

1	exp hospitalization/
2	exp *hospital/
3	hospitali?ation.ti,ab.
4	exp hospital admission/
5	admission*.ti,ab.
6	hospital*.ti,ab.
7	exp *hospital patient/
8	hospital system.ti,ab.
9	*health service/
10	exp *health care delivery/
11	*Health Services Research/
12	*Primary Health Care/
13	Outpatient care/
14	*Health Centre/
15	Patient referral/
16	*Health Care Survey/
17	*Ambulatory Care/
18	*Diagnostic Imaging/
19	*medical technology/
20	*Public Health Service/
21	primary medical care/
22	*Hospital Management/
23	exp health survey/
24	exp cross-sectional study/
25	exp prospective study/
26	exp longitudinal study/
27	exp retrospective study/
28	exp cohort analysis/
29	meta-analysis/
30	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29
31	exp health care utilization/
32	utili?ation.ti,ab.
33	"use".ti,ab.
34	usage.ti,ab.
35	*"Utilization Review"/
36	health care need/
37	exp probability/
38	exp trend study/
39	trend.ti,ab.
40	"length of stay"/
41	*"Health Care Cost"/
42	*Medical fee/
43	"cost control"/

44 exp "hospital cost"/ or exp "hospitalization cost"/
45 *cost benefit analysis/
46 *productivity/
47 *Health care availability/
48 exp health care disparity/
49 exp health care access/
50 exp *health care quality/
51 *health care distribution/
52 inequalit*.ti,ab.
53 inequit*.ti,ab.
54 *health economics/
55 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54
56 exp health care policy/
57 *health care system/
58 health care reform.ti,ab.
59 medical scheme.ti,ab.
60 exp health insurance/
61 health insurance.ti,ab.
62 exp socioeconomics/
63 socioeconomic.ti,ab.
64 socio-economic.ti,ab.
65 *health status/
66 *social status/
67 *sex ratio/
68 "hospital type".mp.
69 exp hospital bed utilization/
70 hospital bed capacity/
71 *health care personnel/
72 *Financial Management/
73 *"Organisation and management"/
74 "provider payment".mp.
75 *Practice Guideline/
76 *Middle Aged/
77 *Adult/
78 *demography/
79 *Urban population/
80 Rural population/
81 Chronic Disease/
82 *non communicable disease/
83 exp sex factor/
84 56 or 57 or 58 or 59 or 60 or 61 or 62 or 63 or 64 or 65 or 66 or 67 or 68 or 69 or 70 or 71 or 72 or 73 or 74 or 75 or 76 or 77 or 78 or 79 or 80 or 81 or 82 or 83
85 exp cerebrovascular accident/
86 exp ischaemic heart disease/ or heart infarction/
87 85 or 86

88	exp China/
89	(china or chinese).ti,ab.
90	exp Taiwan/
91	exp Hong Kong/
92	(88 or 89) not (90 or 91)
93	30 and 55 and 84 and 87 and 92
94	limit 93 to english language
95	limit 94 to (article or article in press)

Colour Code: Outcome, outcome measure, exposures, medical conditions of interest, location

Table B.3 Quality assessment checklist adapted from the National Heart, Lung and Blood Institute's quality assessment tool for cohort and cross-sectional studies and the quality assessment checklist for prevalence studies[†]

Criteria	Yes	No	Other (CD, NA, NR)[*]
1. Was the research question or objective in this paper clearly stated?			
2. Was the study population clearly specified and defined?			
3. Was the participation rate of eligible persons at least 50%?			
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?			
5. Was a sample size justification, power description, or variance and effect estimates provided?			
6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?			
7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?			
8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g. categories of exposure, or exposure measured as continuous variable)?			
9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?			
10. Was the exposure(s) assessed more than once over time?			
11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?			
12. Were the outcome assessors blinded to the exposure status of participants?			
13. Was loss to follow-up after baseline 20% or less?			
14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?			
15. Was the study's target population a close representation of the national population in relation to relevant variables, e.g. age, sex, occupation?			
16. Was the sampling frame a true or close representation of the target population			
17. Was some form of random selection used to select the sample or was a census undertaken			
18. Was the likelihood of nonresponse bias minimal?			
19. Were data collected directly from the subjects (as opposed to a proxy)?			
20. Was an acceptable case definition used in the study?			
21. Was the same mode of data collection used for all subjects?			

*CD: cannot determine; NA: not applicable; NR: not reported. Criteria shaded in blue are from the National Heart, Lung and Blood Institute's quality assessment tool for cohort and cross-sectional studies. Criteria shaded in grey are from the Quality assessment checklist for prevalence studies Overall quality rating of good, fair or poor was given based on the number of negative answers.[†]Adapted from Hoy et al (2012)[1].

Table B.4 Summary of data characteristics for included studies for stroke

Study	Year of data	Location	Data sources	Study design	Population (inclusions and exclusions)	Sample size	Hospital information
Gong et al (2016)[2]	2012	Zhejiang, 30 counties/districts: urban and rural areas	Internet-based Comprehensive Chronic Disease Surveillance System	Cross-sectional	First or recurrent stroke, 74.2% IS	51 413	Hospital and primary care facilities
He et al (2014)[3]	2007-2010	10 northern, 4 eastern, 7 southern, 10 western provinces	Hospital discharge data	Cross-sectional	Stroke patients	2007: 79 894 2010: 85 475	109 tier 3 class A hospitals
Huang et al (2010)[4]	2006	37 cities in 8 major economic/geographic regions	ChinaQuest (prospective)	Cross-sectional	Acute stroke (ICH and IS) patients aged ≥15 years	6354 (ICH: 1572, IS: 4782)	62 hospitals: tier 2 and tier 3
Huo et al (2017)[5]	2012	Beijing	Beijing Public Health Information Centre database	Cross-sectional	Stroke patients	94 906	121 hospitals: 71 tier 2 and 50 tier 3
Ji et al (2013)[6]	2007-2008	27 provinces, 4 municipalities	CNSR (prospective)	Cross-sectional	Stroke patients aged ≥18 years with direct admission to hospital from a physician's clinic or emergency	22 077	132 hospitals: 100 tier 3, 32 tier 2
Li Y et al (2012)[7]	2006-2010	Beijing	Beijing Municipal Health Bureau's hospitalisation summary reports	Retrospective	First-ever in-hospital patients with IS	5559	3 general teaching hospitals affiliated with Peking University

Li Z et al (2016)[8]	2007-2008, 2012-2013	National	CNSR, phase 1 and 2 (prospective)	Cross-sectional	Inpatients aged≥18 years with acute IS as evidenced by CT/MRI	31 777	278 hospitals: tier 2 or 3
Liang et al (2008)[9]	2005-2006	Shunde District, Foshan city, Guangdong	Hospital records	Cross-sectional	All registered residents	1.11 million	N/A
Liu et al (2018)[10]	2012-2015	Beijing	Beijing Public Health Information Centre database	Retrospective	Haemorrhagic stroke patients aged 20-90 years. Incl: LOS: 1-180 days, total hospital charges: 100-300,000¥, Chinese nationality	34 890	75 tier 3 hospitals, 77 tier 2 hospitals, 115 Western medicine hospitals, 37 TCM hospitals
Tian et al (2018)[11]	2006-2015	Beijing	Hospital-based study	Retrospective	Acute IS or HS (defined as ≤14 days), ≥18 years old. Excl: recurrent IS	5521	Peking University Third Hospital
Wang D et al (2017)[12]	2006	Nationwide	Hospital-based registry study (prospective)	Cross-sectional	Acute stroke within 7 days of symptom onset (first-ever or recurrent)	5273	281 hospitals (West: 62, Middle: 85, Eastern: 134; University: 9, Non-University: 118)
Wei et al (2010)[13]	2006-2007	37 cities	ChinaQuest (prospective)	Cross-sectional	Stroke patients aged≥15 years. Excl: registered in HK, no cost or missing data	5255	48 tier 3 hospitals, 14 tier 2 hospitals
Wen et al (2017)[14]	2012. Until: 09/2013 for random	Beijing, urban sites	Urban HI database	Retrospective	Patients with IS	4061 (w/ AF: 992; w/o AF: 3069)	N/A

	10% sample						
Yan et al (2018)[15]	09/2010-12/2016	Tianjin	Hospital discharge data	Prospective	Aged 18-80 years with acute first-ever ICH within 14 days of symptoms onset	1187	Tianjin Huanhu Hospital: tier 3 cerebral specialty
Zhang et al (2019)[16]	2006-2013	Guangzhou City	UEBMI and URBMI claims databases	Cross-sectional	Stroke patients aged ≥18 years	114 872	Tier 1, 2 and 3 hospitals
CNSR: China National Stroke Registry, CT: computed tomography, HI: health insurance, ICH: intracerebral haemorrhage, IS: ischaemic stroke, MRI: magnetic resonance imaging, UEBMI: urban employee basic medical insurance, URBMI: urban resident basic,							

Table B.5 Summary of data characteristics for included studies for IHD

Study	Year of data	Location	Data sources	Study design	Population (inclusions and exclusions)	Sample size	Hospital information
Bueno et al (2018)[17]	2011-2012	China	EPICOR	Prospective	NSTE-ACS patients	4253	Tier 3 hospitals
Cai et al (2018)[18]	2013-2017	Shanxi	EMR database	Cross-sectional	AMI patients aged ⩾18 years	87 219	168 hospitals
Chen et al (2018)[19]	2015	Nationwide	Hospital discharge database	Cross-sectional	AMI patients aged ⩾18 years. Excl: missing sex, LOS 0 day	242 866	1055 tier 3 hospitals
Ding et al (2017)[20]	2015	Xi'an	Hospital discharge records	Retrospective	CHD patients	10 301	Xijing hospital: tier 3, best and largest non-profit hospital in northwest
Dreyer et al (2019)[21]	12/2012-05/2014	10 regions	China PEACE Prospective AMI study	Prospective	AMI patients aged ⩾18 years presenting within 24 hours of symptom onset, Excl: AMI caused by physical trauma or elevated cardiac biomarkers as a complication of elective revascularization, died in-hospital, withdraw treatment, transferred to other facilities	3415	At least one tier 2 and one tier 3 hospital per region
Du X et al (2016)[22]	2001, 2006, 2011	Nationally representative	China PEACE Retrospective AMI Study	Retrospective	STEMI patients (w/ or w/o prior CVD). Excl: STEMI occurred during hospitalisation, transferred in or out, discharged alive in first 24h of admission	11 986	162: 63 urban vs 99 rural

Du X et al (2017)[23]	10/2007-08/2010	Several provinces	CPACS - Phase 2	Cluster randomised trial	ACS patients	15 141	50 tier 3 and 25 tier 2 or 1 hospitals
Gao et al (2008)[24]	09/2004-05/2005	18 provinces, urban areas	CPACS	Prospective	ACS patients	2973	51 large hospitals: 14 in Beijing, 37 in 17 provinces, 3 small township hospitals, 80% tier-3
Gong et al (2016)[2]	2012	Zhejiang, 30 counties/districts: urban and rural areas	Internet-based Comprehensive Chronic Disease Surveillance System	Cross-sectional	First or recurrent IHD, 56.8% AMI	9866	Hospital and primary care facilities
Han et al (2019)[25]	2007-2010	4 eastern, 10 western, 7 southern, 10 northern provinces: urban areas	Hospital discharge data	Cross-sectional	STEMI patients. Excl: transferred from other hospitals, undergoing PCI and CABG concurrently or receiving thrombolysis	32 228	109 tier 3 teaching hospitals
Hao et al (2019)[26]	11/2014-06/2018	Nationwide	CCC-ACS project	Prospective	ACS patients	82 196	192 hospitals: 150 tier 3, 42 tier 2
Jian et al (2019)[27]	2012-2013, 2017-2018	25 provinces	Medical records	Retrospective	Patients with STEMI aged ⩾18 years	7031	33 tier 3 hospitals
Li G-X et al (2017)[28]	2009-2010, 2015	Liaoning province, rural areas	Medical records	Retrospective	STEMI patients Excl: time course from symptom onset to hospital >24h; STEMI resulting from invasive diagnosis and/or treatment that blocked coronary blood flow; patients w/ history of cancers	1244	12 tier 2 hospitals

Li J et al (2015)[29]	2001, 2006, 2011	Nationally representative	China PEACE-Retrospective AMI	Retrospective	STEMI patients. Excl for tests: transferred in, LOS≤24h Excl for in-hospital outcomes: transferred in or out, discharged alive≤24h	12 264 (11 986 for in-hospital outcome)	162 hospitals
Li Q et al (2015)[30]	2001, 2006, 2011	Nationally representative	China PEACE-Retrospective AMI	Retrospective	AMI patients. Excl: died within hospital, withdrew treatment by request of patient/family due to deteriorating clinical condition, transferred in or out, had a CABG during hospitalisation, patients with LOS>42 days	16 100	162 hospitals
Li X et al (2017)[31]	2001, 2006, 2011	Nationally representative	China PEACE-Retrospective AMI	Retrospective	STEMI patients. Excl for tests: discharged or died within 24h after admission, transferred in. Excl for in-hospital outcome: transferred out or in, discharged alive within 24h of admission	13 815	162 hospitals: 63 urban: 58 tier 3, 5 tier 2 or 1 99 rural: 7 tier 3, 92 tier 2 or 1
Lin et al (2017)[32]	2014-2015	Shanxi province	Hospital electronic health records	Cross-sectional	AM patients aged ≥18 and <90 years. Excl: missing HI data and discharge disposition, transferred out, discharged alive within 1 day after admission	22 392	31 tier 3 hospitals (teaching, public)
Murugiah et al (2017)[33]	2001, 2006, 2011	Nationally representative	China PEACE-Retrospective AMI	Retrospective	AMI patients. Excluded: transferred in, unknown type of AMI	15 416	Tier 3 hospitals
Wang Q et al (2019)[34]	2013-2014	Liaoning province, rural areas	Hospital discharge records	Retrospective	IHD patients ≥20 years	4635	10 tier 2 / township hospitals

Zhan et al (2015)[35]	2001, 2006, 2011	Nationally representative	China PEACE-Retrospective AMI study	Retrospective	AMI patients. Excl: transferred in or out within 24h, discharged alive or died within 24h	14 370	162: 99 rural and 63 urban (2011). 93% of rural hospitals = tier 2, 92% of urban hospitals = tier 3
Zhang Q et al (2016)[36]	2007-2012	Beijing	Hospital discharge records	Cross-sectional	AMI patients. Excl: patients with LOS of ≤1 day and discharged alive	77 943	162 tier 3 and 2 public and private hospitals (non-military)
Zhang Y et al (2016)[37]	2011	Henan: rural area	Medical records	Retrospective	STEMI patients	1311	5 tier 2 and 4 tier 3 hospitals
Zheng X et al (2015)[38]	2001, 2006, 2011	Nationally representative	China PEACE-Retrospective AMI Study	Retrospective	STEMI patients. Excl: transferred in or out or discharged within 24h of admission	11 986	162 hospitals
Zheng X et al (2016)[39]	2001, 2006, 2011	Urban regions	China PEACE-Retrospective CathPCI	Retrospective	Patients undergoing coronary angiography and PCI	11 241	55 tier 3 hospitals

AMI: acute myocardial infarction, CABG: Coronary artery bypass grafting, CPACS: Clinical Pathways in Acute Coronary Syndromes, EMR: electronic medical records, Excl: excluded, LOS: length of stay, NSTEMI: non-ST-elevation myocardial infarction, PCI: Percutaneous coronary intervention, STEMI: ST-elevation myocardial infarction

Table B.6 Characteristics of the methods and results of included studies for stroke

Study	Outcomes measured	Factor(s) of interest	Covariates	Methods	Rates of hospital admissions	LOS (days)	Case fatality / In-hospital mortality rate* (%)	Use of tests (%)
Gong et al (2016)[2]	28-day case fatality (1st and recurrent)	Urban/rural residence		Crude and direct age-standardised rates using WHO standard population, by gender and age			All: 27.2 (Age std 13.4). Male: 26.4 (13.4). Female: 28.2 (12.0). Urban: 31.8 (12.0). Rural: 25.1% (13.4%). <35 years: 10.7 35-64 years: 12.2, ≥65 years: 33.0	
He et al (2014)[3]	No. admission LOS In-hospital mortality	Calendar period	Age, gender, primary payer, Charlson comorbidity index, disease severity, hospital region of disease, LOS	Descriptive statistics, by disease type and region	2007: 79 894 vs 2010: 85 475	SAH: 2007: median 12 (IQR 5-20) vs 2010: 12 (5-19) ICH: 2007: 14 (6-23) vs 2010: 15 (7-24) IS: 2007: 13 (9-18) vs 2010: 12 (8-16)	2007: 3.16 vs 2010: 2.30 (p<0.0001)	
Huang et al (2010)[4]	Use of tests LOS	Gender	Age, random effects for clustering at hospital level. Single, living alone, low education,	Crude, age-adjusted, multi-adjusted logistic models.		LOS ≥16 days: multi-adjusted OR: 1.05 (0.89, 1.23)		CT: male: 88 vs female: 91. OR (multi-adj): 1.10 (0.84, 1.44). MRI: 49 vs 43. OR: 1.02

			retired/unemployed, manual worker. Prior history of hypertension, diabetes, hyperlipidaemia, AF; prior stroke, CAD, dependency; current cigarette smoking, regular alcohol	Subgroup by age, stroke type, hospital level, hospital type				(0.85, 1.23). Carotid Doppler: 36 vs 34, OR: 0.97 (0.79, 1.18). Transcranial Doppler: 33 vs 30, OR: 0.96 (0.76, 1.21). Transthoracic echocardiogram: 13 vs 13, OR: 1.07 (0.82, 1.40)
Huo et al (2017)[5]	LOS In-hospital mortality			Descriptive statistics by hospital tier and stroke type		Total: median (IQR): 14 (9-19) IS: 13 (9-18) vs HS: 16 (9-25) - p<0.001 tier 2: 13 (9-18) vs tier 3:14 (10-20) - p<0.001. Western medicine: 13 (9-18) vs TCM: 14 (10-21) -p<0.001	Total: 2.7; tier 2: 2.8 vs tier 3: 2.7 (p<0.001); IS: 1.8 vs HS 9.1 (p<0.001); Western medicine: 3.0 vs TCM: 1.7 (p<0.001)	
Ji et al (2013)[6]	Median LOS In-hospital mortality	Macroeconomic status: developed areas with GRP[1]/capita> average (med: 38,873, IQR:	Age, gender, education level, marital status, HI, stroke risk factors (HTN, DM, dyslipidaemia, AF, CHD, history of stroke/TIA and current smoking),	Multivariate regression analysis using generalised estimation equation.		Any: 15 (IQR: 10-21), AIS/TIA: 14 (IQR: 10-20). SAH/ICH: 18 (IQR: 11-26).	AIS/TIA: total: 3.2, developed areas: 3.5, under-developed areas: 2.7, p=0.004. aOR (ref: underdeveloped	

		31,559-62,803¥) vs. underdeveloped areas with GRP/ capita< average (med: 17116, IQR:14345.6-19530.8 ¥).	stroke subtypes, OCSP classification, admission NIH Stroke Scale score, hospital facilities factors, LOS	Clustering effects within hospitals. Subgroups by stroke type			): 1.07 (0.87-1.31) p=0.53 SAH/ICH: Total: 10.3, developed areas: 11.4, underdeveloped areas: 8.9 p=0.002. aOR: 1.20 (0.98-1.46)	
Li Y et al (2012)[7]	LOS	Ischemic stroke subtypes	Gender, age, payment method, discharge year, subordinate diagnosis, disease status at admission, treatment method, primary outcomes at discharge	Generalised linear model		Unadj: single cerebral infarction: 17.3 (17.0, 17.6), lacunar infarction: 14.3 (13.6, 15.0) Adj: single cerebral infarction: 17.5 (17.3, 17.8), lacunar infarction: 14.4 (13.7, 15.1)		
Li Z et al (2016)[8]	Median LOS In-hospital mortality	Phase 1 (2007-2008) and phase 2 (2012-2013)		Descriptive statistics		2007-2008: (IQR): 14 (11-20) 2012-2013: (IQR): 13 (9-16). trend: p<0.001	2007-2008: 4.1 vs 2012-2013: 1.1 - p<0.001	

Liang et al (2008)[9]	Rate of hospitalisation		Age (10-year bands)	Rates standardised to the Segi world population and WHO world population (presented). Subgroups by age, sex, stroke type	IS: Male: 48.18 (43.75, 52.60) per 100 000 person-years Female: 35.49 (31.78, 39.21) ICH: Male: 25.61 (22.43, 28.78). Female: 20.06 (17.33, 22.79). Age-adjusted: IS: 36.1 (33.6, 38.6), ICH: 20.1 (18.2, 21.9), SAH: 1.2 (0.7, 1.6), all stroke: 57.4 (54.2, 60.5)			
Liu X et al (2018)[10]	Median LOS In-hospital mortality			Descriptive statistics. Subgroups by hospital tier and type		All: 15 (IQR: 9.1-23.0), tier 2: 16 (8.7-25.0), tier 3: 15.0 (9.5, 22.2) - p<0.05, Western medicine: 15.0 (9.0-22.8), TCM: 18.3 (12.0, 26.0) - p<0.05	All: 8.1, tier 2: 9.2, tier 3: 7.5 - p<0.05, Western medicine: 8.6, TCM: 4.7 - p<0.05	
Tian et al (2018)[11]	Mean LOS	Admission year: 2006-2008, 2009-		Descriptive statistics,		IS: 2006-2008: 18.01 (SD 8.45), 2009-2012:		Intracranial artery: 2006-08: 25.6, 2009-

	Use of tests	2012, 2013-2015		by stroke type		16.57 (7.99), 2013-2015: 14.81 (7.43) - p<0.001 ICH: 19.22 (9.80), 18.43 (11.62), 16.38 (9.71) - p=0.014 SAH: 18.73 (10.77), 19.50 (13.65), 15.50 (7.59) - p=0.302		12: 61.1, 2013-15: 75.4 - p<0.001 Extracranial artery: 82.4, 83.0, 87.8 - p<0.001. Echocardiograph: 47.4, 69.5, 82.6 - p<0.001 Holter monitoring: 0.4, 0.2, 8.2 - p<0.001
Wang D et al (2017)[12]	LOS Death at discharge (or 30-day)	Non-university vs university hospitals	Age, sex, mRs on admission	Binary logistic regression Subgroups by stroke type		IS: non-university hospital: median 13 (IQR: 8), University hospital: 14 (9): p<0.001 ICH: 17 (10) vs 16 (12) - p=0.603 SAH: 19 (12) vs 17 (10) - p=0.235	Overall: IS: 2.3 vs ICH: 9.4 vs SAH: 6.0: p<0.001 IS: non-university hospital: median 2, university hospital: 2.9 p=0.092. ICH: 9.1 vs 10.0 - p=0.588. SAH: 5.9 vs 6.2 - p=1	
Wei et al (2010)[13]	LOS	Hospital tier 3 vs tier 2	Age, gender, marital status, living alone, HI, CVD risk, stroke type, severe GCS score, assisted feeding, in-	Descriptive statistics, by stroke type: ICH vs IS		Overall: average 20 (median: 17 IQR (12-25) tier 3: 20 vs tier 2: 18 IS: 19 vs ICH: 23		

			hospital complication, LOS, hospital size, teaching status, location, annual income, dependency on discharge					
Wen et al (2017)[14]	Rate of hospitalisation LOS	Patient w/ and w/o atrial fibrillation (AF)	Age, gender, co-morbidities, frequency of outpatient visits and hospitalisations	Descriptive statistics	Frequency of hospitalisation: IS with AF: mean 5.72 (SD 4.03) vs IS without AF: 2.54 (2.05) - p=0.0003	IS with AF: mean 18.94 (SD 14.03) vs IS without AF: 17.30 (SD 11.85): p=0.0003		
Yan et al (2018)[15]	Mortality rate within 1 month		Sex, age, risk factors: hypertension, diabetes mellitus, dyslipidaemia, atrial fibrillation, current smoker, current drinker, obesity, LPA	Multivariate analysis. Subgroups by sex, age, risk factors, localization			12.5 (>50 during admission) No diff by sex, age, AF, LPA. Diabetes: yes: 19.1 vs no: 9.5 Dyslipidaemia: yes: 16.2 vs 9.2 Smoker: yes: 9.6 vs 13.9. Drinker: yes: 8.1 vs 13.5 obesity: yes: 20.7 vs no: 11.4	

Zhang et al (2019)[16]	Mean LOS Distribution of admission by tier	Stroke type		Descriptive statistics, by hospital tier	% of admissions: Any stroke: tier 3: 60.1%, tier-2: 30.4%, tier-1: 9.5% IS: 60.8%, 29.7%, 9.5% SAH: 78.3%, 18.7%, 3.0% ICH: 66.3%, 26.5%, 7.2% TIA: 61.9%, 33.8%, 4.3% Other: 37.1%, 43.1%, 19.6%	Any stroke: 26.7 (SD 55.3) ICH: 41.0 (73.2) IS: 25.1 (52.7) SAH: 25.2 (34.4) TIA: 11.7 (11.0) Other stroke: 36.9 (72.1)		

*The second column of the table "Outcome measured" indicates whether case fatality or in-hospital mortality rate was measured.
AF: atrial fibrillation, aOR: adjusted odds ratio, CAD: coronary artery disease, CVD: cardiovascular disease, DM: diabetes mellitus, GCS: Glasgow Coma score, GRP: gross regional product, HI: health insurance, HS: haemorrhagic stroke, HTN: hypertension, ICH: intracerebral haemorrhage, IS: ischaemic stroke, LPA: lipoprotein (a), LOS: length of stay, mRS: Modified Rankin Scale, OR: odds ratio, OCSP: Oxfordshire Community Stroke Project, SAH: subarachnoid haemorrhage, SD: standard deviation, TIA: transient ischaemic attack, TCM: Traditional Chinese Medicine hospital, Western medicine: Western medicine hospital

Table B.7 Characteristics of the methods and results of included studies for IHD

Studies	Outcomes measured	Factor(s) of interest	Covariates	Methods	Rates of hospital admissions / Distribution of admissions	LOS (days)	Case fatality / in-hospital mortality rate* (%)	Use of diagnostic tests or procedures (%)
Bueno et al (2018)[17]	Use of test Median LOS 30-day case fatality	Different geographic patterns in hospital care of patients	Age, gender, marital status, occupation, LOS, disease severity, PCI, Elixhauser score, hospital level	Descriptive statistics		9 (IQR: 6, 12)	Crude: 0.3	CAG: 80.2 Revascularisation: 66.1 PCI: 65.6 CABG: 0.8
Cai et al (2018)[18]	In-hospital mortality Use of PCI	Rural (with NRCMS) vs urban (with URBMI or UEBMI)	Age, gender, marital status, occupation, length of stay, gravity of disease, PCI, Elixhauser score, tier 3 hospital or not	Multivariable logistic regressions	Use of tier 3 hospitals (%): 2013: urban: 98.8 vs rural: 99.2; 2014: 99.2 vs 98.2; 2015: 85.5 vs 61.0; 2016: 83.4 vs 61.5; 2017: 85.1 vs 62.7		Unadj: 2013-2017: urban: 3 vs rural: 1 aOR rural (vs urban): 2013: 0.173, 2014: 0.34, 2015: 0.605, 2016: 0.522, 2017: 0.556 (all $p \leq 0.001$)	2013: urban: 14 vs rural: 15 2014: 17 vs 15 2015: 19 vs 13 2016: 23 vs 17 2017: 31 vs 24
Chen et al (2018)[19]	In-hospital mortality Use of PCI	Region, hospital level, hospital teaching status	Sex, age, AMI subtype, CCI, HI status	Multivariable logistic regressions			National: 4.71 (4.62-4.79); Male: 3.92 (3.83-4.01) vs Female: 6.65 (6.47-6.84); NSTEMI: 3.59 (3.44-3.75) vs	National: 45.3 (45.1-45.5); Male: 49.6 (49.4-49.8) vs Female: 34.7 (34.3-35.1) STEMI: 47.8 (47.6-48.0) vs NSTEMI:

							STEMI: 5.05 (4.95-5.15) Higher rates in non-teaching hospitals, female, older, STEMI, higher morbidity UEBMI, socialized medicine and self-pay	37.2 (36.8-37.6) Adjusted models: higher PCI use in the East vs other regions, level A hospital, teaching hospital, male, younger, STEMI, lower morbidity index, UEBMI
Ding et al (2017)[20]	Median LOS	Patients who received compensation vs paid OOP		Descriptive statistics		Compensation: 5.0 (IQR 3.0-7.0) vs. OOP: 4.0 (3.0-7.0)		
Dreyer et al (2019)[21]	Use of test	Sex		Descriptive statistics				Revascularisation: total: 6.4%, men: 6.5%, women: 6.2% (p=0.78). PCI/CABG (primary or other): total: 7.0%, 7.4%, 5.8% (p=0.14)
Du X et al (2016)[22]	Rates of hospitalisation Use of tests	Sex	Age, hypertension, diabetes, current smoker, CHD, MI, PCI, stroke, symptom onset to admission, chest discomfort,	Nationally representative rates of hospitalisation: weights proportion	Men: 2006: 10.0 per 100 000, 2011: 18.0 Women: 2006: 4.1, 2011: 8.0			**Non-primary PCI:** 2001-2011: men: 21.8 vs women: 14.3 p<0.0001 Men: 2006: 19.4, 2011: 24.4 p <0.0001. Women: 2006: 10.2, 2011:

			cardiogenic shock, cardiac arrest, acute stroke, heart rate, SBP, LDL-C, eGFR, hospital characteristics, economic-geographic region	al to inverse sampling fraction of hospitals within each stratum + sampling fraction of patients within each hospital Multivariable logistic models				17.1 p<0.0001 aORs: 2001-2011: 0.78 (0.65, 0.95); 2006: 0.57 (0.39, 0.86); 2011: 0.87 (0.70, 1.07) **CAG:** 2001-2011: 21.8 vs 14.3 p<0.0001. 2006: 41.7 vs. 25.0, 2011: 51.1 vs. 35.5 (all p<0.0001). aORs: 2001-2011: 0.72 (0.63, 0.82). 2006: 0.58 (0.42, 0.80). 2011: 0.74 (0.63, 0.88)
Du X et al (2017)[23]	Distribution of admission by tier Difference in LOS Use of test	Sex	Age, SBP, heart rate, Killip classification, prior HTN, diabetes, MI, angina pectoris, stroke or TIA, smoking status, education level, occupation, hospital level	Log-binomial GEE regressions models, clustering effects within hospitals	Female: tier 2: 41.2%, tier 3: 58.8% Male: tier 2: 32.5%, tier 3: 67.5%	Adjusted mean difference: men vs women: -0.42 [-0.73, -0.12] (p=0.007)		Adjusted: Mean difference: -0.42 (-0.73, -0.12) High-risk patients undergoing CAG: Risk ratio: 0.82 (0.78, 0.86)
Gao et al (2008)[24]	In-hospital mortality Use of test			Descriptive statistics by tier, ACS subtype, baseline risk			All: 5; Tier 2: STEMI: 8.5, NSTEMI: 7, UAP: 2; High-risk: 12, intermediate risk: 2, low risk: 1	**Tier 2:** Exercise test: STEMI: 0, NSTEMI: 1.4, UAP: 3.7 Echocardiogram: 39, 46.5, 55.1. CAG: 27.5, 19.7, 27.7; PCI: 22.2, 14.8,

							Tier 3: STEMI: 7.5, NSTEMI: 9, UAP: 2, High-risk: 11, intermediate risk: 3, low risk:0.5	18.4. CABG: 0.2, 0.7, 3.1 **By risk:** Exercise test: High-risk: 0, intermediate: 0.8, low: 4.6. Echocar-diogram: 36.5, 50.9, 48.7; CAG: 14.7, 30.5, 31.0. PCI: 9.7, 21.6, 25.1. CABG: 0.5, 1.1, 2.0 **Tier 3:** Exercise test: STEMI: 0.1, NSTEMI: 1.1, UAP: 3.1.Echocardiogram: 66.5, 63.9, 68.3; CAG: 56.8, 45.0, 56.0. PCI: 52.7, 38.9, 38.1; CABG: 3.2, 3.3, 4.8 **By risk:** Exercise test: High-risk: 0, intermediate: 1.1, low: 3.1. Echocar-diogram: 64.3, 68.6, 67.8; CAG: 41.0, 59.6, 63.0. PCI: 35.5, 49.0, 47.3; CABG: 2.5, 3.6, 5.5
Gong et al (2016)[2]	28-day case fatality (1st and recurrent)	Urban/rural residence		Crude and direct age-standardised rates using WHO			73.2 (Age std: 42.8). Male: 67.8 (53.3). Female: 80.5 (50.0)	

				standard population, by gender and age			Urban: 68.8 (48.2). Rural: 76.6 (55.4) <35 years: 52.1. 35-64 years:51.2 ≥65 years: 78.8	
Han et al (2019)[25]	In-hospital mortality Median LOS		Age, sex, year, diabetes, hypertension, cardiac dysrhythmias, congestive heart failure, congenital heart disease, blood transfusion, liver disease, gastrointestinal bleeding, cardiogenic shock	For LOS: Generalised linear mixed models		Total: 10 (IQR: 6-14) Aged 18-64: 9 (6-14) Aged>65y: 10 (6-15)	8.23	PCI: 37.22 CABG: 1.85
Hao et al (2019)[26]	Use of tests Median LOS In-hospital mortality	Sex	Age, HI, acute heart failure, cardiogenic shock, cardiac arrest; heart rate, SBP; diabetes; smoking; history of CHD, heart failure, renal failure, cerebro-vascular disease; prehospital statin use; renal insufficiency; transfer status;	Descriptive statistics by ACS type and age group (<55, 55-64, 65-74, ≥75) Logistic regression models		Total: 9.7 (IQR 7, 13), men: 9 (7, 12), women: 10 (7, 13) - p<0.001	ACS: men: 1.50 vs women: 2.60 (p<0.001). STEMI: 1.71 vs 3.68 (p<0.001). aOR: 1.18 (1.00, 1.41) P=0.057 NSTE-ACS: 1.11 vs 1.42 (p=0.017). aOR: 0.84 (0.66, 1.06) p=0.147. Sign diff men vs women in 55-64, 65-74, ≥75.	Primary PCI: men 51.4 vs women 44.1

			DAPT at arrival, fibrinolysis therapy, PCI				Interaction sex* age: STEMI p= 0.07, NSTE-ACS: p=0.64	
Jian et al (2019)[27]	PCI received within 90 min after hospital arrival	Years: 2012-13 vs 2017-18	Age, gender, CCI	Linear regression model				2012/2013: 66.3 vs 2017/2018: 80.1 - p=0.001
Li G-X et al (2017)[28]	Median LOS Use of tests In-hospital mortality	Calendar period		Descriptive statistics		2010: 9 (3, 13) vs 2015: 9 (4, 12) - p=0.119	2010: 13.01 vs 2013: 10.20 - p=0.121	**2010:** Troponin: 31.63, Cardiac enzymes: 88.80, Creatinine: 81.38, Echocardiogram: 14.17 **2015**: 95.60, 93.72, 92.78, 56.99. All time trends p<0.01
Li J et al (2015)[29]	Number and rate of hospitalisation Use of tests Median LOS In-hospital mortality	Calendar years: 2001, 2006, 2011 (ref: 2001)	Age, sex, hypertension, diabetes, current smoker, previous MI, previous IHD, previous stroke, chest discomfort, cardiac arrest, acute stroke, heart rate, SBP, symptom onset to admission time	Nationally representative weighted rates of hospitalisation Logistic regressions	Rate: 2006: 7.9, 2011: 15.4 per 100,000 No. of admissions: 2006: 103 743, 2011: 207 928	2006: 10 (6-15), 2011: 10 (6-14)	Unadjusted: 2001: 8.7, 2006: 9.6, 2011: 7.1 - p trend=0.0007 Adjusted: OR: 2006 (ref: 2001): 1.05 (0.82-1.36), 2011: 0.82 (0.62-1.10) - p trend = 0.07	**2006:** CAG: 25.8 (24.3, 27.2), PCI (non-primary): 12.3 (11.2, 13.4), CABG: 0.9 (0.6, 1.3), troponin: 46.9 (45.3, 48.5), cardiac enzyme: 93.1 (92.3-93.9), creatinine: 84.7 (83.5, 85.9), echocardiogram: 47.6 (46.0, 49.2) **2011:** 41.9 (40.7, 43.1), 20.3 (19.4, 21.3), 0.6 (0.4, 0.8), 68.6 (67.5, 69.7), 97.2 (96.8, 97.6),

								94.9 (94.4, 95.5), 67.7 (66.6, 68.8)
Li Q et al (2015)[30]	Median LOS Use of tests	Hospital tertile based on the median LOS across all years	Socio-demographics, cardiac and noncardiac comorbidities, severity of AMI, year	Two-level generalised linear mixed model with patients nested within hospitals		2006: 11 (IQR: 7-16), after weighting: 12.6; 2011: 11 (7-15), after weighting: 11.9; Risk-std LOS is 1.6 days shorter in central vs. eastern region		Echocardiogram: 55 Biomarkers none: 10.5 CK only: 6.7 CK-MB only: 36.9 Troponin only: 3.1 CK-MB + Troponin: 42.8 Catheterisation: 42.8 PCI: 23.7
Li X et al (2017)[31]	Use of tests Median LOS	Urban vs rural		Descriptive statistics with weighted %		2006: rural hospitals 9 (5-15) vs urban: 12 (7-16) p<0.001 2011: 11 (7-14) vs 10 (7-15) - p=0.07		**2006:** CAG: urban: 37 vs rural: 8; OR: 6.55 (5.31-8.07) **PCI (non-primary):** 17 vs 4; OR: 4.56 (3.45, 6.02); CABG: 0; Troponin: 55 vs 34, OR: 2.31 (2.02-2.66); Creatinine: 90 vs 77, OR: 2.71 (2.25, 3.26) Echocardiogram: 57 vs 33, OR: 2.73 (2.37, 3.13). **2011:** CAG: 55 vs 19; OR: 5.27 (4.68-5.92) PCI (non-primary): 28 vs 6;

								OR: 5.87 (4.92, 7.00). CABG: 1 vs 0. Troponin: 71 vs rural: 65, OR: 1.33 (1.20-1.48). Creatinine: 96 vs 94, OR: 1.49 (1.20, 1.86); Echocardiogram: urban: 75 vs 54, OR: 2.60 (2.35, 2.89)
Lin et al (2017)[32]	In-hospital mortality Mean LOS	Health insurance type: URBMI (reference group), URBMI, NCMS, self-payment	Age, gender, admission source, admission condition, comorbid disease, hospital volume, no. of hospital beds, no. of nurses per 100 beds, no. of doctors per 100 beds and hospital region	In-hospital mortality: multilevel mixed-effect logistic regression LOS: multilevel mixed effects negative binomial regression model		Unadj: 11.7 (SD 6.6), UEBMI: 12.5 (7.8), URBMI: 12.1 (6.1), NCMS: 11.2 (5.6), Self-payment: 10.6 (6.0) - p<0.001 aOR: (ref UEBMI): URBMI: 0.96 (0.93, 0.98), NCMS: 0.90 (0.89, 0.92), Self-payment: 0.85 (0.83, 0.87)	Unadj rates: 4.0, UEBMI: 3.1, URBMI: 4.4, NCMS: 4.7, Self-payment: 4.2 (p<0.001) aOR (ref: UEBMI): URBMI: 1.22 (0.91, 1.63), NCMS: 1.39 (1.17 to 1.66), Self-payment: 1.69 (1.31, 2.20) - AUC: 0.80	

Murugiah et al (2017)[33]	Rate of hospitalisation Use of troponins	Calendar year		Nationally representative weighted rates of hospitalisation, subgroups by hospital level, region, location, teaching status	14% of patients had NSTEMI 2001: 7.2%, 2006: 10.3%, 2011: 17.6% (trend p<0.001) Increase across hospital tier, region, teaching status. NSTEMI: 2001: 0.3 per 100 000, 2006: 1.0, 2011: 3.3 (p<0.001) STEMI: 3.5, 7.6, 14.3 (p<0.001) Median (Q1-Q3) proportion of NSTEMI in 2011: tier 3: 16.6% (10.5-25.6) vs tier 2: 10.9% (5.0-17.9) (p= 0.02) urban: 16.8			% of hospitals using **any biomarker** in ≥75% of all AMI: 2001: 64.7%, 2011: 91.9% % of hospitals using **troponins** in ≥75% of all AMI: 2001: 11.0% to 46.6% - p trend<0.001

					(10.5, 25.6) vs rural hospitals: 10.9 (5.6-17.6) (p=0.02)			
Wang et al (2019)[34]	LOS No. of admissions			Descriptive statistics	Mean no. of admissions: 1.69, median: 1	Mean: 8.89 (SD: 4.68) Median: 8		
Zhan et al (2015)[35]	Use of tests	Calendar years: 2001, 2006, 2011		Descriptive statistics by AMI type				**CK-MB/troponin:** 2001: 63.7 vs 2011: 95.1; rural hospital: 2001: 35.9 vs 2011: 94.0; **Troponin:** 19.3 vs 63.9; 2011: rural: 56.9 vs urban 68.3, p<0.001. **CK-MB/troponin:** STEMI vs NSTEMI: 2001 63.4 vs. 67.3, p=0.321, 2006: 85.1 vs. 88.7, p=0.046, 2011: 95.1 vs. 94.9, p=0.696 **Troponin:** STEMI vs NSTEMI: 2001: 19.3 vs. 19.4, p=0.976, 2006: 43.0 vs. 52.8, p<0.001, 2011: 63.2 vs. 67.3, p=0.002
Zhang Q et al (2016)[36]	Hospitalisation rate Mean LOS In-hospital	Calendar years:	Age, sex	Rates of hospitalisation: standardis	AMI: 2007: 55.8 per 100,000 vs 2012: 73.3	2007: 10.6 vs 2012: 9.7, change: -	Age-standardised 2007: 11.2 vs 2012: 8.6,	STEMI: 2007: 28.7, 2012: 55.6 vs NSTEMI: 2006: 22.7, 2012: 30.0 (both

	mortality Use of PCI	2007-2012		ed to 2000 Census Beijing population Poisson regression, results by age, sex, subtypes	Age standardised change: 2007-2012: 31.2%. Greatest increase in <55 years old. STEMI: 47.2 vs 40.5. NSTEMI: 6.8 vs 26.9 (all p<0.001)	8.5%. Male: 2007: 10.4 vs 2012: 9.5, change: -8.7%. Female: 2007 10.8 vs 2012: 10.1, change: -6.5% (all p<0.001)	change -23.2% male: 2007: 8.8 vs 2012: 6.8 - change: -22.7% female: 2007: 16.3 vs 2012: 12.1 - relative change -25.8% (all p<0.001)	p<0.001) STEMI: CABG: 2006: 2.7, 2012: 2.3 (p=0.04) vs NSTEMI: 2006: 3.6, 2012: 3.2 (p=0.65)
Zhang Y et al (2016)[37]	Use of test In-hospital mortality Median LOS		Age, sex, race risk factors, medical history, anterior MI, Killip class≥2, symptom onset-to-FMC>12h, successful reperfusion, medication use	Mortality: multivariate logistic regression, propensity score matching, by hospital tier		Total: 11.0 (IQR 7.0, 14.0), tier-2: 10.0 (6.0, 14.0), tier-3: 12 (8.0, 15.0) (p<0.001)	Total: 5.8, tier-2: 6.0, tier-3: 5.6 unadj OR for tier 3: 0.92 (0.58-1.47), aOR: 1.58 (0.81-3.11). PSM: tier 2: 4.9 vs tier-3: 6.0, aOR: 1.23 (0.59-2.54)	**Primary PCI**: 5.9, tier-2: 0.2, tier-3: 10.9 (p<0.001) **Elective PCI**: 19.5, tier-2: 10.3, tier-3: 27.5 (p<0.001)
Zheng X et al (2015)[38]	Use of tests In-hospital mortality Distribution of LOS	Sex	CVD risk factors, medical history, clinical characteristics at admission, treatment during hospitalisation, hospital characteristics, LOS, year of discharge	In-hospital mortality: multivariable logistic regression, results by age		**Women:** <8 days: 29.5%, 8-11 days: 20.9%, 12-15 days: 21.4%, ≥16 days: 28.2% **Men:** <8: 22.7%, 8-	All: women: 17.2 vs men: 9.1, unadj OR: 2.07 (1.85-2.33). <60 years: 9.4 vs 4.5, aOR: 1.69 (1.01, 2.83); 60-69 years: 15.2 vs 7.5, aOR: 1.64 (1.24 to 2.19); 70-79 years:18.6	**CAG:** women: 18.8 vs men: 28.8; **PCI:** 8.6 vs 13.9; **CABG:** 0.34 vs 0.61; **Any revascularisation:** 8.9 vs 14.4; **Troponin:** 48.9 vs 49.9 **Echocardiogram:** 46.1 vs 52.6

						11: 24.0%, 12-15%: 23.4%, ≥16: 29.2%	vs 14.3, aOR: 1.15 (0.90, 1.46), ⩾80 years of age: 24.8 vs 20.8 (p=0.09), aOR: 0.82 (0.60, 1.11)	
Zheng X et al (2016)[39]	Use of tests	Calendar years: 2001, 2006, 2011		Descriptive statistics: nationally representative weighted rates				**No. of hospital admissions with CAG**: 2001: 26 570, 2006: 133 942, 2011: 452 784 (17-fold increase). **PCI**: 2001: 9678, 2006: 62 308, 2011: 208 954 (21-fold increase)

*The second column of the table "Outcome measured" indicates whether case fatality or in-hospital mortality rate was measured.
aOR: adjusted Odds Ratio, AUC: area under the curve, CABG: coronary artery bypass surgery, CAG: coronary angiography, CCI: Charlson Comorbidity Index, CVD: cardiovascular disease, DAPT: dual antiplatelet therapy, eGFR: estimated Glomerular Filtration Rate, GEE: generalised estimating equation, IQR: interquartile range, LDL-C: low-density lipoprotein cholesterol, LOS: length of stay, NSTEMI: non ST-elevation myocardial infarction, OR: Odds Ratio, PCI: percutaneous coronary intervention, RR: Risk or Rate Ratio, SBP: systolic blood pressure, STEMI: ST-elevation myocardial infarction, TIA: Transient ischaemic attack, UEBMI: Urban employee basic medical insurance, URBMI: Urban resident basic medical insurance.

Table B.8 Quality assessments results

Study	Overall Quality	Questions																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Stroke																						
He (2014)[3]	Good																					
Huang (2010)[4]	Fair																					
Huo (2017)[5]	Poor																					
Ji (2013)[6]	Poor																					
Li (2012)[7]	Fair																					
Li (2016)[8]	Fair																					
Liang (2008)[9]	Fair																					
Liu (2018)[10]	Fair																					
Tian (2018)[11]	Fair																					
Wang (2017)[12]	Poor																					
Wei (2010)[13]	Fair																					
Wen (2017)[14]	Fair																					
Yan (2018)[15]	Poor																					
Zhang (2019)[16]	Fair																					
Ischaemic heart disease																						
Bueno (2018)[17]	Fair																					
Cai (2018)[18]	Good																					
Chen (2018)[19]	Fair																					
Ding (2017)[20]	Fair																					
Dreyer (2019)[21]	Fair																					
Du (2016)[22]	Good																					
Du (2017)[23]	Fair																					
Gao (2008)[24]	Fair																					
Han (2019)[25]	Good																					
Hao (2019)[26]	Fair																					
Jian (2019)[27]	Fair																					
Li G-X (2017)[28]	Fair																					

Li J (2015)[29]	Good	
Li Q (2015)[30]	Good	
Li X (2017)[31]	Good	
Lin X (2017)[32]	Fair	
Murugiah (2017)[33]	Good	
Wang (2019)[34]	Fair	
Zhan (2015)[35]	Good	
Zhang Q (2016)[36]	Fair	
Zhang Y (2016)[37]	Fair	
Zheng (2015)[38]	Good	
Zheng (2016)[39]	Good	
Stroke and IHD		
Gong (2016)[2]	Fair	

Overall quality was assessed by one reviewer (Muriel Levy) using questions from the quality assessment tool in **Table B.3**. The boxes shaded in grey indicate that the study is considered not to have met the quality criteria for the specified questions. The boxes shaded in grey indicate that the study is considered not to have met the quality criteria for the specified questions. The lightly shaded boxes indicate that the questions were considered not applicable for this study. Studies that did not meet ≥40% of criteria were classified as having poor overall quality. Studies that did not meet <40% and ≥20% of criteria were classified as having fair overall quality. Studies that did not meet <20% were classified as having good overall quality.

References

1. Hoy D, Brooks P, Woolf A, et al. Assessing risk of bias in prevalence studies: modification of an existing tool and evidence of interrater agreement. *Journal of Clinical Epidemiology*. 2012; **65**(9): 934-9.
2. Gong W, Wei X, Liang Y, et al. Urban and Rural Differences of Acute Cardiovascular Disease Events: A Study from the Population-Based Real-Time Surveillance System in Zhejiang, China in 2012. *PLOS One*. 2016; **11**(11): e0165647.
3. He Q, Wu C, Luo H, et al. Trends in in-hospital mortality among patients with stroke in China. *PLOS One*. 2014; **9**(3): e92763.
4. Huang Y, Wang J-G, Wei JW, et al. Age and gender variations in the management of ischaemic stroke in China. *International Journal of Stroke*. 2010; **5**(5): 351-9.
5. Huo X, Jiang B, Chen Z, et al. Difference of hospital charges for stroke inpatients between hospitals with different levels and therapeutic modes in Beijing, China. *The International Journal of Neuroscience*. 2017; **127**(9): 752-61.
6. Ji R, Wang D, Liu G, et al. Impact of macroeconomic status on prehospital management, in-hospital care and functional outcome of acute stroke in China. *Clinical Practice*. 2013; **10**(6): 701-12.
7. Li Y, Liu H, Wang J, et al. Variable lengths of stay among ischemic stroke subtypes in Chinese general teaching hospitals. *PLOS One*. 2012; **7**(9): e45101.
8. Li Z, Wang C, Zhao X, et al. Substantial Progress Yet Significant Opportunity for Improvement in Stroke Care in China. *Stroke*. 2016; **47**(11): 2843-9.
9. Liang W, Huang R, Lee AH, Hu D, Binns CW. Hospitalizations for incident stroke in Shunde District, Foshan, South China. *Neuroepidemiology*. 2008; **30**(2): 101-4.
10. Liu X, Kong D, Lian H, et al. Distribution and predictors of hospital charges for haemorrhagic stroke patients in Beijing, China, March 2012 to February 2015: a retrospective study. *BMJ Open*. 2018; **8**(3): e017693.
11. Tian D, Yang Q, Dong Q, Li N, Yan B, Fan D. Trends in stroke subtypes and vascular risk factors in a stroke center in China over 10 years. *Scientific Reports*. 2018; **8**(1): 5037.
12. Wang D, Liu J, Liu M, Lu C, Brainin M, Zhang J. Patterns of Stroke Between University Hospitals and Nonuniversity Hospitals in Mainland China: Prospective Multicenter Hospital-Based Registry Study. *World Neurosurgery*. 2017; **98**: 258-65.
13. Wei JW, Heeley EL, Jan S, et al. Variations and determinants of hospital costs for acute stroke in China. *PLOS One*. 2010; **5**(9): e13041.
14. Wen L, Wu J, Feng L, Yang L, Qian F. Comparing the economic burden of ischemic stroke patients with and without atrial fibrillation: a retrospective study in Beijing, China. *Current Medical Research and Opinion*. 2017; **33**(10): 1789-94.
15. Yan F, Yi Z, Hua Y, et al. Predictors of mortality and recurrent stroke within five years of intracerebral hemorrhage. *Neurological Research*. 2018; **40**(6): 466-72.

16. Zhang H, Yin Y, Zhang C, Zhang D. Costs of hospitalization for stroke from two urban health insurance claims data in Guangzhou City, southern China. *BMC Health Services Research*. 2019; **19**(1): 671.
17. Bueno H, Rossello X, Pocock S, et al. Regional variations in hospital management and post-discharge mortality in patients with non-ST-segment elevation acute coronary syndrome. *Clinical Research in Cardiology*. 2018; **107**(9): 836-44.
18. Cai M, Liu E, Li W. Rural Versus Urban Patients: Benchmarking the Outcomes of Patients with Acute Myocardial Infarction in Shanxi, China from 2013 to 2017. *International Journal of Environmental Research and Public Health*. 2018; **15**(9).
19. Hui C, Lizheng S, Ming X, et al. Geographic Variations in In-hospital Mortality and Use of Percutaneous Coronary Intervention Following Acute Myocardial Infarction in China: A Nationwide Cross-sectional Analysis. *Journal of the American Heart Association*. 2018; **7**(8): e008131.
20. Ding JM, Zhang XZ, Hu XJ, Chen HL, Yu M. Analysis of hospitalization expenditures and influencing factors for inpatients with coronary heart disease in a tier-3 hospital in Xi'an, China A retrospective study. *Medicine*. 2017; **96**(51): e9341.
21. Dreyer RP, Zheng X, Xu X, et al. Sex differences in health outcomes at one year following acute myocardial infarction: A report from the China Patient-Centered Evaluative Assessment of Cardiac Events prospective acute myocardial infarction study. *European Heart Journal - Acute CardioVascular Care*. 2019; **8**(3): 273-82.
22. Du X, Spatz ES, Dreyer RP, et al. Sex Differences in Clinical Profiles and Quality of Care Among Patients With ST-Segment Elevation Myocardial Infarction From 2001 to 2011: Insights From the China Patient-Centered Evaluative Assessment of Cardiac Events (PEACE)-Retrospective Study. *Journal of the American Heart Association*. 2016; **5**(2).
23. Du X, Patel A, Li X, Wu Y, Turnbull F, Gao R. Treatment and outcomes of acute coronary syndromes in women: An analysis of a multicenter quality improvement Chinese study. *International Journal of Cardiology*. 2017; **241**: 19-24.
24. Gao R, Patel A, Gao W, et al. Prospective observational study of acute coronary syndromes in China: practice patterns and outcomes. *Heart*. 2008; **94**(5): 554-60.
25. Han H, Wei X, He Q, et al. Comparison of In-Hospital Mortality and Length of Stay in Acute ST-Segment-Elevation Myocardial Infarction Among Urban Teaching Hospitals in China and the United States. *Journal of the American Heart Association*. 2019; **8**(22): e012054.
26. Hao Y, Liu J, Liu J, et al. Sex Differences in In-Hospital Management and Outcomes of Patients With Acute Coronary Syndrome. *Circulation*. 2019; **139**(15): 1776-85.
27. Jian W, Figueroa J, Woskie L, et al. Quality of care in large Chinese hospitals: an observational study. *BMJ Quality & Safety*. 2019; **28**(12): 963-70.
28. Li G-X, Zhou B, Qi G-X, et al. Current Trends for ST-segment Elevation Myocardial Infarction during the Past 5 Years in Rural Areas of China's

Liaoning Province: A Multicenter Study. *Chinese Medical Journal*. 2017; **130**(7): 757-66.
29. Li J, Li X, Wang Q, et al. ST-segment elevation myocardial infarction in China from 2001 to 2011 (the China PEACE-Retrospective Acute Myocardial Infarction Study): a retrospective analysis of hospital data. *The Lancet*. 2015; **385**(9966): 441-51.
30. Li Q, Lin Z, Masoudi FA, et al. National trends in hospital length of stay for acute myocardial infarction in China. *BMC Cardiovascular Disorders*. 2015; **15**: 9.
31. Li X, Murugiah K, Li J, et al. Urban-Rural Comparisons in Hospital Admission, Treatments, and Outcomes for ST-Segment-Elevation Myocardial Infarction in China From 2001 to 2011: A Retrospective Analysis From the China PEACE Study (Patient-Centered Evaluative Assessment of Cardiac Events). *Circulation Cardiovascular Quality and Outcomes*. 2017; **10**(11).
32. Lin X, Cai M, Tao H, et al. Insurance status, inhospital mortality and length of stay in hospitalised patients in Shanxi, China: A cross-sectional study. *BMJ Open*. 2017; **7**(7): e015884.
33. Murugiah K, Wang Y, Nuti SV, et al. Are non-ST-segment elevation myocardial infarctions missing in China? *European Heart Journal - Quality of Care and Clinical Outcomes*. 2017; **3**(4): 319-27.
34. Wang Q, Zhang S, Wang Y, Zhang X, Zhang Y. Factors Associated With Hospitalization Costs of Coronary Heart Disease in Township Hospitals in Rural China. *Inquiry*. 2019; **56**: 46958019886958.
35. Zhan L, Masoudi FA, Li X, et al. Trends in cardiac biomarker testing in China for patients with acute myocardial infarction, 2001 to 2011: China PEACE-Retrospective AMI Study. *PLOS One*. 2015; **10**(4): e0122237.
36. Zhang Q, Zhao D, Xie W, et al. Recent Trends in Hospitalization for Acute Myocardial Infarction in Beijing: Increasing Overall Burden and a Transition From ST-Segment Elevation to Non-ST-Segment Elevation Myocardial Infarction in a Population-Based Study. *Medicine*. 2016; **95**(5): e2677.
37. Zhang Y, Yang S, Liu X, et al. Management of ST-segment elevation myocardial infarction in predominantly rural central China: A retrospective observational study. *Medicine*. 2016; **95**(49): e5584.
38. Zheng X, Dreyer RP, Hu S, et al. Age-specific gender differences in early mortality following ST-segment elevation myocardial infarction in China. *Heart*. 2015; **101**(5): 349-55.
39. Zheng X, Curtis JP, Hu S, et al. Coronary Catheterization and Percutaneous Coronary Intervention in China: 10-Year Results From the China PEACE-Retrospective CathPCI Study. *JAMA Internal Medicine*. 2016; **176**(4): 512-21.

C. Data and methodology

C.1 China Kadoorie Biobank recruitment questionnaire

Section 1: Background information

1.1 Study ID: ☐☐☐☐☐☐☐☐☐ *(The date & time of interview will be recorded by computer)*

1.2 Name_____, Sex： Male ☐ Female ☐ , **Name of spouse**_____

1.3 Date of birth: ☐☐☐☐ Year ☐☐ Month ☐☐ Day

1.4 National ID number (if no, put #) ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

1.5 Home address： _____ Province _____ City_____ District/County _____ Street/Village

Home telephone: Not available ☐, ☐☐☐-☐☐☐☐☐☐☐☐☐☐☐☐

1.6 What is the highest level of school education you ever received

- ☐ No formal school
- ☐ Primary School
- ☐ Middle School
- ☐ High School
- ☐ Technical school / college
- ☐ University

1.7 What is your current occupation?

- ☐ Agriculture & related workers
- ☐ Factory worker
- ☐ Administrator / manager
- ☐ Professional / technical
- ☐ Sales & service workers
- ☐ Retired
- ☐ House wife / husband
- ☐ Self-employed
- ☐ Unemployed
- ☐ Other or not stated

1.8 How many people living together in the household? ☐☐ persons

1.9 What is your current marital status?

- □ Married
- □ Separated / divorced
- □ Widowed
- □ Never married

1.10 What is the total income last year in your household?

- ☐ <2,500 yuan
- ☐ 2,500-4,999 yuan

☐ 5,000-9,999 yuan

☐ 10,000-19,999 yuan

☐ 20,000-34,999 yuan

☐ ≥35,000 yuan

1.11 Do you have any health care cover and following items in your household?

Yes	No	
□	□	Health care cover
□	□	Own house / apartment
□	□	Toilet for private use
□	□	Telephone or mobile phone
□	□	Motor vehicle (e.g. car or motorbike)
□	□	Holiday during last five years

Section 2: Tea drinking

2.1 During the past 12 months, how often did you drink any tea?

☐ Never or almost never

☐ Only occasionally

☐ Only at certain seasons

☐ Every month but less than weekly

☐ Usually at least once a week → ***Go to Q2.2***

2.1a In the past, did you ever have a period of at least 1 year during which you usually drank tea at least once a week?

☐ Yes → 2.1b if so, how long ago did it end? ☐☐ Years } ***Go to section 3***

☐ No

2.2 During the past 12 months, on how many days did you drink tea in a typical week?

☐ 1-2 days/week

☐ 3-5 days/week

☐ Daily or almost every day

2.3 At about what age did you start drinking tea in most weeks? ····· ☐☐ Years

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2.4 On days when you drink tea, how many cups do you usually drink? (choose one only)

Green /Jasmine tea …… ☐☐ cups/day

Oolong tea …… ☐☐ cups/day

Black tea …… ☐☐ cups/day

Other tea …… ☐☐ cups/day

2.5 How often do you change tea leaves during a day? …… ☐☐ times

2.6 About how much tea leaves do you usually add each time? ····· ☐☐ Grams

2.7 What strength of tea do you usually prefer to drink?

- ☐ Weak
- ☐ Moderate
- ☐ Strong

2.8 At about what temperature do you usually drink your tea?

- ☐ Room temperature / warm
- ☐ Hot
- ☐ Burning hot

2.9 Has your tea consumption changed significantly compared with that some years ago?

☐ About the same as before, ☐ Has increased a lot, ☐ Has decreased a lot

Section 3: Alcohol consumption

3.0 Have you drunk any alcohol today? ☐ Yes, ☐ No

3.1During the past 12 months, how often did you drink any alcohol?

- ☐ Never
- ☐ Only occasionally
- ☐ Only at certain seasons
- ☐ Every month but less than weekly
- ☐ Usually at least once a week → ***Go to Q3.2***

3.1a In the past, did you ever have a period of at least 1 year, during which you usually drank some alcohol at least once a week?

- □ Yes, → if so, how long ago did it end? ☐☐ Years } ***Go to section 4***
- □ No

3.2 During the past 12 months, on how many days did you drink alcohol in a typical week?

- ☐ 1-2 days/week
- ☐ 3-5 days/week
- ☐ Daily or almost every day

3.3 At about what age did you start drinking some alcohol in most weeks? ☐☐ Years

3.4 On days when you drink, how much alcohol do you usually drink in a day?

(Can choose up to 3 types of alcohol for special occasions; for beer, 1 large bottle=2 small ones**)**

Alcohol type	On a typical day	On a special day	Last time

	(choose one)		when you drink a lot		when you drank	
Beer (large)	☐☐	Bottle	☐☐	Bottle	☐☐	Bottle
Rice Wine	☐☐	liang	☐☐	liang	☐☐	liang
Wine	☐☐	liang	☐☐	liang	☐☐	liang
Spirit (≥50% alcohol)	☐☐	liang	☐☐	liang	☐☐	liang
Spirit (<50% alcohol)	☐☐	liang	☐☐	liang	☐☐	liang

3.5 On a typical day when you drink alcohol, when do you usually take the drink?

- ☐ Usually drink with the meal
- ☐ Usually drink between or after the meals
- ☐ No regular pattern

3.6 After drinking alcohol, do you usually experience hot flushes or dizziness?

- ☐ Yes, soon after first mouthful
- ☐ Yes, after drinking small amount of alcohol
- ☐ Yes, but only after drinking large amount of alcohol
- ☐ No

3.7 During the past month, how often have you drunk alcohol in the morning?

- ☐ Never
- ☐ <1 day/week
- ☐ A few days a week
- ☐ Daily or almost daily

3.8 During the past month, have you ever had the following experiences?

Yes	No	
□	□	Unable to work or to do anything because of drinking
□	□	Felt depressed, irritated or couldn't control yourself after drinking
□	□	Could not keep away from drinking
☐	□	Had shakes when you stopped drinking

3.9 Has your alcohol consumption changed significantly compared with that some years ago?

- ☐ About the same as before
- ☐ Has increased a lot
- ☐ Has decreased a lot

Section 4: Smoking history

4.0 Have you smoked any tobacco today? ☐ **Yes,** ☐ **No,** →if yes how many: __ total, __in last hour

4.1 How often do you smoke tobacco now?

- ☐ Do not smoke now
- ☐ Only occasionally
- ☐ Yes, on most days
- ☐ Yes, daily or almost every day

} → ***Go to Q4.5***

4.2 In the past, how frequently did you smoke?

- ☐ Did not smoke
- ☐ Smoked only occasionally
- ☐ Smoked on most days
- ☐ Smoked daily or almost every day

} → ***Go to Q 4.3***

4.2a In your life time, have you smoked a total of at least 100 cigarettes or equivalent?

- ☐ Yes
- ☐ No

} ➔ ***Please go to section 5***

4.3 How many years ago did you last stop smoking regularly? ☐☐ Years

4.4 What was your main reason for stopping?

- ☐ Physical illness that you already had
- ☐ Money
- ☐ Health concerns (about future illness)
- ☐ Family against
- ☐ Other

4.5 At about what age did you first start smoking on most days? ☐☐ Years

4.6 What tobacco did you use when you first started smoking on most days?

Mainly cigarette ☐, Mainly non-cigarette ☐, Mixed types ☐

↳ 4.6a If so, have you always smoked some cigarettes on most days, never having a month or more without them? Yes ☐, No ☐

4.7 How much tobacco do you usually smoke (or did you smoke before giving up)?

Filter cigarettes (factory) ……	☐☐	number/day
Non-filter cigarettes (factory)……	☐☐	number/day
Hand-rolled cigarettes …… ……	☐☐	liang/month
Pipe or water pipe ……	☐☐	liang/month
Cigars ……	☐☐	number/day

4.9 How deeply do you usually inhale the smoke?

- ☐ Mouth only
- ☐ Throat
- ☐ Lung ➔ 4.9a Have you nearly always inhaled a lot of smoke into your lung when smoking? Yes ☐, No ☐

4.10 Has your tobacco consumption changed significantly compared with that some years ago?

☐ About the same as before, ☐ Has increased a lot, ☐ Has decreased a lot

Section 5: Diet

5.2 During the past 12 months, about how often did you eat the following foods?

	Daily	4-6 days per week	1-3 days per week	Monthly	Never/rarely
Rice	☐	☐	☐	☐	☐
Wheat	☐	☐	☐	☐	☐
Other staple food (corn, millet etc.)	☐	☐	☐	☐	☐
Meat	☐	☐	☐	☐	☐
Poultry	☐	☐	☐	☐	☐
Fish/sea food	☐	☐	☐	☐	☐
Fresh eggs	☐	☐	☐	☐	☐
Fresh vegetables	☐	☐	☐	☐	☐
Soybean products	☐	☐	☐	☐	☐
Preserved vegetables	☐	☐	☐	☐	☐
Fresh fruit	☐	☐	☐	☐	☐
Dairy products (milk, yogurt)	☐	☐	☐	☐	☐

5.3 During the past 12 months, have you taken the following supplements regularly?

Yes	No	
□	□	Fish oil/cod liver oil
□	□	Vitamins
□	□	Calcium/iron/zinc
□	□	Ginshen (at least 5 or more times during a year)
□	□	Other herbal products

5.3a Have you ever experienced any severe food shortage? □ Yes, □ No → ***Go to Q5.3c***

5.3a1 What year was the worst food shortage you experienced? _____ years

5.3b During the most severe food shortage you experienced:

- **did you lose weight?** □ No, □ Yes, → **If yes, about how much?** _____ *jing*,
- **did you develop any specific disease related to food shortage?** □ No, □ Yes

5.3c How many years have you had a refrigerator in your home? | | | Years

5.4 During the past month, about how often did you eat hot spicy food?

☐ Never or almost never
☐ Only occasionally } → ***Go to section 6***
☐ 1-2 days/week
□ 3-5 days/week
□ Daily or almost every day

5.5 At what age did you start to eat spicy food at least once a week? [ ][ ] Years

5.6 What strength of spicy food do you usually prefer to eat?

☐ Weak, □ Moderate, □ Strong

5.7 On day when you eat spicy food, what are the main sources of spice usually used?

Yes	**No**	
□	□	Chili sauce
□	□	Chili oil
□	□	Dried chili pepper
□	□	Fresh chili pepper
□	□	Other or don't know

Section 6: Passive smoking & indoor air pollution

6.1 Have you ever lived with smoker in the same house for at least 6 months?

- ☐ Never
- ☐ Yes, but not now
- ☐ Yes, at present

} → ***If yes, duration of living together*** ☐☐ years

6.2 How frequently are you exposed to other people's tobacco smoke either at home, workplace or in public places? *(i.e. a minimum of 5 consecutive minutes each time)*

- ☐ Never or almost never
- ☐ Occasionally (<1 time/week)

} → ***Go to Q6.4***

- ☐ 1-2 days/week
- ☐ 3-5 days/week
- ☐ Daily or almost every day

6.3 What is the usual duration of your exposure per week? ☐☐ Hours

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6.4 During past year, how long did you store pesticides at home? ☐☐ Months

---

6.4a Please tell us the duration you lived in 3 most recent houses (each for at least 1 year)?

Present house ☐☐ years

Previous house ☐☐ years

The house before previous ☐☐ years

6.5 In your present & two previous houses, how often did you cook at home?

- ☐ Daily
- ☐ Weekly
- ☐ Monthly
- ☐ Never/Rarely → ***Go to Q6.8***
- ☐ No cooking facility → ***Go to Q6.11***

6.6 In your present & two previous houses, what was the main cooking fuel used?

- ☐ Gas
- ☐ Coal
- ☐ Wood
- ☐ Eletricity
- ☐ Other

6.7 In your present & two previous houses, what was the main cooking oil used?

- ☐ Rapeseed
- ☐ Peanut
- ☐ Soybean
- ☐ Lard
- ☐ Other

6.7a How much time have you spent on cooking so far today? ☐☐ minutes

---

6.8 In your present & two previous houses, did your stove(s) all have a chimney / extractor?

☐ Yes ☐ Not all stoves ☐ No

6.9 In your present & two previous houses, was your stove always kept under slow burning throughout the day?

☐ Yes, always ☐ Yes, sometimes ☐ No → if ticked, ***Go to Q6.11***

— **If yes, types of the fuel most commonly used?**

☐ Smokeless coal ☐ Coal brick / Coalite

☐ Smoky coal ☐ Other

— **And, the place where stove was usually kept?**

☐ Inside the house ☐ Outside the house

6.11 In winter, did you normally heat your house?

☐ Yes, ☐ No

— **If yes, what was the main heating fuel used?**

☐ Central heating ☐ Wood

☐ Gas ☐ Electricity

☐ Coal ☐ Other

6.12 From what year did the inside of your house tend to be coal-smoky in winter?

☐ Never → if ticked, ***Go to next section***

☐ Ever since childhood

☐ Since the year: _____ year

6.13 In what year did the inside of your house stop being really coal-smoky in winter?

☐ In the year: _____ year

☐ Still is

Section 7: Personal & Family medical history

7.1 How is your current general health status?

a). Self-rated health status?

- □ Excellent
- □ Good
- □ Fair
- □ Poor

b). Compared to someone of your own age?

- □ Better
- □ About the same
- □ Worse
- □ Don't know

7.2 If you were walking on level ground with other healthy people of the same age, would you usually:

a). Become short of breath? □ Yes □ No □ Disabled

b). Slow down due to chest discomfort? □ Yes □ No □ Disabled

7.3 During the past 12 months, have you usually had the following symptoms?

a). Cough frequently?

- □ No
- □ Yes, for <3 months
- □ Yes, for ≥3months

b). Cough up sputum after getting up in the morning?

- □ No
- □ Yes, for <3 months
- □ Yes, for ≥3 months

7.4 Has a doctor EVER told you that you had had the following disease?

	Diagnosed disease?		Age at first	Still on treatment?	
	Yes	**No**	**diagnosis**	**Yes**	**No**
Diabetes	□	□	_____	□	□
CHD	□	□	_____	□	□
Stroke or TIA	□	□	_____	□	□
Hypertension	□	□	_____	□	□
Rheumatic heart dis.	□	□	_____	□	□
TB	□	□	_____	□	□
Emphysema/bronchitis	□	□	_____	□	□
Asthma	□	□	_____	□	□
Cirrhosis/chronic hepatitis	□	□	_____	□	□
Peptic ulcer	□	□	_____	□	□
Gallstone/gallbladder dis.	□	□	_____	□	□
Kidney disease	□	□	_____	□	□
Fracture	□	□	_____	□	□
Rheumatoid arthritis	□	□	_____	□	□
Psychiatric disorders	□	□	_____	□	□
Neurasthenia	□	□	_____	□	□
Head injury	□	□	_____	□	□
Cancer*	□	□	_____	□	□

For CHD, stroke, and hypertension what is the current medication:

1. Aspirin
2. ACE-I
3. Beta-blocker
4. Statins
5. Diuretics
6. Ca^{++} antagonist

& for diabetes, the above list plus

7. Chlorpropamide or metformin
8. Insulin

***If yes, please indicate the site of cancer** □ *(If more than one, choose the one that occurred first)*

0. Lung 1. Esophagus 2. Stomach 3. Liver 4. Intestine 5. Breast 6. Prostate 7. Cervix 8. Other

7.5 Have many blood transfusions have you ever received? *(If none, put 0)* ☐☐ times

7.5a How many times have you ever donated blood for financial payment?

(If none, put 0) ☐☐ times

7.6 About how often do you have bowel movements each week?

- ☐ More than once on most days
- ☐ About daily
- ☐ Once every 2-3 days
- ☐ Less than 3 times a week

7.7 How often do your gums bleed when you brush your teeth?

- ☐ Occasionally, rarely or never
- ☐ Sometimes
- ☐ Always
- ☐ Brush teeth rarely or never

7.8 How many brothers & sisters do you have? *(Including half siblings. If unknown, put#)* ☐☐

7.9 How many children do you have? *(Including only biological ones)* ☐☐

7.9a Is your mother still alive?

- ☐ Yes → If ticked, current age: ☐☐
- ☐ No → If ticked, age at death: ☐☐
- ☐ Unknown

7.9b Is your father still alive?

- ☐ Yes → If ticked, current age: ☐☐
- ☐ No → If ticked, age at death: ☐☐
- ☐ Unknown

7.10 Did any of your parents, siblings or children have following diseases? *(For sibling and children, please record the number with disease*)

	Stroke	Heart attack	Diabetes	Mental disorder	Cancer
Mother *(tick box)*	☐	☐	☐	☐	☐
Father *(tick box)*	☐	☐	☐	☐	☐
Siblings *(inclu. half)*	☐	☐	☐	☐	☐
Children	☐	☐	☐	☐	☐

Section 8U: Physical activities (Urban)

8.1 During the past 12 months, how active were you at work?

- ☐ Mainly sedentary (e.g. office worker)
- ☐ Standing occupation (e.g. guard, shop assistant)
- ☐ Manual work (e.g. plumber, carpenter)
- ☐ Heavy manual work (e.g. miner, construction worker)
- ☐ Retired or housewife/husband or unemployed or disabled → ***If ticked, please go to Q8.8***

8.1a In a typical week, about how many hours did you usually work? _____ hours

---

8.2 During the past 12 months, how did you usually get to work?

- ☐ Mainly walk
- ☐ By motorbike
- ☐ By bicycle
- ☐ By bus/car/ferry/train
- ☐ Mainly stay at home or work near home

↳***If ticked, please go to Q8.8***

8.3 How much time did you spend each day on journey to & from work? _____minutes

---

Section 8F: Physical activities (New section for rural farmers)

8.1 During the past 12 months, did your farming work change seasonally?

- ☐ No → ***go to Q8.3***
- ☐ Yes

8.2 During the farming season in the last 12 months:

— How many months did it usually last? ☐☐ month

— What types of work did it usually involve?

☐ manual ☐ Semi-mechanized ☐ Fully mechanized

— How many hours did you usually work each day? ☐☐ hours

— Of which, how many hours did you sweat or have a much faster heartbeat? ☐☐ hours

---

8.3 In a typical week, how many hours did you usually work in the field? ☐☐ hours

---

8.4 Apart from agriculture work, did you have any other job?

- ☐ No → ***go to Q8.7***
- ☐ Yes

8.5 How active were you at work with other job?

- ☐ Mainly sedentary
- ☐ Mainly standing
- ☐ Mainly general manual work
- ☐ Mainly heavy manual work

8.6 In a typical week, about how many hours did you work at other job? ☐☐ hours

---

8.7 In a typical day how much time did you usually spend on the journey to and from work on foot or by bicycle? ☐☐☐ minutes

Section 8C: Physical activities (Common to both rural farmers and urban)

8.8 During the past 12 months, how often did you do exercise in your leisure time?

☐ Never or almost never } → ***If ticked, please go to Q8.11***
☐ 1-3 times/month
☐ 1-2 times/week
☐ 3-5 times/week
☐ Daily or almost every day

8.9 What is your main type of exercise? *(tick one box only)*

☐ Taichi / Qigong
☐ Jogging/aerobic exercise
☐ Ball games (basketball, table tennis, etc)
☐ Walking
☐ Swimming
☐ Other (eg. mountain climbing)

8.10 About how many hours per week did you do such exercise in leisure time? ___ hours

8.11 In a typical week during the past 12 months, how often did you sweat or have a much faster heartbeat because of heavy physical activities/exercise?

☐ Never or almost never } → ***If ticked, please go to Q8.13***
☐ <1 time / week
☐ 1-2 times/week
☐ 3-5 times/week
☐ Daily or almost every day

8.12 About how many hours per week did you do such activities? _____ hours

8.13 About how many hours per week did you do house work? _____ hours

8.14 About how many hours per week did you watch TV or read? _____hours

8.15 During the past 12 months, has your weight changed significantly?

☐ About the same as before ☐ Yes, gained ≥2.5 kg ☐ Yes, lost ≥2.5 kg

8.16 Have you tried to reduce weight in the past 12 months? No ☐, Yes ☐

8.17 How much did you weigh when you were at age 25? (If unknown put #) ☐☐☐ jin

Section 9: Reproductive history (for women)

9.1 How old were you when you had your first menstrual period? ☐☐ Year

9.2 Have you had your menopause?

☐ No
☐ Yes, currently
☐ Yes, had menopause → If so, age of completion of menopause: ☐☐ Year

9.3 How many times have you ever been pregnant? (if none, put 0. Go to Q9.6) ☐☐ imes

— Of which,

Live birth ☐☐ times → If none, Go to Q9.6

Still birth ☐ times, Spontaneous abortion ☐☐ times, Induced abortion ☐☐ times

9.4 Age and length of breastfeeding at each live birth (twins=one birth)?

Live Birth	Age at end of pregnancy	Months of breastfeeding
1st	☐☐	☐☐
2nd	☐☐	☐☐
3rd	☐☐	☐☐
4th	☐☐	☐☐
5th	☐☐	☐☐

9.6 Have you ever used oral contraceptive pills?

☐ Never → ***If ticked, please go to Q9.9***
☐ Past use → **if ticked,** age when you last stopped the pill: ☐☐ Year
☐ Current use

9.7 How old were you when you first used oral contraceptives? ☐☐ Year

9.8 For how long altogether have you used oral contraceptives? ☐☐ Year

9.9 Have you had a hysterectomy?

☐ No**,** ☐ Yes → If yes, age when you had the operation ☐☐ Year

9.10 Have you had one or both ovaries removed?

☐ No**,** ☐ Yes → If yes, age when you had the most recent operation ☐☐ Year

9.11 Have you ever had surgery to remove a breast lump?

☐ No, ☐ Yes → If yes, age when you most recently had the operation ☐☐ Year

Section 10: Sleeping, mood & mental situation

10.1 In general, how satisfied are you with your life?

- ☐ Very satisfied
- ☐ Satisfied
- ☐ Neither satisfied nor dissatisfied
- ☐ Unsatisfied
- ☐ Very unsatisfied

10.2 Over the past two years have you had any of the following major events in your life?

Yes	No		Yes	No	
□	□	Marital separation/divorce	□	□	Major injury or traffic accident
□	□	Loss of job/retirement	□	□	Death /major illness of spouse
□	□	Business bankrupt	□	□	Death/major illness of other close family member
□	□	Violence	□	□	Major natural disaster (e.g. flood & drought)
□	□	Major conflict within family	□	□	Loss of income / living on debt

10.3 During the past month, did you have any of the following for ≥3 days each week?

Yes	No	
□	□	Taking >30 minutes to fall asleep after going to bed or waking up in the middle of the night
□	□	Waking up early and not being able to go back to sleep
□	□	Needing to take medicine (including herbal or sleeping pills) at least once a week to help sleep
□	□	Having difficulty staying alert while at work, eating or meeting people during daytime

10.4 Do you usually take a daytime nap? □ Yes usually, □ Yes ,but only in summer , □ No

10.4a Do you snore during sleep? □ Yes, Frequently, □ Yes, Sometimes, □ No / Don't know

10.5 How many hours do you typically sleep per day (incl. naps)? ☐☐ Hours

10.6 During the past 12 months, have you had following situations for 2 or more weeks?

(If answer yes to any of the questions, complete CIDI-SF, starting from A1a)

Yes	No	
□	□	Feeling much more sad, or depressed than usual
□	□	Loss of interest in most things like hobbies or activities that usually give you pleasure
□	□	Felt so hopeless that you had no appetite to eat even your favourite food
□	□	Feeling worthless and useless, everything went wrong was your fault and life is very difficult that there was no way out

10.7 During the past 12 months, have you experienced the following situations?

Yes	No	
□	□	Having a period lasting <u>one month or longer</u> when <u>most of time</u> you felt worried, tense, or anxious and it interfered your life *(if yes, go to CIDI-SF, B1a section)*
□	□	Having a pain or discomfort in your body lasting ≥3 months that interfered with your life

□ □ Having had a spell or an attack when all of sudden felt frightened, anxious, or very uneasy

□ □ Having had inexplicable strong fear in situations such as closed space (cave, elevator, airplane etc), in the crowds or public such that you would avoid such situations

Section 11: Physical examination

11.1 **Standing height** (without shoes) …… ☐☐☐.☐ cm

11.2 **Sitting height** …… ☐☐☐.☐ cm

11.3 **Waist** …… ☐☐☐.☐ cm

11.4 **Hip** …… ☐☐☐.☐ cm

11.5 **Weight** (without shoes, but in light clothing) …… ☐☐☐.☐ Kg

11.6 **BMI** …… ☐☐.☐ Kg/m^2

11.7 **Impedance** …… ☐☐☐ **Ω**

Staff code ☐☐☐

11.8 **Fat %** (with one decimal point) …… ☐☐.☐

11.9 **Did you take any drugs to lower blood pressure in the last 2 days?** ☐ Yes ☐ No

11.10 **Blood pressure & heart rate** (to be measured after 5 minutes in the seated position)

	First	Second
SBP	☐☐☐	☐☐☐
DBP	☐☐☐	☐☐☐
Heart rate	☐☐☐	☐☐☐

11.10a **Hours since last ate anything (ignore any drinks)? _____ hours** *Staff code* ☐☐☐

11.11 **Blood sample collected:** Yes ☐, □ Failed ☐

11.12 **Lung function & CO levels:**

	First	Second
CO	☐☐☐.☐☐	☐☐☐.☐☐
%COHB		
FEV1	☐.☐☐	☐.☐☐
FVC	☐.☐☐	☐.☐☐

Staff code ☐☐☐

11.13 **Assessment of subject's cooperation and the reliability of data collected?**

a) Subject's cooperation?

☐ Good

b) The reliability of the information collected?

☐ Good

☐ Fair	☐ Fair
☐ Poor	☐ Poor

Date of interview _____Year_____Month____Day, **Signature of interviewer**_____

C.2 Imputation methods for missing health insurance (HI) membership information

The following steps were used to impute the missing HI membership information:

(1) The “unknown” HI scheme was used to code participants that were insured, but whose HI type could not be identified. To reduce the proportion of unknown HI types in 2012-2017, the unknown scheme was imputed by participants’ HI scheme in the previous year (if not uninsured or unknown), or by participants’ HI scheme in the following year (if not uninsured or unknown).

(2) Between 2009 and 2011, all participants were assumed to be enrolled in the same HI scheme as in 2012.

(3) If uninsured participants in 2012 (5.5%) had a hospital admission reported in the HI records in 2009-2011, they were coded as having unknown HI type for that given year.

(4) Participants censored before 2012 (0.6%) were assumed to be insured and their HI type was replaced by a “Missing” scheme.

(5) Participants with missing and unknown HI scheme in 2012-2017 (1.3%), had their HI scheme replaced by one of the three main schemes (UEBMI, URBMI, NRCMS) based on their self-reported occupation at entry into the study:

a) For participants who reported being agriculture or related workers, their missing/unknown scheme was replaced by NRCMS.

b) For participants living in rural areas, their missing/unknown scheme was replaced by NRCMS, as the majority of individuals living in rural areas were enrolled in this scheme in 2012-2017.

c) For participants living in urban areas and in formal employment (factory worker, sales and services, administration/manager, professional/technical), their missing scheme was replaced by UEBMI.

d) For participants living in urban areas and in informal employment (housewife/househusband, unemployed, other or non-stated), their missing/unknown scheme was replaced by URBMI.

e) For retired individuals living in urban areas, if they were male and aged ⩾60 or female and aged ⩾55 (official retirement ages), their missing/unknown scheme was replaced by UEBMI, as the majority of retired individuals in urban areas were enrolled in UEBMI in 2012-2017.

f) Remaining participants with an unknown/missing information about scheme (0.02% in 2009-2017) were combined with the uninsured category.

C.3 The health insurance characteristics questionnaire

须知 / INSTRUCTIONS

地区/城市名称:	从下拉列表中选择一个中心
Name of CKB Regional Centre (RC code)	Choose one centre from the drop down list

所有问题都是针对上面选择的城市（城市区域中心）或县（农村区域中心）

对于每个健康保险计划（选项卡一到四），请尽可能完整地填写表格中的信息
For each health insurance scheme (tabs 1-4), please complete the information in the tables to the best of your knowledge

如果调查问卷中提供的信息（标签一到二）在公开网站可以找到，请在第五部分参考文献告诉我们网址或将相关文件直接邮寄给NCC。
If the information asked in the questionnaire (tabs 1-2) is openly available online, could you please share the website links in

问卷

第一节: 职工基本医疗保险 / Section 1: Urban Employee Basic Medical Insurance Scheme (UEBMI)

第二节 : 城镇居民基本医疗保险 / Section: Urban Resident Basic Medical Insurance Scheme (URBMI)

第三节: 新型农村合作医疗 / Section 3: New Rural Cooperative Medical Scheme (NRCMS)

第四节: 商业健保 / Section 4: Commercial health insurance

第五节: 引用 / Section 5: References

谢谢！/ THANK YOU！

社会医疗保险: 职工基本医疗保险
Health Insurance Scheme: Urban Employee Basic Medical Insurance (UEBMI)

1.1 请注明职工基本医疗保险开始日期：
Please indicate the date when the UEBMI started to be enrolled: 月 month / 年 year

1.2 请填写表一
Please fill in TABLE 1:

	参保率 (%) Enrolment rate	每人每年总保费 (¥) Total premium per person per year	住院治疗 / Inpatient Care										门诊治疗 / Outpatient Care									
			报销率 (%) Reimbursement rate			每人每年报销最高限额 (¥) Reimbursement ceiling per year			每人每年预付限额 (¥) Deductible limit per person per year			主要支付类型[4] Main hospital payment method	报销率 (%) Reimbursement rate			每人每年报销最高限额 (¥) Reimbursement ceiling per year			每人每年预付限额 (¥) Deductible limit per person per year			主要支付类型[4] Main hospital payment method
			三级医院[1] Tier III	二级医院[2] Tier II	一级医院[3] Tier I	三级医院 Tier III	二级医院 Tier II	一级医院 Tier I	三级医院 Tier III	二级医院 Tier II	一级医院 Tier I		三级医院 Tier III	二级医院 Tier II	一级医院 Tier I	三级医院 Tier III	二级医院 Tier II	一级医院 Tier I	三级医院 Tier III	二级医院 Tier II	一级医院 Tier I	
2008												*请选择一个选项*										*请选择一个选项*
2009												*请选择一个选项*										*请选择一个选项*
2010												*请选择一个选项*										*请选择一个选项*
2011												*请选择一个选项*										*请选择一个选项*
2012												*请选择一个选项*										*请选择一个选项*
2013												*请选择一个选项*										*请选择一个选项*
2014												*请选择一个选项*										*请选择一个选项*
2015												*请选择一个选项*										*请选择一个选项*
2016												*请选择一个选项*										*请选择一个选项*
2017												*请选择一个选项*										*请选择一个选项*

[1] 三级医院 / Hospital tier III: 最高级别，包括国家，省，市，医学院附属医院 / Higher level facility, includes national, provincial, municipal and medical-school affiliated hospitals
[2] 二级医院 / Hospital tier II: 县，区医院 / County and district hospitals
[3] 一级医院 / Hospital tier I: 社区保健中心/车站，乡镇卫生所和乡村诊所 / Community health centres/stations, township health centres and village clinics.

[4] 主要病人支付类型 : 医疗保险经办机构与医疗机构根据不同医疗服务的性质和特征将医疗服务划分为不同的付费单元并确定付费及标准的方法和措施
Main patient payment types: Medical insurance agencies and medical institutions divide medical services into different payment units according to the nature and characteristics of different medical services and determine the methods and measures for payment

-按病种分组付费 :疾病诊断相关分类付费 / Payment by disease category: payment by category related to disease diagnosis

-单病种付费: 医疗保险经办机构按照每种疾病的诊断确定定额支付标准，向医疗机构支付医疗费用 / Single disease payment: The medical insurance agency determines the

-按人头付费: 医疗保险经办机构按合同规定的时间（一月、一季度或一年），根据医疗机构服务的参保人数和每个人的支付定额标准，向医疗机构支付费用，医疗机构按合同规定提供医疗服务 / Pay per capita: The medical insurance agency p

社会医疗保险: 城镇居民基本医疗保险
Health Insurance Scheme: Urban Resident Basic Medical Insurance (URBMI)

2.1 请注明城镇居民基本医疗保险开始日期
Please indicate the date when the URBMI started to be enrolled:

月 month / 年 year

2.2 请填写表二：
Please fill in TABLE 2:

	参保率 (%) Enrolment rate	每人每年总保费 (¥) Total premium per person per year				住院治疗 / Inpatient Care										门诊治疗 / Outpatient Care									
						报销率 (%) Reimbursement rate			每人每年报销最高限额 (¥) Reimbursement ceiling per year			每人每年预付限额 (¥) Deductible limit per person per year			主要支付类型[4] Main hospital payment method	报销率 (%) Reimbursement rate			每人每年报销最高限额 (¥) Reimbursement ceiling per year			每人每年预付限额 (¥) Deductible limit per person per year			主要支付类型[4] Main hospital payment method
		总额 Total	个人贡献 Individual contribution	地方政府补贴 Local government subsidy	中央政府的贡献 Central government contribution	三级医院[1] Tier III	二级医院[2] Tier II	一级医院[3] Tier I	三级医院 Tier III	二级医院 Tier II	一级医院 Tier I	三级医院 Tier III	二级医院 Tier II	一级医院 Tier I		三级医院 Tier III	二级医院 Tier II	一级医院 Tier I	三级医院 Tier III	二级医院 Tier II	一级医院 Tier I	三级医院 Tier III	二级医院 Tier II	一级医院 Tier I	
2008															*请选择一个选项*										*请选择一个选项*
2009															*请选择一个选项*										*请选择一个选项*
2010															*请选择一个选项*										*请选择一个选项*
2011															*请选择一个选项*										*请选择一个选项*
2012															*请选择一个选项*										*请选择一个选项*
2013															*请选择一个选项*										*请选择一个选项*
2014															*请选择一个选项*										*请选择一个选项*
2015															*请选择一个选项*										*请选择一个选项*
2016															*请选择一个选项*										*请选择一个选项*
2017															*请选择一个选项*										*请选择一个选项*

2.3 2008年至2017年，城镇居民基本医疗和新型农村合作医疗保险合并？
Did the URBMI and NRCMS merge between 2008 and 2017?

如果是，何时？
If YES. when ?

月/年

[1] 三级医院 / Hospital tier III: 最高级别，包括国家，省，市，医学院附属医院 / Higher level facility, includes national, provincial, municipal and medical-school affiliated hospitals
[2] 二级医院 / Hospital tier II: 县，区医院 / County and district hospitals
[3] 一级医院 / Hospital tier I: 社区保健中心/车站，乡镇卫生所和乡村诊所 / Community health centres/stations, township health centres and village clinics.

[4] 主要病人支付类型：医疗保险经办机构与医疗机构根据不同医疗服务的性质和特征将医疗服务划分为不同的付费单元并确定付费及标准的方法和措施
Main patient payment types: Medical insurance agencies and medical institutions divide medical services into different payment units according to the nature and characteristics of different medical services and determine the methods and measures for payment and standards

-按病种分组付费 疾病诊断相关分类付费 / Payment by disease category: payment by category related to disease diagnosis

-单病种付费: 医疗保险经办机构按照每种疾病的诊断确定定额支付标准，向医疗机构支付医疗费用 / Single disease payment: The medical insurance agency determines the fixed

-按人头付费: 医疗保险经办机构按合同规定的时间（一月、一季度或一年），根据医疗机构服务的参保人数和每个人的支付定额标准，向医疗机构支付费用，医疗机构按合同规定提供医疗服务 / Pay per capita: The medical insurance agency pays the medical

社会医疗保险: 新型农村合作医疗
New Rural Cooperative Medical Scheme

3.1 请注明新型农村合作医疗开始日期：
Please indicate the date when the NRCMS started to be enrolled:

月 month / 年 year

3.2 请填写表三：
Please fill in TABLE 3:

	参保率 (%) Enrolment rate	每人每年总保费 (¥) Total premium per person per year				住院治疗 / Inpatient Care										门诊治疗 / Outpatient Care									
						报销率 (%) Reimbursement rate			每人每年报销最高限额 (¥) Reimbursement ceiling per year			每人每年预付限额 (¥) Deductible limit per person per year			主要支付类型[4] Main hospital payment method	报销率 (%) Reimbursement rate			每人每年报销最高限额 (¥) Reimbursement ceiling per year			每人每年预付限额 (¥) Deductible limit per person per year			主要支付类型[4] Main hospital payment method
		总额 Total	个人贡献 Individual contribution	地方政府补贴 Local government subsidy	中央政府的贡献 Central government contribution	三级医院[1] Tier III	二级医院[2] Tier II	一级医院[3] Tier I	三级医院 Tier III	二级医院 Tier II	一级医院 Tier I	三级医院 Tier III	二级医院 Tier II	一级医院 Tier I		三级医院 Tier III	二级医院 Tier II	一级医院 Tier I	三级医院 Tier III	二级医院 Tier II	一级医院 Tier I	三级医院 Tier III	二级医院 Tier II	一级医院 Tier I	
2008															*请选择一个选项*										*请选择一个选项*
2009															*请选择一个选项*										*请选择一个选项*
2010															*请选择一个选项*										*请选择一个选项*
2011															*请选择一个选项*										*请选择一个选项*
2012															*请选择一个选项*										*请选择一个选项*
2013															*请选择一个选项*										*请选择一个选项*
2014															*请选择一个选项*										*请选择一个选项*
2015															*请选择一个选项*										*请选择一个选项*
2016															*请选择一个选项*										*请选择一个选项*
2017															*请选择一个选项*										*请选择一个选项*

[1] 三级医院 / Hospital tier III: 最高级别，包括国家，省，市，医学院附属医院 / Higher level facility, includes national, provincial, municipal and medical-school affiliated hospitals
[2] 二级医院 / Hospital tier II: 县，区医院 / County and district hospitals
[3] 一级医院 / Hospital tier I: 社区保健中心/车站，乡镇卫生所和乡村诊所 / Community health centres/stations, township health centres and village clinics.

[4] 主要病人支付类型：医疗保险经办机构与医疗机构根据不同医疗服务的性质和特征将医疗服务划分为不同的付费单元并确定付费及标准的方法和措施
Main patient payment types: Medical insurance agencies and medical institutions divide medical services into different payment units according to the nature and characteristics of different medical services and determine the methods and measures for payment

-按病种分组付费 :疾病诊断相关分类付费 / Payment by disease category: payment by category related to disease diagnosis

-单病种付费: 医疗保险经办机构按照每种疾病的诊断确定定额支付标准，向医疗机构支付医疗费用 / Single disease payment: The medical insurance agency determines the fixed payment

-按人头付费: 医疗保险经办机构按合同规定的时间（一月、一季度或一年），根据医疗机构服务的参保人数和每个人的支付定额标准，向医疗机构支付费用，医疗机构按合同规定提供医疗服务 / Pay per capita: The medical insurance agency pays th

社会医疗保险: 商业或私人健康保险
Health Insurance Scheme: Commercial or Private

4.1 请填写表四:
Please fill in TABLE 4:

	参保率 (%) Enrolment rate
2008	
2009	
2010	
2011	
2012	
2013	
2014	
2015	
2016	
2017	

引用 / References

5.1 请在下面的框中注明填写调查问卷的参考资料（如网站）：
Please indicate the sources (e.g. websites) that were used to fill in the questionnaire (tabs 1 - 4) in the box below:

5.2 请在下面的框中注明填写调查问卷的参考资料（如网站）：
Please add any comments or additional information that might be relevant

C.4 Assumptions related to the data collection for HI characteristics

During this second phase of secondary data collection for HI characteristics and in order to match HI characteristics data and the long-term follow-up data of CKB participants, the following assumptions were made:

- When policy information for a CKB city or county was not found, policy documents for the higher geographical administrative unit (e.g. city-level if county-level data was not found and province-level if city-level was not found) were retrieved instead.
- When policy information for a specific year was not found, the HI characteristics were assumed to be unchanged between the two years for which data could be found.
- When the deductibles varied with the hospital admission number (i.e. first, second or third in the year), only HI characteristics corresponding to the first admission in the year were recorded (in 4 CKB centres).
- When reimbursement rates varied with the amount of medical expenses, the reimbursement rate for the medical expense range that covered average hospitalisation costs for stroke, IHD or any cause, as reported in the China Health Yearbooks, was used (in 7 CKB centres).
- The influence of other HI programmes or health policies on HI characteristics in some centres was not taken into account. For example, in Hainan province (CKB centre: Haikou), the health poverty alleviation policy (2016) increased the reimbursement rate of the NRCMS by 5%, and in

Qingdao reimbursements rates were 5% higher in tier 1 hospitals that implemented the National Essential Medicine System.

- HI characteristics data for hospital tiers below tier 1 were not collected. For instance, in two CKB centres, community and township health centres had different HI characteristics than tier 1 hospitals.
- When the reimbursement ceiling varied depending on the number of consecutive enrolment years, the ceiling for the first enrolment year was used (in 2 CKB centres).
- When secondary data sources reported HI characteristics by township/county/city/province level instead of by hospital tier (in 2 CKB centres), the following assumptions were made: city level hospitals were equivalent to tier 3 hospitals, county level hospitals were equivalent to tier 2 hospitals, and township level hospitals were equivalent to tier 1 hospitals. HI characteristics for province-level hospitals were not reported as most tier 3 hospitals attended by CKB participants were assumed to be city-level rather than provincial-level hospitals.

Other very rare variations in HI characteristics could not be captured, including variations in reimbursement rates for URBMI or NRCMS by type of premium (in 2 CKB centres) and lower reimbursement rates and higher deductibles for outside region hospitals, due to lack of corresponding data in the CKB study.

C.5 Approximated equivalent household income

Equivalent income was not used as the main income variable in the thesis, because self-reported income data was collected as income categories and data on the age distribution of the household composition were not available in the CKB. Approximated equivalent household income was estimated by dividing the mid-point of participants' income category by the square root of the household size (square root scale). When cross tabulating the original income groups and quartiles of approximated equivalent income at baseline for participants alive in 2009, there was substantial overlap:

- 99.6% of participants in the 1st approximated equivalent income quartile were in the income category: <10 000¥
- 96.7% of participants in the 2nd approximated equivalent income quartile were in the income category 10 000-19 999¥
- 78.5% of participants in the 3rd approximated equivalent income quartile were in the income category 20 000-34 999¥
- 84.9% of participants in the 4th approximated equivalent income quartile were in the income category >35 000¥

D. Socioeconomic differences in hospital care utilisation and outcomes for stroke and ischaemic heart disease in China

D1. Selection of statistical models

The modified Park test was used to identify the appropriate variance function, and the Pregibon link test[1] and Modified Hosmer-Lemeshow test[2] were used to test the link function.[1-3]

For rates of hospitalisation, the Poisson family was preferred over Gamma, Gaussian NLLS and Inverse Gaussian or Wald models, and the Log link was preferred over the Identity and Square root link. Then, models using Poisson and Negative Binomial distributions were compared, and the Negative Binomial distribution was selected as the likelihood ratio test indicated a significant over-dispersion parameter (i.e. over dispersion of 0 count; $p<0.001$) for this model.

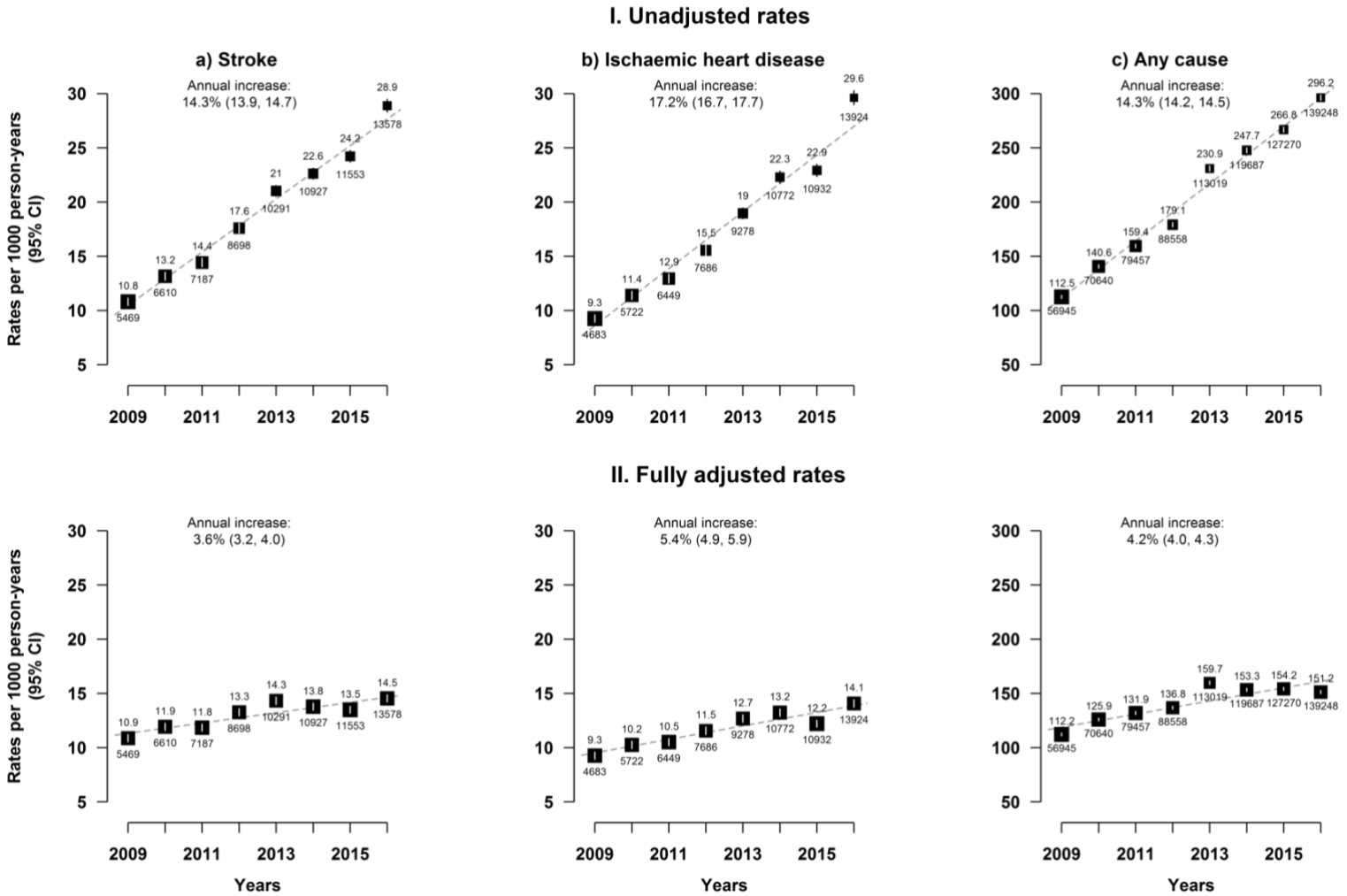
Values of mean length of stay (LOS) were positive and their distribution was highly skewed. For ALOS, the Modified Park test indicated that the Gamma family was preferred (any cause: coefficient 2.03) and results for tests of GLM Log link were all non-significant (any cause: Pregibon Link test: 0.13, Modified Hosmer-Lemeshow test: 0.41).

[1]Checks for linearity of response on the scale of estimation.
[2]Checks for systematic bias in fit on raw scale.

D2. Imputation methods for missing values for length of stay

Multiple imputations with Poisson regression adjusted with the same covariates (e.g. calendar years, demographic, socioeconomic, lifestyle, and morbidity factors, region and type of stroke and IHD) as included in fully adjusted model for ALOS overall, were used. The number of imputations (*m*) was chosen based on: m≥100*Fraction of Missing Information.[4] The number of imputations used was 20, 10 and 5 in models for stroke, IHD and any cause, respectively.

Figure D.1 Annual unadjusted and fully adjusted rates of hospitalisation for stroke, ischaemic heart disease and any cause



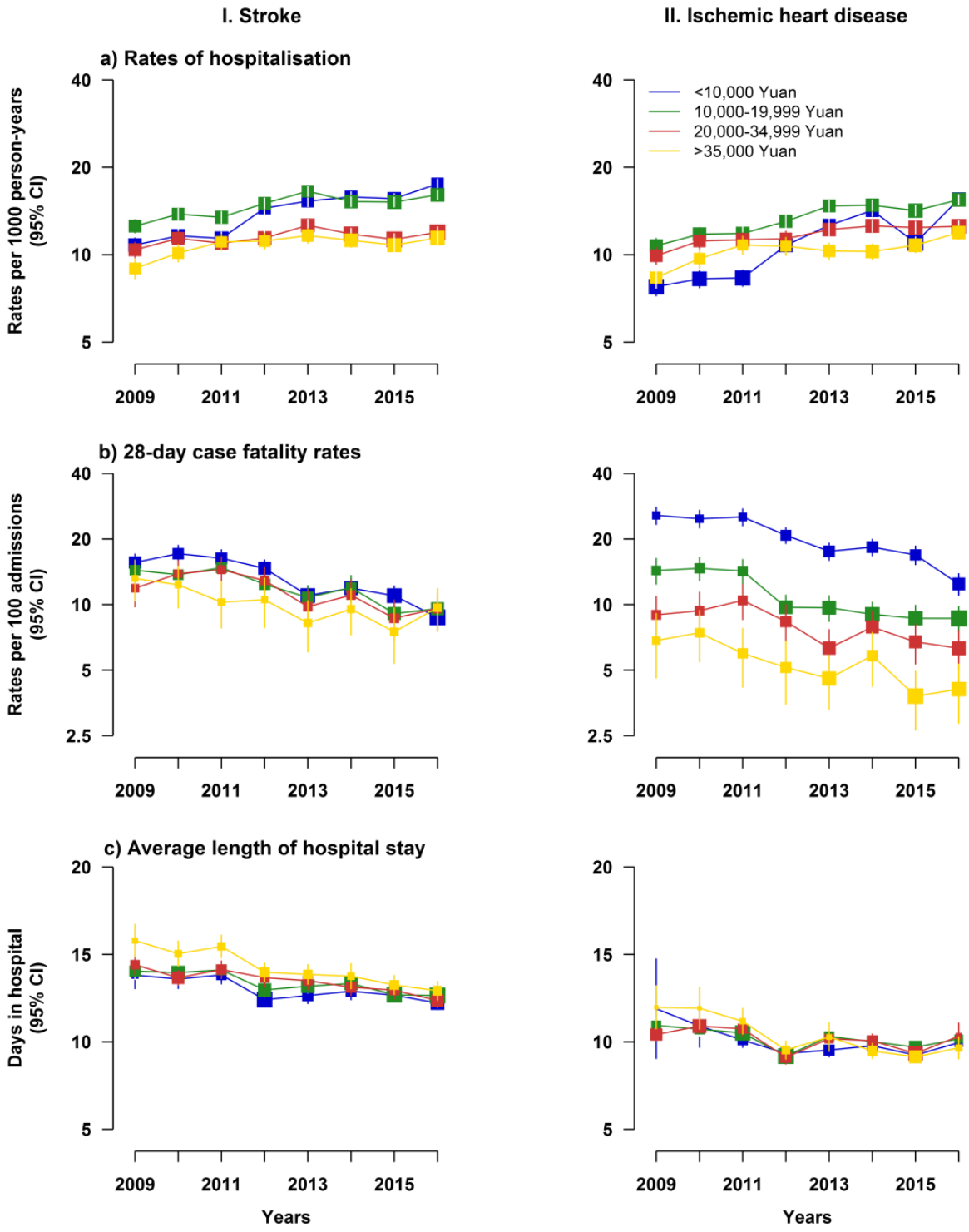
Rates of hospitalisation were standardised for the overall CKB participant population in 2009. Numbers above the squares are rates per 1000 person-years. Numbers below the squares are numbers of admissions. The area of each square is inversely proportional to the variance.

Table D.1 Differences in fully adjusted rates of hospitalisation between highest and lowest category of each socioeconomic characteristic and slope index of inequality (SII) (per 1000 person-years), by calendar year

	Stroke					Ischaemic heart disease				
	Urban/ Rural	Education		Health insurance		Urban/ Rural	Education		Health insurance	
	Diff[1]	Diff[1]	SII[2]	Diff[1]	SII[2]	Diff[1]	Diff[1]	SII[2]	Diff[1]	SII[2]
2009	4.81 (0.34)	0.07 (0.50)	-0.04 (0.50)	2.43 (0.36)	4.78 (0.58)	6.66 (0.34)	-0.19 (0.53)	-0.07 (0.52)	3.15 (0.36)	6.20 (0.58)
2010	4.66 (0.34)	1.23 (0.50)	1.39 (0.51)	2.34 (0.36)	4.62 (0.58)	7.52 (0.34)	1.68 (0.54)	2.10 (0.53)	3.82 (0.37)	7.50 (0.60)
2011	6.82 (0.33)	0.61 (0.50)	0.80 (0.50)	4.04 (0.36)	7.93 (0.58)	9.05 (0.34)	2.64 (0.52)	3.54 (0.51)	5.65 (0.37)	11.12 (0.64)
2012	6.78 (0.34)	-1.46 (0.54)	-1.64 (0.53)	3.45 (0.38)	6.80 (0.61)	5.65 (0.34)	0.16 (0.57)	0.47 (0.56)	3.05 (0.41)	6.00 (0.68)
2013	7.74 (0.35)	-1.27 (0.53)	-1.57 (0.53)	3.33 (0.38)	6.56 (0.61)	7.13 (0.35)	-1.12 (0.53)	-1.56 (0.53)	2.75 (0.39)	5.42 (0.64)
2014	5.71 (0.32)	-1.86 (0.51)	-2.19 (0.50)	1.80 (0.35)	3.56 (0.56)	6.25 (0.34)	-2.66 (0.55)	-3.10 (0.54)	1.32 (0.38)	2.61 (0.62)
2015	6.41 (0.31)	-2.30 (0.49)	-2.53 (0.48)	2.16 (0.34)	4.28 (0.54)	7.88 (0.32)	0.37 (0.50)	0.72 (0.48)	3.21 (0.35)	6.32 (0.57)
2016	5.50 (0.32)	-3.06 (0.51)	-3.45 (0.50)	2.24 (0.35)	4.43 (0.56)	5.74 (0.33)	-3.33 (0.56)	-3.64 (0.53)	2.24 (0.39)	4.42 (0.63)
p-value for trend	0.0155	<0.0001	<0.0001	0.0392	0.0138	0.0113	<0.0001	<0.0001	<0.0001	<0.0001

Standard errors are shown in parentheses below. [1]Diff: difference in predicted rates between the highest and lowest group of each socioeconomic characteristic. [2]SII: difference in predicted rates between the highest (ridit score of 1) and the lowest (ridit score of 0) values of the distribution of each socioeconomic characteristic. SII for urban/rural were not estimated, due to collinearity between the ridit score and the region covariate. Rates were standardised for the overall CKB participant population in 2009 for education and HI, and for the separate populations of CKB participants living in urban or rural areas, respectively, in 2009 for urban/rural.

Figure D.2 Fully adjusted annual rates of hospitalisation, 28-day case fatality and average length of stay for stroke and ischaemic heart disease, by income



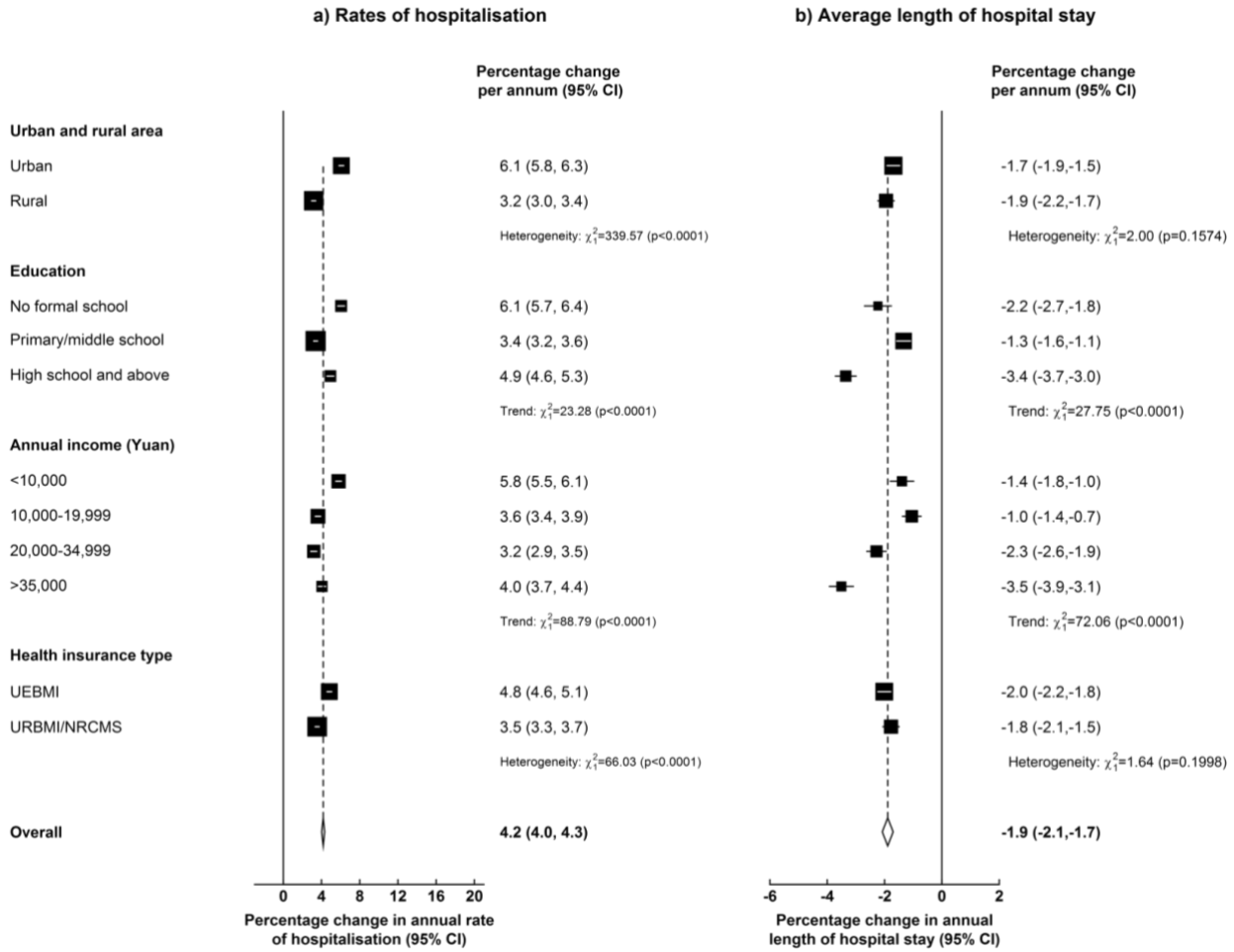
All estimates were standardised for the overall CKB participant population in 2009. The area of each square is inversely proportional to the variance.

Table D.2 Differences in fully adjusted 28-day case fatality rates between lowest and highest category of each socioeconomic characteristic and slope index of inequality (SII) (per 100 events), by calendar year

	Stroke					Ischaemic heart disease				
	Urban/ Rural	Education		Health insurance		Urban/Rural	Education		Health insurance	
	Diff[1]	Diff[1]	SII[2]	Diff[1]	SII[2]	Diff[1]	Diff[1]	SII[2]	Diff[1]	SII[2]
2009	14.30 (0.88)	0.03 (1.89)	0.86 (1.66)	7.04 (1.13)	16.05 (2.28)	11.73 (1.12)	4.03 (1.77)	4.43 (1.75)	13.16 (1.10)	16.05 (2.28)
2010	12.85 (0.90)	-0.40 (1.67)	1.92 (1.62)	3.80 (1.12)	14.61 (2.16)	10.75 (1.06)	6.79 (1.79)	8.46 (1.82)	12.57 (1.05)	14.61 (2.16)
2011	15.74 (0.88)	4.93 (1.70)	6.18 (1.51)	6.69 (1.08)	14.80 (2.12)	10.61 (1.04)	7.24 (1.65)	8.86 (1.69)	12.65 (1.03)	14.80 (2.12)
2012	14.97 (0.82)	2.79 (1.50)	4.67 (1.39)	6.26 (0.97)	9.38 (1.60)	8.82 (0.85)	-0.29 (1.41)	-0.37 (1.38)	9.62 (0.83)	9.38 (1.60)
2013	12.05 (0.77)	1.34 (1.40)	1.88 (1.28)	3.44 (0.91)	8.69 (1.44)	9.74 (0.77)	3.50 (1.18)	4.35 (1.19)	8.85 (0.77)	8.69 (1.44)
2014	11.75 (0.81)	-0.20 (1.51)	0.40 (1.39)	3.41 (0.93)	7.07 (1.42)	7.70 (0.78)	0.14 (1.27)	0.19 (1.26)	8.37 (0.77)	7.07 (1.42)
2015	10.05 (0.76)	-1.31 (1.34)	-1.08 (1.25)	3.02 (0.85)	7.49 (1.42)	5.70 (0.77)	3.11 (1.16)	3.67 (1.17)	8.30 (0.75)	7.49 (1.42)
2016	7.75 (0.75)	-2.21 (1.24)	-2.84 (1.18)	1.33 (0.82)	4.09 (1.20)	4.86 (0.72)	-0.44 (1.11)	-0.44 (1.10)	6.24 (0.69)	4.09 (1.20)
p-value for trend	<0.0001	0.0163	<0.0001	<0.0001	<0.0001	0.0022	0.0006	<0.0001	<0.0001	<0.0001

Standard errors are shown in parentheses below. [1]Diff: difference in predicted rates between the lowest and highest group of each socioeconomic characteristic. [2]SII: difference in predicted rates between the lowest (ridit score of 0) and the highest (ridit score of 1) values of the distribution of each socioeconomic characteristic. SII for urban/rural were not estimated, due to collinearity between the ridit score and the region covariate. Rates were standardised for the overall CKB participant population in 2009 for education and HI, and for the separate populations of CKB participants living in urban or rural areas, respectively, in 2009 for urban/rural.

Figure D.3 Fully adjusted annual percentage change in rates of hospitalisation and average length of hospital stay for any cause, by urban/rural area, education, income and health insurance type



In analyses by health insurance type, uninsured participants were excluded due to small number of events. UEBMI: urban employee basic medical insurance. URBMI/NRCMS: urban resident basic medical insurance/new rural cooperative medical scheme. The area of each square is inversely proportional to the variance.

Table D.3 Differences in fully adjusted average length of stay between highest and lowest category of each socioeconomic characteristic and slope index of inequality (SII) (in days), by calendar year

	Stroke					Ischaemic heart disease				
	Urban/ Rural	Education		Health insurance		Urban/ Rural	Education		Health insurance	
	Diff[1]	Diff[1]	SII[2]	Diff[1]	SII[2]	Diff[1]	Diff[1]	SII[2]	Diff[1]	SII[2]
2009	2.28 (0.35)	0.73 (0.73)	1.07 (0.65)	3.55 (0.36)	7.21 (0.61)	3.72 (0.80)	0.64 (0.59)	0.85 (0.74)	3.70 (0.77)	3.45 (1.34)
2010	2.74 (0.24)	1.84 (0.38)	2.38 (0.40)	3.81 (0.28)	7.75 (0.51)	4.45 (0.40)	0.96 (0.94)	1.44 (0.79)	4.40 (0.39)	5.00 (0.69)
2011	2.23 (0.28)	1.62 (0.38)	2.07 (0.41)	3.84 (0.31)	7.81 (0.56)	3.97 (0.23)	1.79 (0.39)	2.44 (0.40)	3.97 (0.23)	4.25 (0.48)
2012	1.51 (0.22)	1.32 (0.37)	1.71 (0.36)	3.04 (0.25)	6.15 (0.45)	2.58 (0.18)	0.73 (0.30)	0.94 (0.31)	1.99 (0.18)	0.62 (0.38)
2013	0.89 (0.24)	0.21 (0.45)	0.37 (0.43)	2.96 (0.29)	6.00 (0.51)	3.02 (0.25)	0.02 (0.54)	0.16 (0.49)	3.48 (0.25)	3.41 (0.49)
2014	1.07 (0.25)	0.18 (0.42)	0.27 (0.42)	2.40 (0.29)	4.84 (0.50)	3.68 (0.19)	-0.19 (0.37)	-0.18 (0.35)	3.74 (0.20)	4.02 (0.42)
2015	1.04 (0.21)	-1.05 (0.40)	-1.23 (0.37)	2.41 (0.25)	4.86 (0.45)	3.14 (0.16)	-0.33 (0.31)	-0.29 (0.29)	3.20 (0.17)	3.08 (0.35)
2016	1.01 (0.19)	-1.07 (0.33)	-1.39 (0.32)	2.04 (0.22)	4.10 (0.37)	1.94 (0.28)	-0.50 (0.33)	-0.85 (0.38)	-0.03 (0.17)	0.71 (0.49)
p-value for trend	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0005	<0.0001	<0.0001	0.0609	0.0160

Standard errors are shown in parentheses below. [1]Diff: difference in predicted ALOS between the highest and lowest group of each socioeconomic characteristic. [2]SII: difference in predicted ALOS between the highest (ridit score of 1) and the lowest (ridit score of 0) values of the distribution of each socioeconomic characteristic. SII for urban/rural were not estimated, due to collinearity between the ridit score and the region covariate. ALOS were standardised for the overall CKB participant population in 2009 for education and HI, and for the separate populations of CKB participants living in urban or rural areas, respectively, in 2009 for urban/rural.

Table D.4 Annual differences in adjusted rates of hospitalisation, 28-day case fatality rates, average length of hospital stay and slope index of inequality (SII) between rural and urban participants, without region adjustment

	Rates of hospitalisation (per 1000 person-years)				Case fatality rates (per 100 events)				Average length of stay (in days)			
	Stroke		Ischaemic heart disease		Stroke		Ischaemic heart disease		Stroke		Ischaemic heart disease	
	Diff[1]	SII[2]	Diff[1]	SII[2]	Diff[1]	SII[2]	Diff[1]	SII[2]	Diff[1]	SII[2]	Diff[1]	SII[2]
2009	1.34 (0.33)	2.68 (0.52)	0.71 (0.34)	1.42 (0.53)	3.49 (1.05)	70.13 (16.46)	3.42 (1.20)	68.78 (19.24)	2.04 (0.39)	4.14 (0.62)	2.23 (1.39)	4.54 (2.16)
2010	0.86 (0.33)	1.72 (0.52)	0.91 (0.34)	1.81 (0.54)	1.36 (1.04)	27.21 (16.41)	2.03 (1.10)	40.61 (17.59)	2.80 (0.27)	5.71 (0.46)	3.54 (0.51)	7.33 (0.81)
2011	3.00 (0.32)	5.97 (0.51)	2.25 (0.33)	4.47 (0.53)	4.85 (1.03)	97.4 (16.16)	2.21 (1.07)	44.30 (17.16)	1.98 (0.32)	4.01 (0.53)	3.05 (0.26)	6.30 (0.45)
2012	2.57 (0.33)	5.11 (0.53)	-1.88 (0.38)	-3.82 (0.64)	4.49 (0.93)	90.15 (14.66)	1.57 (0.88)	31.39 (13.96)	0.86 (0.23)	1.73 (0.37)	1.70 (0.20)	3.46 (0.34)
2013	3.17 (0.34)	6.31 (0.54)	-1.20 (0.35)	-2.43 (0.58)	2.22 (0.87)	44.47 (13.67)	2.60 (0.80)	52.23 (12.84)	0.53 (0.29)	1.06 (0.47)	1.98 (0.28)	4.02 (0.48)
2014	1.33 (0.32)	2.64 (0.50)	-2.51 (0.34)	-5.09 (0.58)	2.02 (0.90)	40.48 (14.02)	0.32 (0.79)	6.42 (12.40)	0.91 (0.28)	1.83 (0.46)	3.03 (0.24)	6.25 (0.45)
2015	2.17 (0.30)	4.32 (0.47)	-0.18 (0.31)	-0.36 (0.50)	1.34 (0.86)	26.79 (13.43)	-0.85 (0.78)	-17.01 (12.34)	0.88 (0.25)	1.77 (0.41)	2.35 (0.20)	4.82 (0.36)
2016	1.00 (0.31)	1.98 (0.48)	-3.52 (0.33)	-7.20 (0.56)	-0.81 (0.88)	-16.21 (13.56)	-1.68 (0.72)	-33.64 (11.45)	1.23 (0.25)	2.48 (0.42)	1.64 (0.29)	3.33 (0.48)
p-value for trend	0.7720	0.6832	<0.0001	<0.0001	0.0003	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0984	0.0161

Standard errors are shown in parentheses below. [1]Diff: difference in predicted rates/ALOS between the highest and lowest group of each socioeconomic characteristic. [2]SII: difference in predicted rates/ALOS between the highest (ridit score of 1) and the lowest (ridit score of 0) values of the distribution of each socioeconomic characteristic. Rates/ALOS were standardised for the overall CKB participant population in 2009.

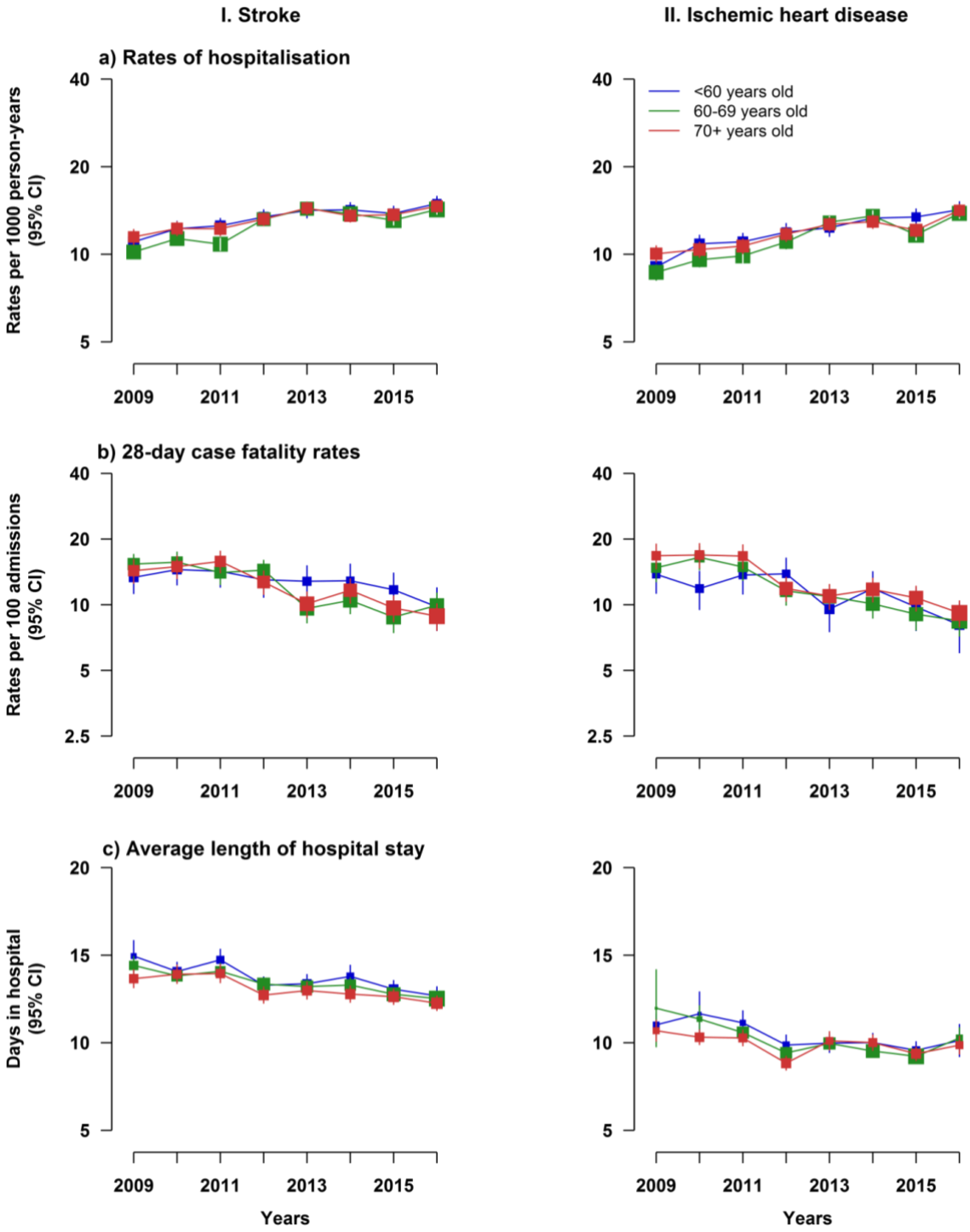
Table D.5 Fully adjusted annual percentage change in rates of hospitalisation, case fatality rates and ALOS for stroke and IHD by quartile of approximated equivalent household income

	Rates of hospitalisation		Case fatality rates		ALOS	
	Stroke	**IHD**	**Stroke**	**IHD**	**Stroke**	**IHD**
Quartile 1	7.32 (6.52, 8.13)	10.43 (9.40, 11.47)	-14.98 (-17.45, -12.44)	-18.93 (-21.49, -16.3)	-1.61 (-2.25, -0.97)	-2.00 (-3.71, -0.27)
Quartile 2	3.13 (2.31, 3.96)	5.62 (4.63, 6.62)	-12.71 (-15.6, -9.71)	-13.58 (-17.06, -9.96)	-1.57 (-2.10, -1.03)	-0.78 (-1.54, -0.01)
Quartile 3	1.85 (1.09, 2.62)	3.39 (2.54, 4.25)	-5.51 (-9.53, -1.31)	-11.68 (-15.24, -7.97)	-1.63 (-2.17, -1.09)	-0.23 (-1.41, 0.96)
Quartile 4	1.49 (0.64, 2.34)	2.67 (1.72, 3.63)	-10.37 (-14.58, -5.96)	-8.74 (-13.66, -3.54)	-2.52 (-3.15, -1.90)	-3.20 (-4.09, -2.30)

Table D.6 Annual percentage change (95% CI) in fully adjusted rates of hospitalisation, 28-day case fatality and average length of stay for stroke, ischaemic heart disease (IHD) and any cause, by age group

	Rates of hospitalisation		Case fatality rates		Average length of stay	
	Stroke	**IHD**	**Stroke**	**IHD**	**Stroke**	**IHD**
<60 years old	3.73 (2.91, 4.56)	5.78 (4.83, 6.74)	-6.53 (-10.06, -2.86)	-10.35 (-14.14, -6.39)	-2.01 (-2.61, -1.40)	-2.18 (-3.16, -1.20)
60-70 years old	4.29 (3.61, 4.98)	6.17 (5.36, 6.98)	-13.95 (-16.84, -10.95)	-15.95 (-19.09, -12.69)	-1.84 (-2.28, -1.39)	-2.14 (-3.47, -0.79)
≥70 years old	2.95 (2.28, 3.64)	4.58 (3.78, 5.39)	-13.11 (-15.53, -10.63)	-14.98 (-17.47, -12.42)	-1.78 (-2.25, -1.31)	-0.84 (-1.51, -0.16)

Figure D.4 Fully adjusted rates of hospitalisation, 28-day case fatality rates and average length of hospital stay for stroke and ischemic heart disease, by age group



All estimates were standardised for the overall CKB participant population in 2009. The area of each square is inversely proportional to the variance.

References

1. Pregibon D. Goodness of Link Tests for Generalized Linear Models. *Journal of the Royal Statistical Society Series C (Applied Statistics)*. 1980; **29**(1): 15-4.

2. Hosmer DW, Lemesbow S. Goodness of fit tests for the multiple logistic regression model. *Communications in Statistics - Theory and Methods*. 1980; **9**(10): 1043-69.

3. Manning WG, Mullahy J. Estimating log models: to transform or not to transform? *Journal of Health Economics*. 2001; **20**(4): 461-94.

4. White IR, Royston P, Wood AM. Multiple imputation using chained equations: Issues and guidance for practice. *Statistics in Medicine*. 2011; **30**(4): 377-99.

E. Gender differences in use of invasive diagnostic and therapeutic procedures for acute ischaemic heart disease in Chinese adults

E.1 Imputation methods for missing values for length of hospital stay

For participants with retrieved admission medical records (study outcomes: cardiac enzyme tests, coronary angiography, ECG, echocardiogram, CCTA, or Holter monitor test), 9% of IHD admissions had missing information on the length of stay (11% of admissions for men and 9% of admissions for women). For AMI, 14% of admissions had missing length of stay and the proportion was slightly lower in men (13%) than women (15%). For angina, 5% of admissions had missing length of stay and the proportion was slightly higher in men (6%) than women (4%). For other IHD, 12% of admissions had missing length of stay and the proportion was slightly higher in men (14%) than women (11%).

For all participants, regardless of whether admission medical records were retrieved (study outcome: coronary revascularisation), 6% of IHD admissions had missing information on the length of stay (7% of admissions for men vs 5% of admissions for women). For AMI, 11% of admissions had missing length of stay and the proportion was similar in men and women. For angina, 5% of admissions has missing length of stay and the proportion was slightly higher in men (5%) than women (4%). For other IHD, 5% of admissions had missing length of stay and the proportion was slightly higher in men (6%) than women (5%).

Checking the patterns of missingness, the odds of missing length of stay were related to several of the risk factors included in our main models. There was

evidence that missing length of stay was not missing completely at random (MCAR), thus it was assumed to be missing at random (MAR). All factors considered in the main analysis were included in the imputation. Multiple imputation with Poisson regression was used, and the same covariates (e.g. demographic factors, lifestyle factors, morbidity factors, health insurance type, socioeconomic factors, hospital tier and IHD type) as in the fully adjusted models for the use of diagnostic tests and procedures were included. The number of imputations (*m*) was chosen so that m≥100*Fraction of Missing Information.[1] Missing values were imputed using chained equations. The average length of stay was estimated using the 10 separate datasets including imputed data with estimates combined using Rubin's rules.[2]

Day case admissions (i.e. participants admitted and discharged on the same day) were counted as having a length of stay of 0.5 days.

Table E.1 Selected characteristics of men and women with retrieved medical records for hospital admissions for AMI, angina and other IHD, in 2004-2016

	AMI			Angina			Other IHD		
	Men (n=1558)	Women (n=937)	*P*	Men (n=3549)	Women (n=6284)	*P*	Men (n=4483)	Women (n=7597)	*P*
(A) Characteristics at baseline									
Age (years), Mean (SD)	58.8 (10.1)	62.4 (8.8)	**	58.3 (10.1)	58.7 (9.2)		60.9 (9.6)	59.2 (9.5)	**
Prior medical history, %									
Diabetes[1]	14.4	26.5	**	14.2	15.0		10.6	12.5	**
Hypertension[1]	55.7	60.7	*	52.5	44.7	**	55.1	48.9	*
Stroke or TIA	7.8	3.6	**	5.9	4.1	**	5.0	3.3	**
IHD	11.7	16.1	**	18.7	22.0	**	14.5	14.7	
CKD	1.7	2.1		3.2	3.9		1.6	2.3	**
Poor health status	11.5	19.1	**	12.7	16.2	**	13.8	18.7	
Mental illness	9.9	11.4		9.7	13.5	**	10.6	12.9	
Physical measurements									
Overweight or obese (>25 kg/m²), %	44.8	48.8		51.6	52.4		38.9	48.2	***
SBP (mmHg), Mean (SD)	142.3 (22.1)	145.8 (24.4)	**	138.8 (20.8)	134.8 (23.2)	**	140.5 (21.9)	138.3 (23.9)	**
Lifestyle characteristics									
Current smoker, %	62.6	6.7	**	51.6	3.9	**	53.2	3.9	**
Regular alcohol drinker, %	41.5	3.3	**	47.9	5.3	**	40.2	4.0	**
Physical activity (MET-h/day), Mean (SD)	15.6 (13.7)	12.7 (8.5)	**	14.2 (11.5)	13.2 (8.3)	**	15.4 (13.3)	14.1 (9.3)	**
Socioeconomic characteristics									
Currently married, %	94.0	76.6	**	94.3	82.4	**	90.7	82.0	**
Household size, Mean (SD)	3.5 (1.6)	3.3 (1.6)	**	3.2 (1.4)	3.1 (1.4)	**	3.6 (1.7)	3.5 (1.7)	*
High School or above, %	28.4	13.4	**	43.6	32.2	**	26.3	18.9	**
Annual household income ≥20 000¥, %	46.6	31.2	**	53.8	46.1	**	43.3	36.4	**
Rural residents, %	34.8	37.7		21.0	14.2	**	51.2	47.4	**
(B) Characteristics at hospital admission									
Age (years), Mean (SD)	64.9 (9.9)	68.6 (8.8)	**	64.5 (9.9)	64.9 (9.0)	*	67.3 (9.5)	65.8 (9.4)	**
Health insurance type[2], %			**						**
NRCMS or URBMI	36.7	48.6		19.6	19.5		48.8	50.5	
UEBMI	61.9	50.4		79.6	80.1		50.2	49.0	
Other or uninsured	1.4	1.1		0.7	0.5		1.0	0.5	
Hospital tier, %			*						*
Tier 1 or missing	9.2	12.3		10.0	10.2		29.4	32.7	
Tier 2	14.6	16.8		16.8	17.3		21.5	19.9	
Tier 3	76.3	71.0		73.2	72.6		49.1	47.4	

Length of stay (days)[3], Mean (SD)	10.5 (5.9)	10.7 (5.8)	10.4 (5.6)	9.1 (5.2)	10.8 (5.3)	9.4 (5.5)

AMI: acute myocardial infarction, CKD: chronic kidney disease, IHD: ischaemic heart disease, MET: metabolic equivalents of task, NRCMS: New Rural Cooperative Medical Scheme, SD: standard deviation, TIA: transient ischemic attack, UEBMI: urban employee basic medical insurance, URBMI: urban resident basic medical insurance. **p-value<0.01 and *p-value<0.5. [1]Self-reported and screen-detected. [2]Data on health insurance types for each participant was identified annually in 2012-2016, but was unavailable for the years prior to 2012. Missing data on HI type in 2004-2011 were imputed based on the insurance scheme in which participants were enrolled in 2012. [3]Missing length of stay (14% for AMI and 9% for other IHD) was imputed using multiple imputation.

References

1. White IR, Royston P, Wood AM. Multiple imputation using chained equations: Issues and guidance for practice. *Statistics in Medicine*. 2011; **30**(4): 377-99.

2. Rubin DB. Multiple Imputation for Nonresponse in Surveys. New York: John Wiley & Sons, Inc. ; 1987.

F. The influence of health insurance and socioeconomic characteristics on choice of hospital tier for stroke and ischaemic heart disease

Table F.1 MEDLINE search terms

1	exp Health Facilities/
2	health care provider.mp.
3	choice.mp.
4	health seeking.mp.
5	exp China/
6	1 or 2
7	3 or 4
8	5 and 5 and 7
9	limit 8 to English language
10	limit 9 to yr="2004 -Current"

Table F.2 Summary of data characteristics for included studies

Authors	Study year	Region	Data	Study design	Sample size	Type of care	Evidence revealed or stated
Babiarz et al. (2010)[1]	2004, 2007	Shaanxi, Sichuan, Jiangsu, Hebei, Jilin (nationally representative)	Survey: village clinic module, HH module, county module	Panel data: 2 waves	2004: 3257 2007: 8339	Not specified	RP
Brown & Theoharides (2009)[2]	10/2006	Anhui and Jiangsu: 25 counties	Household survey data	Cross-sectional	442	Inpatient	RP
Cao Y et al (2019)[3]	2016	Gaoyou City, Jiangsu Province	Patient medical outpatient records	Cross-sectional	1139 chronic disease patients (diabetes, hypertension, hyperlipidaemias)	Outpatient	RP
Hou Z et al (2014)[4]	2006-2008	Ningxia and Shandong (6 counties)	Survey and administrative data	Repeated cross-sectional, panel data at village level	1143	Inpatient	RP
Jin et al. (2020)[5]	2008, 2013	2008: 94 counties, 2013: 156 counties	China National Health Service Surveys, County-level data	Cross-sectional	2008: 177 501, 2013: 273 687	Inpatient and outpatient	RP
Li C et al (2021)[6]	2011-2015	29 regions (nationally representative)	CHARLS	Panel data	10 061 (65+ years)	Outpatient care	RP
Li X et al (2021)[7]	2018	Hubei: 1 urban and 1 rural area in Yichang	Survey of residents with medical care in last 14 days	Cross-sectional	728	Not specified	RP

Liu et al (2019)[8]	2018	Shanghai	Questionnaire	Discrete choice experiment	532	Not specified	SP
Liu et al (2019)[9]	12/2017-03/2018	Chongqing 14 townships rural areas	Questionnaire	Discrete choice experiment	559	Not specified	SP
Ma Q et al (2020)[10]	2006, 2009, 2011, 2015	12 regions (urban and rural)	China Health Nutrition Survey	Unbalanced longitudinal data	7408 (10164 observations)	Not specified	RP
Qian et al (2009)[11]	2004	Gansu: rural areas	Household survey	Cross-sectional	4376	Outpatient	RP
Qian et al (2010)[12]	2008	Urban areas	China National Health Services Survey	Retrospective cohort study	1058	Outpatient	RP
Shu et al (2019)[13]	2014	29 provinces	China Family Panel Studies	Cross-sectional	5260 patients with chronic conditions	Not specified	RP
Tang L et al (2012)[14]	2009-2010	17 provinces, autonomous regions, municipalities	Household survey	Cross-sectional	4853	Not specified	RP
Wu et al (2017)[15]	2014-2015	Hangzhou (Zhejiang)	Questionnaire	Mixed methods: cross-sectional survey, focus group and individual interviews	6 focus groups, 13 individual interviews, 1248 respondents	Outpatient	RP
Xiong et al (2018)[16]	2003-2015	Nationwide	Average-level data of medical service institutions and average hospital	Ecological	NA	Not specified	NA

			service utilisation data of 3 HI schemes, China Statistical Yearbook, national sample survey on medical service utilisation of HI participants				
Yu et al (2017)[17]	2013	Shanghai	Questionnaire	Retrospective cross-sectional	1114	Outpatient	RP
Zhang A et al (2020)[18]	2011, 2013, 2015	Nationally representative	CHARLS, official province-level data from China health statistical yearbooks	Repeated cross-sectional	8085	Outpatient	RP
Zhang C et al (2017)[19]	2011-2012	Nationally representative	CHARLS	Longitudinal	17 343	Inpatient and outpatient	RP
Zhang L et al (2014)[20]	2010-2011	Jiangsu: 3 counties	Province-level NRCMS administrative database	Panel data	14 169 type 2 diabetics	Outpatient	RP
Zhou et al (2014)[21]	2012-2013	Guangdong, rural areas	Questionnaire data	Cross-sectional	12 800 older adults	Not specified	RP
Zhou et al (2021)[22]	2012, 2014, 2016, 2018	25 provinces	China Family Panel Study, China health and family planning statistical yearbook	Longitudinal	61 932	Not specified	RP
CHARLS: China Health and Retirement Longitudinal Survey, HI: health insurance, NRCMS: new rural cooperative medical scheme, RP: revealed preference, SP: stated preference							

Table F.3 Characteristics of the methods and results of included studies

Authors	Method	Dependent variables (of interest)	Independent variables	Covariates	Results
Babiarz et al. (2010)[1]	Multivariate ordinary least squares regression	Whether medical care was sought at THC or hospital	NRCMS enrolment	Gender, age, age squared, education, urban or rural resident status, mean per capita village income. village and year fixed effects	Reimbursement available at VC was associated with a decrease in the probability of using a THC or hospital (or an increase in VC use), but findings fall just below significance levels.
Brown & Theoharides (2009)[2]	Two-level nested logit, interaction alternative-specific variables with poor households and elderly	Hospital choice: township, county, prefecture/province and none	Case-specific: age, gender, disability, emigration previous year, education, % of expenditures for food, sick HH members, eligibility of non-chronic conditions for NRCMS reimbursement, OP treatment covered. Alternative-specific: deductible, logged benefit ceiling, average daily expenditures of inpatient care, average travel costs		Patients who sought care generally choose township hospitals (38.9%). The effects of deductible and daily expenditure were negative, while the effect of positive for logged reimbursement ceiling, inconsistent for travel cost
Cao et al (2019)[3]	Nested multiple logit model	County-level hospitals and above, township-level hospitals, private clinics, and village-level hospitals (ref)	Socioeconomic: age, sex, education, marital status, self-rated health status, length of time since diagnosis, income, HI. Medical institution: subjective satisfaction levels in use of		Young age: +ve effect on choice of township hospital. Middle-aged group: -ve effect on choice of private hospitals, +ve effect for county-level hospitals. Males +ve effect of choosing county level and above. W/ lower education or

			medical resources. Environment: public transportation convenience, medical accessibility around residential area		income: higher probability of choosing private clinics. W/ higher education or incomes, and HI: more likely to choose county-level hospitals. Patients w/ less severe diseases have higher probability of choosing township hospitals and private institutions. Patients w/ serious diseases more inclined to choose higher level hospitals. Patients w/ <1year to live were more likely to choose township and county-level hospitals. Patients w/ >2 years to live: more likely to choose private clinics. Satisfied patients w/ level of medical services, more likely to choose township hospitals and private clinics. Bus travel>10 min, higher probability of patients choosing medical institutions above county level. Bus travel<10 min: more likely to choose private clinic. For medical accessibility (bus ride<10 min), higher probability of patients choosing private clinics and county hospitals. For ride>10 min, patients preferred VC (vs private clinic) and county level or above.

Hou et al (2014)[4]	Conditional logit model, clustered SE at county level	Choice of inpatient and outpatient facility (first visit in last year/4 weeks)	Ratio of the ARR for county or higher-level hospitals to the reimbursement rate for THCs	SES: age, sex, marital status, HH size, education, occupation, log income, other HI. Health status: self-perceived severity of sickness, type of sickness, rest days due to sickness, surgery, no. of chronic diseases, types of chronic diseases, village FE, county GDP per capita	A one-unit increase in the ratio of ARR raises the probability of seeking care at a county hospital or higher level by 0.68. The maximum variation in this ratio is 0.48, or an increase of 0.33 in the probability of using higher-level care, equivalent to a 41% increase compared with baseline mean (0.795).
Jin et al. (2020)[5]	Multilevel multinomial logistic	Type of healthcare providers: village/CHS, township/CHCs, county hospitals, municipal or higher-level hospitals	No. of registered (assistant) doctors per 1000 at county hospitals and PHC institutions, HI average reimbursement rate (ARR) of IP care at county hospitals and PHC institutions	Age, sex, marital status, education, occupation. Enabling: income, HI status, distance to nearest healthcare provider. Health needs: sickbed days for illness, chronic	Increasing ARR and physician density at PHC were associated with higher likelihood of visiting PHC. When ARR at PHC increased by 1% point, likelihood of inpatients choosing county-, municipal- and higher-level hospitals (vs township) decreased by 25%, 45% and 46%, respectively, in 2008; and by 46%, 71%, 63% in 2013. Interaction terms: negative impact of ARR at PHC institutions on

				diseases. Environmental: rural/urban	likelihood of visiting county-, municipal- and higher-level hospitals in 2013 was 28%, 66% and 33% larger than in 2008
Li C et al (2021)[6]	Random effects logistic regression, stratified by urban/rural	PHC: CHC, THC, community health clinic, village clinic/private clinic) vs Secondary or Tertiary Facility (STF or bypassing): General, specialised, Chinese medicine	Age, sex, education, marital status, income, travel time to the facility, HI status, health status, chronic conditions (hypertension, dyslipidaemia, diabetes, cancer, chronic lung diseases, liver disease, heart diseases, stroke, emotional, nervous/psychiatric problems), functional limitations, hospitalisation in past 12 month		Choice of STF: wave 1: 34.0%, Wave 2: 39.4%, Wave 3: 41.8%. Rural areas: 7.0%, 33.0%, 34.6%. Urban areas: 62.4%, 61.1%, 60.1%. Choice of SFT associated with: longer travel time to PHC, higher education, hospitalisation in past 12 months in urban/rural areas, poor health, UEBMI (vs uninsured) in rural areas, older adults (65+) and NRCMS (vs uninsured) in urban areas.
Li X et al (2021)[7]	Binary logistic regression	PHC (CHC, village clinics, THC) or non-PHC (county/city/district, municipal, and provincial- level health institutions)	(1) gender, age (2) education, employment. marital status, income, HI (3) nearest medical service provider, transport time to nearest medical institution; (4) self-perceived severity of illness, chronic illness (5) reason for service use: buying medicine, OP/IP; (6) urban or rural residence (7) registration with family doctor or not.		55.22% chose PHC for first contact. Patients who are older, less educated, with lower family income, not living near non-PCIs, with better self-perceived health status, only buying medicines, and living in rural instead of urban areas had significantly higher probability of choosing PHC.
Liu et al (2019)[8]	Mixed logit model, interaction	Choice of CHC vs higher level facility	Attributes: personal connection, travel time, facility size, time taken for a		Respondents placed different weights on the identified attributes, depending if perceived

	terms as fixed effects, main attributes as random effects except for the cost		visit, OOP for visit, medical professionals' skill, medical equipment condition, minor condition, severe condition		condition was minor or severe. For conditions perceived as minor, most valued attributes: visit time, equipment, medical skill. Only 14% preferred visiting a facility over opting out, % would be 37% if CHCs were maximally improved. For conditions perceived as severe, most valued attributes: equipment, travel time, facility size. Improvements in CHCs may almost double first visits to primary care, mostly from patients who would otherwise choose higher-level facilities.
Liu et al (2019)[9]	Mixed logit model, with interaction between disease severity and each main attribute	Choice of a facility: large size-facility vs small size facility	Attributes: time taken for a visit, OOP, medical professionals' skill, personal connection in facility, general condition of medical equipment, drug availability, travel time, facility size Scenario variable: hypothetical perceived disease severity		Highly valued factors: visit time, travel time, OOP cost. When facilities changed simultaneously from its worst to best attribute levels, predicted probability of choosing to visit a facility increased from 4.8% to 66.5% under perceived minor disease scenario, whereas no significant change under perceived severe disease scenario. Choosing to visit large-size hospitals has never been respondents' preferred level for first-contact care, even in severe disease scenario.
Ma et al (2020)[10]	Generalised linear mixed	Primary-level (ref) hospital, county-level hospital, and	Internet usage (Do you participate in surfing the internet?)	Marital status, age, gender, education level,	2006: self-care: 40.60%, PCH: 35.97%, county: 12.45% municipal: 10.97%, 2015: self-

	model with multinomial distribution and logit link function	municipal-level hospital		HI, district, residence site, Time, Disease/injury severity, No. of chronic diseases, BMI, years with hypertension	care: 36.13% PHC: 37.61%, county: 10.93%, municipal: 15.33% Adults w/ online browsing activities: OR 1.86 (1.35-2.58) of choosing municipal vs PHC. However, non-significant effect for county-level hospitals. Factors associated with higher use of municipal hospitals: older age, female, urban, higher level of education, more severe disease, chronic disease. Factors associated with higher use of county hospital: rural, higher education level, higher severity, higher BMI.
Qian et al (2009)[11]	Mixed multinomial logit model	Patient choice of healthcare provider for OP care: self-treatment, public village clinic, private village clinic, township health centre, country hospital	Marital status, HI status, age, chronic illness, other illness, illness time, bed-days, distance, log income		Price is strongest determinant of HC demand in poor rural areas, with change in demand in response to a change in price (price elasticity) higher for low-income vs high-income groups, and for county hospital vs village clinics. When provider quality or reputation is a particular concern, or when health status is poor, some rural outpatients are willing to travel further to obtain better treatment. Enrolment in NRCMS increased individual's probability of seeking treatment at a public VC vs self-treatment. Rural elderly have a higher probability

					of visiting lower level providers or self-treatment vs accessing higher levels of care.
Qian et al (2010)[12]	Multinomial logit model	4 types of health care provider: self-treatment, private clinics, CHCs and city hospitals.	Age, sex, marital status, education, occupation, consumption, city size, severity of illness, insurance status		NRCMS patients are less likely to use private clinics and more likely to use CHC (vs self-treatment). UEBMI patients did not exhibit statistically significant differences in their choice of provider. Factors determining provider utilisation: city size, severity of illness.
Shu, Han, Xiao and Li (2019)[13]	Multinomial logistic regression	3 healthcare choices: Clinic/CHS, Township hospital/CHC, Tertiary/specialised hospital	HI coverage: UEBMI, Gong Fei Medical Insurance (GFMI), NRCMS and URBMI	Predisposing: age, gender, occupation, education, trust in doctors. Enabling: HI, health financial risk (medical expenditure/family income), location of residence, marital status, rural/urban migration status. Need: self-rated health 2-week morbidity, occurrence of hospitalisation	Patients were more likely to choose hospital care than PHC. Patients with NRCMS preferred primary healthcare, compared with patients with no HI (OR 1.852, 95%CI [1.458, 2.352]). Patients with UEBMI and GFMI made use of hospital care (OR 2.654 [1.85, 3.81]; OR 1.629 [1.15, 2.30], respectively). Patients who had medium (≥0.2and<0.4) or high financial risk (≥0.4) were more likely to choose tertiary/specialised hospital care vs those at low financial risk (OR 1.629 [1.15, 2.30]; 1.220 [1.04, 1.43], respectively).

Tang et al (2012)[14]	Ordered probit model	Do not go to hospital or only go to pharmacy to buy the medicine for self-medication, CHC, level 1 hospital, level 2 hospital, level 3 hospital	Patient's self-rating anxiety (SAS) before seeing a doctor	Age, gender, marital status, education, income, employment, occupation, health status, HI, reimbursement % of medical costs, severity of disease, stage of disease	High level of anxiety could predict if patient was more likely to choose high level hospital, and also accurately predict which level of hospital patient would choose. Low level of anxiety before seeing a doctor could only predict that patient was more likely to choose low level hospital, but it could not clearly predict which level of hospital would be chosen.
Wu et al (2017)[15]	Multiple logistic regression	Binary: Agree vs disagree with: "When I am ill, I am inclined to go to see a doctor in a big hospital" and "If the child in my family gets sick, I am inclined to take him/her to a big hospital"	Distance, expenses, availability of medication, opportunity costs due to seeing a doctor, reputation of the facility, personal connections with doctors, family or friends' recommendation, severity of illness, average education of doctors, level of sophistication of medical equipment, on-site waiting time	Sex, age, education, employment status, monthly household income, HI status	70% of respondents preferred hospital-based services for first-contact care, especially for paediatric patients (83.3%). Major cause: public distrust in competence of PHC practitioners with lower educational qualifications. In decision-making process, participants attached greater emphasis on organisational characteristics compared to cost factors (medical expenses and waiting times). Respondents who rated sophisticated medical equipment, reputation of the facility, average education of doctors as important were significantly more inclined to choose hospital services.

Xiong et al (2018)[16]	Segmented time-series regression analysis	Seeking-care choices: UEBMI: tier 1, 2, 3 URBMI: tier 1, 2, 3 NRCMS: outside county hospital, county hospital, township hospital	Implementation of universal medical insurance system (2008)		A higher proportion of UEBMI patients chose inpatient services in tier 3 hospitals, URBMI patients tended to choose tier 2, NRCMS patients preferred township hospitals. Trend in hospital-care choices of patients enrolled in the UEBMI, URBMI, and NRCMS for tertiary hospitals increased from 2008 to 2014. Hospital-care choices of UEBMI patients for tier 2 and 1 hospitals and URBMI patients for tier 2, and NRCMS patients for township hospitals showed downward trends.
Yu et al (2017)[17]	Multinomial logistic regression by disease severity (mild, chronic, serious)	Drug stores, clinics, specialised hospitals, CHFs, district hospitals, and general hospitals (ref)	Age, sex, occupation, education, close proximity, short waiting times, low medical costs, a good environment, first-class medical technology, good service attitude, medical insurance, personal preference, acquaintance, and media publicity		CHFs: most frequently selected in mild illness and by elderly. Patients who had no personal preference, no preference for good environment or first-class medical technology, concerned about close proximity and short waiting times, and pursued low medical costs were most likely to choose CHFs. General hospitals: most frequently selected in chronic and serious illness. Patients who earned higher incomes, did not pursue low medical costs, not concerned about short waiting times or close proximity, and expressed preference for first-class medical

					technology, were most likely to choose general hospitals.
Zhang A et al (2020)[18]	Separate logistic regressions for demand and supply-side factors, adjusted for sampling weights, robust SE	Patient choice between hospitals and primary care facilities for outpatient care (most recent in past month)	Supply-side: no. of hospitals per 10 000, no. of PHC facilities per 10 000, no. of licensed doctors in hospitals per 1000, no. of licensed doctors in PHC per 1000, no, of village doctors in rural areas per 1000 Demand-side: gender, education level, log per capita household expenditure, age, any chronic condition, HI status	County fixed effects (demand side regressions), year dummies	53% of OP visits were paid to PHC facilities vs hospitals in 2015, compared to 60% in 2011. Supply and demand factors were associated with this decline. Supply side: density of PHC facilities did not account for this decline, but higher densities of hospitals and licensed doctors were associated with lower use of PHC facilities. Demand side: individuals with higher SES and greater health care needs were less likely to use PHC facilities
Zhang C et al (2017)[19]	Multinomial logistic regression	Hospital types: 1) general hospital, 2) specialised hospital and Chinese medicine hospital, 3) township hospital 4) for OP: community health centre and for IP: CHC, health care post, others	SES variables: education categories, log of per capita expenditure (log PCE)	Age, Sex, marital status, self-reported poor health, any major chronic conditions, any minor chronic conditions, any ADL/IADL	UEBMI enrollees are more likely to visit general hospitals than URBMI or NRCMS enrollees. Among NRCMS enrollees, ~40% of OP visits occur in VC or private clinic. Only 16.3% of OP visits occur in CHC for UEBMI enrollees, 9.6% for URBMI enrollees. Of UEBMI, URBMI, NRCMS enrollees, >80%, 91%, 56% IP visits occur in general hospitals, respectively. Of uninsured, 54.6% visit general hospitals for last IP visit. URBMI and UEBMI enrollees are less likely to choose type 2 and 3 for IP care vs type 4 hospitals. For rural people, difference exists for

					OP care only. People with any HI are more likely to use type 1 through type 3 hospitals vs type 4. For OP in urban people, better-educated people are more likely to visit type 1 and less likely to visit type 3 hospitals (vs type 4); married people are more likely to use type 1. For OP among rural people, respondents with higher education levels and higher PCE are more likely to visit type 1 and 2 hospitals. Results are similar for IP services.
Zhang L et al (2014)[20]	Difference-in-difference, propensity score matching	Ratio of utilisation of health institution: VC, THCs, and county level hospitals	Changes in outpatient reimbursement rates	Sex, age and severity of illness	Reimbursement rate changes at VCs, THCs and county-level hospitals did have a significant effect on the ratio of utilisation. Compared w/ control group, OP of treated group are 5.99% more likely to visit THCs and 2.34% more likely to visit county- level hospitals.
Zhou et al (2014)[21]	Descriptive analysis	Health-seeking behaviour: community health service (CHS), district hospitals or secondary hospitals (DH/SH), tertiary general hospitals or special hospitals (TGH/SH), and	Chronic condition vs no chronic condition		Preferred health-seeking institutions by rural elderly when had medical needs included CHS: 40.8%, DH/SH: 49.4%, TGH/SH: 9.8%. Healthy rural elderly selected CHS (43.8%) as preferred institutions more than that of rural elderly with chronic conditions (37.1%) when felt unwell, while rural elderly with chronic conditions selected

		reasons for selecting and not selecting CHS			DH/SH (55.8%) and TGH/SH (7.1%) as preferred institutions more than healthy rural elderly (50.7% and 5.5%). Main reasons why rural elderly did not select CHS: lack of drug varieties, obsolete equipment, doubt in medical skills of staff, uncomfortable consulting environment.
Zhou et al (2021)[22]	Difference-in-differences	Health-seeking behaviour: PHC facilities including CHCs/THCs, CHS and VC vs large hospitals	Implementation of hierarchical medical system (HMS)	Demand side: gender, age, economic level, marital status, education, HI type, self-assessed health, chronic disease Supply side: % of PHC facilities, no. of health workforce in PHC facilities	Implementation of HMS had a positive effect on the probability of urban residents going to PHC facilities, but not for rural residents. Health-seeking behaviour was strongly associated with HI, self-assessed health, chronic disease, proportion of primary care facilities in the entire medical institutions, economic level, and education status.

ARR: average reimbursement rate, CHC: community health centres, CHF: community health facilities, CHS: community health stations, DH/SH: district hospitals or secondary hospitals, IP: inpatient, LOS: length of stay, RR: reimbursement rates, HH: household, HI: health insurance, HMS: hierarchical medical system, no.: number, NRCMS: new rural cooperative medical scheme, OLS: ordinary least square, OR: odds ratio, OP: outpatient, PHC: primary health care (facilities), SE: standard errors, SES: socioeconomic status, SRH: self-rated health, TGH/SH: tertiary general hospitals or special hospitals, THC: township health centres, VC: village clinics, UEBMI: urban employee basic medical insurance, URBMI: urban resident basic medical insurance

Table F.4 Per capita medical expenses (Yuan) of discharged patients in 2009 and 2017, by hospital tier

	2009			2017		
	Tier 1	**Tier 2**	**Tier 3**	**Tier 1**	**Tier 2**	**Tier 3**
Ischaemic stroke	5277.0	6954.8	9598.7	6053.2	7838.7	12008.5
Haemorrhagic stroke	8465.5	11404.9	20405.4	13764.0	12452.8	21949.0
AMI	5467.6	11390.1	25592.5	12833.7	17735.6	30270.9
Any disease	3205.4	11404.9	11979.8	4602.8	5799.1	13086.7

AMI: Acute myocardial infarction. Medical expenses in 2009 were inflated to 2017 values.
Source: China health statistical yearbooks.

Table F.5 Proportions of participants with stroke, IHD and any cause enrolled in URBMI or NRCMS and UEBMI in CKB centres

	Stroke		IHD		Any cause	
	URBMI/NRCMS (n=23 044)	UEBMI (n=18 388)	URBMI/NRCMS (n=18 270)	UEBMI (n=18 758)	URBMI/NRCMS (n=138 796)	UEBMI (n=91 209)
Urban areas						
Qingdao	3.37	96.63	2.88	97.12	3.14	96.86
Harbin	6.16	93.84	5.34	94.66	6.56	93.44
Haikou*	28.25	71.75	25.85	74.15	37.45	62.55
Suzhou	66.67	33.33	62.91	37.09	53.49	46.51
Liuzhou	16.40	83.60	14.47	85.53	16.72	83.28
Rural areas						
Sichuan	74.23	25.77	76.49	23.51	77.22	22.78
Gansu	97.53	2.47	96.65	3.35	97.60	2.40
Henan	96.49	3.51	96.97	3.03	96.97	3.03
Zhejiang	87.45	12.55	78.57	21.43	81.49	18.51
Hunan	92.17	7.83	91.39	8.61	92.15	7.85

In Qingdao, Harbin, Liuzhou, most participants are enrolled in URBMI. In Suzhou and all rural centres, most participants are enrolled in NRCMS.
*Stroke: 13.59% of participants were enrolled in NRMCS and 14.66% of participants were enrolled in URBMI. IHD: 12.54% of participants were enrolled in NRMCS and 13.10% of participants were enrolled in URBMI. Any cause: 12.51% of participants were enrolled in NRMCS and 13.34% of participants were enrolled in URBMI. NRCMS: New Rural Cooperative Medical Scheme, UEBMI: Urban Employee Basic Medical Insurance, URBMI: Urban Resident Basic Medical Insurance.

Table F.6 Selected characteristics of individuals with first admission for any cause in urban and rural areas in 2009-2017

	Urban (n=97 315)	Rural (n=132 690)
Demographic characteristics		
Age (years) at admission, Mean (SD)	61.4 (10.5)	59.5 (10.4)
Women, %	61.2	60.0
Socioeconomic characteristics		
Married, %	88.1	91.0
Household size, Mean (SD)	3.2 (1.3)	4.2 (1.6)
Highest level of education attained, %		
No formal school	12.7	23.7
Primary/middle School	52.6	68.1
High School or above	34.7	8.3
Annual household income (Yuan), %		
<10 000	14.2	38.9
10 000-19 999	30.4	29.4
20 000-34 999	31.5	19.6
>35 000	23.9	12.1
Health insurance type at admission, %		
URBMI or NRCMS	21.4	88.9
UEBMI	78.6	11.1
Lifestyle characteristics		
Current smoker, %		
Women	2.5	3.0
Men	54.1	65.6
Regular alcohol drinker, %		
Women	4.9	3.8
Men	51.1	40.4
Physical activity (MET-h/day), Mean (SD)	17.3 (12.2)	22.0 (14.0)
Overweight or obese[1], Mean (SD)	43.0	29.0
Medical history, %		
Poor self-rated health	10.2	12.2
Hypertension	16.5	11.7
CVD	8.1	3.5
Diabetes	10.0	4.7
COPD	6.8	9.1
Other disease	24.5	18.9

[1]One individual in rural areas has missing body-mass index data. All characteristics were measured at baseline unless otherwise specified. COPD: chronic obstructive pulmonary disease, CVD: cardiovascular disease, NRCMS: new rural cooperative medical scheme, UEBMI: urban employee basic medical insurance, URBMI: urban resident basic medical insurance.

Table F.7 Selected characteristics of individuals with stroke admissions in urban and rural area, by hospital tier in 2009-2017

	Urban			Rural		
	Tier 1	**Tier 2**	**Tier 3**	**Tier 1**	**Tier 2**	**Tier 3**
Age at admission, Mean (SD)	67.6 (9.6)	67.3 (9.4)	65.8 (9.9)	64.7 (9.9)	65.5 (9.8)	64.8 (9.4)
Women, %	60.9	56.9	56.1	53.7	54.4	55.5
Married, %	83.1	84.4	85.9	86.2	87.3	88.6
Household size, Mean (SD)	2.9 (1.3)	3.1 (1.4)	3.2 (1.5)	4.1 (1.7)	4.2 (1.7)	4.3 (1.7)
Levels of education, %						
No formal school	25.5	17.8	11.4	25.4	26.8	34
Primary/middle School	45.8	54.6	49.5	66.7	67.2	57.9
High School or above	28.7	27.6	39.1	7.9	6.0	8.1
Annual household income (¥), %						
<10 000	23.0	20.9	14.8	49.0	41.6	47.8
10 000-19 999	31.7	33.8	33.1	35.2	30.2	26.7
20 000-34 999	26.6	27.5	29.3	11.4	18.8	14.9
≥35 000	18.7	17.8	22.9	4.3	9.3	10.6
HI type, %						
NRCMS or URBMI	35.0	24.8	13.7	96.4	90.1	88.1
UEBMI	65.0	75.2	86.3	3.6	9.9	11.9
Current smoker (men), %	53.2	47.5	51.5	62.1	66.5	65.9
Regular alcohol drinker (men), %	51.2	47.0	51.8	38.5	39.2	38.3
Overweight or obese, %	41.7	43.3	48.8	37.1	31	33.8
Physical activity (MET-h/day), Mean (SD)	16.8 (12.6)	14.7 (11.2)	13.6 (10.2)	17.4 (13.6)	18.5 (13.0)	21.2 (13.6)
Poor self-rated health, %	10.9	11.2	9.0	15.4	13.2	13.9
Disease type, %						
Lacunar ischaemic stroke	37.6	21.6	18.9	5.9	8.1	16.7
Non-lacunar ischaemic stroke	60.1	71.5	72.3	83.3	75.3	71.9
Haemorrhagic stroke	2.3	7.0	8.7	10.9	16.7	21.5
Mean length of stay (days)*	10.3 (4.6)	11.9 (7.4)	13.1 (7.9)	10.4 (5.1)	12.8 (8.6)	13.5 (9.5)

Current smoker in women: tier 1: 2.8%, tier 2: 4.1%, tier 3: 4.0%. Regular alcohol drinker in women: tier 1: 3.4%, tier 2: 4.3%, tier 3: 4.6%. All characteristics were measured at baseline unless otherwise specified. MET: metabolic equivalent of task, NRCMS: new rural cooperative medical scheme, SD: standard deviation, UEBMI: urban employee basic medical insurance, URBMI: urban resident basic medical insurance. *Multiple imputations were used for missing values of length of stay as described on page 402.

Table F.8 Selected characteristics of individuals with IHD admissions in urban and rural area, by hospital tier in 2009-2017

	Urban			Rural		
	Tier 1	**Tier 2**	**Tier 3**	**Tier 1**	**Tier 2**	**Tier 3**
Age at admission, Mean (SD)	65.9 (10.1)	66.2 (9.7)	64.9 (9.9)	65.2 (10.2)	67.0 (9.7)	65.2 (9.7)
Women, %	70.6	66	59.9	63.7	57.9	53.8
Married, %	83.9	84.6	86.8	85.9	85.4	88.7
Household size, Mean (SD)	2.9 (1.2)	3.0 (1.3)	3.0 (1.3)	4 (1.8)	4.1 (1.8)	4.2 (1.7)
Levels of education, %						
No formal school	18.8	12.8	9.3	24.2	31.1	26.7
Primary/middle School	47.4	54.6	50.2	69.7	63.1	63.3
High School or above	33.8	32.6	40.5	6.1	5.8	10.0
Annual household income, %						
<10 000 Yuan	22.8	16.7	12.3	48.2	43.5	40.4
10 000-19 999 Yuan	32	36	32.4	33.4	27.5	27.7
20 000-34 999 Yuan	28.3	29.3	31.9	13.8	19.1	18.1
≥35 000 Yuan	16.9	18	23.3	4.6	9.9	13.9
HI type, %						
NRCMS or URBMI	25.1	15.7	9.4	94.3	86.9	83.3
UEBMI	74.9	84.3	90.6	5.7	13.1	16.7
Current smoker (men), %	53.3	49.5	51.7	64.4	65.4	68.0
Regular alcohol drinker (men), %	54.2	47.7	50.5	38.0	38.3	39.1
Overweight or obese, %	45.5	47.5	52.5	34.5	31.3	36.2
Physical activity, (MET-h/day), Mean (SD)	15.0 (10.6)	14.1 (9.8)	13.6 (9.8)	17 (12.0)	17.9 (12.7)	19.6 (13.4)
Poor self-rated health, %	10.7	11.7	9.5	19.1	16.1	14.8
Disease type, %						
AMI or angina	5.2	7.0	11.2	6.6	8.8	12.2
Other IHD	94.8	93.0	88.8	93.4	91.2	87.9
Mean length of stay (days)*	10.0 (6.5)	9.6 (4.8)	10.5 (6.7)	6.5 (4.0)	8.2 (5.9)	8.7 (5.3)

Current smoker in women: tier 1: 4.9%, tier 2: 3.6%, tier 3: 4.2%. Regular alcohol drinker in women: tier 1: 4.7%, tier 2: 4.3%, tier 3: 5.5%. All characteristics were measured at baseline unless otherwise specified. AMI: acute myocardial infarction, SD: standard deviation, MET: metabolic equivalent of task. NRCMS: new rural cooperative medical scheme, UEBMI: urban employee basic medical insurance, URBMI: urban resident basic medical insurance. *Multiple imputations were used for missing values of length of stay as described on page 402.

Table F.9 Selected characteristics of individuals with any cause admissions in urban and rural area, by hospital tier in 2009-2017

	Urban			Rural		
	Tier 1	**Tier 2**	**Tier 3**	**Tier 1**	**Tier 2**	**Tier 3**
Age at admission, Mean (SD)	62.3 (10.5)	62.0 (10.4)	61.1 (10.4)	59.3 (10.4)	60.1 (10.7)	59.4 (10.1)
Women, %	62.8	61.6	60.8	61.3	59.9	58.4
Married, %	88.4	87.5	88.3	90.3	90.3	92.3
Household size, Mean (SD)	3.3 (1.4)	3.2 (1.3)	3.1 (1.3)	4.1 (1.6)	4.2 (1.6)	4.3 (1.5)
Levels of education, %						
No formal school	30.4	14.2	9.9	20.2	24.6	26.9
Primary/middle School	52.0	55.3	51.5	72.0	67.7	63.7
High School or above	17.6	30.5	38.6	7.9	7.6	9.4
Annual household income (¥), %						
<10 000	20.1	16.2	12.7	45.5	38.6	31.1
10 000-19 999	24.9	30.6	31.0	32.8	28.7	25.8
20 000-34 999	30.3	29.5	32.4	15.1	20.9	23.9
≥35 000	24.6	23.7	23.8	6.6	11.8	19.2
HI type at admission, %						
NRCMS/URBMI	48.5	25.7	16.2	93.1	87.6	85.1
UEBMI	51.5	74.3	83.8	6.9	12.4	14.9
Current smoker (men), %	61.6	53.8	53.3	64.6	66.3	66.2
Regular alcohol drinker (men), %	52.9	47.3	52.3	40.1	40.9	40.3
Overweight or obese, %	39.4	39.4	45.0	26.6	28.3	27.7
Physical activity (MET-h/day), Mean (SD)	21.9 (14.7)	17.8 (12.4)	16.5 (11.6)	20.9 (13.5)	21.3 (13.7)	23.9 (14.6)
Poor self-rated health, %	11.4	11.1	9.7	14.7	11.8	9.6
Prior diseases, %						
Hypertension	14.9	17.6	16.2	10.6	12.8	12.1
Diabetes	7.2	9.4	10.5	4.8	4.8	4.5
COPD	11.9	8.0	5.6	10.2	9.1	7.8
CVD	5.0	7.4	8.7	3.7	3.9	3.0
Other diseases	26.8	25.9	23.6	18.7	19.1	19.0
Mean length of stay (days)*	7.9 (5.8)	9.9 (7.9)	11.7 (9.8)	7.6 (6.4)	9.3 (9.5)	11.5 (13.3)

Current smoker in women: tier 1: 3.5%, tier 2: 2.6%, tier 3: 2.5%. Regular alcohol drinker in women: tier 1: 4.2%, tier 2: 4.0%, tier 3: 4.4%. All characteristics were measured at baseline unless otherwise specified. URBMI: urban resident basic medical insurance, MET: metabolic equivalent of task, NRCMS: new rural

cooperative medical scheme, UEBMI: urban employee basic medical insurance. *Multiple imputations were used for missing values of length of stay as described on page 403.

Appendix F.1 Imputation methods for missing values for length of hospital stay (LOS)

For stroke, IHD and any cause, 19.2%, 24.6% and 5.8% of admissions had missing information on LOS, respectively.

Multiple imputation with Poisson regression was used and relevant covariates (e.g. demographic factors, lifestyle factors, morbidity factors, health insurance type, socioeconomic factors, hospital tier and disease type) were included. The number of imputations (*m*) was chosen so that m≥100*Fraction of Missing Information.[23] The number of imputations used was 30, 30 and 10 in models for stroke, IHD and any cause, respectively. Day case admissions (i.e. participants admitted and discharged on the same day) were counted as having a length of stay of 0.5 days.

Table F.10 Proportions of admissions for stroke and IHD (%) by hospital tier in urban and rural areas, by health insurance type

	Stroke				IHD			
	Urban areas		Rural areas		Urban areas		Rural areas	
	URBMI/NRCMS	UEBMI	URBMI/NRCMS	UEBMI	URBMI/NRCMS	UEBMI	URBMI/NRCMS	UEBMI
Tier 1	11.50	4.80	31.57	12.38	12.35	5.01	49.86	25.66
Tier 2	41.14	28.03	40.07	46.84	33.80	24.74	25.26	32.10
Tier 3	47.36	67.17	28.35	40.78	53.86	70.25	24.89	42.24

IHD: ischaemic heart disease, NRCMS: new rural cooperative medical scheme, UEBMI: urban employee basic medical insurance, URBMI: urban resident basic medical insurance.

Figure F.1 Proportions of admissions for stroke and IHD by hospital tier in urban and rural areas, between 2009 and 2017

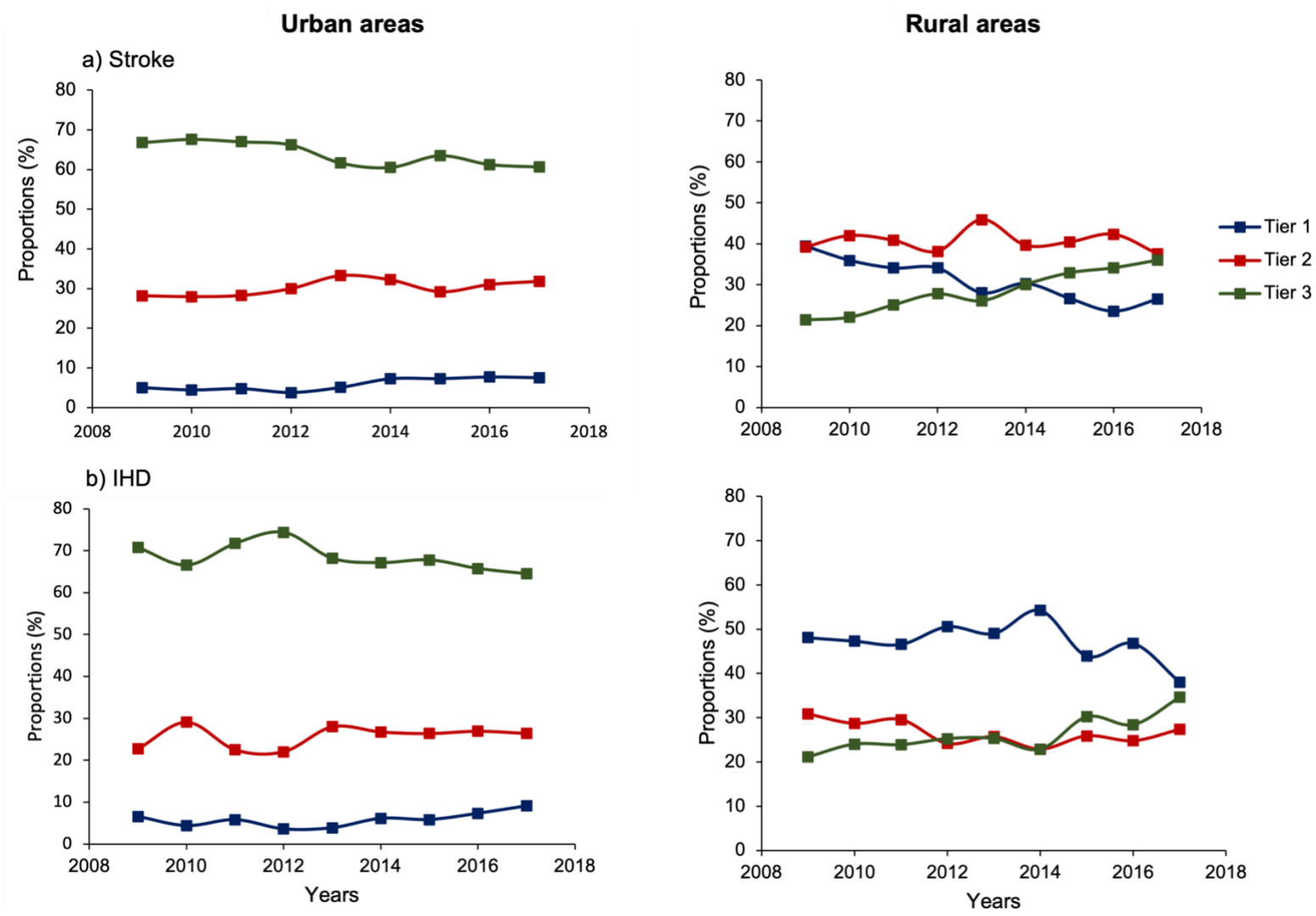
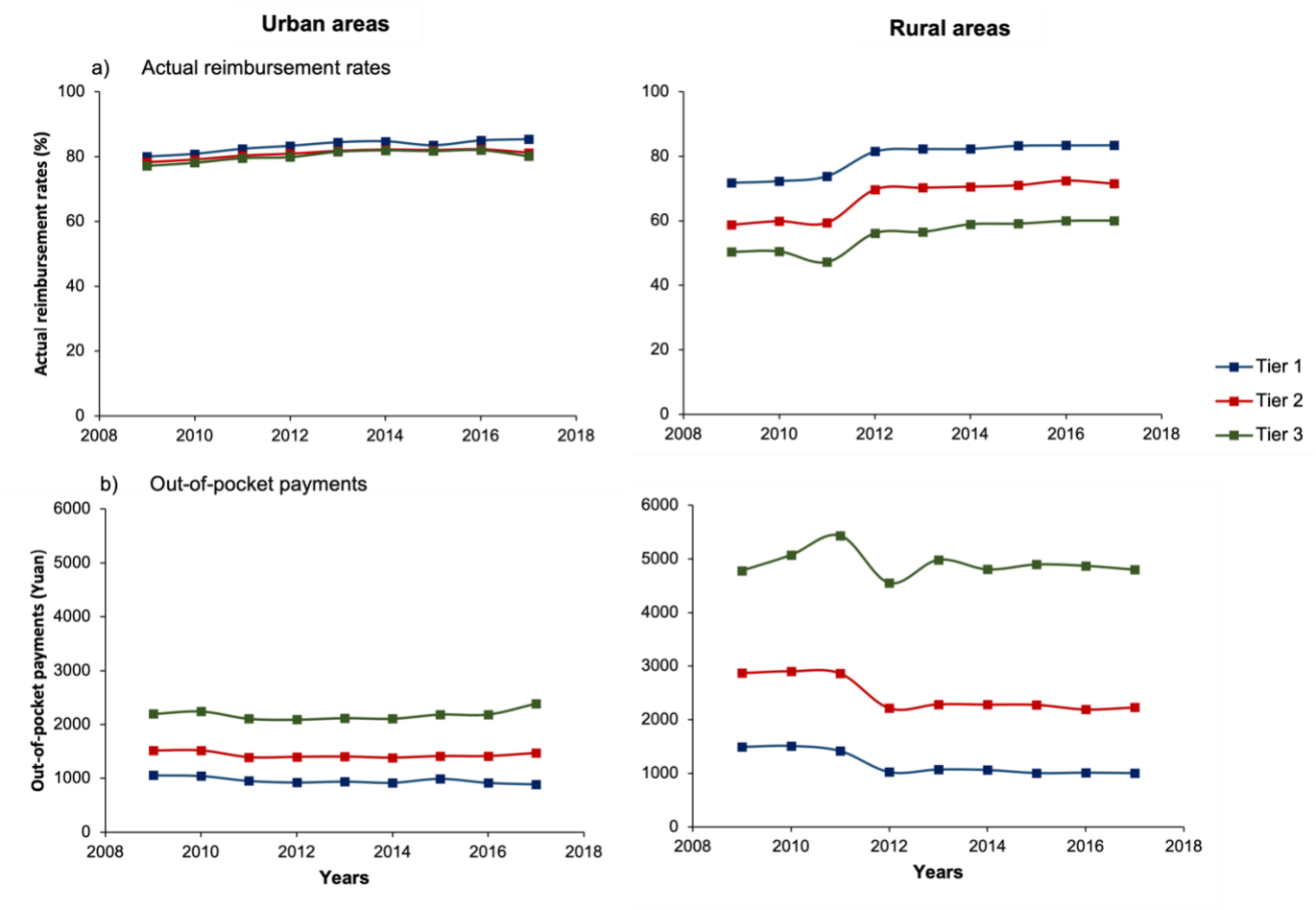


Figure F.2 Actual reimbursement rates and out-of-pocket payments by hospital tier in urban and rural CKB centres, between 2009 and 2017



Actual reimbursement rates and out-of-pocket payments were averaged across health insurance schemes and regions, within urban and rural areas, and inflated to 2017 values. The averages were weighted by the proportion of individuals enrolled in each scheme in urban and rural areas.

Table F.11 Effects of patient characteristics and reimbursement ceiling (relative risk ratios [95% CI]) on hospital tier choice for stroke admissions

	Urban areas		Rural areas	
	Tier 1 (ref: tier 3)	**Tier 2 (ref: tier 3)**	**Tier 1 (ref: tier 3)**	**Tier 2 (ref: tier 3)**
Age group (ref: <55 years old)				
55-64 years old	1.20 (0.96, 1.50)	1.26 (1.11, 1.42)	0.94 (0.83, 1.06)	0.91 (0.82, 1.02)
65-74 years old	1.35 (1.07, 1.71)	1.38 (1.22, 1.56)	1.02 (0.90, 1.16)	1.02 (0.91, 1.15)
≥75 years old	1.30 (1.00, 1.69)	1.33 (1.15, 1.52)	1.30 (1.11, 1.53)	1.19 (1.03, 1.37)
Female	0.93 (0.78, 1.11)	0.85 (0.77, 0.93)	0.93 (0.83, 1.04)	1.04 (0.94, 1.15)
Not married	1.07 (0.89, 1.28)	1.02 (0.92, 1.13)	1.18 (1.04, 1.33)	0.96 (0.86, 1.07)
Household size	0.96 (0.91, 1.02)	1.03 (1.01, 1.06)	1.03 (1.00, 1.05)	1.01 (0.98, 1.03)
Education level (ref: primary/middle school)				
No formal school	1.22 (1.00, 1.49)	1.06 (0.94, 1.19)	1.06 (0.96, 1.18)	1.09 (0.99, 1.19)
High School or above	1.05 (0.89, 1.23)	0.89 (0.82, 0.97)	0.80 (0.69, 0.93)	0.80 (0.69, 0.92)
Annual household income (ref: 10 000-19 999¥)				
<10 000¥	1.04 (0.86, 1.26)	1.20 (1.08, 1.34)	1.02 (0.92, 1.13)	1.02 (0.92, 1.11)
20 000-34 999¥	0.90 (0.76, 1.06)	0.95 (0.87, 1.04)	0.82 (0.72, 0.94)	0.91 (0.81, 1.02)
≥35 000¥	0.72 (0.59, 0.88)	0.80 (0.72, 0.89)	0.70 (0.58, 0.84)	0.69 (0.60, 0.80)
Prior disease				
Ischaemic heart disease	1.22 (1.03, 1.45)	1.05 (0.95, 1.15)	1.04 (0.92, 1.19)	1.04 (0.92, 1.16)
Cerebrovascular disease	1.32 (1.07, 1.62)	1.07 (0.94, 1.21)	1.08 (0.91, 1.27)	1.10 (0.95, 1.27)
Cancer	0.75 (0.54, 1.05)	0.81 (0.67, 0.97)	0.94 (0.73, 1.21)	1.01 (0.81, 1.25)
Respiratory disease	1.72 (1.44, 2.05)	0.99 (0.88, 1.11)	1.28 (1.13, 1.44)	1.00 (0.90, 1.11)
Infectious and parasitic disease	1.10 (0.74, 1.63)	1.14 (0.91, 1.42)	1.20 (0.97, 1.49)	0.98 (0.81, 1.18)
Diabetes mellitus	0.86 (0.73, 1.03)	0.90 (0.83, 0.99)	0.90 (0.79, 1.02)	1.06 (0.95, 1.18)
Chronic kidney disease	0.27 (0.07, 1.15)	0.69 (0.43, 1.11)	0.43 (0.22, 0.82)	0.31 (0.18, 0.52)
Tuberculosis	0.41 (0.12, 1.43)	1.08 (0.67, 1.74)	0.63 (0.34, 1.15)	0.86 (0.53, 1.39)
Disease type (non-lacunar ischaemic stroke)				
Lacunar stroke	4.20 (3.55, 4.96)	2.02 (1.84, 2.21)	1.64 (1.40, 1.93)	1.65 (1.43, 1.89)
Haemorrhagic stroke	0.18 (0.12, 0.26)	0.54 (0.47, 0.61)	0.50 (0.44, 0.55)	0.68 (0.62, 0.74)
Smoker	0.83 (0.69, 0.99)	0.76 (0.69, 0.84)	1.04 (0.93, 1.17)	1.10 (0.99, 1.21)
Current alcohol drinker	0.91 (0.76, 1.09)	0.97 (0.88, 1.07)	0.92 (0.82, 1.03)	0.99 (0.90, 1.10)
Overweight or obese	0.83 (0.73, 0.94)	0.92 (0.86, 0.98)	0.92 (0.85, 1.00)	0.98 (0.91, 1.05)

Physical activity (MET/h)	1.01 (1.00, 1.02)	1.00 (1.00, 1.01)	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)
Self-rated health (ref: fair)				
Excellent	1.13 (0.96, 1.33)	0.96 (0.88, 1.05)	0.86 (0.76, 0.98)	0.89 (0.80, 1.00)
Good	1.24 (1.05, 1.46)	0.96 (0.88, 1.05)	0.96 (0.87, 1.05)	1.07 (0.98, 1.16)
Poor	1.16 (0.93, 1.44)	1.08 (0.96, 1.21)	1.02 (0.91, 1.15)	1.01 (0.90, 1.12)
Log of reimbursement ceiling	0.96 (0.76, 1.21)	0.77 (0.68, 0.86)	1.25 (1.05, 1.49)	1.32 (1.12, 1.55)
Region fixed effects	x	x	x	x
Year fixed effects	x	x	x	x
ASC	0 (0, 0.04)	0.12 (0.03, 0.45)	0.23 (0.03, 1.50)	0.13 (0.02, 0.77)
Number of cases	20302		21130	
Log-likelihood (final)	-14188.0		-19957.0	
AIC	28555.5		40094.5	
BIC	29367.1		40909.6	

ASC: alternative specific constant. AIC: Akaike information criterion, BIC: Bayesian information criterion. Results are from a multinomial logit model with as alternative-specific variables: interactions between tier and, reimbursement rate and deductible. Only case-specific RRRs are presented and interpreted as parameters of a binary logit model against the base category “Tier 3 hospital”. Alternative specific ORs from this regression are presented in **Figure 7.2**.

Table F.12 Effects of patient characteristics and reimbursement ceiling (relative risk ratios [95% CI]) on hospital tier choice for any cause admissions

	Urban areas		Rural areas	
	Tier 1 (ref: tier 3)	**Tier 2 (ref: tier 3)**	**Tier 1 (ref: tier 3)**	**Tier 2 (ref: tier 3)**
Age group (ref: <55 years old)				
55-64 years old	1.08 (1.01, 1.16)	1.09 (1.04, 1.14)	1.00 (0.97, 1.04)	0.99 (0.95, 1.02)
65-74 years old	1.12 (1.03, 1.21)	1.19 (1.13, 1.25)	1.03 (0.99, 1.07)	1.11 (1.07, 1.16)
≥75 years old	1.21 (1.09, 1.34)	1.23 (1.15, 1.31)	1.19 (1.12, 1.27)	1.36 (1.28, 1.44)
Female	1.07 (0.99, 1.16)	0.99 (0.94, 1.03)	1.05 (1.01, 1.10)	1.03 (0.98, 1.07)
Not married	0.97 (0.90, 1.06)	0.96 (0.92, 1.02)	1.14 (1.08, 1.20)	1.06 (1.00, 1.12)
Household size	1.06 (1.04, 1.09)	1.01 (1.00, 1.03)	1.04 (1.03, 1.05)	1.01 (1.00, 1.02)
Education level (ref: primary/middle school)				
No formal school	1.23 (1.15, 1.33)	1.07 (1.02, 1.14)	1.08 (1.04, 1.13)	1.13 (1.09, 1.18)
High School or above	0.96 (0.89, 1.03)	0.95 (0.92, 0.99)	0.80 (0.76, 0.84)	0.84 (0.80, 0.89)
Annual household income (ref: 10 000-19 999¥)				
<10 000¥	1.26 (1.16, 1.36)	1.15 (1.09, 1.21)	1.12 (1.08, 1.16)	1.08 (1.04, 1.12)
20 000-34 999¥	0.88 (0.82, 0.94)	0.94 (0.90, 0.98)	0.89 (0.85, 0.93)	0.96 (0.92, 1.00)
≥35 000¥	0.64 (0.59, 0.70)	0.97 (0.92, 1.01)	0.70 (0.66, 0.74)	0.76 (0.72, 0.80)
Prior disease at baseline				
Hypertension	0.90 (0.84, 0.97)	1.01 (0.97, 1.06)	0.99 (0.94, 1.04)	1.08 (1.03, 1.12)
Diabetes	0.91 (0.83, 1.01)	0.97 (0.92, 1.02)	1.08 (1.01, 1.15)	1.06 (0.99, 1.14)
COPD	1.18 (1.08, 1.29)	1.12 (1.06, 1.20)	1.11 (1.06, 1.17)	0.98 (0.93, 1.03)
CVD	0.96 (0.86, 1.08)	1.00 (0.94, 1.06)	0.93 (0.86, 1.01)	1.06 (0.98, 1.15)
Other diseases	0.98 (0.93, 1.04)	1.01 (0.98, 1.05)	0.97 (0.93, 1.01)	0.99 (0.95, 1.02)
Current smoker	0.96 (0.89, 1.04)	0.96 (0.92, 1.01)	0.98 (0.94, 1.03)	0.99 (0.95, 1.04)
Regular alcohol drinker	1.07 (1.00, 1.16)	0.99 (0.94, 1.03)	0.95 (0.91, 0.99)	1.04 (0.99, 1.08)
Overweight or obese	0.99 (0.94, 1.05)	0.96 (0.93, 1.00)	1.05 (1.02, 1.09)	1.06 (1.03, 1.10)
Physical activity (MET/h)	1.01 (1.01, 1.01)	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)
Self-rated health (ref: fair)				
Excellent	1.06 (0.99, 1.14)	1.02 (0.97, 1.06)	0.90 (0.87, 0.95)	0.99 (0.95, 1.04)
Good	1.08 (1.01, 1.15)	0.97 (0.93, 1.01)	0.93 (0.90, 0.96)	0.98 (0.95, 1.02)
Poor	0.95 (0.87, 1.03)	0.98 (0.93, 1.03)	1.04 (1.00, 1.09)	0.99 (0.94, 1.04)
Log of reimbursement ceiling	0.91 (0.83, 1.00)	0.93 (0.89, 0.98)	0.66 (0.62, 0.70)	0.96 (0.89, 1.02)

Region fixed effects	x	x	x	x
Year fixed effects	x	x	x	x
ASC	0.03 (0.01, 0.10)	0.07 (0.04, 0.13)	599.01 (300.08, 1195.74)	3.15 (1.55, 6.42)
Number of cases	97315		132689	
Log-likelihood (final)	-70501.7		-134861.0	
AIC	141163.4		269882.2	
BIC	142010.1		270753.8	

ASC: alternative specific constant. AIC: Akaike information criterion, BIC: Bayesian information criterion. Results are from a multinomial logit model with as alternative-specific variables: interactions between tier and, reimbursement rate and deductible. Only case-specific RRRs are presented and interpreted as parameters of a binary logit model against the base category “Tier 3 hospital”. Alternative specific coefficients from this regression were presented in **Figure 7.2**.

Table F.13 Effects of patient characteristics and reimbursement ceiling (relative risk ratios [95% CI]) on hospital tier choice for IHD admissions

	Urban areas		Rural areas	
	Tier 1 (ref: tier 3)	**Tier 2 (ref: tier 3)**	**Tier 1 (ref: tier 3)**	**Tier 2 (ref: tier 3)**
Age group (ref: <55 years old)				
55-64 years old	0.97 (0.79, 1.19)	1.02 (0.91, 1.15)	0.85 (0.75, 0.96)	0.98 (0.85, 1.13)
65-74 years old	0.96 (0.77, 1.20)	1.05 (0.93, 1.19)	0.90 (0.79, 1.02)	1.11 (0.96, 1.28)
≥75 years old	0.91 (0.71, 1.17)	1.02 (0.89, 1.18)	0.99 (0.85, 1.15)	1.27 (1.07, 1.50)
Female	1.42 (1.17, 1.72)	1.18 (1.07, 1.30)	1.18 (1.07, 1.30)	1.07 (0.94, 1.21)
Not married	0.94 (0.78, 1.14)	0.98 (0.88, 1.09)	1.17 (1.03, 1.32)	1.08 (0.95, 1.23)
Household size	1.07 (1.00, 1.13)	1.02 (0.99, 1.05)	1.03 (1.00, 1.06)	1.01 (0.98, 1.04)
Education level (ref: primary/middle school)				
No formal school	1.13 (0.90, 1.41)	1.08 (0.95, 1.23)	1.15 (1.03, 1.27)	1.21 (1.08, 1.35)
High School or above	0.99 (0.85, 1.17)	0.90 (0.83, 0.98)	0.72 (0.62, 0.84)	0.81 (0.69, 0.96)
Annual household income (ref: 10 000-19 999¥)				
<10 000¥	1.40 (1.15, 1.70)	1.09 (0.98, 1.23)	1.08 (0.97, 1.20)	1.09 (0.97, 1.22)
20 000-34 999¥	0.86 (0.73, 1.01)	0.89 (0.82, 0.98)	0.92 (0.81, 1.04)	0.99 (0.87, 1.13)
≥35 000¥	0.61 (0.50, 0.75)	0.81 (0.72, 0.90)	0.57 (0.48, 0.68)	0.70 (0.60, 0.82)
Prior disease				
Cerebrovascular disease	1.36 (1.19, 1.57)	1.52 (1.40, 1.64)	0.98 (0.89, 1.07)	1.80 (1.64, 1.98)
Cancer	0.63 (0.43, 0.93)	0.71 (0.59, 0.86)	1.08 (0.87, 1.33)	1.06 (0.84, 1.32)
Respiratory diseases	1.46 (1.22, 1.76)	1.08 (0.96, 1.21)	1.82 (1.64, 2.01)	1.26 (1.13, 1.41)
Infectious and parasitic diseases	0.87 (0.55, 1.39)	1.31 (1.05, 1.63)	1.32 (1.10, 1.57)	0.93 (0.76, 1.14)
Diabetes mellitus	0.74 (0.61, 0.89)	0.93 (0.85, 1.02)	0.96 (0.85, 1.08)	1.19 (1.05, 1.35)
Chronic kidney disease	0.12 (0.02, 0.83)	0.91 (0.62, 1.33)	0.39 (0.27, 0.57)	0.41 (0.27, 0.63)
Tuberculosis	0.36 (0.08, 1.58)	0.79 (0.48, 1.31)	0.74 (0.46, 1.20)	1.08 (0.64, 1.83)
Other IHD (ref: AMI or angina)	1.70 (1.28, 2.25)	1.34 (1.17, 1.53)	1.85 (1.62, 2.11)	1.39 (1.21, 1.59)
Smoker	0.83 (0.68, 1.01)	0.84 (0.75, 0.93)	0.89 (0.79, 0.99)	0.90 (0.79, 1.01)
Current alcohol drinker	1.07 (0.88, 1.29)	0.99 (0.89, 1.09)	0.92 (0.82, 1.03)	1.03 (0.91, 1.16)
Overweight or obese	0.89 (0.78, 1.01)	0.94 (0.88, 1.01)	0.79 (0.72, 0.86)	0.88 (0.80, 0.97)
Physical activity (MET/h)	1.00 (0.99, 1.01)	1.00 (1.00, 1.01)	1.00 (1.00, 1.00)	1.00 (0.99, 1.00)
Self-rated health (ref: fair)				
Excellent	1.03 (0.88, 1.22)	1.06 (0.97, 1.17)	0.93 (0.81, 1.07)	0.85 (0.73, 0.99)

Good	0.99 (0.83, 1.17)	1.02 (0.93, 1.12)	1.05 (0.95, 1.16)	1.18 (1.06, 1.30)
Poor	0.88 (0.71, 1.10)	1.04 (0.92, 1.17)	1.01 (0.90, 1.13)	1.06 (0.93, 1.20)
Log of reimbursement ceiling	0.79 (0.62, 1.00)	0.97 (0.86, 1.1)	1.09 (0.92, 1.3)	0.86 (0.71, 1.04)
Region fixed effects	x	x	x	x
Year fixed effects	x	x	x	x
ASC	0.06 (0, 1.01)	0.03 (0.01, 0.11)	6.48 (0.89, 47.19)	7.55 (0.94, 60.48)
Number of cases	19283		17890	
Log-likelihood (final)	-13241.90		-16863.30	
AIC	26655.77		33898.57	
BIC	27426.81		34663.16	

ASC: alternative specific constant. AIC: Akaike information criterion, BIC: Bayesian information criterion. Results are from a multinomial logit model with as alternative-specific variables: interactions between tier and, reimbursement rate and deductible. Only case-specific RRRs are presented and interpreted as parameters of a binary logit model against the base category “Tier 3 hospital”. Alternative specific coefficients from this regression are presented in **Figure 7.2**.

Figure F.3 Probabilities of choosing each hospital tier for stroke and IHD types in urban and rural areas in 2009-2017

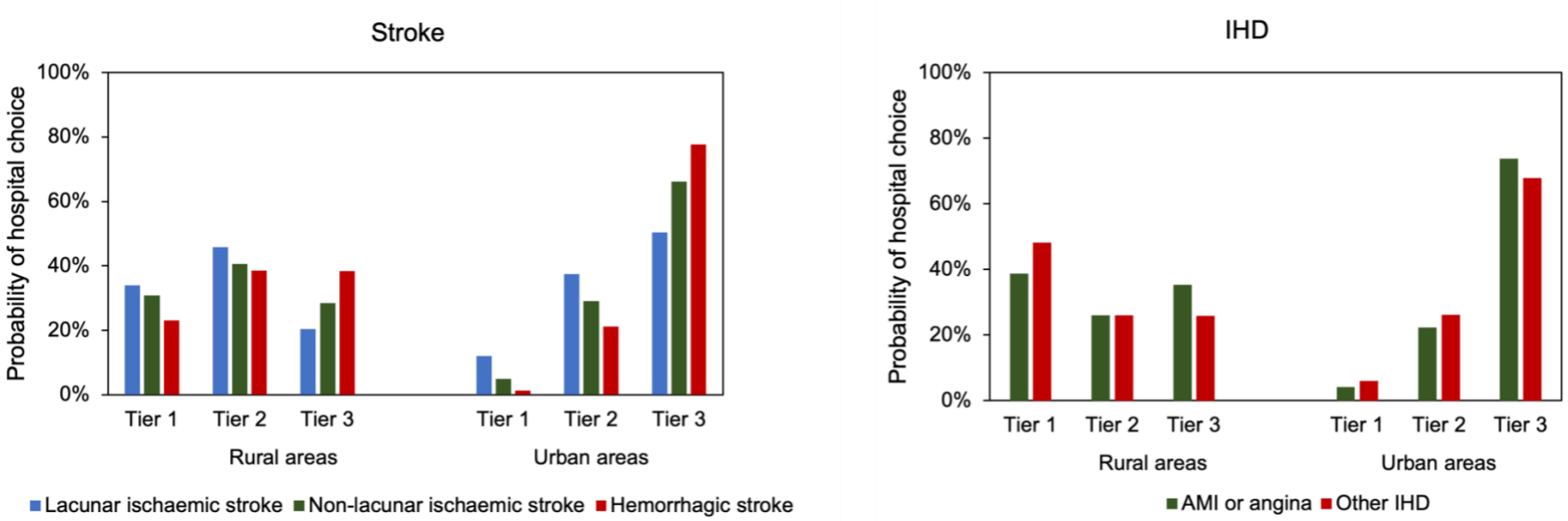


Figure F.4 Probabilities of choosing each hospital tier for stroke and IHD by CKB centre in rural and urban areas in 2009-2017

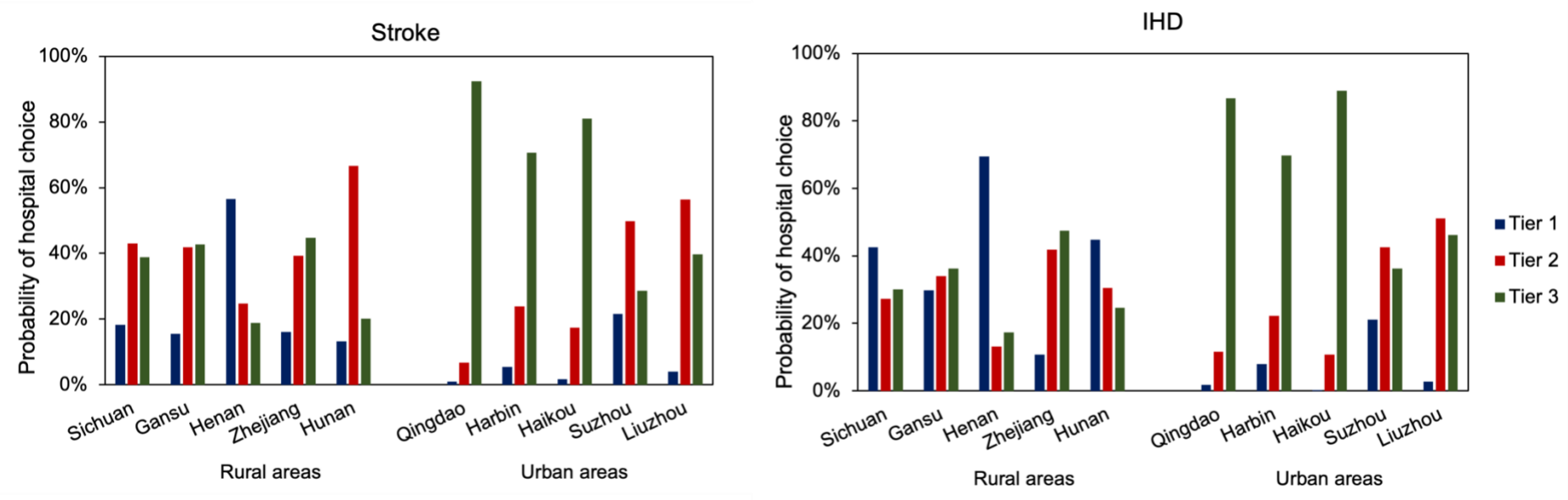


Table F.14 Own and cross elasticities (95% CI) of choice of hospital tier in terms of co-insurance rate for stroke and IHD in urban and rural areas

	Stroke			IHD		
With respect to:	**Tier 1**	**Tier 2**	**Tier 3**	**Tier 1**	**Tier 2**	**Tier 3**
Urban areas						
Tier 1	-0.47 (-0.68, -0.24)	0.05 (0.02, 0.07)	0.02 (0.01, 0.03)	-0.29 (-0.49, -0.09)	0.02 (0.01, 0.04)	0.02 (0.00, 0.03)
Tier 2	0.32 (0.21, 0.42)	-0.40 (-0.52, -0.27)	0.16 (0.11, 0.21)	0.14 (0.07, 0.20)	-0.24 (-0.37, -0.13)	0.08 (0.04, 0.12)
Tier 3	0.29 (0.18, 0.39)	0.32 (0.20, 0.43)	-0.18 (-0.24, -0.12)	0.21 (0.09, 0.32)	0.21 (0.10, 0.33)	-0.10 (-0.15, -0.04)
Rural areas						
Tier 1	-0.05 (-0.14, 0.04)	0.02 (-0.02, 0.06)	0.02 (-0.02, 0.06)	0.10 (0.02, 0.18)	-0.09 (-0.17, -0.02)	-0.09 (-0.16, -0.02)
Tier 2	0.00 (-0.07, 0.08)	-0.01 (-0.13, 0.12)	0.00 (-0.09, 0.10)	0.04 (-0.01, 0.10)	-0.13 (-0.30, 0.04)	0.05 (-0.02, 0.12)
Tier 3	0.13 (0.08, 0.18)	0.17 (0.10, 0.24)	-0.36 (-0.51, -0.22)	0.09 (0.04, 0.15)	0.12 (0.05, 0.19)	-0.28 (-0.44, -0.11)

Elasticities were based on the effects of the co-insurance rates on choice of hospital tier. Example for stroke: a 1% increase in the co-insurance rate in tier 3 is associated with: a 0.18% decrease in the probability of choosing tier 3 hospitals (own elasticity), a 0.29% and 0.32% increase in the probability of choosing tier 1 and 2 hospitals, respectively (cross elasticities). Choice elasticity is elastic when |elasticity|>1 and inelastic when |elasticity|<1.

Table F.15 Effects (Odds Ratios [95% CI]) of reimbursement rates and deductibles on choice of hospital tier for admissions for stroke, IHD and any cause in models without adjustment for ceiling

	Stroke		IHD		Any cause	
	Reimbursement rate (per % point)	**Deductible (per 100¥)**	**Reimbursement rate (per % point)**	**Deductible (per 100¥)**	**Reimbursement rate (per % point)**	**Deductible (per 100¥)**
Urban areas						
Tier 1	1.04 (1.03, 1.06)	1.03 (0.94, 1.12)	1.03 (1.01, 1.05)	0.95 (0.86, 1.06)	1.02 (1.01, 1.03)	0.90 (0.86, 0.94)
Tier 2	1.05 (1.04, 1.07)	0.98 (0.92, 1.03)	1.04 (1.02, 1.05)	1.01 (0.95, 1.08)	1.04 (1.03, 1.04)	0.92 (0.89, 0.95)
Tier 3	1.05 (1.03, 1.06)	0.85 (0.82, 0.88)	1.03 (1.02, 1.04)	0.91 (0.88, 0.95)	1.03 (1.03, 1.04)	0.85 (0.83, 0.87)
Rural areas						
Tier 1	1.01 (1.00, 1.02)	0.88 (0.82, 0.95)	0.99 (0.97, 1.00)	0.94 (0.88, 1.02)	0.99 (0.99, 1.00)	0.97 (0.95, 0.99)
Tier 2	1.00 (0.99, 1.01)	1.13 (1.08, 1.17)	1.00 (0.99, 1.01)	1.12 (1.07, 1.18)	1.01 (1.01, 1.01)	1.05 (1.04, 1.07)
Tier 3	1.01 (1.01, 1.02)	1.06 (1.02, 1.10)	1.01 (1.00, 1.01)	1.14 (1.10, 1.19)	1.01 (1.01, 1.01)	1.02 (1.01, 1.03)

Results are from multinomial logit models with as alternative-specific variables: interactions between tier and, reimbursement rate or deductible, and as case-specific variables: age, sex, years and regions. Only alternative-specific ORs are presented and interpreted as follows: an OR>1 means that if the regressor increases for one hospital tier, then that hospital tier is chosen more; and vice versa for an OR<1.

Table F.16 Fit statistics for models with and without tier specific effects of reimbursement rates and deductibles on choice of hospital tier for admissions for stroke, IHD and any cause

		Urban areas			Rural areas		
		Stroke	**IHD**	**Any cause**	**Stroke**	**IHD**	**Any cause**
Model with tier-specific coefficients for reimbursement rate and deductible (main analysis)	AIC	28555.53	26655.77	141163.40	40094.48	33898.57	269882.20
	BIC	29268.19	27332.33	141922.02	40810.74	34568.68	270665.90
	Log likelihood	-14187.76	-13241.89	-70501.69	-19957.24	-16863.29	-134861.10
Model with a single coefficient for reimbursement rate and deductible (sensitivity analysis)	AIC	28676.04	26686.67	141388.10	40156.08	33968.31	270072.40
	BIC	29357.03	27331.76	142109.00	40840.51	34607.25	270816.08
	Log likelihood	-14252.02	-13261.33	-70618.06	-19992.04	-16902.15	-134960.20
LRT* χ^2 (df=4) (p-value)		128.51 (<0.0001)	38.90 (p<0.0001)	232.74 (p<0.0001)	69.60 (<0.0001)	77.73 (p<0.0001)	198.13 (p<0.0001)

AIC: Akaike information criterion, BIC: Bayesian information criterion, *Likelihood ratio test (LRT) between multinomial logit model with and without tier-specific reimbursement rates and deductibles. Results are from multinomial logit models with as alternative-specific variables: reimbursement rate and deductible, and as case-specific variables: age, sex, years and regions.

Table F.17 Effects (Odds Ratios [95% CI]) of reimbursement rates and deductibles on choice of hospital tier for admissions for any cause in urban areas, by income and education level

	Reimbursement rates (per % point)			Deductibles (per 100¥)		
	Tier 1	**Tier 2**	**Tier 3**	**Tier 1**	**Tier 2**	**Tier 3**
Income group						
1st (bottom)	1.02 (1.01, 1.03)	1.03 (1.03, 1.04)	1.03 (1.03, 1.04)	0.98 (0.91, 1.04)	0.92 (0.88, 0.97)	0.83 (0.80, 0.86)
2nd	1.01 (1.01, 1.02)	1.03 (1.02, 1.04)	1.03 (1.02, 1.03)	0.90 (0.85, 0.95)	0.90 (0.87, 0.94)	0.85 (0.83, 0.88)
3rd	1.01 (1.00, 1.02)	1.03 (1.02, 1.04)	1.02 (1.01, 1.03)	0.89 (0.84, 0.95)	0.93 (0.89, 0.97)	0.86 (0.84, 0.89)
4th (top)	1.03 (1.02, 1.05)	1.05 (1.04, 1.06)	1.05 (1.04, 1.06)	0.89 (0.83, 0.95)	0.96 (0.91, 1.00)	0.88 (0.85, 0.91)
Education						
No formal school	1.01 (1.00, 1.03)	1.03 (1.02, 1.04)	1.03 (1.02, 1.04)	0.93 (0.87, 1.00)	0.87 (0.83, 0.93)	0.79 (0.76, 0.82)
Primary/middle school	1.02 (1.01, 1.03)	1.03 (1.02, 1.04)	1.03 (1.02, 1.03)	0.90 (0.86, 0.95)	0.93 (0.89, 0.96)	0.85 (0.83, 0.87)
High school and above	1.01 (1.00, 1.02)	1.02 (1.01, 1.03)	1.02 (1.01, 1.03)	0.81 (0.75, 0.87)	0.92 (0.88, 0.95)	0.87 (0.84, 0.89)

Results are from multinomial logit models with as alternative-specific variables: triple interactions between tier and, reimbursement rate and deductible, and income or education. Case-specific variables included demographic, socioeconomic (excluding income or education), lifestyle and morbidity factors, and log reimbursement ceiling. Only alternative-specific ORs are presented and interpreted as follows: an OR>1 means that if the regressor increases for one hospital tier, then that hospital tier is chosen more; and vice versa for an OR<1. Income groups are: 1st: <10 000¥, 2nd: 10 000-19 999¥, 3rd: 20 000-34 999¥, 4th: ≥35 000¥.

Table F.18 Effects (Odds Ratios [95% CI]) of reimbursement rates and deductibles on choice of hospital tier for admissions for any cause in rural areas, by income and education level

	Reimbursement rates (per % point)			Deductibles (per 100¥)		
	Tier 1	**Tier 2**	**Tier 3**	**Tier 1**	**Tier 2**	**Tier 3**
Income group						
1st (bottom)	1.00 (1.00, 1.00)	1.01 (1.00, 1.01)	1.01 (1.01, 1.01)	0.85 (0.81, 0.89)	1.03 (1.01, 1.05)	0.99 (0.987 1.01)
2nd	1.00 (1.00, 1.00)	1.01 (1.00, 1.01)	1.01 (1.01, 1.01)	0.91 (0.88, 0.94)	1.02 (0.99, 1.04)	0.99 (0.98, 1.01)
3rd	0.99 (0.99, 0.99)	1.00 (1.00, 1.00)	1.01 (1.00, 1.01)	0.96 (0.93, 0.98)	1.00 (0.98, 1.03)	0.95 (0.93, 0.98)
4th (top)	0.98 (0.98, 0.99)	1.00 (0.99, 1.00)	1.01 (1.01, 1.01)	1.00 (0.97, 1.03)	1.00 (0.97, 1.03)	0.94 (0.91, 0.97)
Education						
No formal school	1.00 (0.99, 1.00)	1.01 (1.00, 1.01)	1.01 (1.01, 1.01)	0.98 (0.94, 1.01)	1.06 (1.04, 1.08)	1.01 (0.99, 1.04)
Primary/middle school	0.99 (0.99, 1.00)	1.00 (1.00, 1.01)	1.01 (1.01, 1.01)	0.97 (0.96, 0.99)	1.02 (1.01, 1.04)	0.99 (0.98, 1.01)
High school and above	1.00 (0.99, 1.00)	1.01 (1.01, 1.02)	1.02 (1.02, 1.02)	0.94 (0.90, 0.98)	0.99 (0.956 1.02)	0.97 (0.94, 1.00)

Results are from multinomial logit models with as alternative-specific variables: triple interactions between tier and, reimbursement rate and deductible, and income or education. Case-specific variables included demographic, socioeconomic (excluding income or education), lifestyle and morbidity factors, and log reimbursement ceiling. Only alternative-specific ORs are presented and interpreted as follows: an OR>1 means that if the regressor increases for one hospital tier, then that hospital tier is chosen more; and vice versa for an OR<1. Income groups are: 1st: <10 000¥, 2nd: 10 000-19 999¥, 3rd: 20 000-34 999¥, 4th: ≥35 000¥.

Table F.19 Effects of socioeconomic characteristics (relative risk ratios [95% CI]) on hospital tier choice for stroke admissions without adjustment for lifestyle and morbidity factors

	Urban areas		Rural areas	
	Tier 1 (ref: tier 3)	**Tier 2 (ref: tier 3)**	**Tier 1 (ref: tier 3)**	**Tier 2 (ref: tier 3)**
Age group (ref: <55 years old)				
55-64 years old	1.28 (1.03, 1.59)	1.30 (1.16, 1.46)	0.98 (0.87, 1.11)	0.94 (0.84, 1.04)
65-74 years old	1.39 (1.12, 1.73)	1.41 (1.25, 1.58)	1.10 (0.97, 1.24)	1.07 (0.96, 1.20)
≥75 years old	1.36 (1.08, 1.72)	1.37 (1.21, 1.55)	1.42 (1.22, 1.64)	1.23 (1.08, 1.41)
Female	1.14 (1.00, 1.30)	1.03 (0.96, 1.10)	0.96 (0.88, 1.04)	1.00 (0.93, 1.08)
Education level (ref: primary/middle school)				
No formal school	1.22 (1.01, 1.48)	1.05 (0.94, 1.18)	1.06 (0.96, 1.18)	1.09 (1.00, 1.19)
High School or above	1.15 (0.98, 1.35)	0.93 (0.86, 1.01)	0.80 (0.69, 0.94)	0.80 (0.69, 0.92)
Annual household income (ref: 2nd income group)				
1st income group (bottom)	1.00 (0.83, 1.20)	1.19 (1.07, 1.31)	1.03 (0.93, 1.13)	1.01 (0.92, 1.11)
3rd income group	0.92 (0.78, 1.09)	0.95 (0.87, 1.04)	0.82 (0.71, 0.93)	0.92 (0.82, 1.03)
4th income group (top)	0.75 (0.61, 0.91)	0.80 (0.72, 0.89)	0.70 (0.58, 0.84)	0.70 (0.61, 0.81)
Not married (ref: married)	1.04 (0.87, 1.24)	1.00 (0.90, 1.10)	1.17 (1.03, 1.32)	0.95 (0.85, 1.06)
Household size	0.96 (0.90, 1.01)	1.03 (1.01, 1.06)	1.02 (1.00, 1.05)	1.01 (0.98, 1.03)

Results are from multinomial logit models with as alternative-specific variables: interactions between tier and, reimbursement rate and deductible. Case-specific variables included demographic, socioeconomic, and log reimbursement ceiling. Only case-specific RRRs are presented and interpreted as parameters of a binary logit model against the base category “Tier 3 hospital”. Income groups are: 1st: <10 000¥, 2nd: 10 000-19 999¥, 3rd: 20 000-34 999¥, 4th: ≥35 000¥.

Table F.20 Effects of socioeconomic characteristics (relative risk ratios [95% CI]) on hospital tier choice for IHD admissions without adjustment for lifestyle and morbidity factors

	Urban areas		Rural areas	
	Tier 1 (ref: tier 3)	**Tier 2 (ref: tier 3)**	**Tier 1 (ref: tier 3)**	**Tier 2 (ref: tier 3)**
Age group (ref: <55 years old)				
55-64 years old	0.98 (0.81, 1.20)	1.06 (0.95, 1.19)	0.86 (0.77, 0.97)	1.06 (0.93, 1.22)
65-74 years old	0.99 (0.80, 1.21)	1.13 (1.00, 1.27)	0.94 (0.84, 1.07)	1.28 (1.11, 1.47)
≥75 years old	1.01 (0.80, 1.27)	1.16 (1.02, 1.32)	1.10 (0.95, 1.27)	1.55 (1.33, 1.82)
Female	1.51 (1.31, 1.75)	1.29 (1.19, 1.39)	1.34 (1.23, 1.45)	1.15 (1.06, 1.26)
Education level (ref: primary/middle school)				
No formal school	1.13 (0.90, 1.40)	1.07 (0.94, 1.22)	1.15 (1.04, 1.28)	1.21 (1.08, 1.34)
High School or above	1.02 (0.87, 1.19)	0.91 (0.83, 0.99)	0.70 (0.61, 0.82)	0.79 (0.67, 0.94)
Annual household income (ref: 2nd income group)				
1st income group (bottom)	1.40 (1.15, 1.70)	1.10 (0.98, 1.23)	1.09 (0.98, 1.21)	1.07 (0.96, 1.21)
3rd income group	0.86 (0.73, 1.02)	0.89 (0.82, 0.97)	0.90 (0.80, 1.02)	0.99 (0.87, 1.13)
4th income group (top)	0.61 (0.50, 0.76)	0.80 (0.72, 0.90)	0.55 (0.47, 0.65)	0.70 (0.60, 0.82)
Widowed/Separated/divorced/Never married	0.94 (0.78, 1.13)	0.97 (0.87, 1.08)	1.17 (1.03, 1.32)	1.07 (0.94, 1.21)
Household size	1.07 (1.00, 1.13)	1.02 (0.99, 1.06)	1.04 (1.01, 1.06)	1.01 (0.98, 1.04)

Results are from multinomial logit models with as alternative-specific variables: interactions between tier and, reimbursement rate and deductible. Case-specific variables included demographic, socioeconomic, and log reimbursement ceiling. Only case-specific RRRs are presented and interpreted as parameters of a binary logit model against the base category "Tier 3 hospital". Income groups are: 1st: <10 000¥, 2nd: 10 000-19 999¥, 3rd: 20 000-34 999¥, 4th: ≥35 000¥.

Table F.21 Determinants (relative risk ratios [95% CI]) of hospital tier choice for admissions for any cause without adjustment for lifestyle and morbidity factors

	Urban areas		Rural areas	
	Tier 1 (ref: tier 3)	**Tier 2 (ref: tier 3)**	**Tier 1 (ref: tier 3)**	**Tier 2 (ref: tier 3)**
Age group (ref: <55 years old)				
55-64 years old	1.03 (0.96, 1.10)	1.07 (1.03, 1.12)	1.00 (0.97, 1.04)	1.01 (0.97, 1.04)
65-74 years old	1.02 (0.94, 1.10)	1.16 (1.11, 1.21)	1.03 (0.99, 1.07)	1.16 (1.11, 1.20)
≥75 years old	1.08 (0.98, 1.18)	1.20 (1.14, 1.28)	1.18 (1.11, 1.26)	1.42 (1.34, 1.51)
Female	1.03 (0.97, 1.09)	1.01 (0.97, 1.04)	1.09 (1.05, 1.12)	1.04 (1.01, 1.07)
Education level (ref: primary/middle school)				
No formal school	1.24 (1.15, 1.33)	1.07 (1.01, 1.13)	1.09 (1.05, 1.13)	1.13 (1.09, 1.18)
High School or above	0.96 (0.89, 1.03)	0.96 (0.92, 1.00)	0.79 (0.75, 0.84)	0.85 (0.80, 0.90)
Annual household income (ref: 2nd income group)				
1st income group (bottom)	1.23 (1.13, 1.34)	1.14 (1.08, 1.20)	1.13 (1.08, 1.17)	1.07 (1.03, 1.12)
3rd income group	0.88 (0.82, 0.94)	0.94 (0.91, 0.98)	0.88 (0.85, 0.92)	0.96 (0.92, 1.00)
4th income group (top)	0.64 (0.59, 0.69)	0.96 (0.92, 1.01)	0.69 (0.65, 0.73)	0.76 (0.73, 0.80)
Widowed/Separated/divorced/Never married	0.97 (0.90, 1.06)	0.96 (0.92, 1.01)	1.15 (1.09, 1.21)	1.06 (1.00, 1.12)
Household size	1.06 (1.04, 1.09)	1.02 (1.00, 1.03)	1.04 (1.03, 1.05)	1.01 (1.00, 1.02)

Results are from multinomial logit models with as alternative-specific variables: interactions between tier and, reimbursement rate and deductible. Case-specific variables included demographic, socioeconomic, and log reimbursement ceiling. Only case-specific RRRs are presented and interpreted as parameters of a binary logit model against the base category “Tier 3 hospital”. Income groups are: 1st: <10 000¥, 2nd: 10 000-19 999¥, 3rd: 20 000-34 999¥, 4th: ≥35 000¥.

Table F.22 Effects of approximated equivalent income (relative risk ratios [95% CI]) on hospital tier choice for stroke and IHD admissions

	Urban areas		Rural areas	
	Tier 1 (ref: tier 3)	**Tier 2 (ref: tier 3)**	**Tier 1 (ref: tier 3)**	**Tier 2 (ref: tier 3)**
Stroke (ref: 2nd income quartile)				
1st income quartile	1.08 (0.86, 1.36)	1.01 (0.92, 1.11)	1.05 (0.95, 1.16)	1.15 (1.02, 1.31)
3rd income quartile	1.03 (0.87, 1.23)	0.96 (0.86, 1.07)	0.88 (0.78, 1.00)	1.01 (0.92, 1.11)
4th income quartile	0.75 (0.63, 0.90)	0.71 (0.63, 0.81)	0.67 (0.57, 0.80)	0.85 (0.77, 0.93)
IHD (ref: 2nd income quartile)				
1st income quartile	1.14 (0.92, 1.43)	1.12 (0.98, 1.28)	1.05 (0.94, 1.17)	1.06 (0.94, 1.19)
3rd income quartile	0.73 (0.61, 0.87)	0.95 (0.86, 1.05)	0.90 (0.80, 1.01)	1.00 (0.88, 1.14)
4th income quartile	0.62 (0.51, 0.75)	0.85 (0.76, 0.95)	0.56 (0.48, 0.66)	0.70 (0.60, 0.82)

Results are from multinomial logit models with as alternative-specific variables: interactions between tier and, reimbursement rate and deductible. Case-specific variables included demographic, socioeconomic, and log reimbursement ceiling. Only case-specific RRRs are presented and interpreted as parameters of a binary logit model against the base category “Tier 3 hospital.

Table F.23 Effects (Odds Ratios [95% CI]) of reimbursement rates, deductibles, and number of beds on choice of hospital tier for admissions for stroke and IHD in models adjusted for supply-side factors

	Stroke			IHD		
	Reimbursement rate (per % point)	**Deductible (per 100¥)**	**No. of beds (per 10 000 beds)**	**Reimbursement rate (per % point)**	**Deductible (per 100¥)**	**No. of beds (per 10 000 beds)**
Urban areas						
Tier 1	1.04 (1.02, 1.06)	1.00 (0.91, 1.10)	0.94 (0.78, 1.13)	1.02 (1.00, 1.04)	0.82 (0.74, 0.92)	0.98 (0.83, 1.16)
Tier 2	1.05 (1.03, 1.07)	1.00 (0.95, 1.06)	0.94 (0.78, 1.13)	1.03 (1.01, 1.04)	0.95 (0.89, 1.01)	1.10 (0.93, 1.30)
Tier 3	1.04 (1.03, 1.05)	0.85 (0.82, 0.88)	0.92 (0.76, 1.11)	1.02 (1.00, 1.03)	0.87 (0.84, 0.91)	1.06 (0.90, 1.26)
Rural areas						
Tier 1	1.01 (1.00, 1.02)	0.87 (0.80, 0.94)	0.97 (0.88, 1.06)	0.98 (0.97, 1.00)	0.93 (0.86, 1.01)	1.02 (0.94, 1.12)
Tier 2	1.01 (1.00, 1.01)	1.09 (1.05, 1.14)	0.96 (0.88, 1.05)	1.00 (1.00, 1.01)	1.14 (1.08, 1.19)	1.04 (0.95, 1.14)
Tier 3	1.02 (1.01, 1.02)	1.03 (0.99, 1.07)	0.95 (0.87, 1.05)	1.01 (1.00, 1.02)	1.15 (1.10, 1.20)	1.04 (0.95, 1.14)

Results are from multinomial logit models with as alternative-specific variables: interactions between tier and, reimbursement rate, deductible, and number of beds. Case-specific variables included demographic, socioeconomic, lifestyle and morbidity factors, log reimbursement ceiling and density of doctors. Only alternative-specific ORs are presented and interpreted as follows: an OR>1 means that if the regressor increases for one hospital tier, then that hospital tier is chosen more; and vice versa for an OR<1.

References

1. Babiarz KS, Miller G, Yi H, Zhang L, Rozelle S. New evidence on the impact of China's New Rural Cooperative Medical Scheme and its implications for rural primary healthcare: multivariate difference-in-difference analysis. *BMJ*. 2010; **341**: c5617.
2. Brown PH, Theoharides C. Health-seeking behavior and hospital choice in China's New Cooperative Medical System. *Health Economics*. 2009; **18**(S2): S47-S64.
3. Cao Y, Zhen F, Wu H. Public Transportation Environment and Medical Choice for Chronic Disease: A Case Study of Gaoyou, China. *International Journal of Environmental Research and Public Health*. 2019; **16**(9): 1612.
4. Hou Z, Poel E, Doorslaer E, Yu B, Meng Q. Effects of NCMS on Access to Care and Financial Protection in China. *Health economics*. 2014; **23**(8): 917-34.
5. Jin Y, Xu J, Zhu W, Zhang Y, Xu L, Meng Q. Synergy of policies to strengthen primary care: evidence from a national repeated cross-sectional study. *BMC Health Services Research*. 2020; **20**(1): 865.
6. Li C, Chen Z, Khan MM. Bypassing primary care facilities: health-seeking behavior of middle age and older adults in China. *BMC Health Services Research*. 2021; **21**(1): 895.
7. Li X, Zhang L, Li Z, Tang W. Patient Choice and Willingness Toward Gatekeepers as First-Contact Medical Institutions in Chinese Tiered Healthcare Delivery System: A Cross-Sectional Study. *Frontiers in Public Health*. 2021; **9**: 665282-.
8. Liu Y, Kong Q, Wang S, Zhong L, van de Klundert J. The impact of hospital attributes on patient choice for first visit: evidence from a discrete choice experiment in Shanghai, China. *Health Policy and Planning*. 2019; **35**(3): 267-78.
9. Liu Y, Kong Q, de Bekker-Grob EW. Public preferences for health care facilities in rural China: A discrete choice experiment. *Social Science & Medicine*. 2019; **237**: 112396.
10. Ma Q, Sun D, Cui F, et al. Impact of the Internet on Medical Decisions of Chinese Adults: Longitudinal Data Analysis. *Journal of Medical Internet Research*. 2020; **22**(9): e18481-e.
11. Qian D, Pong RW, Yin A, Nagarajan KV, Meng Q. Determinants of health care demand in poor, rural China: the case of Gansu Province. *Health Policy and Planning*. 2009; **24**(5): 324-34.
12. Qian D, Lucas H, Chen J, Xu L, Zhang Y. Determinants of the use of different types of health care provider in urban China: A tracer illness study of URTI. *Health Policy*. 2010; **98**(2): 227-35.
13. Shu Z, Han Y, Xiao J, Li J. Effect of medical insurance and family financial risk on healthcare utilisation by patients with chronic diseases in China: a cross-sectional study. *BMJ Open*. 2019; **9**(11): e030799-e.
14. Tang L. The patient's anxiety before seeing a doctor and her/his hospital choice behavior in China. *BMC Public Health*. 2012; **12**(1): 1121.
15. Wu D, Lam TP, Lam KF, Zhou XD, Sun KS. Health reforms in china: the public's choices for first-contact care in urban areas. *Family Practice*. 2017; **34**(2): 194-200.

16. Xiong X, Zhang Z, Ren J, et al. Impact of universal medical insurance system on the accessibility of medical service supply and affordability of patients in China. *PLOS One*. 2018; **13**(3): e0193273.
17. Yu W, Li M, Ye F, Xue C, Zhang L. Patient preference and choice of healthcare providers in Shanghai, China: a cross-sectional study. *BMJ Open*. 2017; **7**(10): e016418.
18. Zhang A, Nikoloski Z, Albala S, Yip W, Xu J, Mossialos E. Patient Choice of Health Care Providers in China: Primary Care Facilities versus Hospitals. *Health Systems & Reform*. 2020; **6**.
19. Zhang C, Lei X, Strauss J, Zhao Y. Health Insurance and Health Care among the Mid-Aged and Older Chinese: Evidence from the National Baseline Survey of CHARLS. *Health Economics*. 2017; **26**(4): 431-49.
20. Zhang L, Wang Z, Qian D, Ni J. Effects of changes in health insurance reimbursement level on outpatient service utilization of rural diabetics: evidence from Jiangsu Province, China. *BMC Health Services Research*. 2014; **14**: 185-.
21. Zhou Z, Wang C, Yang H, Wang X, Zheng C, Wang J. Health-Related Quality of Life and Preferred Health-Seeking Institutions among Rural Elderly Individuals with and without Chronic Conditions: A Population-Based Study in Guangdong Province, China. *BioMed Research International*. 2014; **2014**: 192376.
22. Zhou Z, Zhao Y, Shen C, Lai S, Nawaz R, Gao J. Evaluating the effect of hierarchical medical system on health seeking behavior: A difference-in-differences analysis in China. *Social Science & Medicine*. 2021; **268**: 113372.
23. White IR, Royston P, Wood AM. Multiple imputation using chained equations: Issues and guidance for practice. *Statistics in Medicine*. 2011; **30**(4): 377-99.