REPORT ON CARDIOVASCULAR DISEASES IN CHINA 2018

中国心血管病报告 2018

National Center for Cardiovascular Diseases, China
国家心血管病中心

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Preface

Rapid socioeconomic progress in China has greatly impacted the lifestyle of citizens. The tendency to develop cardiovascular diseases (CVD) has increased in China as a consequence of lifestyle changes, urbanization, and the accelerated aging of the population. The incidence of CVD has been continuously increasing and will continue an upward trend in the next decade.

CVD is the leading cause of death in both urban and rural Chinese populations. Currently, 45.50% of deaths in rural areas and 43.16% in urban areas are attributable to CVD. The growing burden of CVD has become a major public health issue. Effective strategies for the prevention and treatment of CVD should be enforced urgently under the supervision of the government. On 14th February 2017, General Office of the State Council issued *The Medium- and Long-term Plan for Chronic Disease Prevention and Control in China (2017-2025)*, a guideline for the prevention and control of chronic diseases, especially CVD in China, which should be appropriately followed and implemented as the recommendations.

Since 2005, the National Center for Cardiovascular Diseases has been recruiting experts nationwide to compile the *Report on Cardiovascular Diseases in China* annually (herein after referred to as the annual report). To date, 13 annual reports have been published. In the year of the publication of the first annual report, it was selected among the top ten academic news for its innovation and importance. In 2015, the National Health Commission listed the annual report as one of the five most important regularly-released health information in the field of diseases prevention and control in China. The annual report was published to dynamically track the prevalence of CVD and comprehensively evaluate the progress of research on CVD prevention in the country. It covers various aspects of the research and development of prevention for CVD throughout the nation, primarily focusing on monitoring cardiovascular (CV) epidemic trends to guide the management of CVD. The report seeks to be comprehensive, timely, accurate and complete, to reflect its representativeness and authority, and to provide technical guidance for the government, medical research institutions and communities to carry out more effective research on prevention and control of CVD.

In addition to maintaining the continuity of the core content in the previous annual reports, the *Report on Cardiovascular Diseases in China 2018* has added three key points to deal with the current severe situation of CVD in China: (1) Prediction for the trend of CVD and individual risks in Chinese population. A comprehensive analysis of predictive models on CVD risks was performed in individuals or populations at different control levels of risk factors, emphasizing a lifetime risk assessment for young- and middle-aged people with low- or intermediate-level of risk of CVD, to facilitate the early prevention and control of CVD; (2) Medical care quality assessment on CVD. Based on relevant literatures published in recent years, objective analysis was conducted on the medical care quality of CVD in China. It revealed that both progress and weakness exist. In 2015, the medical care quality and accessibility index in China ranked the 48th in the world, and the progress ranked third between 1990 to 2015. The medical care quality of CVD in China is improving steadily. The proportion of implementing standardized medications and other treatments recommended by the guidelines is increasing, but there is still much room for improvement. Moreover, the disparity of medical care capabilities in different hospitals at different levels is still significant. (3) At the end of the annual report 2018, we added the appendix of *Guidelines for CVD Released in China in the Past Five Years* , listing the titles, institutions, and the published journal names for reference.

It should be noted that the term “cardiovascular diseases” in this report refers to cardiovascular and cerebrovascular diseases, as well as their related diseases.

The information in the annual report is an essential reference for the government to formulate relevant policies. It serves as an information platform for national prevention and control of CVD, and for international communication and cooperation. It is also a crucial element of enhancing China's international status and influence in the research field of CVD management. The work of compiling the *Report on Cardiovascular Diseases in China* has received full support from the leaders of the National Health Commission, the National Center for Cardiovascular Diseases, the Fuwai Hospital, the annual report writing group members, the editorial board, and the academic committee, especially the experts from the writing group. We would like to express our deep appreciation to them.

Although we strive for excellence in the process of writing, there might still be some missing information. We look forward to having valuable opinions from the readers to make the annual report better.

Abbreviations and Acronyms

ABI：Ankle Brachial Index
ACC：American College of Cardiology
ACEI：Angiotensin Converting Enzyme Inhibitor
ACR：(Urinary) Albumin/Creatinine Ratio
ACS：Acute Coronary Syndrome
AHA：American Heart Association
AMI：Acute Myocardial Infarction
ARB：Angiotensin II Receptor Blocker
AS：Atherosclerosis
ASCVD：Atherosclerotic Cardiovascular Diseases
BMI：Body Mass Index
BP：Blood Pressure
BRIG：Bridging the Gap on Coronary Heart Disease Secondary Prevention in China
CABG：Coronary Artery Bypass Grafting
CAD：Carotid Atherosclerotic Disease
CAMI：China Acute Myocardial Infarction
CCC：Improving Care for Cardiovascular Diseases in China
CCDRFS：China Chronic Disease and Risk Factors Surveillance
CCM：Cardiac Contractility Monitor
CCSR：China Cardiovascular Surgery Registration (Study)
CDC：Center of Disease Control
CDS：Chinese Diabetes Society
cfPWV：carotid -femoral Pulse Wave Velocity
CHD：Coronary Heart Disease
China-HF：China Heart Failure (Registry Study)
China-PAR：Prediction for ASCVD Risk in China
China-PEACE：China Patient-centered Evaluative Assessment of Cardiac Events
CHNS：China Health and Nutrition Survey
CHS：China Hypertension Survey
CI：Confidence Interval
CIMIC：Community Intervention of Metabolic Syndrome in China
CKB：China Kadoorie Biobank
CKD：Chronic Kidney Disease
CNDMDS：China National Diabetes and Metabolic Disorders Survey
CNSCKD：China National Survey of Chronic Kidney Disease
COPD：Chronic Obstructive Pulmonary Disease
CPACS：Clinical Pathways for Acute Coronary Syndrome in China
CPB：Cardiopulmonary Bypass
CRT：Cardiac Resynchronization Therapy
CSPP：China National Stroke Prevention Project
CTD：Connective Tissue Disease
CTEPH：Chronic Thromboembolic Pulmonary Hypertension
CVD：Cardiovascular Diseases
DALY：Disability-Adjusted Life Year
DBP：Diastolic Blood Pressure
DLCO：Diffusing Capacity of the Lungs for Carbon Monoxide
DVT：Deep Vein Thrombosis
ECMO：Extracorporeal Membrane Oxygenation
eGFR：estimated Glomerular Filtration Rate
ESRD：End Stage Renal Disease
FPG：Fasting Plasma Glucose
GATS：Global Adult Tobacco Survey
GBD：Global Burden of Disease
GFR：Glomerular Filtration Rate
GYTS：Global Youth Tobacco Survey
HbA1c：Hemoglobin A1c
HDL-C：High-Density Lipoprotein Cholesterol

HF：Heart Failure
HQMS：Hospital Quality Monitoring System
HR：Hazard Ratio
IABP：Intra-Aortic Balloon Pump
ICD：Implantable Cardiac Defibrillator
ICER：Incremental Cost-Effectiveness Ratio
ICVD：Ischemic Cardiovascular Disease
IDF：International Diabetes Federation
IHD：Ischemic Heart Disease
IMT：(Carotid) Intima-Media Thickness
InterASIA：International Collaborative Study of Cardiovascular Disease in Asia
IPAH：Idiopathic Pulmonary Arterial Hypertension
IQR：Inter-Quartile Range
IRR：Incidence Rate Ratio
JIS：Joint Interim Statement
LDL-C：Low-Density Lipoprotein Cholesterol
LEAD：Lower Extremity Atherosclerotic Disease
LVMI：Left Ventricular Mass Index
MACE：Major Adverse Cardiovascular Events
MET：Metabolic Equivalent of Task
MS：Metabolic Syndrome
MUCA：Multi-center Collaborative Study of Cardiovascular Epidemiology
NCEP-ATPIII：(US) National Cholesterol Education Program-Adult Treatment Panel III
NOAC：New Oral Anticoagulant
NSTEMI：Non-ST-Segment Elevation Myocardial Infarction
OAC：Oral Anticoagulant
OPCABG：Off-Pump Coronary Artery Bypass Grafting
OSAHS：Obstructive Sleep Apnea Hypopnea Syndrome
PAD：Peripheral Arterial Disease
PAH：Pulmonary Arterial Hypertension
PAR：Population Attributable Risk
PARP：Population Attributable Risk Percentage
PCI：Percutaneous Coronary Intervention
PWV：Pulse Wave Velocity
QALY：Quality-Adjusted Life Year
RAS：Renal Artery Stenosis
RFCA：Radiofrequency Catheter Ablation
RR：Risk Ratio
SBP：Systolic Blood Pressure
SCD：Sudden Cardiac Death
SHS：Secondhand Smoke
STEMI：ST-Segment Elevation Myocardial Infarction
TC：Total Cholesterol
TG：Triglyceride
TIA：Transient Ischemic Attack
UAP：Unstable Angina Pectoris
UI：Uncertainty Interval
WC：Waist Circumference
WHO：World Health Organization
WHtR：Waist Height Ratio
YLD：Years Lived with Disability

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Outline of the Report on Cardiovascular Diseases in China 2018

Part 1 Epidemiology of Cardiovascular Diseases

1.1 Prevalence of Cardiovascular Diseases

The prevalence of cardiovascular diseases (CVD) in China has been persistently increasing. It is estimated that about 290 million patients are suffering from CVD, among which the number of patients with stroke, coronary heart disease (CHD), pulmonary heart disease, heart failure (HF), rheumatic heart disease, congenital heart disease and hypertension is 13 million, 11 million, 5 million, 4.5 million, 2.5 million, 2 million and 245 million, respectively.

1.2 Death from Cardiovascular Diseases

CVD remained the major cause of death in 2016, and resulted in more deaths than tumors and other diseases. Since 2009, the mortality of CVD in rural areas has exceeded and remained constantly higher than that in urban areas. In 2016, the mortality of CVD in rural areas was 309.33/100 000, of which 151.18/100 000 was due to heart disease and 158.15/100 000 due to cerebrovascular disease. Meanwhile, the mortality of CVD in urban areas was 265.11/100 000, of which 138.70/100 000 was due to heart disease and 126.41/100 000 due to cerebrovascular disease. In 2016, CVD-related deaths accounting for all deaths were 45.50% in rural areas and 43.16% in urban areas. Two out of five deaths were attributed to CVD.

Part 2 Risk Factors of Cardiovascular Diseases

2.1 Hypertension

Four national sampling surveys on hypertension in China had been conducted during 1958-1959, 1979-1980, and in 1991 and 2002. The prevalence of hypertension among Chinese residents aged ≥15 years was on a rise. China Hypertension Survey (CHS) investigated 451 755 individuals aged ≥18 years from 262 urban and rural areas in 31 provinces, municipalities, and autonomous regions of mainland China in 2012-2015 by stratified multi-stage random sampling. Results showed that the overall crude prevalence of hypertension among Chinese adults was 27.9% (weighted: 23.2%). It was higher in males than in females (crude rate: 28.6% vs 27.2%, weighted rate: 24.5% vs 21.9%), and increased with age.

China Health and Nutrition Survey (CHNS) had conducted 8 cross-sectional surveys among adults aged ≥18 years during 1991-2011 in 9 provinces and municipalities (added up to 12 provinces and municipalities in

2011). Results demonstrated that the age-normalized prevalence of high-normal blood pressure increased from 23.9% in 1991 to 33.6% in 2011. Data from CHS showed that among Chinese residents aged ≥18 years, the overall crude prevalence of high-normal blood pressure was 39.1% and the weighted prevalence was 41.3%.

CHS showed that the weighted SBP was 126.1 mmHg and the weighted DBP was 76.0 mmHg among residents aged ≥18 years. SBP increased with age, while DBP increased at first and then decreased with age. The weighted blood pressure in males was significantly higher than that in females (128.0/77.8 mmHg vs 124.2/74.2 mmHg, $P<0.001$). China Chronic Disease and Risk Factors Surveillance (CCDRFS) recruited 174 621 adults aged ≥18 years from 31 provinces, municipalities, and autonomous regions in mainland China during 2013-2014. Results showed that the weighted SBP was 124.5 mmHg and the weighted DBP was 75.5 mmHg.

According to 2012-2015 CHS, the awareness, treatment, and control rates of hypertension among Chinese adults aged ≥18 years were 51.6%, 45.8% and 16.8%, respectively, and the control rate among treatment was 37.5%. These rates had improved markedly compared with those in previous studies. The awareness, treatment and control rates of hypertension were significantly higher in females than in males (55.3% vs 47.6%, 50.1% vs 41.2%, 18.2% vs 15.3%, respectively). The residents in urban areas had higher awareness, treatment, and control rates of hypertension than those in rural areas (50.9% vs 44.7%, 45.8% vs 38.0%, 19.4% vs 13.1%, respectively).

Chinese National Survey on Students' Constitution and Health (CNSSCH) was conducted in more than 190 000 children and adolescents aged 7-17 years in 2010. Results showed that the prevalence of hypertension was 14.5% in school-aged children. It was higher in boys than in girls (16.1% vs 12.9%), and increased with age. Data from 1993-2011 CHNS demonstrated that the prevalence of hypertension among children and adolescents increased with an annual growth of 0.16% on average. Data from 1995-2014 CNSSCH among 943 128 children and adolescents aged 7-17 years indicated that the population attributable risk percentage (PARP) of hypertension because of overweight or obesity steadily increased from 6.3% in 1995 to 19.4% in 2014. Retrospective analysis on medical records of hospitalized patients revealed that a majority of hypertensive children (52.0%-81.5%) were admitted for secondary hypertension. Renal hypertension was the leading etiology in secondary hypertension among Chinese children.

2.2 Smoking

Since 1984, the prevalence of smoking in male Chinese has been among the highest ones in the world. It was 63% in 1984, and continued to be over 50% from 1996 to 2010. However, the prevalence of smoking has been constantly declining in males aged ≥15 years since 1996. During 2002-2010, the annual decline of normalized prevalence of smoking was 0.08% on average.

Chinese Adult Tobacco Survey was conducted in 2015 and included 15 095 participants from 31 provinces, municipalities, and autonomous regions in mainland China. It demonstrated that the standardized prevalence of current smoking among Chinese residents aged ≥15 years was 27.7%, with 52.1% for males and 2.7% for females. Compared with the profiles in 2010, the number of smokers in the 5-year period increased by 15 million. In 2015, the daily cigarette consumption of each smoker was 15.2 on average, which increased by 1 compared with that in 2010.

Global Youth Tobacco Survey (GYTS)-China investigated 155 117 students aged 13-15 years in 2014. Results showed that the prevalence of current smoking in Chinese teenagers was 6.9%. It was higher in males (11.2%) than in females (2.2%), and higher in rural areas (7.8%) than in urban areas (4.8%).

According to Global Adult Tobacco Survey (GATS), the rate of exposure to secondhand smoke (SHS) was 72.4% in all non-smokers in 2010 in China-an estimated 738 million victims of passive smoking. Compared with the data in 2010, the proportion of non-smokers who witnessed smoking in indoor workshops, public places, public transport vehicles, and at homes decreased in 2015, which indicated that SHS exposure had been improved.

The proportion of smoking cessation among the Chinese population aged ≥15 years had increased from 9.42% in 1996 to 16.9% in 2010. In 2015, 18.7% of all former and current smokers became non-smokers.

2.3 Dyslipidemia

China Chronic Disease and Risk Factor Surveillance (CCDRFS) surveyed 163 641 adults from 31 provinces, municipalities, and autonomous regions during 2013-2014. Results showed that the levels of serum TC, LDL-C, TG, and HDL-C among Chinese population aged ≥18 years were 4.70 mmol/L, 2.88 mmol/L, 1.14 mmol/L, and 1.35 mmol/L, respectively. The level of serum TC was significantly higher than those from 2002 CHNS (3.81 mmol/L) and 2010 CCDRFS (4.04 mmol/L).

Data from CHNS, Chinese National Survey of Chronic Kidney Disease (CNSCKD) and *Report on the Nutrition and Chronic Disease Status of Chinese Residents (2015)* showed that the prevalence of dyslipidemia among Chinese population aged ≥18 years was 18.6% (2002), 34.0% (2010), and 40.4% (2012), respectively. It increased substantially during the last decade (from 2002 to 2012). In general, the prevalence of dyslipidemia was higher in males than in females, and higher in urban areas than in rural areas.

2010 CNSCKD was a cross-sectional study and recruited 43 368 urban and rural residents from 13 provinces and municipalities in mainland China. Results showed that the awareness, treatment, and control rates of dyslipidemia among people aged ≥18 years were 31.0%, 19.5% and 8.9%, respectively. All the rates were lower in males than in females (30.12% vs 31.84%, 18.90% vs 20.01%, 7.27% vs 9.62%, respectively).

2.4 Diabetes

According to a nationwide large-sample epidemiological study in 2013, the overall standardized prevalence of diabetes in Chinese adults was estimated as 10.9%, which was slightly higher in males than in females (11.7% vs 10.2%). Hemoglobin A1c (HbA1c) concentration added an additional 0.5% to the total diabetes group. The estimated prevalence of prediabetes was 35.7%. Among persons with diabetes, 36.5% were aware of their conditions and 32.2% were treated, and 49.2% of patients treated had adequate glycemic control.

China Kadoorie Biobank (CKB) was a 7-year nationwide prospective study. It investigated 512 869 adults aged 30-79 years in China. Results showed that compared with adults without diabetes, individuals with diabetes had a significantly increased risk of all-cause mortality. Presence of diabetes was associated with increased mortality from ischemic heart disease and stroke. Likewise, diabetes was associated with an increased relative risk for mortality from chronic liver disease, infections, and cancer of the liver, pancreas, female breast, and female reproductive system. The increase of mortality from CVD was most salient. Besides the low treatment and control rates of diabetes, low use of cardio-protective medications (e.g., aspirin, statins, and blood pressure lowering agents) also contributed to excess cardiovascular mortality in patients with diabetes. This study estimated that there was a loss of a median of 9 (rural 10, urban 8) years of life for individuals with diabetes diagnosed below age 50.

2.5 Overweight and Obesity

Data from the *Report on the Nutrition and Chronic Disease Status of Chinese Residents (2015)* demonstrated that in 2012, 30.1% of Chinese residents aged ≥18 years were overweight and 11.9% were obese, with an increase of 7.3% and 4.8%, respectively, as compared with the prevalence in 2002. Even though the rural residents had lower rates of overweight and obesity in 2012, they experienced a larger increase than their urban counterparts. The prevalence of abdominal obesity and mean waist circumference also increased among Chinese adults. The increase was greater in rural residents than in urban residents, indicating a decrease in the disparity between the two populations.

The prevalence of overweight and obesity was also increased in children. It was significantly higher among urban and rural children aged ≤6 and 7-17 years in 2012 than in 2002. National Physical Fitness and Health Surveillance of Chinese School Students was conducted 6 times during 1985-2014. The prevalence of overweight and obesity among students aged 7-18 years was on the rise. It was 11 and 56 times, respectively, in 2014 in comparison with that in 1985. More than 120 000 students aged 7-18 years were selected from 7 major geographic areas in China by stratified random cluster sampling in 2013. The results showed that the prevalence of overweight and obesity in Chinese children and adolescents was 12.2% and 7.1%, respectively.

2.6 Physical Inactivity

Results from the CHNS demonstrated a significant decline in overall physical activity (PA) in Chinese residents aged 18-60 years during 1991-2011, which was largely driven by occupational PA reduction. PA fell from 382 MET-h/week in 1991 to 264 MET-h/week in 2011 among adult males (a decrease of 31%), and fell from 420 MET-h/week to 243 MET-h/week among adult females (an decrease of 42%). Results from 2014 National Physical Fitness Surveillance indicated that the proportion of adults aged 20-59 years, who met the minimum leisure-time physical activity (LTPA) recommendation, was slightly increased as compared with those in previous surveys. However, other measures of physical fitness, such as resting heart rate, forced vital capacity, sit and reach distance, hand grip strength, and time standing on one leg, deteriorated over time.

In 2014, about 33.9% of people (including children and adolescents) participated in regular PA, which increased by 5.7% as compared with that in 2007. However, the rate of regular PA was still low among young adults aged 20-49 years.

The 6th National Physical Fitness and Health Surveillance of Chinese School Students was conducted among more than 220 000 students aged 9-22 years in 2014. Results showed that the prevalence of PA time <1 hour was 73.3% in boys, and even higher in girls (79.1%). The prevalence of inactivity increased with age for both genders. Valid data from the 2016 Physical Activity and Fitness in China-The Youth Study on more than 90 000 students aged 9-17 years showed that 29.9% of the participants met the recommendations of PA, with a higher percentage of boys than girls (31.8% vs 28.2%).

2.7 Nutrition

CHNS had been conducted four times during 1982-2012. The results showed that the dietary patterns in China had changed significantly over the past 30 years. As far as the 3 major caloric nutrients were concerned, the intake of protein barely changed, but that of fat increased significantly and carbohydrate declined greatly. In general, the total calorie intake decreased substantially. In 2012, the calories from dietary fat was 32.9% on average in Chinese residents exceeding the recommended upper limit of 20%-30% by *Dietary Guidelines for Chinese Residents (2016)*, while those from carbohydrates decreased to a nationwide average of 55%, the recommended lower limit of 55%-65%. In addition, the consumption of vitamin C, calcium, and potassium also declined. The dietary sodium intake reduced dramatically, but it remained high in 2012 (5 702 mg/day, which corresponds to salt intake of 14.5 g/day) - more than twice the recommended amount (China: < 6g/day, World Health Organization: < 5g/day). The imbalanced calories intake from dietary nutrients was more serious in urban residents than in rural ones.

2.8 Multiple Risk Factors for Cardiovascular Diseases

The 2002 CHNS reported that the prevalence of Metabolic syndrome (MS) in adults aged ≥18 years, based on the criteria from the China Diabetes Society (CDS) and the US National Cholesterol Education Program-Adult Treatment Panel III (NCEP-ATP III), was 6.6% and 13.8%, respectively. The 2010 China Noncommunicable Disease Surveillance covered 31 provinces, municipalities, and autonomous regions of mainland China with a sample of 98 658 adults aged ≥18 years. The prevalence of MS was 33.9% according to ATP III criteria, which was significantly higher than that in 2002.

The CKB cohort study included 461 211 adults aged 30-79 years. After a median of 7.2-year follow-up, it showed that for the participants who had 4 or more low-risk factors as non-smoking or quit-smoking, moderate alcohol consumption <30 g/day, regular physical activity, a diet rich in vegetables and fruits, limited red meat intake and ideal body weight, the risk decreased by 58% for major coronary events, 43% for CHD, and 39% for cerebral infarction. The burden of CVD would be alleviated as the healthy lifestyle factors increased.

2.9 Air Pollution

Findings from the Global Burden of Disease (GBD) Study 2010 showed that the atmospheric pollution and indoor air pollution were the fourth and fifth leading risk factors, respectively, for the age-standardized disability-adjusted life years (DALY) in China. The concentrations of $PM_{2.5}$, SO_2, NOx, and total suspended particles were positively correlated with the incidence and mortality of CVD. From 2010 to 2012, the mean daily $PM_{2.5}$ concentration was 96.2 μg/m^3 in Beijing, and a 10 μg/m^3 increase in $PM_{2.5}$ concentration was associated with a 0.27% increase in IHD morbidity.

The long-term effect of atmospheric pollution on CVD was even greater. A cohort study in Hong Kong analyzed the relationship between baseline exposure of atmospheric particulates and CVD mortality in 66 820 residents aged ⩾65 years. After 10-13 years of follow up, the results indicated that with every 10 μg/m^3 increase in $PM_{2.5}$, the mortality risk from CVD, IHD, and ischemic stroke increased by 22%, 42%, and 21%, respectively.

In 2013, 807 000 deaths were attributable to indoor air pollution in China, including 169 000 from hemorrhagic stroke, 152 000 from IHD, and 88 000 from ischemic stroke. Compared with the data in 1990, the total deaths and DALY due to indoor air pollution decreased by 24.5% and 42.4%, respectively.

Part 3 Cardiovascular Diseases

3.1 Cerebrovascular Disease

According to the data from *China Health and Family Planning Statistics Yearbook (2017)*, the mortality of cerebrovascular disease was still rising in 2016. In comparison with that in 2015, the mortality declined slightly in urban areas (126.41/100 000 vs 128.23/100 000), but increased alarmingly in rural areas (158.15/100 000 vs 153.63/100 000). In general, it was higher in males than in females and higher in rural areas than in urban areas.

A representative sample of 1 292 010 adults aged >40 years were screened from the China National Stroke Screening Survey showed that the prevalence of stroke was 2.06% in adults aged >40 years in 2014. The most significant contributor to stroke was hypertension, followed by family history, dyslipidemia, atrial fibrillation, diabetes, physical inactivity, smoking, and obesity. The incidence of first-ever stroke in adults aged 40-74 years increased from 189/100 000 in 2002 to 379/100 000 in 2013, with an annual increase of 8.3%. The mortality of stroke in adults aged 40-74 years remained stable during 2002-2013, at approximately 124 /100 000.

3.2 Coronary Heart Disease

According to the data from *China Health and Family Planning Statistics Yearbook (2017)*, the mortality of CHD in 2016 was still increasing in both urban and rural areas, as it had been since 2012. It was 113.46/100 000 for urban citizens and 118.74/100 000 for rural residents, which was slightly elevated than that of last year (110.67/100 000 in urban areas and 110.91/100 000 in rural areas). Overall, the mortality of CHD was higher in males than in female, and higher in rural areas than in urban areas.

In general, the mortality of acute myocardial infarction (AMI) kept increasing during 2002-2016 and accelerated rapidly from 2005. In 2007, 2009 and 2011, it was higher in rural areas than in urban areas. Especially from 2012, the mortality of AMI in rural areas started to increase drastically, and it was much higher than that in urban areas in 2013 and 2016. In 2016, the mortality of AMI was 58.69/100 000 in urban areas and 74.72/100 000 in rural areas.

Researchers analyzed the 15-year trend of AMI incidence in Tianjin residents. They found that during 1999-2013, the crude incidence of AMI was 80.46/100 000 - 81.29/100 000 and the standardized incidence was 64.85/100 000-44.57/100 000. Although the standardized incidence was decreasing every year for the whole population, it increased in the residents aged <45 years, while decreased in those aged ≥45 years. The standardized incidence of AMI was higher in males (78.53/100 000-56.61/100 000) than in females (50.31/100 000 - 31.76/100 000). The standardized incidence of AMI was still higher in urban areas than in rural areas despite of the fact that it had declined significantly in urban areas (99.89/100 000 - 50.12/100 000) and increased in rural areas (32.68/100 000 - 43.51/100 000). According to the registry data for the percutaneous coronary intervention (PCI) from the National Health Commission, the total number of PCI was 753 142 in mainland China in 2017 (including data from the network and military hospitals), which increased by about 13% from 2016. The mean number of stents for each patient undergoing PCI was 1.47 in 2017. Radial artery access was still dominant for this procedure (90.89%). The mortality due to PCI remained at a low level (0.23%). About 42.2% of patients with ST-Segment Elevation Myocardial Infarction (STEMI) received primary PCI, which was higher than the proportion in 2016 (38.91%).

3.3 Disorders of Heart Rhythm

Based on a survey conducted in 2004 from 10 different regions in China (4 towns and 6 rural areas), the age-adjusted prevalence of atrial fibrillation (AF) in 19 363 participants aged ≥35 years was 0.77% (0.78% for males and 0.76% for females). A stratified multi-stage random sampling survey on 31 230 community residents in 31 provinces, municipalities, and autonomous regions of mainland China showed that the prevalence of AF in the adults aged ≥35 years was 0.71%. The application of radiofrequency catheter ablation (RFCA) increased during 2010-2017 at an annual growth rate of 13.2%-17.5%. The number of RFCA reached up to 133 900 in 2017. Out of all the RFCA cases, the proportion of RFCA for AF increased annually, from 21.0% in 2015 to 23.1% in 2016 and 27.3% in 2017.

According to the statistics from the National Health Commission's online registration system, 76 717 pacemakers were implanted in 2017, with an increase of 4.98% over 2016. The proportion of dual-chamber pacemakers implanted was approximately 73%, with an increase of 4% over 2016.

The number of implantable cardioverter-defibrillator (ICD) implantation has been increasing persistently in recent years, at an annual growth rate above 10%. In 2017, 4 092 ICDs were implanted and the proportions of single- and dual-chamber ICD implantation were 37.7% and 62.3%, respectively, with little variation from those in 2016. The proportions of ICD implantation for primary and secondary prevention were 44.5% and 55.5%, respectively.

The number of cardiac resynchronization therapy (CRT) in 2017 was 4 138, which was increased by 29.3% and 16.2% as compared with that in 2016 and 2015, respectively. The implantation of CRT-D is increasing every year.

3.4 Heart Failure

A survey involving 15 518 people from 20 urban and rural areas in 10 provinces in China demonstrated that the prevalence of chronic heart failure (HF) in the Chinese population aged 35-74 years was 0.9% in 2000 (0.7% in males and 1.0% in females). It was higher in the north (1.4%) than in the south (0.5%), and higher in urban areas (1.1%) than in rural areas (0.8%). The prevalence of HF increased significantly with age.

In the China Heart Failure Registry Study (China-HF), clinical data collected on 8 516 patients with HF across 88 hospitals during 2012-2014 showed an upward trend in the average age of hospitalized patients with HF. Hypertension and CHD had become the main causes of HF in China, and infection was the most common trigger of HF. The mortality of hospitalized patients with HF was 4.1%, significantly lower than before.

3.5 Pulmonary Vascular Disease

Report on the Nutrition and Chronic Disease Status of Chinese Residents (2015) indicated that the prevalence of chronic obstructive pulmonary disease (COPD) in the Chinese population aged ≥40 years was 9.9% in 2012. Global Burden of Disease (GBD) study 2013 demonstrated that it was 7.3% in the same age group of Chinese residents in 2013 and increased with age. Although the age-standardized mortality of COPD in China decreased in 2013 as compared with that in 1990, it was comparable to the global average level in 1990. A registry study was conducted during 1997-2008 under the National Cooperative Project for the Prevention and Treatment of Venous Thromboembolism (NCPPT) on patients with pulmonary embolism (PE) in more than 60 Grade-III Class-A hospitals. The annual incidence of PE among the 16 972 182 hospitalized patients was 0.1%.

3.6 Cardiovascular Surgery

In 2017, the number of cardiac surgeries in mainland China was 228 938, of which 162 597 were performed on-pump, accounting for up to 71%. In the same year, 77 305 operations for congenital heart diseases, 65 749 surgical inventions for valvular heart diseases, 45 455 coronary artery bypass grafts (CABG), and 19 585 aortic surgeries were carried out in mainland China and Hong Kong, with 2002 patients supported by extracorporeal membrane oxygenation (ECMO). The number of heart transplants in China is increasing every year, and 559 heart transplants were completed in 2017. In 2017, 32 126 patients with congenital heart disease were treated with intervention therapy in mainland China, and the overall success rate was 98.6%.

A retrospective analysis was conducted on 195 708 echocardiographic recordings of 157 039 patients during 2008-2012 and showed that the prevalence of bicuspid aortic valves was 0.43%.

According to the China Health Insurance Research data 2011, the annual incidence of acute aortic dissection in mainland China was estimated to be 2.8/100 000. It was significantly higher in males than in females (3.7/100 000 vs 1.5/100 000, $P<0.001$).

3.7 Chronic Kidney Disease

A nation-wide survey was conducted during September 2009 - September 2010 and showed that the overall prevalence of chronic kidney disease (CKD) was 10.8% among adults aged >18 years. The prevalence of estimated glomerular filtration rate (eGFR) <60 ml/min/1.73 m^2 was 1.7%, and that of urinary albumin/creatinine ratio (ACR) >30 mg/g was 9.4%. Therefore, the number of patients with CKD in China is estimated to be about 120 million.

According to the annual report from China Kidney Disease Network (CK-NET), CVD are present in 27.8% of hospitalized patients with CKD, CHD is the most common CVD (17.7%), followed by HF (13.0%) and stroke (9.2%).

3.8 Peripheral Arterial Disease

Lower extremity atherosclerotic disease (LEAD) is a common disease in the middle-aged and elderly population. The major cause is atherosclerosis. Cerebrovascular disease and IHD are present in 30% and 25% of patients with LEAD, respectively. The prevalence of LEAD varied greatly among different populations, ranging from 2.1% to 27.5%.

A total of 84 880 residents aged 40 years from 31 provinces, municipalities, and autonomous regions of mainland China underwent carotid ultrasonography examination in the China National Stroke Prevention Project (CSPP). The results showed that the overall prevalence of carotid atherosclerosis was 36.2%. Approximately 26.5% of participants had increased intima-media thickness (IMT $\geqslant$1 mm), and 13.9% presented plaques.

Renal artery stenosis (RAS) is a common peripheral arterial disease in the middle-aged and elderly population. According to an 18-year follow-up study in 2 906 patients with RAS, the proportion of three major causes of RAS changed substantially. The atherosclerotic RAS increased from 50% during 1999-2000 to 85% during 2015-2016, the Takayasu's arteritis-induced RAS decreased from 31% to 10%, and the RAS due to fibromuscular dysplasia caused by FMD had little change, varying between 2.9% and 6.5%.

3.9 Medical Care Quality Assessment for CVD

The studies on evaluation and improvement of medical care for CHD include the Clinical Pathways for Acute Coronary Syndromes (CPACS) in China, the Improving Care for Cardiovascular Diseases in China (CCC), the China Patient-centered Evaluative Assessment of Cardiac Events (China PEACE), the China Acute Myocardial Infarction (CAMI), and the Bridging the Gap on Coronary Heart Disease Secondary Prevention in China (BRIG). Although the quality of medical care for CVD in China has improved rapidly in recent years, there are still some shortcomings to be addressed. The China PEACE study demonstrated that the percentage of evidenced-based medication and PCI following the recommendations of guidelines increased among patients with AMI in 2011 compared with that in 2001, while the percentage of thrombolysis decreased. The in-hospital mortality did not drop robustly due to delayed visit time and low reperfusion rate.

Part 4. Community-based Prevention and Control of CVD

The exploration and practice of community-based management of CVD in China have been preceded for 40 years. With a progressive expansion from part to whole and a comprehensive intervention strategy for the prevention and control of hypertension, the community-based management of CVD in China is moving forward in the process of exploration and has achieved notable success.

In order to further standardize the implementation of national basic public health service programs and improve the hypertension management in primary health care (PHC) institutions, the Department of Primary Health of National Health and Family Planning Commission (NHFPC) of China authorized the National Center for Cardiovascular Diseases (NCCD) to establish the Office of "National Basic Public Health Service Program/National PHC Hypertension Management" (herein after referred to as "the Office") on March 30, 2017. The Office is responsible for developing guidelines for hypertension management in PHC institutions, monitoring and evaluating the practice of hypertension management, and carrying out health education and other related work for the public, to homogenize the hypertension management between PHC institutions and Grade-III Class-A hospitals.

A low-cost comprehensive intervention study was conducted in rural patients with hypertension in Fuxin city, Liaoning province, with each village as a unit. Patients were randomly divided into 3 groups: health education group, elementary intervention group, and comprehensive intervention group. The aim was to explore the effect of comprehensive intervention on reducing CV events. By the end of a 15-month follow-up, the mean blood pressure decreased by 16.07 /9.42 mmHg and the control rate of hypertension increased significantly from 1.1% at baseline to 33.1%. Compared with the health education group, the risk of total CVD and stroke in the medication group decreased by 55.9% and 55.2%, respectively.

Part 5 Medical Treatment and Expenditure on CVD

The number of patients with CVD or diabetes discharged from hospitals in China has been increasing since 1980. Correspondingly, the total expenditure on hospitalization for CVD has also increased rapidly.

In 2016, 20.021 9 million patients with CVD were discharged from hospitals, which accounted for 12.57% of the total number of discharges during the same period. Among all the discharged patients, patients with heart diseases were 10 026 300, accounting for 6.30%, and those with cerebrovascular disease were 9 995 600, accounting for 6.27%. Among the discharged patients with CVD, IHD (7 382 400) and cerebral infarction (6 403 000) were the leading causes, which accounted for 36.87% and 31.98%, respectively. Other causes included hypertension (2 407 000) and intracranial hemorrhage (1 429 100).

During 1980-2016, the average annual growth rate of discharged patients with CVD in China was 9.85%, which was higher than that of the all discharged patients (6.33%) in the same period. The rank of annual average growth rates of various CVD in descending order were: cerebral infarction (12.16%), IHD (11.42%), AMI (10.73%), intracranial hemorrhage (9.48%), hypertension (7.45%), hypertensive heart disease and kidney disease (5.77%), and rheumatic heart disease (1.20%). In addition, the annual average growth rate of patients with diabetes was 13.59% during 1980-2016.

In 2016, the hospitalization cost was 19.085 billion RMB for AMI, 25.419 billion for intracranial hemorrhage, and 60.105 billion for cerebral infarction. The average annual growth rates of hospitalization cost for the above-mentioned three major CVD since 2004 were 29.15%, 16.88%, and 22.24%, respectively. In 2016, the average expense of each hospitalization for AMI, intracranial hemorrhage, and cerebral infarction was 26 056.9, 17 787.0, and 9 387.0 RMB, with an annual growth rate of 7.12%, 5.90%, and 2.30%, respectively.

Part 1
Epidemiology of Cardiovascular Diseases

1.1 Prevalence of Cardiovascular Diseases

The prevalence of CVD in China has been persistently increasing. It is estimated that about 290 million patients are suffering from CVD, among which the number of patients with stroke, CHD, pulmonary heart disease, HF, rheumatic heart disease, and congenital heart disease is 13 million, 11 million, 5 million, 4.5 million, 2.5 million and 2 million, respectively.

According to China Hypertension Survey (CHS, 2012-2015),[1] the weighted prevalence of hypertension among Chinese citizens aged ≥18 years was 23.2%. Based on the data from the Sixth National Population Census (2010), it was estimated that 245 million people in China suffering from hypertension.

1.2 Death from Cardiovascular Diseases

1.2.1 Mortality of Cardiovascular Diseases [2]

CVD remained the major cause of death in 2016, and resulted in more deaths than tumors and other diseases did (Figure 1-2-1, Figure 1-2-2). Since 2009, the mortality of CVD in rural areas had exceeded and remained constantly higher than that in urban areas (Figure 1-2-3).

In 2016, the mortality of CVD in rural areas was 309.33/100 000, of which 151.18/100 000 was due to heart disease and 158.15 /100 000 due to cerebrovascular disease. Meanwhile, the mortality rate of CVD in urban areas was 265.11/100 000, of which 138.70/100 000 was due to heart disease and 126.41/100 000 due to cerebrovascular disease.

[1] Wang Z, Chen Z, Zhang L, et al. Status of Hypertension in China: Results from the China Hypertension Survey, 2012-2015. Circulation, 2018,137(22):2344-2356.

[2] National Health and Family Planning Commission. China Health and Family Planning Statistics Yearbook (2017). Beijing: Peking Union Medical College Press, 2017.

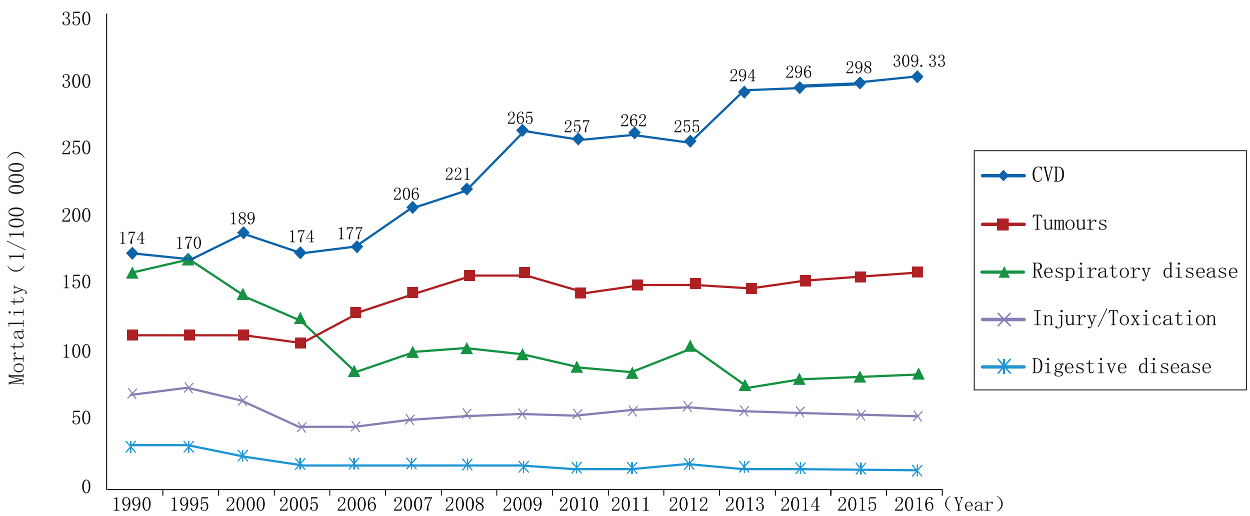

Figure 1-2-1 Mortality rates of major diseases in rural population, 1990-2016

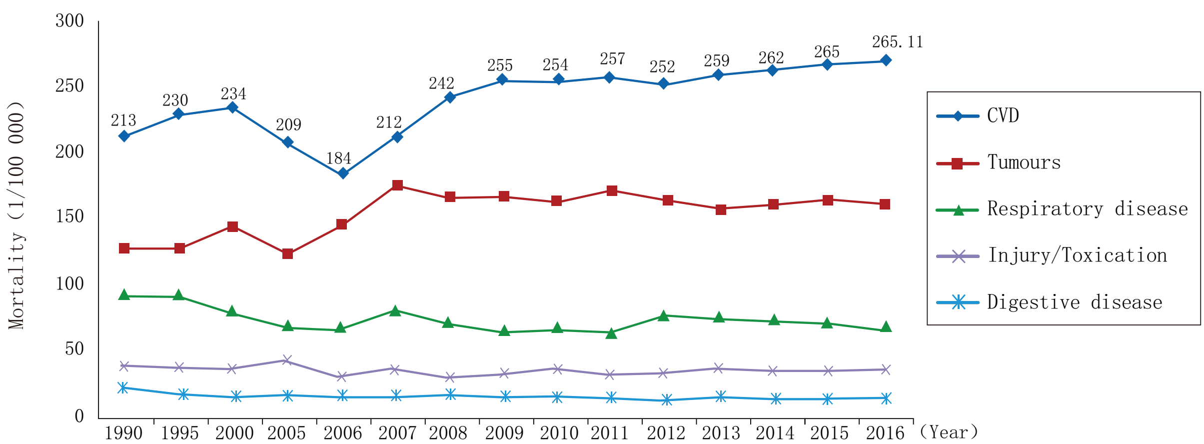

Figure 1-2-2 Mortality rates of major diseases in urban population, 1990-2016

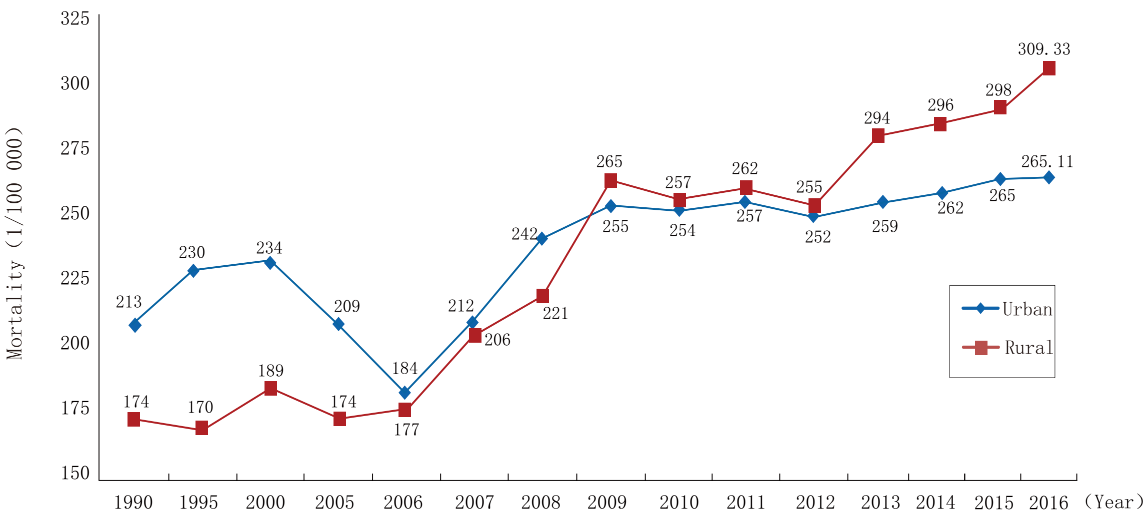

Figure 1-2-3 Mortality rates of CVD in urban and rural population, 1990-2016

1.2.2 Deaths Attributable to CVD among All-Cause Deaths [1]

CVD is the leading cause of death in both rural and urban population of China. In 2015, CVD-related deaths accounted for 45.01% and 42.61% of all deaths in rural and urban areas, respectively (Figure1-2-4 , 1-2-5). Two out of five cases of deaths were attributed to CVD.

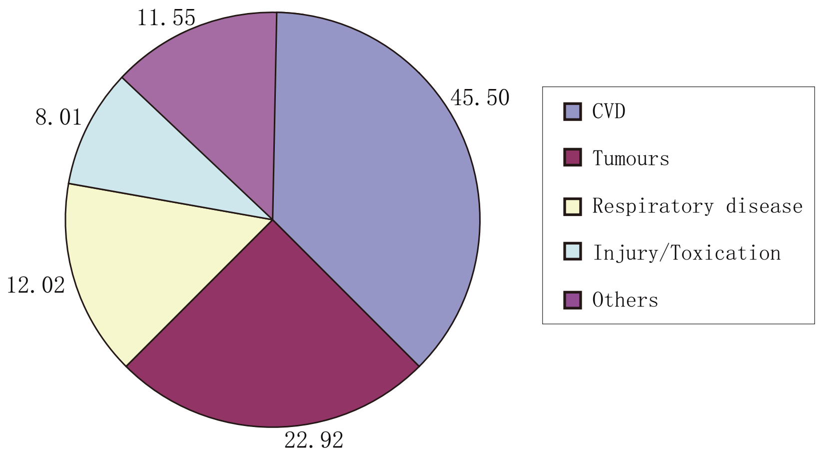

Figure 1-2-4 Major causes of death in rural population in 2016 (%)

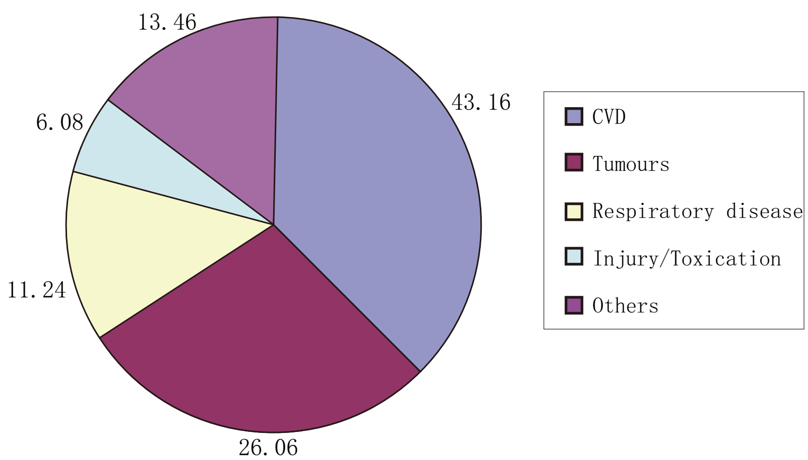

Figure 1-2-5 Major causes of death in urban population in 2016 (%)

[1] National Health and Family Planning Commission. China Health and Family Planning Statistics Yearbook (2017). Beijing: Peking Union Medical College Press, 2017.

1.2.3 The Change of Burden of CVD in China

Guided by the Global Burden of Disease Study 2013 (GBD 2013),[1] all available demographic and epidemiological data sources for each accessible province within China were comprehensively analyzed by the Center of Disease Control (CDC) in China. The nationwide age-standardized mortality of CVD decreased by 21%-from a rate of 389.93/100 000 in 1990 to 307.18/100 000 in 2013. Among all causes of CVD, the mortality rates of rheumatic heart disease, cerebrovascular disease, and hypertensive heart disease had decreased by 71.2%, 20.9%, and 41.3%, respectively, while those of IHD and peripheral vascular diseases had increased by 2.6% and 91.9%, respectively. Cerebrovascular disease was the leading cause of death in both genders in China, with an increase in ischemic stroke (28.8%) and a decrease in hemorrhagic stroke (37.7%). The mortality rate of IHD had increased in males, but decreased in females.

Notably, due to factors such as aging of Chinese population, although age-standardized mortality of CVD had decreased, the absolute number of CVD deaths continued to increase dramatically by 46% from 1990 to 2013, of which deaths due to IHD and cerebrovascular disease increased by 90.9% and 47.7%, respectively.

The mortality of cerebrovascular disease was inversely correlated to per capita income, with the highest mortality in the poorest provinces (except for Yunnan). The lowest age-standardized mortality of IHD was in Zhejiang province for both genders, while the highest mortality was in Heilongjiang province. Although the rank order of death causes was not directly related to all-cause mortality, the mortality of IHD was significantly higher in the North than in the South, demonstrating a relatively clear pattern of geological gradient.

GBD 2010 [2] revealed that the leading cause of death in Chinese residents in 2010 was stroke (1.7 million deaths), followed by IHD (948 700) and COPD (934 000). The proportion of Years Lived with Disability (YLD) in Disability-Adjusted Life Year (DALY) increased from 28.1% in 1990 to 39.4% in 2010. The main diseases affecting DALY in China were CVD (stroke and IHD), tumors (lung cancer and hepatoma), osphyalgia and depression. The top three risk factors were diet, hypertension, and smoking, while the atmospheric pollution and indoor air pollution were ranked as the fourth and fifth, respectively (Figure 1-2-6).

[1] Zhou MG, Wang HD, Zhu J, et al. Cause-specific Mortality for 240 Causes in China during 1990-2013: A Systematic Subnational Analysis for the Global Burden of Disease Study 2013. Lancet, 2016,387(10015):251-272.

[2] Gonghuan Yang, Yu Wang, Yixin Zeng, et al. Rapid Health Transition in China, 1990-2010: Findings from the Global Burden of Disease Study 2010. Lancet, 2013,8;381(9882):1987-2015.

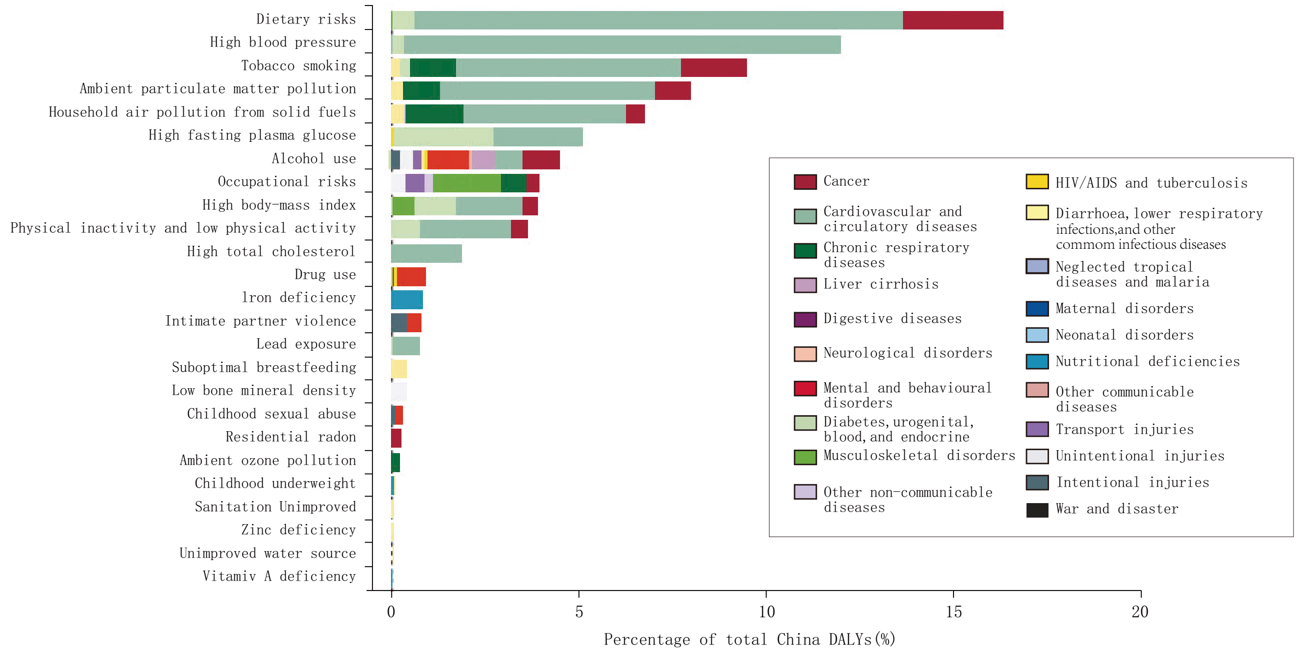

Figure 1-2-6 Risk factors of DALY in China in 2010

1.3 Prediction for the Trend of CVD and Individual Risks in Chinese Population

1.3.1 Prediction for the Trend of CVD in Chinese Population

1.3.1.1 The Effects of Aging and Risk Factors on the Incidence of CVD [1]

The Chinese population is expected to grow from 1.27 billion in 2000 to 1.46 billion in 2030, and the proportion of people aged ≥65 years in the population will double from 7% to 14%. Even the risk factors of CVD in 2030 remain the same as in 2010, only population growth and aging will drive the cardiovascular (CV) events (angina pectoris, myocardial infarction, sudden cardiac death and stroke) to increase by more than 50%.

Based on the current trends in blood pressure (an annual increase of 0.17-0.21mmHg), total cholesterol (increase to 5.4 mmol/L), diabetes prevalence (increase by 15%), and active smoking (decline), even if other risk factors remain flat, the CV events will still increase by 23% from 2010 to 2030, i.e., an increase of 21.3 million CV events and 7.7 million CV deaths (Figure 1-3-1, Figure 1-3-2).

[1] 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. Circ Cardiovasc Qual Outcomes, 2010;3(3):243-252.

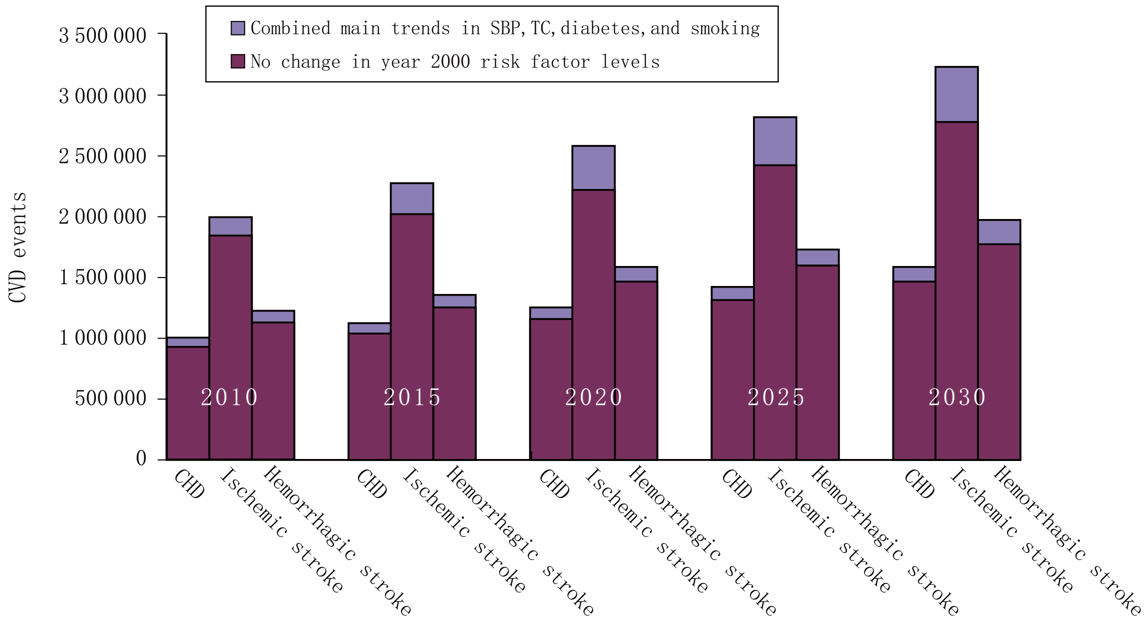

Figure 1-3-1 The number of cardiovascular events in male Chinese projected for the year 2010-2030

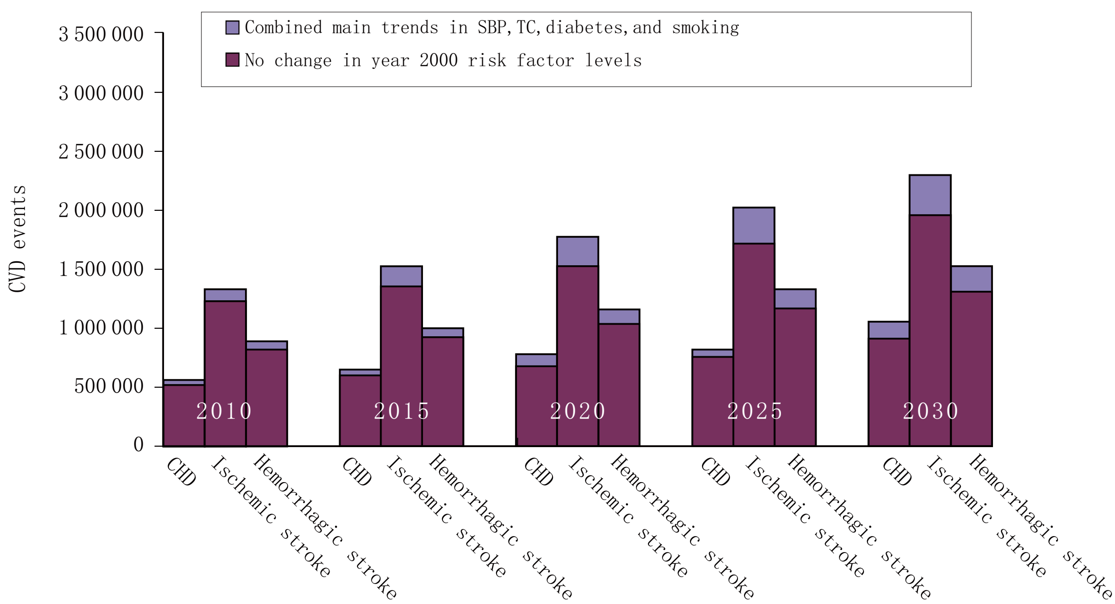

Figure 1-3-2 The number of cardiovascular events in female Chinese projected for the year 2010-2030

The incidence of CV events in the Chinese population is mainly due to increased smoking, blood pressure, and total cholesterol level. About 12% of CV events in females are attributed to passive smoking.

It is expected that if the prevalence of active smoking in the Chinese male population was reduced to 20% by 2020 and 10% by 2030, or the SBP was reduced by 3.8 mmHg in both genders, the adverse trends of CV events caused by other risk factors would be neutralized, and 2.9 million to 5.7 million total deaths over the next 2 decades would be prevented.

1.3.1.2 The Effects of Controlling CVD Risk Factors to Premature Mortality [1]

The United Nation's Sustainable Development Goals for 2030 include reducing premature mortality from non-communicable diseases (NCD) by one third. To assess the feasibility of this goal in China, China results from the GBD 2013 were used as empirical data to project premature mortality in 2030 of NCD under different risk factor (smoking, obesity, hypercholesteremia, elevated SBP, physical inactivity, and hyperglycemia) reduction scenarios.

If current trends for each risk factor continued to 2030, the total premature deaths from NCD would increase from 3.11 million to 3.52 million, but the premature mortality rate would decrease by 13.1%. The premature deaths from CVD would increase by 280 000, accounting for the largest portion, and followed by cancer and diabetes. Males had a higher premature mortality than females. In the combined scenario in which all risk factor reduction targets are achieved, one-third reduction goal would be achieved for all NCD combined. More specifically, the goal would be achieved for CVD and chronic respiratory diseases, but not for cancer and diabetes.

The effect of antihypertension, smoking cessation and BMI management was most favorable. Reduction in the prevalence of hypertension provided the largest reduction in premature deaths for both genders (390 000 in males and 170 000 in females), all in CVD. Smoking cessation avoided 326 000 deaths, particularly 222 000 deaths on cancer. A halt in the rise of average BMI could prevent 55 000 extra deaths from CVD and 27 000 from cancer. There were also notable benefits of achieving the targets for fasting glucose and total cholesterol, with 57 000 and 53 000 deaths avoided, respectively.

1.3.1.3 The Effects of Lipid and Blood Pressure Control on the Trend of CVD Incidence [2]

A study obtained data from the 2009 China Health and Nutrition Survey (CHNS), which included almost 30 000 individuals in 15 provinces and municipalities in mainland China, and estimated the incidence and mortality risk of both AMI and stroke (hemorrhagic and ischemic) from the peer-reviewed literature. Longitudinal population trends were modeled using the United Nations Population Division predictions. Preventative intervention effects were modeled using the World Health Organization (WHO) region-specific bivariate risk model.

The rises in prevalence of CVD risk and population aging would likely increase the incidence of AMI by 7.5 million and strokes by 11.8 million, while the number of CVD deaths would rise by 3.9 million in the next 15 years. Table 1-3-1 shows the estimated number of Acute Myocardial Infarction (AMI), strokes, and CVD deaths over the 2016-2030 period by age and gender.

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[1] Li Y, Zeng X, Liu J, et al. Can China Achieve a One-third Reduction in Premature Mortality from Non-communicable Diseases by 2030? BMC Med, 2017,15(1):132. DOI 10.1186/s12916-017-0894-5.

[2] Stevens W, Peneva D, Li JZ, et al. Estimating the Future Burden of Cardiovascular Disease and the Value of Lipid and Blood Pressure Control Therapies in China. BMC Health Serv Res, 2016,16:175. doi:10.1186/s12913-016-1420-8.

Table 1-3-1 Estimated number of AMI, stroke and CVD deaths by gender and age, 2016-2030

CVD Events	35-45	45-55	55-65	65-75	≥75
AMI					
Male	2 733 082	5 506 290	9 434 189	11 994 178	9 030 523
Female	2 111 375	4 634 030	9 143 257	11 232 330	9 199 603
Total	4 844 457	10 140 320	18 577 446	23 226 508	18 230 126
Stroke					
Male	3 237 421	7 371 258	14 811 925	22 241 630	25 126 874
Female	3 807 198	6 885 464	11 759 056	12 473 629	10 607 893
Total	7 044 619	14 256 722	26 570 981	34 715 259	35 734 767
CVD deaths					
Male	708 068	1 848 423	4 009 758	8 820 599	7 661 065
Female	205 738	651 001	2 127 829	6 476 425	6 573 086
Total	913 806	2 499 424	6 137 587	15 297 024	14 234 151

Effective management of hypertension and dyslipidemia patients with lipid and blood pressure lowering therapies could avert between 10 million and 20 million AMI, between 8 million and 30 million strokes, and between 3 million and 10 million CVD deaths during the 2016-2030 period, producing a positive social value net of health care costs as high as $932 billion.

Treating people with at least one other CVD risk factor with a combination of blood pressure lowering medication and statin therapy would result in 4.3 billion person-years of treatment over the 15 year period, a net social surplus of $787 billion, and a surplus to benefit ratio of 58%. Treating only people over 55 years of age would yield 2.8 billion person-years of treatment, a social surplus of $932 billion, and a surplus to benefit ratio of 75 %. Finally, treating only people over 65 years of age would generate 1.4 billion person-years of treatment, a social surplus of $747 billion, and a surplus to benefit ratio of 89%. Adequate management of hypertension and dyslipidemia in the elderly over 65 years of age would be more cost-effective (Figure 1-3-3).

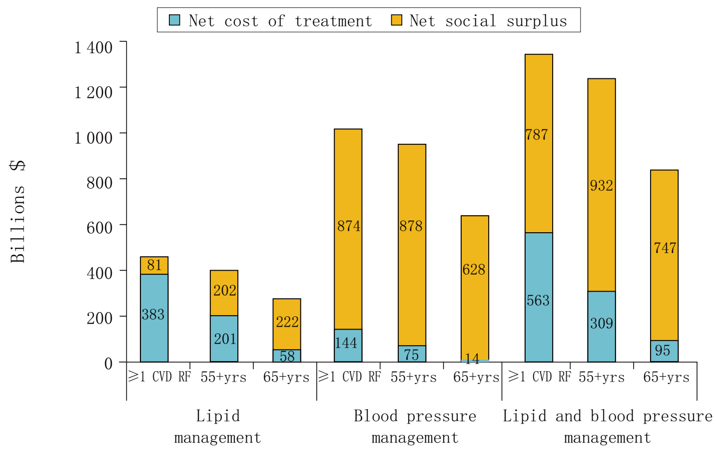

Figure 1-3-3 Estimates of net social value under three targeted approaches to lipid and blood pressure management

1.3.2 Prediction for the Risk of CVD in Chinese Individuals

CVD is the synergetic result of multiple risk factors. The risk of CVD for individuals depends not only on the severity of a particular risk factor, but on the number and levels of other coexisting factors. The overall risk of CVD is not a simple superposition of the independent effect of each risk factor. It is often multiplied by the the complex interaction among multiple risk factors. Therefore, due attention should be paid to controlling the overall risk of CVD in the practice of prevention and treatment.

1.3.2.1 Prediction of 10-year Risk of CVD Incidence in China

The current prediction models of 10-year CVD risk developed for the Chinese population are shown in Table 1-3-2.

Table 1-3-2 Prediction models of 10-year risk of CVD incidence in China

Prediction model	Age	Introduction	Number of events	Indicators	Outcomes
Study on the comprehensive risk assessment and intervention program for CHD and stroke					
Derivation cohort USA-PRC cohort*	35-59	Year of baseline survey:1983-1984. First follow-up survey: 1987-1988. Last follow-up survey:2000. Participants: 9 903. Average length of follow-up: 15.1 years	Coronary events: 105; Ischemic strokes: 266.	Age, systolic BP, serum TC, BMI, current smoking status, and diabetes mellitus. Prediction models were developed by gender	Ischemic CVD (ICVD, including ischemic stroke and coronary events)
Validation cohort The 8th Five-year cohort**	35-59	Year of baseline survey:1992-1994. Participants: 15 102. Average follow-up duration: 6.4 years			
Chinese Multi-Provincial Cohort Study (CMCS)					
Derivation cohort	35-64	Year of baseline survey: 1992. Last follow-up survey: 2002 Participants: 31 728. Follow-up: 192 521 person-years	CHD: 200; Acute ischemic stroke: 335; Acute hemorrhagic stroke: 141	Age, TC, HDL-C, BP, smoking, diabetes. Prediction model was built by gender	ICVD (including CHD and acute ischemic stroke)
Prediction for ASCVD Risk in China (China-PAR)					
Derivation cohort InterAsia*** (2000-2001) and China MUCA**** (1998)	35-74	Year of baseline survey: 1998-2000. Participants: 21 320. Average follow-up duration: 12.3 years	ASCVD****** events: 1 048	Age, TC, HDL-C, SBP, current smoking, diabetes mellitus, WC*******, geographic region, urbanization, family history of ASCVD	ASCVD events (nonfatal AMI or CHD death or fatal or nonfatal stroke)
Validation cohort China MUCA 1992-1994	35-59	Year of baseline survey: 1992-1994 Participants: 14 123. Average follow-up duration: 17.1 years (validating 10-year risk)			
CIMIC cohort***** 2007-2008	≥16	Year of baseline survey: 2007-2008 Participants: 70 838 . Average follow-up duration: 5.9 years (validating 5-year risk)			

*USA-PRC cohort: USA-PRC Collaborative Study of Cardiovascular Epidemiology cohort
**The 8th Five -year cohort: China Multicenter Study of Cardiovascular Epidemiology
***InterASIA: International Collaborative Study of Cardiovascular Disease in Asia
****MUCA: China Multicenter Collaborative Study of Cardiovascular Epidemiology Cohort
*****CIMIC: Community Intervention of Metabolic Syndrome in China & Chinese Family Health Study
******ASCVD: Atherosclerotic cardiovascular disease
*******WC, waist circumference

- Study on the Comprehensive Risk Assessment and Intervention Program for CHD and Stroke

A prediction model was developed based on data from the USA-PRC Collaborative Study of Cardiovascular Epidemiology cohort. It showed that the incidence of CHD, ischemic stroke, and ICVD was positively and independently related to the baseline age, gender, blood pressure, serum total cholesterol, BMI, smoking status, and diabetes mellitus. This study set up a scoring system that assigned risk scores to different levels of the different risk factors, with reference to the corresponding regression coefficients. All possible combinations of risk factors for a specific total score were computed to obtain 10-year risk values.[1]

- Chinese Multi-Province Collaborative Study

The study used ICVD as outcomes to establish a predictive model with age, blood pressure, TC, HDL-C, smoking, and fast plasma glucose as the main parameters. Because of the large difference between the ICVD incidences in male and female, predictive models were established for both genders separately. The absolute 10-year risk of ICVD could be calculated for any individuals at different risk levels with this model.[2]

- Prediction for ASCVD Risk in China (China-PAR) [3]

To develop and validate a Chinese 10-year risk prediction equations for ASCVD, the China-PAR project used follow-up data from 2 prospective studies: International Collaborative Study of Cardiovascular Disease in Asia (InterASIA) and China Multi-Center Collaborative Study of Cardiovascular Epidemiology (China MUCA) as the derivation cohort, with a sample size of more than 120 000 participants in total.

Considering the actual situation and the epidemiological characteristics of diseases in China, besides the major risk factors from previous studies (age, treated or untreated SBP, total cholesterol, HDL-C, current smoking, and diabetes mellitus), additional variables, including waist circumference (WC), geographic region (northern/southern China), urbanization (urban/rural areas) and family history of ASCVD, were added to the prediction equation. Interactions with age were also considered for each risk factor. The China-PAR

[1] Wu YF, Liu XQ, Li X, et al. Estimation of 10-year risk of fatal and nonfatal ischemic cardiovascular diseases in Chinese adults. Circulation, 2006,114(21):2217-2225.
[2] Wang W, Zhao D, Liu J, et al. Prospective study on the predictive model of cardiovascular disease risk in a Chinese population aged 35 to 64. Chin J Cardiol, 2003,31(12):902-908.
[3] Yang XL, Li JX, Hu DS, et al. Predicting the 10-Year Risks of Atherosclerotic Cardiovascular Disease in Chinese Population: The China-PAR Project (Prediction for ASCVD Risk in China). Circulation, 2016,134(19):1430-1440.

equations had excellent performance of 10-year and 5-year ASCVD risk prediction for Chinese population (Figure 1-3-4).

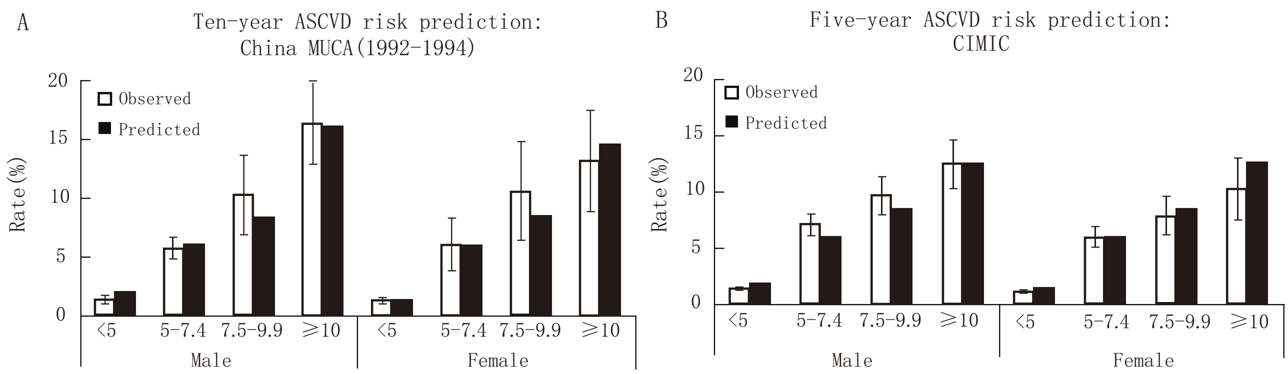

Figure 1-3-4 Ten-year (A) and Five-year (B) Kaplan-Meier observed and predicted ASCVD event rates in the external validation cohorts (China MUCA and CIMIC cohort) using the China-PAR equations, 1992-1994

1.3.2.2 The Lifetime Risk of CVD

Using short-term CVD risk assessments to identify "high-risk" individuals is not conducive for early prevention of CVD. Age is the most important risk factor for predicting CVD risk. For young and middle-aged people with multiple CVD risk factors, although their 10-year CVD risk is low, the long-term (lifetime) risk is high. Prediction of 10-year risk alone may not pay enough attention to the importance of CVD and lifestyle improvements. For young and middle-aged people with moderate 10-year CVD risk, a lifetime risk assessment is recommended to facilitate early identification of high-risk individuals for ASCVD and implement active interventions. Lifetime risk is defined as the absolute cumulative risk of target events that an individual will suffer from before his or her death.[1]

- China-PAR Study

China-PAR project used follow-up data from four prospective cohort studies including InterASIA and China MUCA as the derivation cohort, with a sample size of more than 120 000 participants in total. A model was established to predict the overall lifetime risk of ASCVD for both genders by putting personal variables, such as age, SBP, TC, HDL-C, and diabetes mellitus, into the prediction equation.

This study found that the individuals at high 10-year risk (≥10%) and high lifetime risk (≥32.8%) would likely suffer a premature onset of CVD. For example, the males aged 35 years at high 10-year risk, high lifetime risk or both would develop CVD 3.0, 4.6, and 8.6 years earlier than those at both low 10-year risk and low lifetime risk, respectively. Therefore, lifetime risk assessment is particularly important in the population at low or moderate 10-year risk.

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[1] Liu FC, Li JX, Chen JC, et al. Predicting Lifetime Risk for Developing Atherosclerotic Cardiovascular Disease in Chinese Population: The China-PAR project. Science Bulletin (2018), https://doi.org/10.1016/j.scib.2018.05.020.

- Lifetime Risk for CVD in the Chinese Multi-Provincial Cohort Study [1]

The study sample came from the Chinese Multi-Provincial Cohort Study (CMCS), and 21 935 participants aged 35-84 years without CVD at the baseline were included. They were followed-up every 2 years until the end of 2010. The outcome was defined as acute coronary events and stroke. This study aimed at assessing the impact of traditional risk factors on lifetime risk of CVD in the Chinese population throughout their remaining life up to 80 years old.

The lifetime risk of CVD up to age 80 for males at age 35, 45 and 55 was estimated as 24.4%, 23.8% and 21.9%, respectively.

Blood pressure was the major risk factor among others at discriminating lifetime risk in the population aged 35-55 years. For males aged 35, the lifetime risk of CVD was 11.5% if their blood pressure was at an optimal level. The lifetime risk of CVD was well discriminated by BMI, HDL-C, and diabetes mellitus. The impact of HDL-C and diabetes mellitus on the lifetime risk of CVD was greater in females than in males, but the discrimination ability of TC and Non-HDL-C for lifetime risk was weak in females. Smoking status was good at discriminating the lifetime risk of CVD in males (Figure 1-3-5).

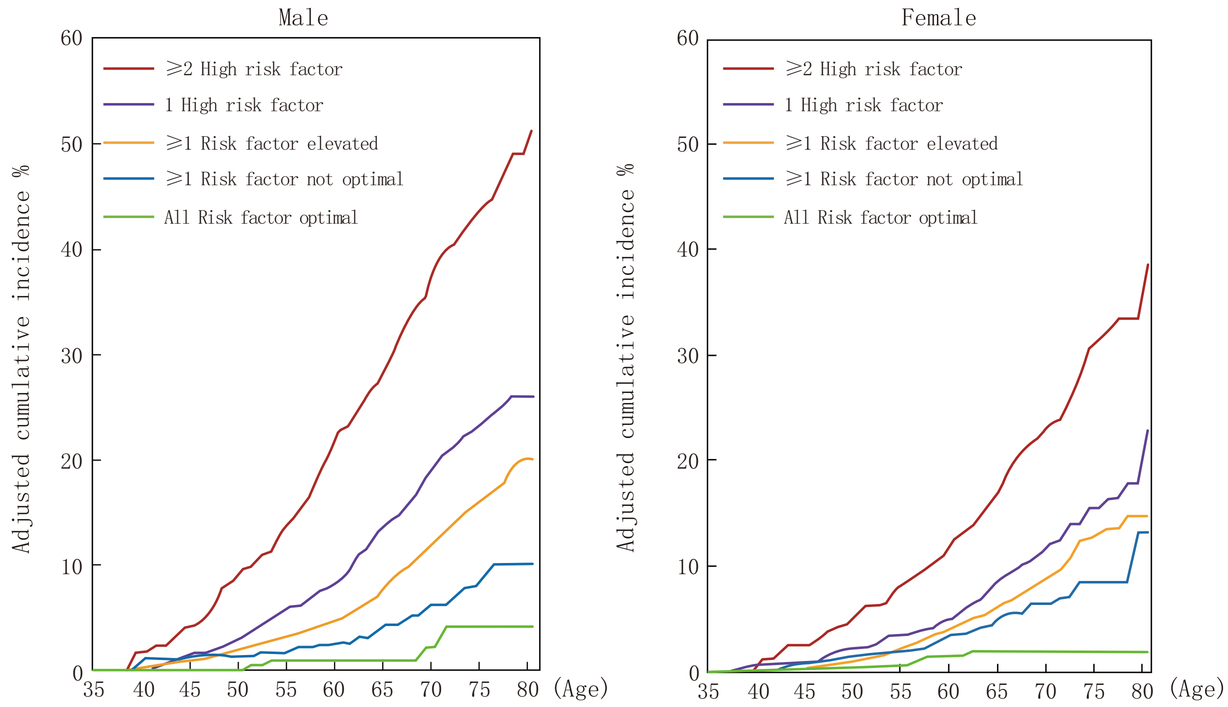

Figure 1-3-5 Cumulative incidence of CVD up to age 80 for males and females at age 35 years by risk factor

[1] Wang Y, Liu J, Wang W, et al. Lifetime risk for cardiovascular disease in a Chinese population: the Chinese Multi-Provincial Cohort Study. Eur J Prev Cardiol, 2015,22(3):380-388.

Part 2

Risk Factors of Cardiovascular Diseases

2.1 Hypertension

Elevated blood pressure is the most common chronic non-communicable disease (NCD) and the biggest single contributor to the global burden of disease [1]. It is also the most important public health issue in China. In 2013, 2.50 million individuals died of hypertension in China, accounting for 27.5% of total deaths and 14.28% of DALY. [2] Furthermore, the direct economic burden of hypertension reached about 6.61% of the total 3.1869 trillion RMB spent on healthcare in China. Therefore, it is crucial to understand the current prevalence of hypertension in China accurately and comprehensively, in order to provide scientific evidence for CVD prevention and policy-making.

2.1.1 Primary Hypertension

2.1.1.1 Prevalence of Hypertension

Several national large-scale sample surveys on prevalence of hypertension have been conducted over past decades. The results are presented in Table 2-1-1.

Table 2-1-1 Prevalence of hypertension in different studies

Survey	Year	Age	Sampling method	N	Crude prevalence of hypertension (%)
Chinese Academy of Medical Sciences Key Project—the Survey on Hypertension	1958-1959	≥15	Non-random sampling	739 204	5.1
National Sampling Survey on Hypertension	1979-1980	≥15	random sampling	4 012 128	7.7
National Sampling Survey on Hypertension	1991	≥15	stratified random sampling	950 356	13.6
China Health and Nutrition Survey (CHNS)	2002	≥18	stratified, multistage, cluster random sampling	272 023	18.8

[1] Poulter NR, Prabhakaran D, Caulfield M. Hypertension. Lancet, 2015,386:801-812.

[2] Forouzanfar MH, Alexander L, Anderson HR, et al. Global, regional, and national comparative risk assessment of 79 behavioral, environmental and occupational, and metabolic risks or clusters of risks in 188 countries, 1990-2013: A Systematic Analysis for the Global Burden of Disease Study 2013. Lancet, 2015,386:2287-2323.

Table 2-1-1 Prevalence of hypertension in different studies (Continued)

Survey	Year	Age	Sampling method	N	Crude prevalence of hypertension (%)
Survey on the Nutrition and Chronic Disease Status	2012	≥18	stratified, multistage random sampling	-	25.2
China Hypertension Survey (CHS)	2012~2015	≥18	stratified, multistage random sampling	451 755	27.9 (weighted prevalence: 23.2)

• Four National Surveys on Prevalence of Hypertension in China

Four national sampling surveys on hypertension in China had been conducted during 1958-1959, 1979-1980, and in 1991 and 2002. [1] The crude prevalence of hypertension among Chinese residents aged ≥15 years was 5.1%, 7.7%, 13.6%, and 17.6%, respectively, demonstrating an increasing trend (Figure 2-1-1).

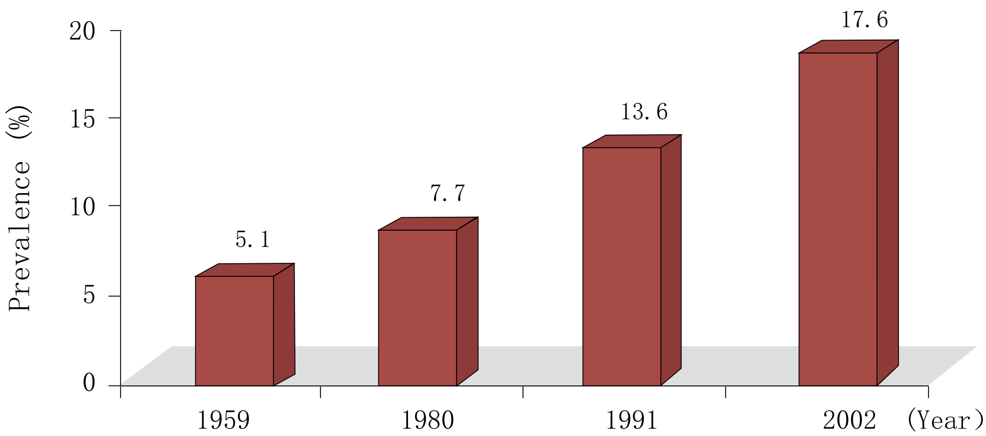

Figure 2-1-1 Prevalence of hypertension in Chinese residents aged ≥ 15 years in four national surveys

• Survey on the Nutrition and Chronic Diseases Status of Chinese Residents

According to the *Report on the Nutrition and Chronic Disease Status of Chinese Residents (2015)*,[2] the prevalence of hypertension in Chinese residents aged ≥18 years was 25.2% in 2012. It was higher in urban areas than in rural areas, higher in males than in females, and increased significantly with age (Figure 2-1-2, Figure 2-1-3).

[1] Li LM, Rao KQ, Kong LZ, et al. A description on the Chinese national nutrition and health survey in 2002. Chinese Journal of Epidemiology, 2005,26(07):478-484.

[2] Bureau of Disease Prevention and Control of National Health and Family Planning Commission. Report on the Nutrition and Chronic Disease Status of Chinese Residents (2015). Beijing: People's Medical Publishing House. 2015.

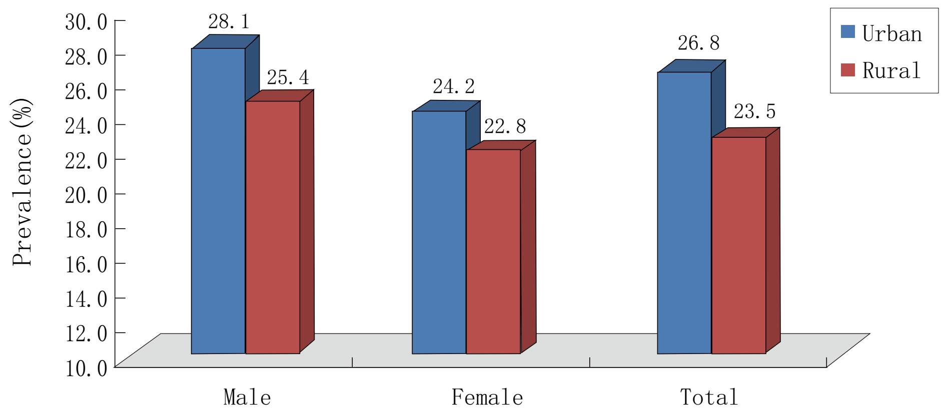

Figure 2-1-2 Prevalence of hypertension among urban and rural residents aged ≥ 18 years by gender in China in 2012

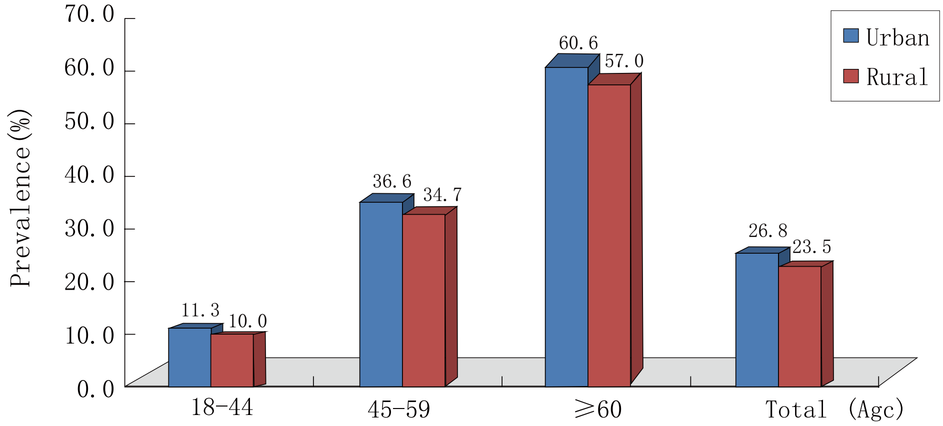

Figure 2-1-3 Prevalence of hypertension among residents by age in China in 2012

• China Hypertension Survey (CHS)

Data from CHS [1] showed that among Chinese adults aged ≥18 years, the overall crude prevalence of hypertension was 27.9% and the weighted prevalence was 23.2%. It was higher in males than in females (crude prevalence: 28.6% vs 27.2%, weighted prevalence: 24.5% vs 21.9%), and increased with age (Figure 2-1-4). The weighted prevalence of hypertension in each province or municipality is listed in Table 2-1-2. Three province-level municipalities—Beijing, Tianjin, and Shanghai—ranked as the top 3 with a hypertension prevalence rate of 35.9%, 34.5%, and 29.1%, respectively, and Hunan province had the lowest prevalence (15.6%). Table 2-1-3 showed the weighted prevalence of hypertension by gender, region, and ethnicity. It was significantly higher in males than in females ($P<0.001$), higher in urban areas than in rural areas (23.4% vs 23.1%), and higher in Han than in other ethnicities (23.5% vs 21.1%). However, no significant difference was found between Han and other ethnicities, as well as urban and rural in the

[1] Wang Z, Chen Z, Zhang L, et al. Status of Hypertension in China: Results from the China Hypertension Survey, 2012-2015. Circulation, 2018,137(22):2344-2356.

prevalence of hypertension.

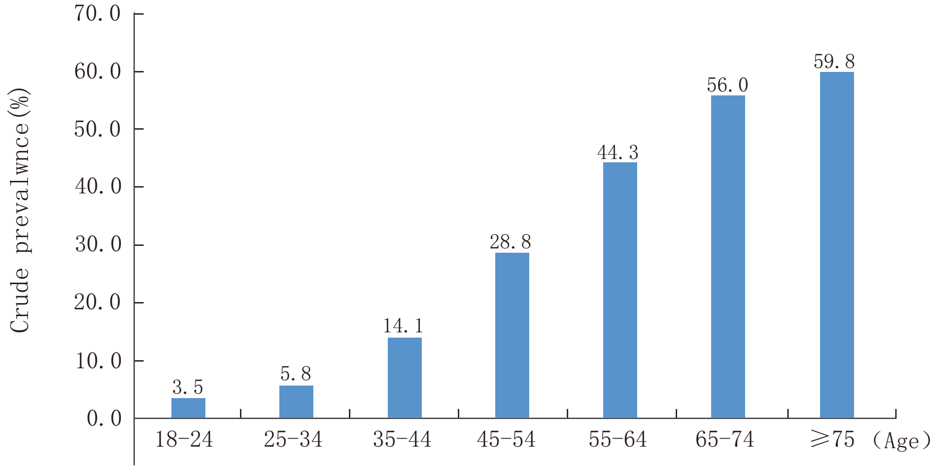

Figure 2-1-4 Crude prevalence of hypertension among Chinese residents by age from CHS

Table 2-1-2 Weighted prevalence of hypertension among Chinese residents in each province or municipality by region and gender (%)

Province or municipality	Region		Gender		Total
	Urban	Rural	Male	Female	
Beijing	36.0	34.2	37.8	34.1	35.9
Tianjin	35.0	32.1	37.3	31.7	34.5
Shanghai	28.7	39.2	30.4	27.8	29.1
Liaoning	30.8	26.2	30.6	26.2	28.4
Yunnan	22.1	30.3	29.9	26.9	28.4
Guangdong	28.5	25.8	29.8	24.7	27.3
Heilongjiang	25.2	27.2	31.2	21.6	26.4
Jilin	23.0	28.3	26.8	25.6	26.2
Shanxi	25.7	26.2	25.5	26.6	26.0
Jiangsu	23.1	26.5	27.5	23.1	25.3
Tibet	27.6	24.6	26.8	23.1	25.0
Henan	24.5	24.0	25.8	22.3	24.1
Fujian	20.0	25.8	25.9	21.8	23.9
Sichuan	18.4	25.3	23.2	24.0	23.6
Guizhou	17.6	26.2	24.6	22.6	23.6
Hebei	19.7	24.1	22.2	24.5	23.3

Table 2-1-2 Weighted prevalence of hypertension among Chinese residents in each province or municipality by region and gender (%) (Continued)

Province or municipality	Region		Gender		Total
	Urban	Rural	Male	Female	
Zhejiang	21.9	23.9	25.4	21.0	23.2
Ningxia	24.6	20.2	23.3	20.9	22.1
Shandong	20.6	22.6	23.3	20.8	22.0
Shaanxi	23.9	21.0	23.4	20.6	22.0
Gansu	20.5	20.8	22.1	19.1	20.7
Chongqing	19.3	21.8	20.4	20.7	20.6
Anhui	21.5	20.0	21.2	19.7	20.5
Hainan	15.7	28.5	22.0	18.4	20.3
Inner Mongolia	22.2	18.6	21.5	17.9	19.7
Guangxi	17.3	18.5	18.3	18.0	18.2
Xinjiang	20.3	16.9	18.8	17.6	18.2
Hubei	19.6	17.1	19.7	16.5	18.1
Jiangxi	19.1	16.8	19.6	15.1	17.3
Qinghai	18.5	16.8	17.5	16.9	17.2
Hunan	14.5	15.9	15.5	15.8	15.6

Table 2-1-3 Weighted prevalence of hypertension and pre-hypertension among Chinese residents by gender, region and ethnicity from CHS (%)

Characteristics	Population	Pre-hypertension	Hypertension
Total	451 755	41.3	23.2
Gender			
Male	216 034	47.8	24.5
Female	235 721	34.6	21.9
P value		<0.001	<0.001
Region			
Urban	220 052	41.1	23.4
Rural	231 703	41.4	23.1
P value		0.869	0.819
Ethnicity			
Others	61 049	40.8	21.1
Han	390 706	41.3	23.5
P value		0.801	0.318

2.1.1.2 Incidence of Hypertension

• Incidence of Hypertension in Chinese Residents from 1991 to 2000

A population-based study [1] followed up 10 525 Chinese adults aged ⩾40 years and free from hypertension at baseline during 1991-2000. Over a mean of 8.2 years of follow-up, 28.9% of males and 26.9% of females developed hypertension(Figure 2-1-5).

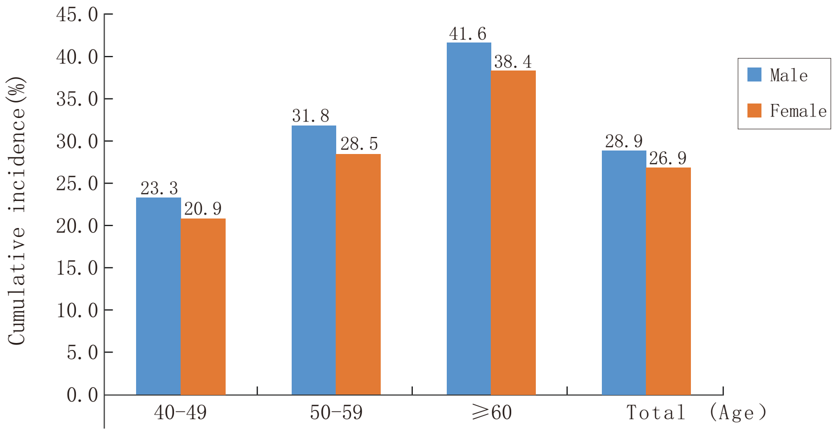

Figure 2-1-5 Cumulative incidence of hypertension by gender and baseline age, 1991-2000

• Incidence of Hypertension among Residents in Rural Areas of Central China

A study published in 2017 [2] enrolled 10 145 non-hypertensive participants aged 18-75 years from rural areas in central China. During a mean follow-up of 6.03±0.69 years from 2007 to 2014, hypertension developed in 19.9% of males and 19.2% of females (Figure 2-1-6). The incidence of hypertension increased with age ($P< 0.001$), and the annual incidence was 3.2/100 person-year.

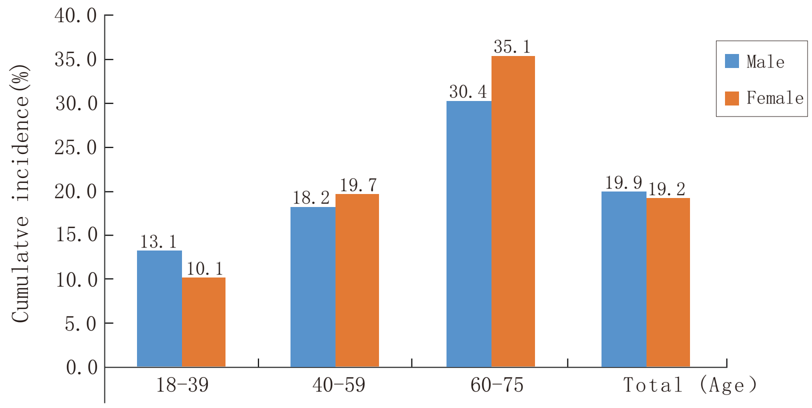

Figure 2-1-6 Cumulative incidence of hypertension by gender and baseline age in central China, 2007-2014

[1] Gu DF, Wildman RP, Wu XQ, et al. Incidence and predictors of hypertension over 8 years among Chinese men and women. Journal of Hypertension, 2007,25(3): 517-523.

[2] Ming Z, Yang Z, Sun H, et al. Effect of dynamic change in body mass index on the risk of hypertension: Results from the Rural Chinese Cohort Study. International Journal of Cardiology, 2017,238:117-122.

2.1.1.3 Detection Rate of High-normal Blood Pressure

• Detection Rate of High-normal Blood Pressure among Chinese Adults in Multiple Provinces

China Health and Nutrition Survey (CHNS) [1] conducted 8 cross-sectional surveys among adults aged ≥18 years during 1991-2011 in 9 provinces and municipalities (added up to 12 provinces and municipalities in 2011). Results demonstrated that the age-normalized detection rate of high-normal blood pressure increased from 23.9% in 1991 to 33.6% in 2011. It was on an apparent rise before 2006, but fluctuated with no significant difference during 2006-2011 (Figure 2-1-7).

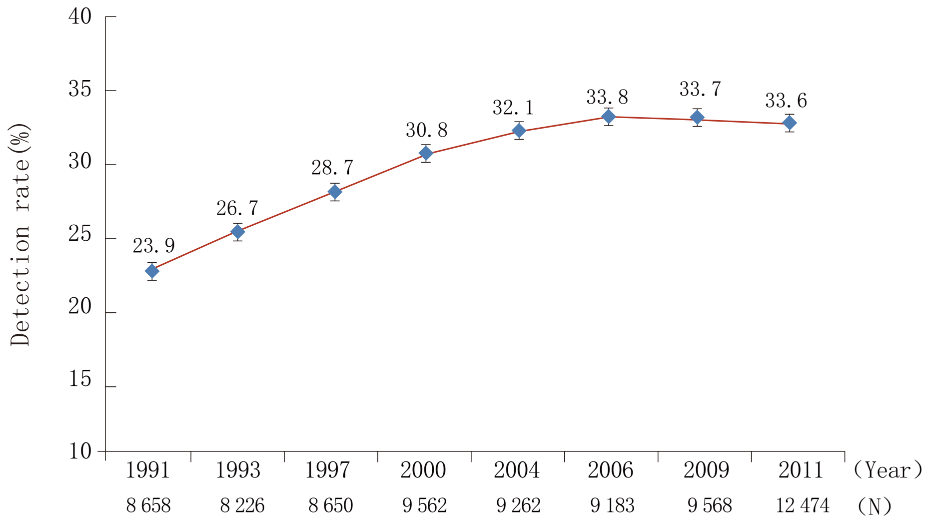

Figure 2-1-7 Age-standardized detection rate of high-normal blood pressure among Chinese adults in multiple provinces, 1991-2011

• Detection Rate of High-normal Blood Pressure in CHS

Data from CHS [2] showed that among Chinese residents aged ≥18 years, the overall crude detection rate of high-normal blood pressure was 39.1% and the weighted one was 41.3%. It increased with age at first and decreased thereafter. The detection rate of high-normal blood pressure varied significantly among age groups (Figure 2-1-8). Comparison between participants with different demographic characteristics showed that the weighted detection rate of high-normal blood pressure was statistically higher in males than in females (47.8% vs 34.6%, $P<0.001$), but no significant difference was found between Han and other ethnicities (41.3% vs 40.8%), as well as residents from urban and rural areas (41.1% vs 41.4%) (Table 2-1-3).

[1] Guo J, Zhu YC, Chen YP, et al. The dynamics of hypertension prevalence, awareness, treatment, control and associated factors in Chinese adults: results from CHNS 1991-2011. J Hypertens, 2015,33(8):1688-1696.

[2] Wang Z, Chen Z, Zhang L, et al. Status of Hypertension in China: Results from the China Hypertension Survey, 2012-2015. Circulation, 2018,137(22):2344-2356.

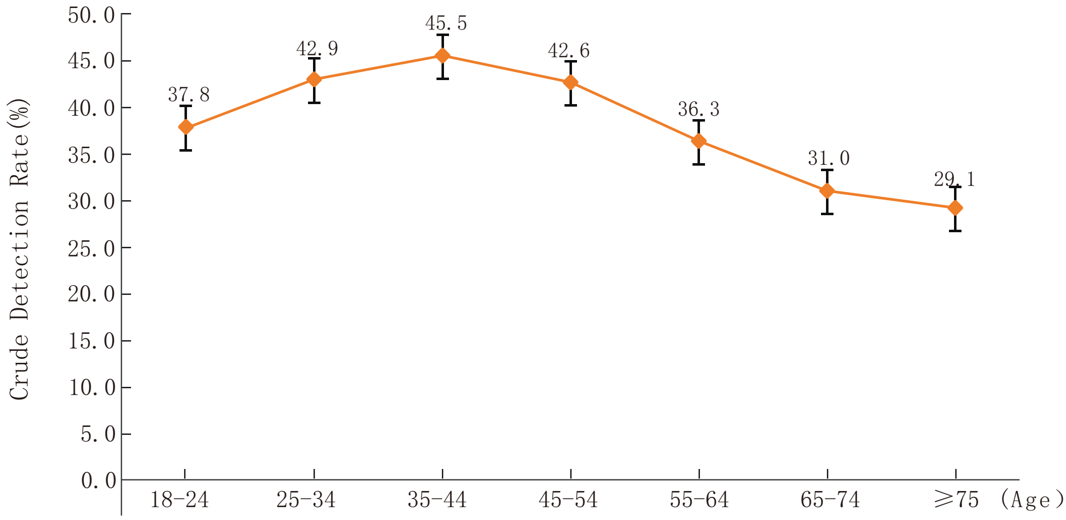

Figure 2-1-8 Crude detection rate of high-normal blood pressure among Chinese residents by age ≥ 18 from CHS

2.1.1.4 Blood Pressure Levels of Chinese Population

• Blood Pressure Levels of Chinese Population: Results from the China Chronic Disease and Risk Factors Surveillance

China Chronic Disease and Risk Factors Surveillance (CCDRFS) study [1] recruited 174 621 adults aged ≥18 years from 31 provinces, municipalities, and autonomous regions in mainland China. Results showed that the mean SBP was 128.5 mmHg (weighted SBP: 124.5 mmHg) and DBP was 77.0 mmHg (weighted DBP: 75.5 mmHg). SBP increased linearly with age. Males had a higher SBP than females before the age of 55 years, while the opposite happened after 55. The relationship between DBP and age was not linear and the trend was similar in both genders. DBP increased with age before 50 years and decreased with age thereafter. The mean DBP was higher in males than in females in all age groups, but the gender difference diminished with age (Figure 2-1-9). Furthermore, SBP level fluctuated with seasons. The mean SBP in winter was 5 mmHg higher than that in summer and the difference was statistically significant (Figure 2-1-10).

[1] Li Y, Yang L, Wang L, et al. Burden of hypertension in China: A nationally representative survey of 174 621 adults. International Journal of Cardiology, 2017,227:516-523.

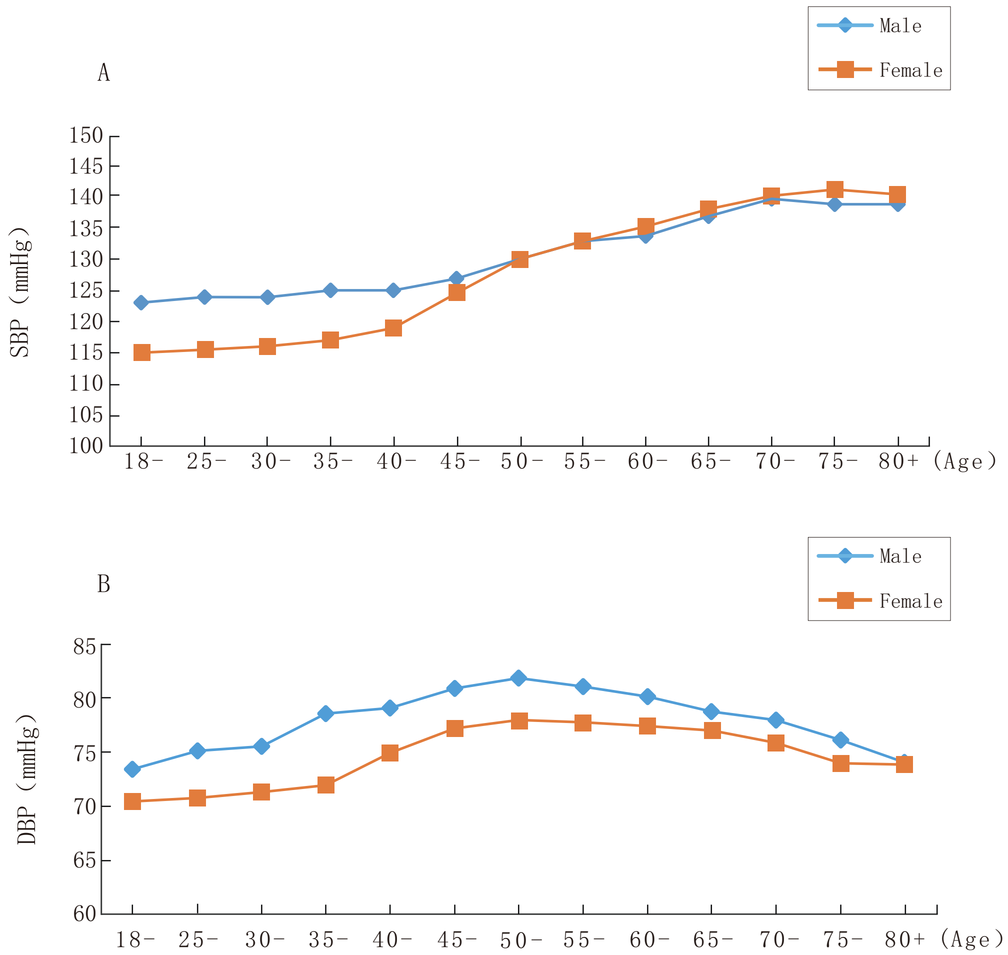

Figure 2-1-9 Mean blood pressure by gender and age in CCDRFS participants

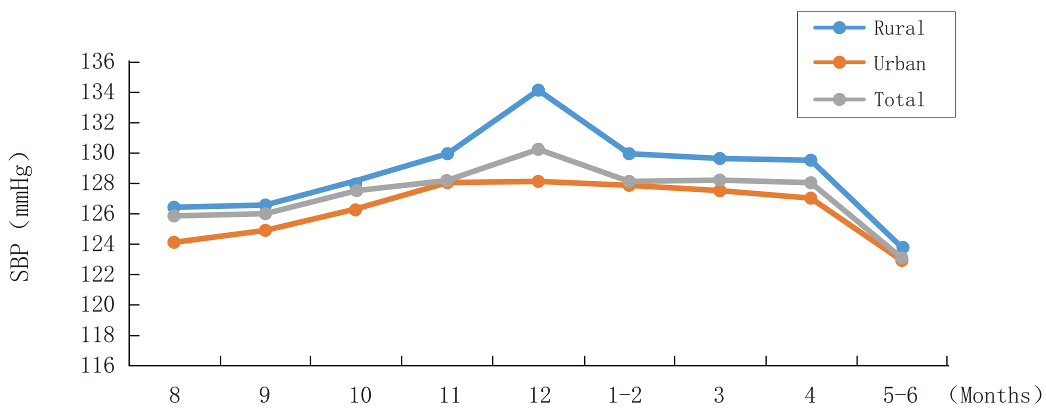

Figure 2-1-10 Variation of blood pressure with seasons in CCDRFS participants

• Blood Pressure in Middle-aged and Elderly Hypertensive Patients

A cross-sectional survey [1] collected valid data from 115 229 hypertensive patients (aged 58.0±13.7 years) on their visiting order to cardiology department in 136 hospitals of 21 cities. Patients were investigated with a questionnaire, whose blood pressure and heart rate were measured. These patients were divided into three groups: uncomplicated hypertension, hypertension with CHD, and hypertension with HF. The average blood pressure is shown in Table 2-1-4. In patients with uncomplicated hypertension, the SBP was higher whereas the DBP was lower in the group aged ⩾60 years compared with those in the group aged <60 years ($P<0.01$) (Figure 2-1-11).

Table 2-1-4 Average blood pressure among 115 229 hypertensive patients

Hypertension	Event number	Male (%)	Female (%)	SBP (mmHg)	DBP (mmHg)
Uncomplicated	86 676	53.8	46.2	139.5±18.8	83.3±12.9
With CHD	26 661	55.5	44.5	136.7±19.1[a]	80.0±12.8[a]
With HF	1 892	58.8	41.2	136.1±19.8[a]	80.0±13.5[a]

Note: [a], in comparison with uncomplicated hypertension，$P<0.01$

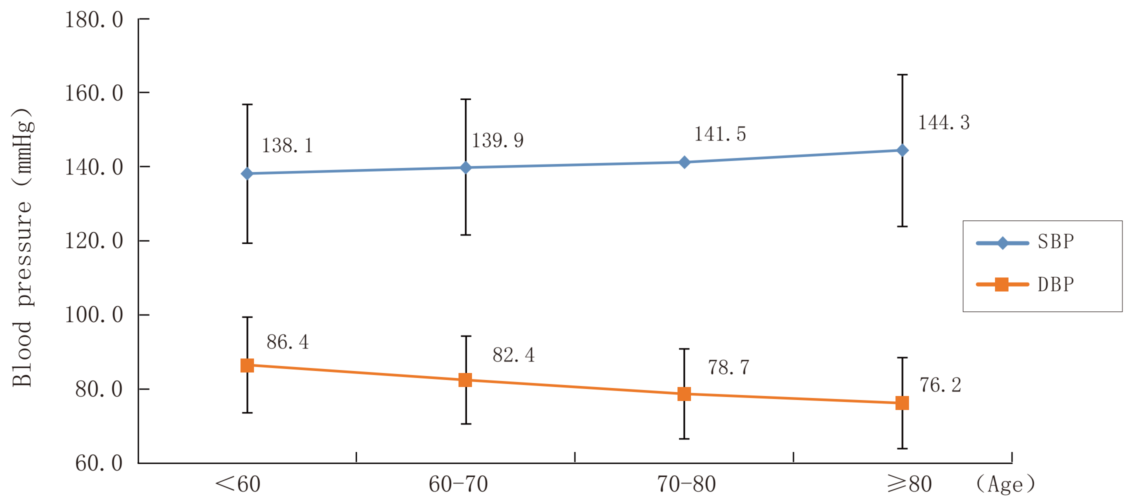

Figure 2-1-11 Average blood pressure of uncomplicated hypertensive patients by age

• Blood Pressure in CHS Participants

The mean SBP and DBP were 126.1 mmHg and 76.0 mmHg in the CHS participants, respectively. [2] SBP

[1] Sun NL, Huo Y, Huang J. Investigation of heart rate in Chinese hypertensive patients. Chinese Journal of Hypertension, 2015,23(10):934-939.
[2] Wang Z, Chen Z, Zhang L, et al. Status of Hypertension in China: Results from the China Hypertension Survey, 2012-2015. Circulation, 2018,137(22):2344-2356.

increased with age, while DBP increased at first and then decreased with age (Figure 2-1-12). The weighted blood pressure was 128.0/77.8 mmHg in males and 124.2/74.2 mmHg in females. Blood pressure also increased with BMI. The population with family history of hypertension had higher blood pressure than those without family history, and the difference was statistically significant. Blood pressure was higher in Han than in other ethnicities (126.2/76.0 mmHg vs 125.9/75.8 mmHg), and higher in rural areas than in urban areas (126.4/76.0 mmHg vs 125.6/76.0 mmHg), but both differences were not statistically significant (Table 2-1-5).

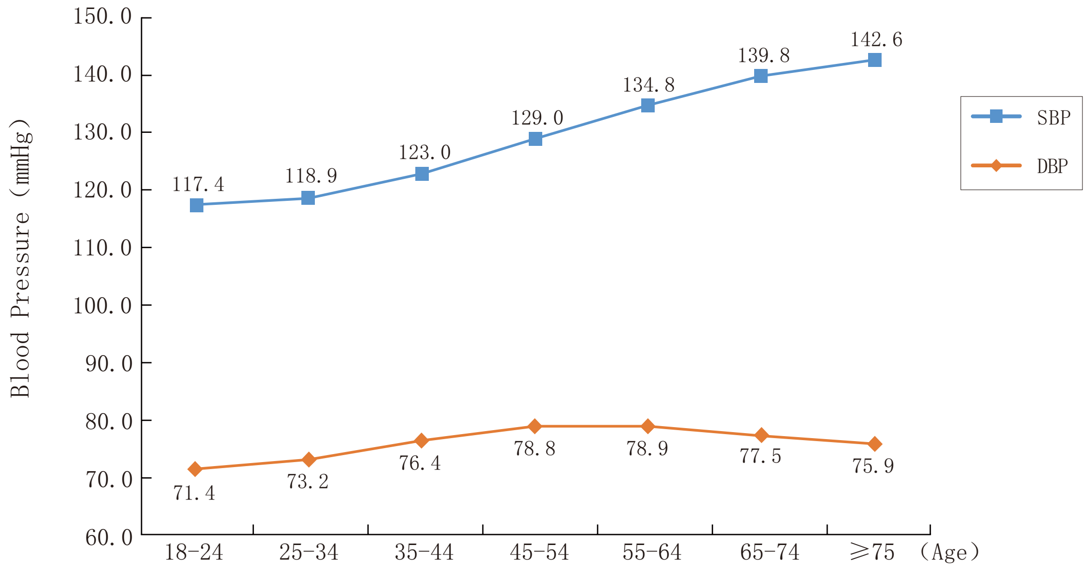

Figure 2-1-12 Blood pressure level of Chinese residents by age

Table 2-1-5 Weighted blood pressure level of Chinese residents aged ≥18 years in CHS by demographic characteristics

Characteristics	Population	Blood pressure (mmHg)	
		SBP	DBP
Total	451 755	126.1	76.0
Ethnicity			
Others	61 049	125.9	75.8
Han	390 706	126.2	76.0
P value		0.786	0.667
Gender			
Male	216 034	128.0	77.8
Female	235 721	124.2	74.2
P value		<0.001	<0.001

Table 2-1-5 Weighted blood pressure level of Chinese residents aged ≥18 years in CHS by demographic characteristics (Continued)

Characteristics	Population	Blood pressure (mmHg)	
		SBP	DBP
BMI			
<18.5	22 518	118.1	71.4
18.5-23.9	232 324	122.6	73.9
24.0-27.9	142 741	129.5	78.0
≥28.0	54 172	135.3	81.1
P value		<0.001	<0.001
Family history of hypertension			
No	349 114	125.3	75.5
Yes	102 641	128.8	77.7
P value		<0.001	<0.001
Region			
Urban	220 052	125.6	76.0
Rural	231 703	126.4	76.0
P value		0.323	0.898

2.1.1.5 Awareness, Treatment and Control of Hypertension

Several national surveys regarding awareness, treatment, and control of hypertension in China have been conducted over past decades. The results are presented in Table 2-1-6.

Table 2-1-6 Awareness, treatment and control of hypertension in national surveys

Survey	Year	Age	Method	N	Awareness (%)	Treatment (%)	Control (%)
National Sampling Survey on Hypertension	1991	≥15	Stratified random sampling	950 356	27.0	12.0	3.0
CHNS	2002	≥18	Stratified, multistage, cluster random sampling	272 023	30.2	24.7	6.1
Survey on the Nutrition and Chronic Disease Status	2012	≥18	Stratified, multistage random sampling	-	46.5	41.1	13.8

Table 2-1-6 Awareness, treatment and control of hypertension in national surveys (Continued)

Survey	Year	Age	Method	N	Awareness (%)	Treatment (%)	Control (%)
Survey on Prevalence, Awareness, Treatment and Control of Hypertension among Chinese Working Population	2012-013	18-60	Multistage, cluster sampling	37 856	57.6 (Standardized rate: 47.8)	30.5 (Standardized rate: 20.6)	11.2 (Standardized rate: 8.5)
CHS	2012-2015	≥18	Stratified, multistage random sampling	451 755	51.6 (Weighted rate: 46.9)	45.8 (Weighted rate: 40.7)	16.8 (Weighted rate: 15.3)
CCDRFS	2013-2014	≥18	Stratified, multistage random sampling	174 621	31.9	26.4	9.7
China PEACE	2014-2017	35-75	Convenience sampling	1 738 886	44. 7 (Standardized rate: 36.0)	30.1 (Standardized rate: 22.9)	7.2 (Standardized rate: 5.7)

• China Hypertension Survey (CHS)

Table 2-1-7 showed the awareness, treatment, and control of hypertension by demographic characteristics among Chinese adults aged ≥18 years in CHS.[1] On the whole, weighted awareness, treatment and control rates of hypertension increased with age. But for the treated hypertensive patients, the control rate increased at first and then decreased with age (Figure 2-1-13). The crude awareness, treatment and control rates of hypertension were significantly higher in females than in males (55.3% vs 47.6%, 50.1% vs 41.2%, 18.2% vs15.3%, respectively) (Figure 2-1-14). The residents in urban areas had higher crude rates of awareness, treatment, control and control among treatment of hypertension than those in rural areas (Figure 2-1-15).

Compared with previous surveys, the awareness, treatment, and control rates of hypertension had improved markedly in CHS (Figure 2-1-16).

Table 2-1-7 Weighted awareness, treatment, control rates of hypertension by demographic characteristics (%)

Characteristics	Awareness	Treatment	Control	Control among treatment
Total	46.9	40.7	15.3	37.5
Ethnicity				
Others	36.9	29.5	8.4	28.3
Han	48.0	42.0	16.1	38.3
P value	<0.001	<0.001	<0.001	0.008

[1] Wang Z, Chen Z, Zhang L, et al. Status of Hypertension in China: Results from the China Hypertension Survey, 2012-2015. Circulation, 2018,137(22):2344-2356.

Table 2-1-7 Weighted awareness, treatment, control rates of hypertension by demographic characteristics (%) (Continued)

Characteristics	Awareness	Treatment	Control	Control among treatment
Gender				
Male	42.5	35.6	13.2	37.0
Female	51.9	46.6	17.7	38.0
P value	<0.001	<0.001	<0.001	0.267
BMI				
<18.5	37.2	31.8	12.7	39.9
18.5-23.9	41.0	35.2	14.4	40.8
24.0-27.9	48.5	42.2	15.8	37.4
≥28.0	53.7	47.1	16.0	33.9
P value	<0.001	<0.001	0.063	<0.001
Education status				
Elementary school	50.1	43.9	15.0	34.2
Middle school	44.4	38.3	15.8	41.2
High school or above	36.6	31.0	13.9	44.8
P value	<0.001	<0.001	0.476	<0.001
Family history of hypertension				
No	39.0	33.4	12.1	36.2
Yes	62.4	55.1	21.6	39.2
P value	<0.001	<0.001	<0.001	0.019
Region				
Urban	50.9	45.8	19.4	42.4
Rural	44.7	38.0	13.1	34.4
P value	0.084	0.031	0.006	0.002

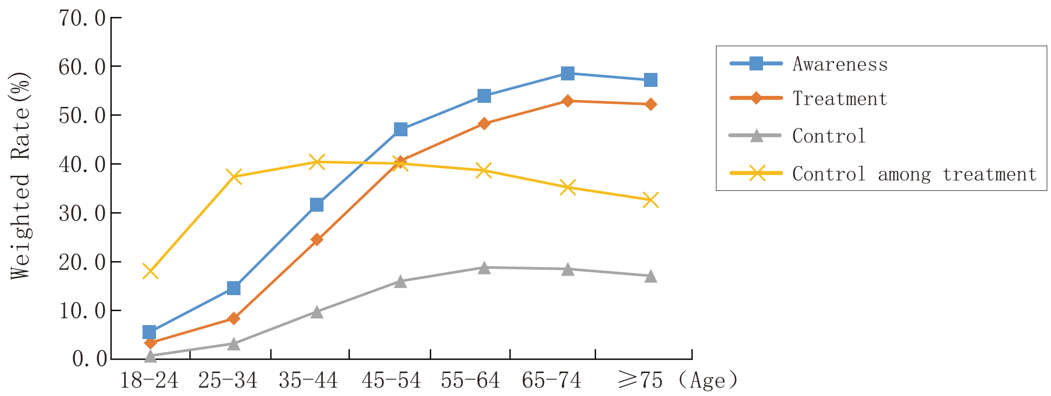

Figure 2-1-13 Awareness, treatment and control of hypertension by age in CHS

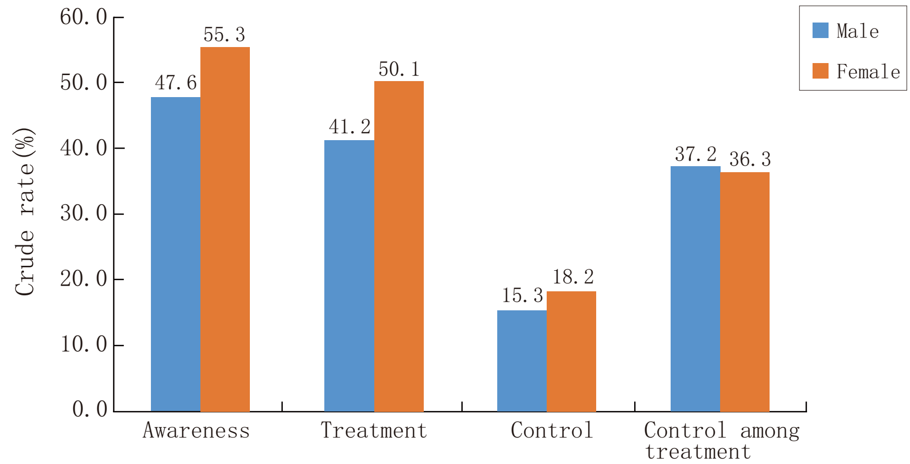

Figure 2-1-14 Awareness, treatment, control of hypertension by gender in CHS

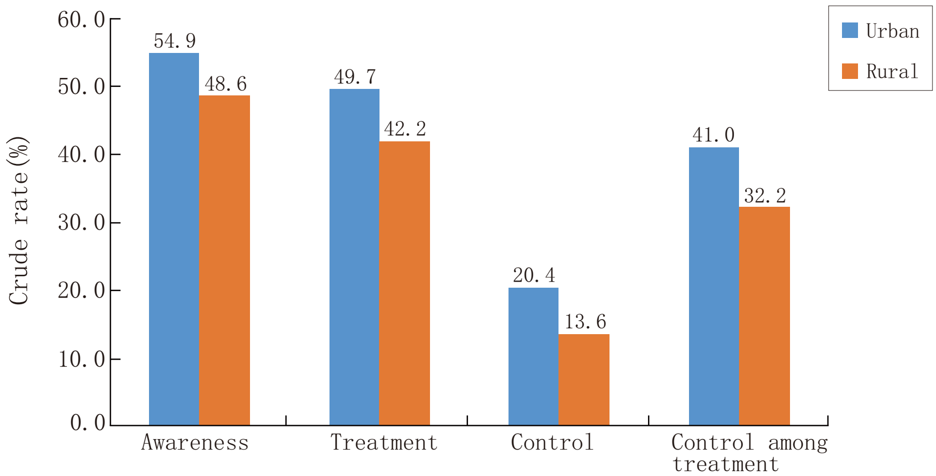

Figure 2-1-15 Awareness, treatment and control of hypertension by region in CHS

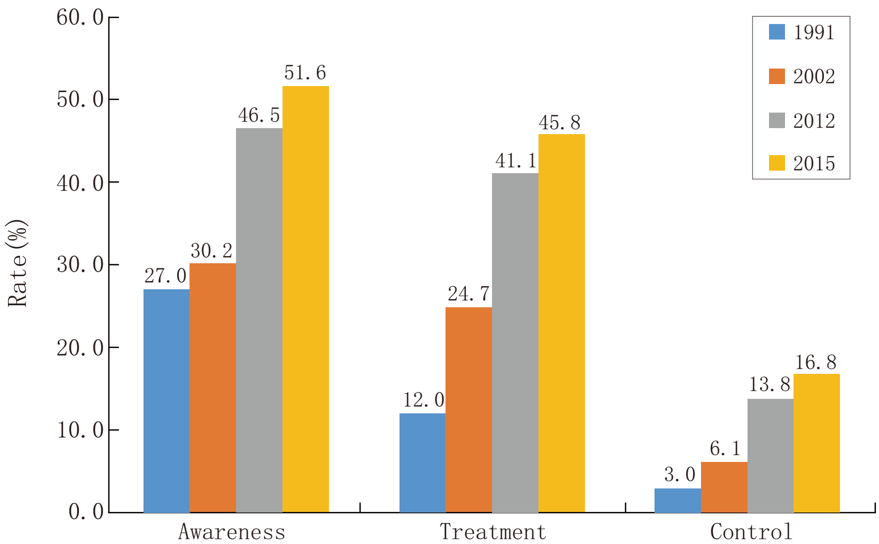

Figure 2-1-16 Awareness, treatment and control of hypertension, 1991-2015

• China Chronic Disease and Risk Factors Surveillance (CCDRFS)

CCDRFS [1] revealed that the awareness, treatment, and control rates of hypertension were 31.9%, 26.4%, and 9.7%, respectively. After adjusting for confounding factors, like gender, age, seasons, etc., these rates were much better in urban areas than in rural areas (P<0.0001). Among hypertensive individuals, older age and female gender tended to be associated with better awareness, treatment, and control rates (Table 2-1-8).

Table 2-1-8 Awareness, treatment and control of hypertension among Chinese residents aged ⩾18 years by demographic characteristics in CCDRFS (%)

	Awareness	Treatment	Control	Treatment among awareness	Control among treatment
Age					
18-29	10.1	9	4	90.6	42.9
30-39	13.2	8.9	3.4	67.3	34.3
40-49	21.5	15.1	6.3	70.7	38.4
50-59	30.9	24.3	9.5	79.4	36.1
60-69	37.1	30.5	11.2	83.1	35
70+	40.2	33.9	11.3	85.3	31.8
P value	<0.01	<0.01	<0.01	<0.01	<0.01
Gender					
Male	24.2	18.5	7.2	77.8	36.7
Female	27.5	22	7.9	82.2	34.5
P value	<0.01	<0.01	<0.01	<0.01	0.049
Region					
Urban	32.5	10.1	84.4	37.9	10.1
Rural	20.1	5.5	74.9	33.4	5.5
P value	<0.01	<0.01	<0.01	<0.01	<0.01
Season					
Winter	21.7	15.6	5.1	73.5	30.8
Spring	26.2	21	7	81.8	32.2
Summer	25.5	20.1	9.6	80.5	43.3
Autumn	30.2	24.8	9.2	83.6	36.7
P value	<0.01	<0.01	<0.01	<0.01	<0.01
Total	31.9	26.4	9.7	82.9	34.6

[1] Li Y, Yang L, Wang L, et al. Burden of hypertension in China: A nationally representative survey of 174 621 adults. International Journal of Cardiology, 2017, 227:516-523.

• China Patient-Centered Evaluative Assessment of Cardiac Events (China PEACE)

China PEACE [1] showed that among hypertensive patients aged 35-75 years, 44.7% were aware of their diagnosis, 30.1% were taking prescribed antihypertensive medications, and 7.2% had achieved control. The age-standardized and sex-standardized rates of hypertension awareness, treatment, and control were 36.0%, 22.9%, and 5.7%, respectively. Compared with urban residents, rural residents had a higher prevalence of hypertension, but lower awareness, treatment, and control rates (Figure 2-1-17).

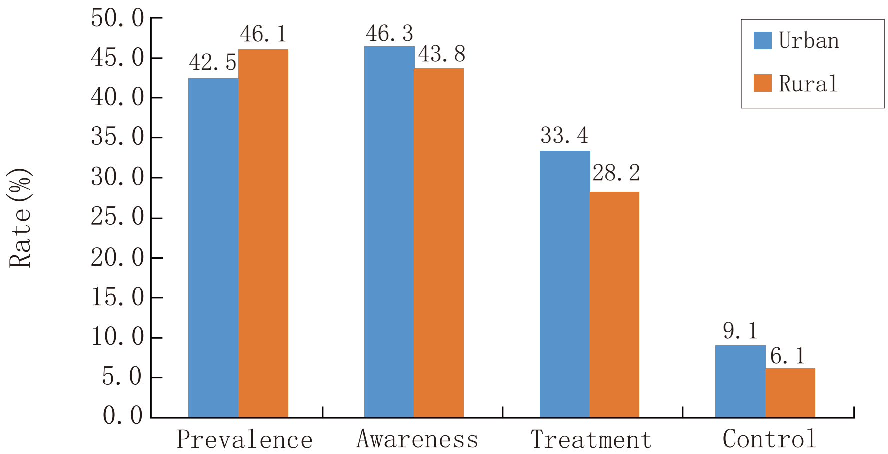

Figure 2-1-17 Prevalence, awareness, treatment, and control of hypertension among urban and rural residents in China PEACE

• Awareness, Treatment and Control of Hypertension among Chinese Working Population

From January 2012 to November 2013, a total of 37 856 employees aged 18-60 years from 61 workplaces in urban areas with different economic levels were sampled [2] . Blue-collar employees had lower treatment and control rates of hypertension than white-collar employees did after standardization of age. Employees in research institute had the highest awareness, treatment and control rates of hypertension (Table 2-1-9).

[1] Lu J, Lu Y, Wang X, et al. Prevalence, awareness, treatment, and control of hypertension in China: data from 1.7 million adults in a population-based screening study (China PEACE Million Persons Project). Lancet, 2017,390(10112):2549-2558.

[2] Shen Y, Wang X, Wang Z, et al. Prevalence, awareness, treatment, and control of hypertension among Chinese working population: results of a workplace-based study. Journal of the American Society of Hypertension, 2018,12(4):311-322.

Table 2-1-9 Awareness, treatment and control of hypertension among Chinese working population by occupation

	Awareness (%)	Treatment (%)	Control (%)
Occupation status			
Blue-collar worker	46.7	18.3	7.4
White-collar worker	49.0	24.1	9.8
Organization cadres	49.5	23.2	12.5
Others	53.9	23.9	9.4
Workplace ownership			
Private enterprise	44.7	16.7	5.1
Stated-owned enterprise	47.8	18.9	6.5
University	48.0	26.5	15.9
Research institute	52.7	31.1	18.6

2.1.2 Secondary Hypertension

Secondary hypertension occurs in about 10% of patients with hypertension [1] and in 14.76% of hospitalized hypertensive patients [2] The causes of secondary hypertension include renal disease, renal artery stenosis or fibromuscular dysplasia, endocrine system diseases like primary aldosteronism, hypercortisolism, andobstructive sleep apnea-hypopnea syndrome (OSAHS).[3,4] A commentary published in 2015 [5] suggested that OSAHS might be the primary cause of secondary hypertension. A study published in 2013 [6] indicated that primary aldosteronism was one of the common forms of secondary hypertension. Compared with essential hypertension patients, primary aldosteronism patients had a higher incidence of target organ damage and cardiovascular events.

[1] Puar TH, Mok Y, Debajyoti R, et al. Secondary hypertension in adults. Singapore J, 2016,57(5):228-232.

[2] Li NF, Wang L, Zhou KM, et al. Analysis of etiology of the patients with hypertension from the People's Hospital of Xinjiang Uygur Autonomous Region. Chinese Journal of Cardiology, 2007,35(9):865-868.

[3] Wang JG, Li LH. Hypertension series: the differential diagnosis and treatment for secondary hypertension- continued. Chinese Circulation Journal, 2012, 27(2):85-86.

[4] Noilhan C, Barigou M. Bieter L. Causes of secondary hypertension in the young population: a monocentric study. Ann Cardiol Angeiol (Paris). 2016, 65(3):159-164.

[5] Wang LH, He QY. Sleep apnea-hypopnea syndrome may be the primary cause of secondary hypertension. Chinese Journal of Hypertension. 2015, 23(6):505-507.

[6] Li JH, Li NF. Hereditary research status of primary hyperaldosteronism. Chinese Journal of Endocrinology and Metabolism, 2013, 29(12):1070-1072.

2.1.3 Hypertension in Children

2.1.3.1 An Update on Blood Pressure References for Chinese Children

Updating blood pressure references by age and height simultaneously for Chinese children aged 3-17 years was developed and published in May 2017 (“2017 Chinese standards” for short) [1] It was based on the data of hypertension in 2010 blood pressure reference standards for Chinese children and adolescents (“2010 Chinese standards” for short), and took into account the influence of height variation among children at the same age and gender. In the 2017 Chinese standards, the age-, gender- and height-specific 95^{th} percentile (P_{95}) of blood pressure (SBP/DBP) was used as the cut-off points for hypertension. Blood pressure at the level of P_{90}-P_{95} or ≥120/80 mmHg was regarded as “pre-hypertension” or “high-normal blood pressure. Additionally, DBP was defined by Korotkoff sound phase 5.

Besides the 2017 Chinese standards, there are another three influential references guiding the practice in China, including 2004 US standards (the Fourth Report), [2] 2017 US standards [3] and 2016 International standards [4] (Table 2-1-10). Data from Beijing Blood Pressure Cohort Study was used to estimate the prevalence of hypertension in childhood (aged 6-18 years), and compare the ability of above 4 pediatric blood pressure standards to predict adult (aged 30-42 years) hypertension and subclinical CVD. [5] Subclinical adult CVD was assessed using the carotid-femoral pulse wave velocity (cfPWV), carotid intima-media thickness (IMT), and left ventricular mass index (LVMI). Results showed that the prevalence of childhood hypertension was significantly higher according to 2017 Chinese standards vs 2014 US standards, 2017 US standards, and 2016 International standards (9.0%, 4.9%, 8.1% and 8.3%, respectively). The 2017 Chinese standards performed better in predicting the association of blood pressure in childhood with subclinical CVD in adulthood in comparison with the 2004 US and international standards (Table 2-1-11). Considering that hypertension screening in childhood is pivotal for early detection, intervention, and treatment of target organ damages and for prevention and reduction of CVD events, the 2017 Chinese standards seem to be more appropriate for early detection of hypertension in childhood and to be used as an accurate standard for assessing blood pressure in the research for prevention and treatment of hypertension among children.

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[1] Fan H, Yan YK, Mi J. Updating blood pressure references for Chinese children aged 3-17 years. Chin J Hypertens, 2017,25(5):428-435.

[2] National High Blood Pressure Education Program Working Group on high blood pressure in children and adolescents. The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. Pediatrics, 2004,114(2 Suppl 4th Report):555-576.

[3] Flynn JT, Kaelber DC, Baker-Smith CM, et al. Clinical practice guideline for screening and management of high blood pressure in children and adolescents. Pediatrics, 2017,140(3): e20171904.

[4] Xi B, Zong X, Kelishadi R, et al. Establishing international blood pressure references among non-overweight children and adolescents aged 6 to 17 years. Circulation, 2016,133(4):398-408.

[5] Fan H, Hou D, Liu J, et al. Performance of 4 definitions of childhood elevated blood pressure in predicting subclinical cardiovascular outcomes in adulthood. J Clin Hypertens (Greenwich). 2018,20(3):508-514.

Table 2-1-10 Characteristics of 4 definitions of childhood elevated blood pressure

Standard name	Data source	N	Cut-off points	Age
2017 Chinese standards	11 cross-sectional studies, excluding severely obese children	106 123	P_{95}	3-17
2004 US standards	11 cross-sectional studies, including obese or overweight children	63 227	P_{95}	1-17
2017 US standards	same as the data from 2004 US standards, but excluding obese and overweight children	49 967	age <12 years: P_{95} age ≥13 years: 130/80 mmHg	1-17
2016 International standards*	cross-sectional studies from 7 countries, excluding obese and overweight children	52 636	P_{95}	6-17

* Proportion of participants from the data of 2016 International standards: Iran 28.2%, China 17.7%, The United States 16.7%, South Korea 11.8%, India 10.9%, Poland 10.1%, Tunisia 4.6%

Table 2-1-11 Odd ratios (95%CI) of adulthood subclinical CVD according to 4 definitioins of childhood elevated blood pressure

Subclinical CVD in adulthood	2017 Chinese Standards	2004 US Standards	2017 US Standards	2016 International Standards
Arterial stiffness	1.78 (1.24-2.55) **	1.62 (1.08-2.41) *	1.83 (1.27-2.65) **	1.71 (1.18-2.46) **
Atherosclerosis	1.49 (1.05-2.10) *	1.37 (0.93-2.02)	1.46 (1.02-2.08) *	1.41 (0.99-2.01)
Left ventricular hypertrophy	1.70 (1.20-2.40) **	1.75 (1.19-2.58) **	1.99 (1.39-2.83) ***	1.83 (1.29-2.60) **
Any of above subclinical CVD	2.09 (1.51-2.91) ***	1.89 (1.31-2.73) **	2.08 (1.48-2.92) ***	2.06 (1.47-2.88) ***

Notes: Arterial stiffness, carotid-femoral pulse wave velocity (cfPWV) $\geqslant P_{75}$; Atherosclerosis, carotid intima-media thickness (IMT) $\geqslant P_{75}$ or presence of plaques; Left ventricular hypertrophy, left ventricular mass index (LVMI) $\geqslant P_{75}$.
* P<0.05; **P <0.01; ***P <0.001.

Furthermore, for the convenience of clinical doctors to achieve a rapid diagnosis of hypertension in children, researchers extracted the age-, gender- , and P_{50} height-specific P_{95} blood pressure from 2017 Chinese standards and came up with a "simplified standards" based on formula for individual quick assessment (Table 2-1-12). The "simplified standards" is simpler than the complicated "tabular standards" that defines blood pressure based on age, gender and height percentiles. The agreement between these two standards was nearly 95% for detecting pediatric hypertension, but the "simplified standards" was better at predicting subclinical CVD and target organ damages in adulthood.[1] As a result, the "simplified standards" could be used for screening of elevated blood pressure among children, while the "tabular standards" could be used to confirm diagnosis on the screened children who were suspected to be hypertensive.

[1] Fan H, Yan YK, Mi J. Establishing the user-friendly screening criteria for elevated blood pressure in Chinese children aged 3-17 yrs. Chin J Hypertens, 2017,25(5):436-440.

Table 2-1-12 Simplified standards for hypertension screening in Chinese children aged 3-17 years

Gender	SBP (mmHg)	DBP (mmHg)
Male	100+2.0×age	65+age
Female	100+1.5×age	65+age

2.1.3.2 Prevalence and Characteristics of Hypertension in Children

Chinese National Survey on Students' Constitution and Health (CNSSCH) was conducted in more than 190 000 Han students aged 7-17 years in 2010 [1] . Results showed that the prevalence of hypertension according to 2010 Chinese standards was 14.5%in school-aged children. It was higher in boys than in girls (16.1% vs 12.9%), and increased with age ($P< 0.001$) (Figure 2-1-18) .

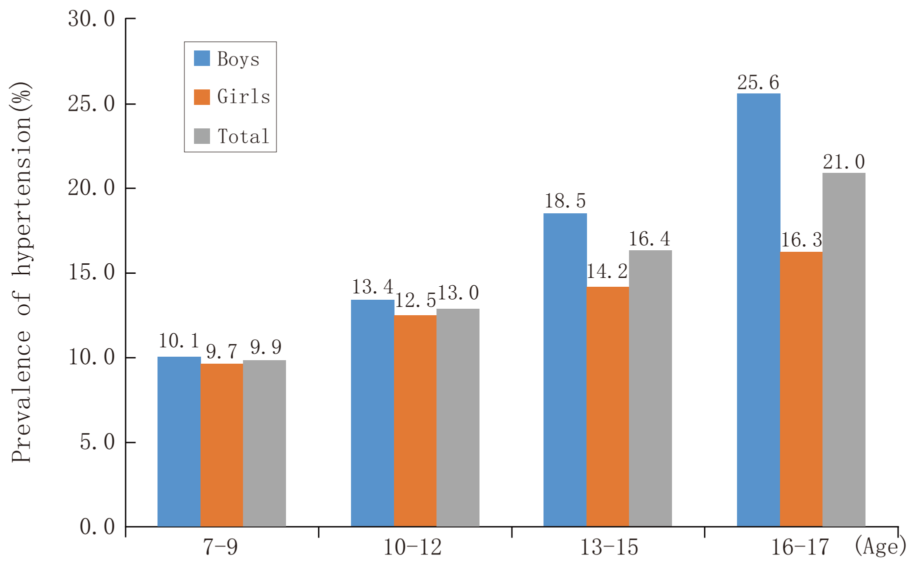

Figure 2-1-18 Prevalence of hypertension in Chinese children and adolescents by age in 2010 (%)

Data from CHNS demonstrated that the prevalence of hypertension, according to 2010 Chinese standards, among children and adolescents increased from 10.0% in 1993 to 12.9% in 2011 [2] , with an annual growth of 0.16% on average (Figure 2-1-19).

[1] Dong B, Wang HJ, Wang Z, et al. The association of overweight and obesity with blood pressure among Chinese children and adolescents. Biomedical and Environmental Science, 2013,26(6):437-444.

[2] Li SS, Ma WW, Xi B, et al. Trends in elevated blood pressure among Chinese children and adolescents, 1993-2011. Chin J Sch Health, 2016,37(10):1449-1452.

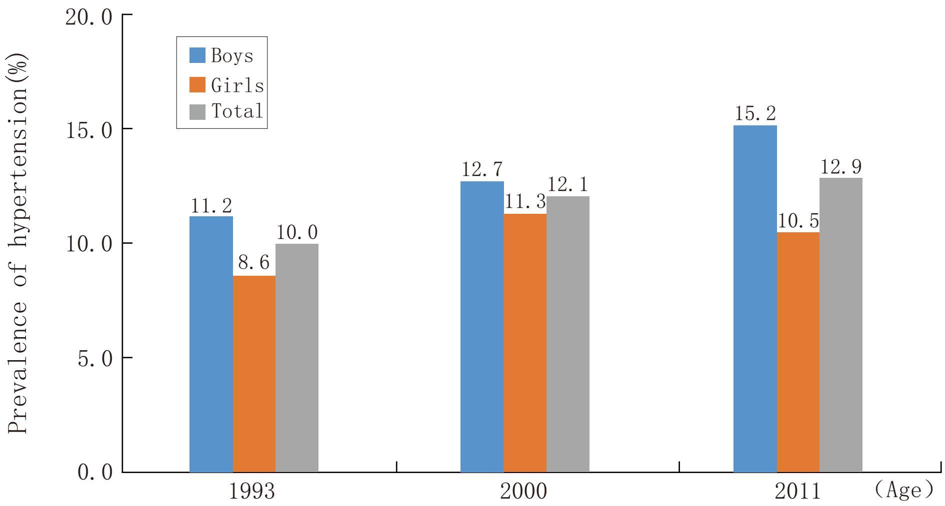

Figure 2-1-19 Trends of hypertensive prevalence in Chinese children and adolescents aged 7-17 years, 1993-2011

2.1.3.3 Influencing Factors of Hypertension in Children

(1)Overweight and obesity

Data were obtained from 1995-2014 CNSSCH on 943 128 Han children and adolescents aged 7-17 years (boys: 49.7%) to examine the trends in hypertension with the concomitant epidemic of overweight and obesity.[1] After adjusting for age, gender, height, area, and socioeconomic status, the impact of being overweight or obese on hypertension in children had increased sharply since 1995, and the population attributable risk percentage (PARP) of hypertension because of overweight or obesity steadily increased from 6.3% in 1995 to 19.2% in 2014. The impact on systolic hypertension was remarkable, and the PARP for systolic hypertension increased by 2.5 times during 1995-2014, which was nearly 2-fold greater than that for diastolic hypertension (Figure 2-1-20). Given the fact that obesity mainly affected systolic hypertension, it reflected that the proportion of school-aged children with moderate and severe obesity also rapidly increased, suggesting that obese children should be the key target population for early prevention and treatment of hypertension.

[1] Dong Y, Ma J, Song Y, et al. Secular trends in blood pressure and overweight and obesity in Chinese boys and girls aged 7 to 17 years from 1995 to 2014. Hypertension, 2018,72(2):298-305.

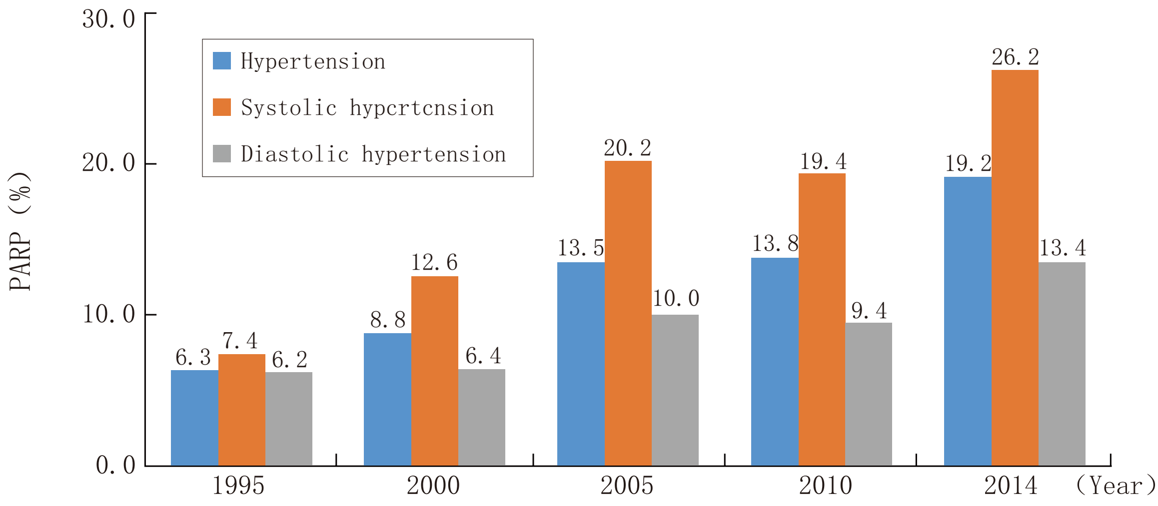

Figure 2-1-20 Trends in the PARP for hypertension because of overweight and obesity in Chinese children, 1995-2014

Note: Hypertension was defined according to the 2004 US standards (the Fourth Report). Overweight and obesity were defined according to the International Obesity Task Force definition

(2)Lifestyle

A cross-sectional survey was conducted among 10 091 primary (Grade 4) and junior high (Grade 7) school students (boys: 53.1%) in urban areas of Nanjing [1] to investigate the association of hypertension and sugar-sweetened beverages (SSB) consumption, like Coca-Cola, Sprite, etc. Results showed that the prevalence of hypertension was higher in the participants who had an experience of SSB intake every week than in those who had no experience of SSB intake, regardless of the students being at a healthy weight, overweight or obese (Figure 2-1-21). After adjustment for school, parental education, physical activity, and diet intake, a significant association between the consumption of SSB and hypertension was observed among the students who were at a healthy weight (OR=1.78, 95%CI:1.20-2.65), as well as who were overweight or obese (OR=1.28, 95%CI: 1.01-1.61).

[1] Qin Z, Xu F, Ye Q, et al. Sugar-sweetened beverages and school students' hypertension in urban areas of Nanjing, China. Journal of Human Hypertension, 2018,32(6):392-396.

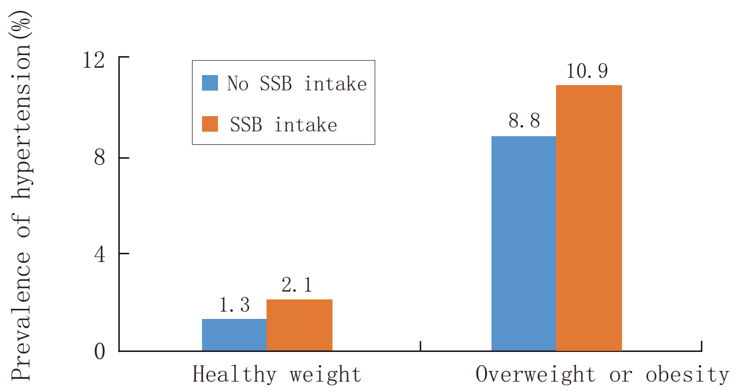

Figure 2-1-21 Association of sugar-sweetened beverages consumption with the prevalence of hypertension among children by weight

Another survey investigated the association between blood pressure and vegetable consumption in 18 757 adolescents (male: 49%) aged 13-17 years from 7 provinces and municipalities (Shanghai, Guangdong, Hunan, Liaoning, Ningxia, Tianjin, Chongqing).[1] After adjusting for age, gender, province, BMI, physical activity, fruit consumption, smoking, and alcohol intake, the odds of hypertension decreased as the amount of daily vegetable intake increased in non-overweight group or overweight and obesity group. In overweight adolescents, the risk of hypertension reduced by 37% in the participants with daily vegetable consumption ≥3 servings compared with those with <1 serving (OR=0.63, 95%CI: 0.42-0.95) (Figure 2-1-22).

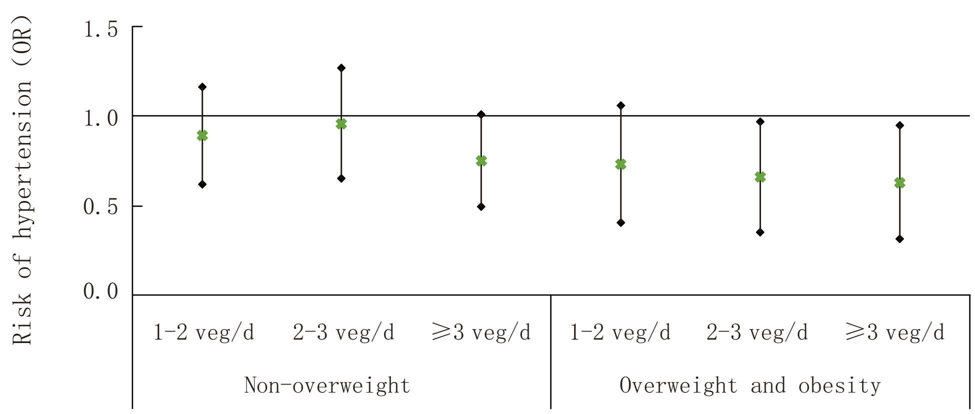

Figure 2-1-22 Association between vegetable consumption and the risk of hypertension in children (OR)

Note: Hypertension was defined according to the 2004 US standards (the Fourth Report).
Overweight and obesity were defined according to "BMI Reference for Screening Overweight and Obesity in Chinese School-age Children" developed by Working Group on Obesity in China in 2004. One serving (1 cup ≈200 g) of vegetable was defined as the size of an adult's closed fist

[1] Yang Y, Dong B, Zou Z, et al. Association between vegetable consumption and blood pressure, stratified by BMI, among Chinese adolescents aged 13-17 years: a national cross-sectional study. Nutrients, 2018, 10(4). pii: E451.

2.1.3.4 Short-term Target Organ Damages in Children with Hypertension

A total of 16 882 junior and senior high school students aged 13-18 years (boys: 49.8%) in Liaoning province were surveyed in 2014 [1] to investigate the association of blood pressure with visual acuity (VA). After adjusting for age, region of inhabitation, sleep duration, BMI, outdoor activity time, and homework time, the risk of low VA (<0.3) was associated with increase in pulse pressure (SBP minus DBP) (Figure 2-1-23). Compared with the reference group (≤30 mmHg), the adolescents with pulse pressure ≥51 mmHg had greater odds for low VA, 1.6 for males (95%CI: 1.3-1.9) and 1.4 for females (95%CI: 1.2-1.7).

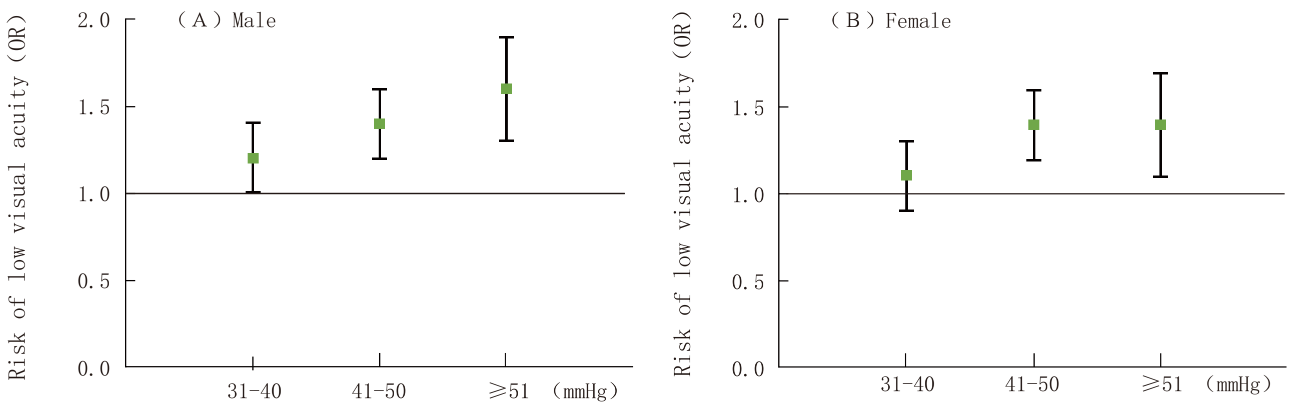

Figure 2-1-23 Association between low visual acuity and pulse pressure categories among children by gender (OR)

Anyang Childhood Eye Study [2] examined the blood pressure and fundus of 1 501 students (boys: 52.8%) in the 7th Grade with mean age of 12.7 years living in Anyang urban area, Henan province. Results showed that after controlling for age, sex, BMI, axial length, spherical equivalent, birth weight and so forth, the retinal arteriolar and venular diameters decreased as the blood pressure increased. For each 10-mmHg increase in SBP, the retinal arteriolar and venular diameters decreased by 3.07 μm and 2.06 μm, respectively. Each 10-mmHg increase in DBP was associated with 4.02 μm decrease in retinal arteriolar diameter and 2.34 μm decrease in retinal venular diameter (Table 2-1-13).

[1] Zhao M, Wang W, Yu H, et al. Elevated blood pressure is associated with higher prevalence of low visual acuity among adolescent males in northeast China. Sci Rep, 2017,7(1):15990. doi: 10.1038/s41598-017-14252-9.

[2] He Y, Li SM, Kang MT, et al. Association between blood pressure and retinal arteriolar and venular diameters in Chinese early adolescent children, and whether the association has gender difference: a cross-sectional study. BMC Ophthalmology, 2018,18(1):133.doi:10.1186/s12886-018-0799-x.

Table 2-1-13 Association between blood pressure and retinal arteriolar and venular diameters (μm) in children

Blood pressure	Retinal arterioles		Retinal venules	
	β (95%CI)	P value	β (95%CI)	P value
SBP	-3.07 (-3.79--2.34)	<0.001	-2.06 (-2.97--1.15)	<0.001
DBP	-4.02 (-4.96--3.08)	<0.001	-2.34 (-3.53--1.15)	<0.001

2.1.3.5 Impact of Childhood Hypertension on Subclinical CVD in Adulthood

Beijing Blood Pressure Cohort Study included 1 259 subjects aged 6-18 years and followed them over 24 years (follow-up rate: 51.6%). Results showed that after adjusting for age, gender, height in adulthood, BMI and other factors, the children with elevated blood pressure were more likely to develop hypertension and cardiovascular remodeling in adulthood (definitions are listed below Table 2-1-14) compared to those with normal blood pressure. The odds ratio was 2.1 for hypertension and 1.5 for cardiovascular remodeling, and it increased with age (Table 2-1-14).[1] Further analysis on this cohort study demonstrated that incremental BMI and SBP from childhood to adulthood predicted an increased risk of cardiovascular remodeling in adulthood by 0.24-1.89 times.[2] Therefore, the screening and intervention should be reinforced for children with both hypertension and obesity.

Table 2-1-14 Impact of blood pressure in childhood on hypertension and cardiovascular remodeling in adulthood (%)

Adulthood	Younger age group (6-12 years)			Older age group (13-18 years)		
	Normal BP	Hypertension	OR (95%CI)	Normal BP	Hypertension	OR (95%CI)
Hypertension	8.6	18.9	1.9 (1.1-3.5)	11.6	24.0	2.5 (1.4-4.4)
Cardiovascular remodeling	40.1	50.7	1.4 (0.9-2.0)	40. 4	57.4	1.6 (1.1-2.4)

Notes: (1) Hypertension in childhood was defined as SBP/DBP $\geqslant P_{80}$ with the BP at baseline as a reference; (2) Hypertension in adulthood was defined as SBP/DBP ≥140/90 mmHg or taking antihypertensive agents; (3) Cardiac remodeling was defined as the presence of at least one of the following conditions: carotid-femoral pulse wave velocity (cfPWV) $\geqslant P_{80}$, carotid intima-media thickness (IMT) $\geqslant P_{80}$ or presence of plaque, left ventricular mass index (LVMI) $\geqslant P_{80}$

2.1.3.6 Secondary Hypertension in Children

Up to now, most data regarding secondary hypertension in Chinese children came from retrospective

[1] Liang Y, Hou D, Shan X, et al. Cardiovascular remodeling relates to elevated childhood blood pressure: Beijing Blood Pressure Cohort Study. International Journal of Cardiology, 2014,177(3):836-839.

[2] Yan YK, Hou DQ, Liu JT, et al. Childhood body mass index and blood pressure in prediction of subclinical vascular damage in adulthood: Beijing blood pressure cohort. Journal of Hypertension, 2017,35:47-54.

analysis on medical records of hospitalized patients with hypertension in different regions.Results showed that: (1) A majority of hypertensive children (52.0%-81.5%) were admitted for secondary hypertension. The most common symptoms were dizziness and headache. (2) Children with age >10 years, increased BMI, and family history of hypertension were more likely to have primary hypertension, while those with younger age and ST-T changes on electrocardiogram usually had secondary hypertension (Table 2-1-15).

Table 2-1-15 Characteristics of hospitalized children with primary or secondary hypertension

	Beijing Children's Hospital [1]		Peking University First Hospital [2]		First Hospital of Jilin University [3]	
	Primary hypertension	Secondary hypertension	Primary hypertension	Secondary hypertension	Primary hypertension	Secondary hypertension
Hospitalization time	2003-2007		1993-2012		2002-2012	
Number of patients, n (%)	146 (48.0)	158(52.0)	51 (18.5)	224 (81.5)	50 (24.6)	153 (75.4)
Age, $\bar{x}\pm s$	12.3±3.1	9.1±4.6	12.0±2.7	9.2±4.7	11.8±3.2	10.2±4.0
Male，n (%)	116 (79.5)	103 (65.2)	44 (86.3)	127 (56.7)	36 (72.0)	91 (59.5)
BMI, $\bar{x}\pm s$	30.0±6.4	28.3±5.9	25.8±5. 3	18.4±5. 1	26.1	18.6
Family history of hypertension, n (%)	99 (67.8)	3 (22.7)	35 (68.6)	38 (16.7)	24 (48.0)	30 (19.6)
Clinical symptoms, n (%)						
Dizziness/headache	56 (38.4)	27 (17.1)	29 (56.9)	63 (28.1)	9 (18.0)	55 (35.9)
Nausea	16 (11.0)	40 (25.3)	--	--	6 (12.0)	43 (28.1)
Abnormal ECG	27 (18.5)	57 (36.1)	6 (11.8)	72 (32.1)	8 (16.0)	59 (38.6)

Note: Hypertension was defined according to 2004 American Guidelines for Children and Adolescents with Hypertension

All the three studies indicated that renal hypertension was the leading etiology in secondary hypertension among Chinese children, and drug-induced hypertension should be paid more attention to by clinicians (Table 2-1-16).

[1] Liu C, Du ZD, Li X, et al. Etiology and differential diagnosis of admitted children with hypertension. Journal of Capital Medical University, 2010,31(2):187-191.
[2] Zhang Y, Qi JG, Xiao HJ, et al. Etiology and clinical analysis of 275 admitted children with hypertension. Chinese Journal of Medicine, 2014,49(12):45-47.
[3] Zhang DL, Zhai SB, Wang JH, et al. Clinical analysis of 203 admitted children with hypertension. Chinese Journal of Laboratory Diagnosis, 2013,17(12):2238 -2240.

Table 2-1-16 Rank order of causes of secondary hypertension in children

Rank order	Beijing Children's Hospital (%)	Peking University First Hospital (%)	First Hospital of Jilin University (%)
1	Renal hypertension (39.9)	Renal hypertension (79.5)	Renal hypertension (49.0)
2	Endocrine hypertension (29.7)	Hypertension caused by drug/poisoning/ metabolism/tumors (6.3)	Drug-induced hypertension (18.3)
3	Hypertension caused by CVD (13.9)	Hypertension caused by CVD (1.9)	Hypertension caused by CVD (16.3)
4	Central nervous system diseases (8.2)	Hypertension caused by endocrine, rheumatic, or immune diseases (1.3)	Endocrine hypertension (5.2)
5	Others (stress, infectious diseases, other congenital abnormalities) (8.3)	Others (11.2)	Central nervous system diseases (4.6)
6	--	--	Others (6.5)

2.2 Smoking

2.2.1 Prevalence of Smoking

2.2.1.1 Prevalence of Smoking in General Population

Since 1984, the prevalence of smoking in male Chinese has been among the highest ones in the world, but it has been constantly declining in males aged ≥15 years since 1996. In the population aged 15-69 years, the annual decline of normalized prevalence of current smoking was 0.87% on average during 1996-2002 and 0.08% during 2002-2010 (Table 2-2-1).[1,2,3,4,5]

Table 2-2-1 Current smoking rates by time among Chinese population aged 15-69 years (%)

Prevalence of Smoking	1996	2002	2010	1996-2002 Annual decline	2002-2010 Annual decline
Male	63.0	57.4	53.9	-0.93	-0.43
Female	3.8	2.6	2.1	-0.20	-0.06
Urban	31.8	25.0	27.0	-1.13	+0.26
Rural	36.9	33.0	30.1	-0.65	-0.38
Total	35.3	31.1	28.7	-0.70	-0.30
Total (Normalized)*	33.7	28.3	27.9	-0.87	-0.08

* Note: The age normalization is based on 2010 sixth national census data.

Sources of survey data and definitions of smoking:

1996 national epidemiological survey of smoking behavior, definition of "smokers": current smoking, continuous or cumulative smoking for 6 months and above.

[1] Yang GH, Ma JM, Liu N, et al. Smoking and passive smoking in Chinese, 2002. Chin J Epidemiol, 2005,26(02):77-83.
[2] Yang G, Fan L, Tan J, et al. Smoking in China: findings of the 1996 National Prevalence Survey. JAMA, 1999,282(13):1247-1253.
[3] Yang GH. Global Adult Tobacco Survey (GATS) - China 2010 Country Report. Beijing: China Sanxia Publishing House, 2011.
[4] Liang XF. China Adult Tobacco Survey Report. Beijing: People's Medical Publishing House, 2015.
[5] Wong XZ. Compilation of 1984 national surveys on smoking. Beijing: People's Medical Publishing House, 1988.

2002 survey of smoking and passive smoking in Chinese population, definition of "smokers": current smoking, continuous or cumulative smoking of 100 cigarettes and above.

The 2010 Global Adult Tobacco Survey (GATS) - China Program, China Adult Tobacco Survey 2015: Smoking rate refers to the current smoking rate, which is the percentage of smokers among the population at the time of the survey

Chinese Adult Tobacco-Consuming Survey was conducted in 2015 and included 15 095 participants from 31 provinces, municipalities, and autonomous regions in mainland China (The target population and survey methods were the same as those in 2010). It demonstrated that the prevalence of smoking in males continued to be high. Data from the 6th National Census was served as a standard population to calculate the standardized prevalence of current smoking. It was 27.7% among Chinese residents aged ≥15 years, with 52.1% for males and 2.7% for females. Compared with the profile in 2010, there was little change in the prevalence of current smoking over the 5-year period. However, due to the impact of population growth, aging and other factors, if the data of national population by the end of 2014 was served as a standard, the number of smokers in the 5-year period increased by 15 million, from 301 million in 2010 to 316 million in 2015. The prevalence of smoking increased among males aged 15-24 years and those above 65 years over this period, but decreased in the groups aged 25-44 and 45-64 years. These changes were not statistically significant, and so did the changes about the prevalence of smoking among both genders between urban and rural areas (Figure 2-2-1, Figure 2-2-2). [1,2]

During 1984-1996, the average cigarettes consumption per person-day increased by 2 cigarettes, from 13 cigarettes/day to 15 cigarettes/day, and this trend remained flat thereafter. The daily cigarette consumption of each smoker was 14.8 cigarettes on average in 2002, 14.2 in 2010, and 15.2 in 2015, respectively. It increased by 1 cigarette in 2015 compared with that in 2010. [1,2,3,4]

2.2.1.2 Prevalence of Smoking among Medical Staff and Teachers

According to China Adult Tobacco Surveys, the prevalence of current smoking among male medical staff was 51.1% in 2010 and 43.0% in 2015, and that among male teachers was 47.8% and 48.1%, respectively.

2.2.1.3 Prevalence of Smoking in Chinese Adolescents

Global Youth Tobacco Survey (GYTS) [5]-China investigated 155 117 junior/high school students aged 13-15 years from 31 provinces, municipalities and autonomous regions in 2014. Results showed that the

[1] Yang GH. Global Adult Tobacco Survey (GATS) - China 2010 Country Report. Beijing: China Sanxia Publishing House, 2011.
[2] Liang XF. China Adult Tobacco Survey Report. Beijing: People's Medical Publishing House, 2015.
[3] Yang GH, Ma JM, Liu N, et al. Smoking and passive smoking in Chinese, 2002. Chin J Epidemiol, 2005,26(02): 77-83.
[4] Yang GH, Fan LX, Tan J, et al. Smoking in China: Findings of the 1996 National Prevalence Survey. JAMA, 1999,282(13):1247-1253.
[5] Tobacco Control Office, Chinese Center for Disease Control and Prevention. China youth tobacco survey report 2014. Beijing: Chinese Center for Disease Control and Prevention, May 2014.

prevalence of current smoking in Chinese teenagers was 6.9%. It was higher in males (11.2%) than in females (2.2%), and higher in rural areas (7.8%) than in urban areas (4.8%). Among current smokers, 71.8% had tried to quit smoking.

2.2.1.4 Present Situation on Smoking in Chinese Elderly Patients with Coronary Heart Diseases [1]

A cross sectional survey was conducted in 2011 to investigate the present situation on secondary prevention of CHD in 7 962 elderly outpatients aged ≥60 years from 116 hospitals of 21 provinces and cities. Results showed that 62.6% of the elderly patients with CHD had active smoking history, among whom 38.9% consumed cigarette ≥1 per day. Passive smokers accounted for 28.4%, among whom 42.5% were exposed to secondhand smoke at home. 19.1% of the elderly patients with CHD had quitted smoking.

2.2.2 Exposure to Secondhand Smoke

Secondhand smoke exposure (SHS) refers to the exposure of non-smokers to tobacco smoke at home or in the workplace. According to GATS, an estimated 738 million Chinese non-smokers were exposed to SHS in 2010.

Compared with the data in 2010, the proportion of non-smokers who witnessed smoking in indoor workshops, public places, public transport vehicles, and homes decreased in 2015, which indicated that SHS exposure had been improved (Figure 2-2-1). [2]

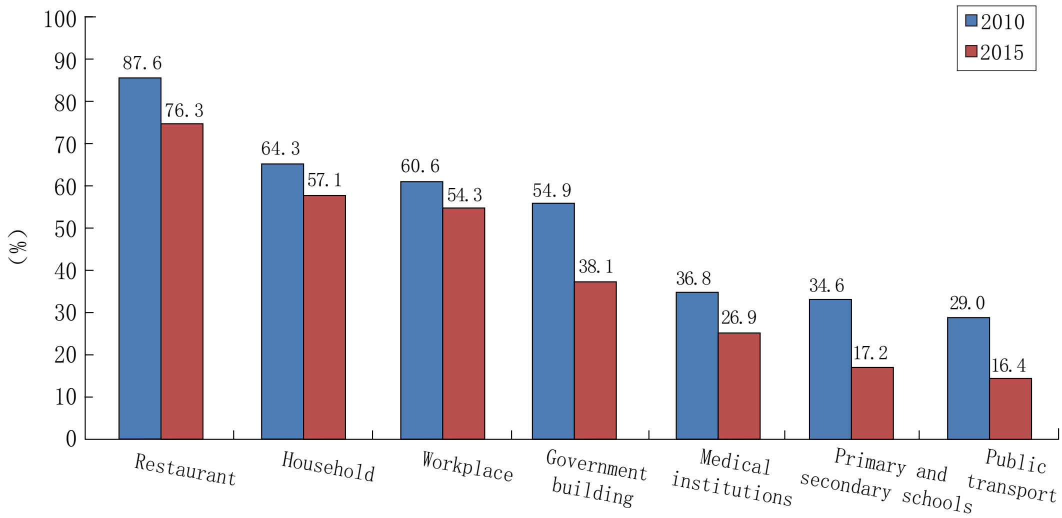

Figure 2-2-1 Witness rates for people smoking in some places in 2010 and 2015

Witness of smoking refers to someone who caught sight of smoking, smelled smoke, or noticed cigarette butts in the past 30 days in a

[1] Li XY, Wang L, Yu PL, et al. Present situation on therapy and secondary prevention of coronary heart disease in the elderly. Chinese Journal of Geriatrics, 2012,31(10):909-914.

[2] Liang XF. China Adult Tobacco Survey Report. Beijing: People's Medical Publishing House, 2015.

particular place

2.2.3 Smoking Cessation

The proportion of smoking cessation among the Chinese population aged ≥15 years had increased from 9.42% in 1996 to 16.9% in 2010. In 2015, 18.7% of all former and current smokers became non-smokers, and 25% of current smokers had tried to quit smoking in the past 12 months.

2.2.4 Hazards of Smoking

2.2.4.1 Sex-specific Associations between Tobacco Smoking and Risk of Cardiovascular Diseases in Chinese Adults [1]

The CKB program followed up 487 373 subjects for a median of 8.9 years. Results showed that the prevalence of smoking was much higher in males (67.9%) than in females (2.7%). Smoking increased risk of all subtypes of CVD. Compared with non-smokers, the HR (95%CI) for current smokers in descending order was 1.54 (1.43-1.66) for major coronary event, 1.28 (1.24-1.32) for IHD, 1.18 (1.14-1.22) for cerebral infarction, and 1.07 (1.00-1.15) for intracerebral hemorrhage, respectively. Among the current smokers, sex-specific associations were found between the risk of developing major coronary event and the amount of tobacco smoked daily(interaction $P = 0.006$) as well as age when smoking started (interaction $P = 0.011$). The risk was higher in female smokers than in male smokers. There was no sex difference in these two effects for IHD, intracerebral hemorrhage and cerebral infarction.

2.2.4.2 The Association of Smoking and Smoking Cessation with Blood Glucose Control in Male Patients with Type 2 Diabetes [2]

A study used cluster sampling to explore the association of smoking and smoking cessation with blood glucose control in 7 763 male patients with type 2 diabetes. Results showed that the levels of fasting plasma glucose (FPG) and HbA1c increased with number of cigarettes smoked per day ($P<0.001$). Among patients with drug treatment, the average increase of HbA1c level in current smokers with smoking duration ≥50 years and smoking index ≥40 pack-years were 0.27% (95%CI: 0.05% - 0.49%) and 0.38% (95%CI: 0.23% - 0.53%), respectively. FPG and HbA1c level decreased obviously with smoking cessation years among former smokers ($P < 0.05$). Among the patients receiving no drug treatment, no dose-response relationships were observed between smoking duration, smoking cessation years and levels of FPG and HbA1c. It suggested that cigarette smoking was negatively related with glycemic control in diabetic patients, especially in those with drug treatment. Smoking cessation may be beneficial for glycemic control and should be encouraged for diabetic patients as early as possible.

[1] Shen Q, Zhu NB, Guo Y, et al. Sex-specific associations between tobacco smoking and risk of cardiovascular diseases in Chinese adults. Chinese Journal of Epidemiology, 2018,39(1):8-15.

[2] Su J, Tan Y, Shen C, et al. Study on the relationship between smoking, smoking cessation and blood glucose control of type-2 male diabetes patients. Chinese Journal of Epidemiology, 2017,38 (11):1454-1459.

2.2.4.3 Disease Burden Attributable to Tobacco

Data of 26 000 Chinese residents from CHNS 1991-2011 indicated that despite a declining trend in smoking in the past 20 years, 53.4% of males used tobacco in 2011. Current smoking was estimated to be associated with 1.3 million CVD events with a population-attributable fraction of about 1/3 among males (Figure 2-2-2). [1]

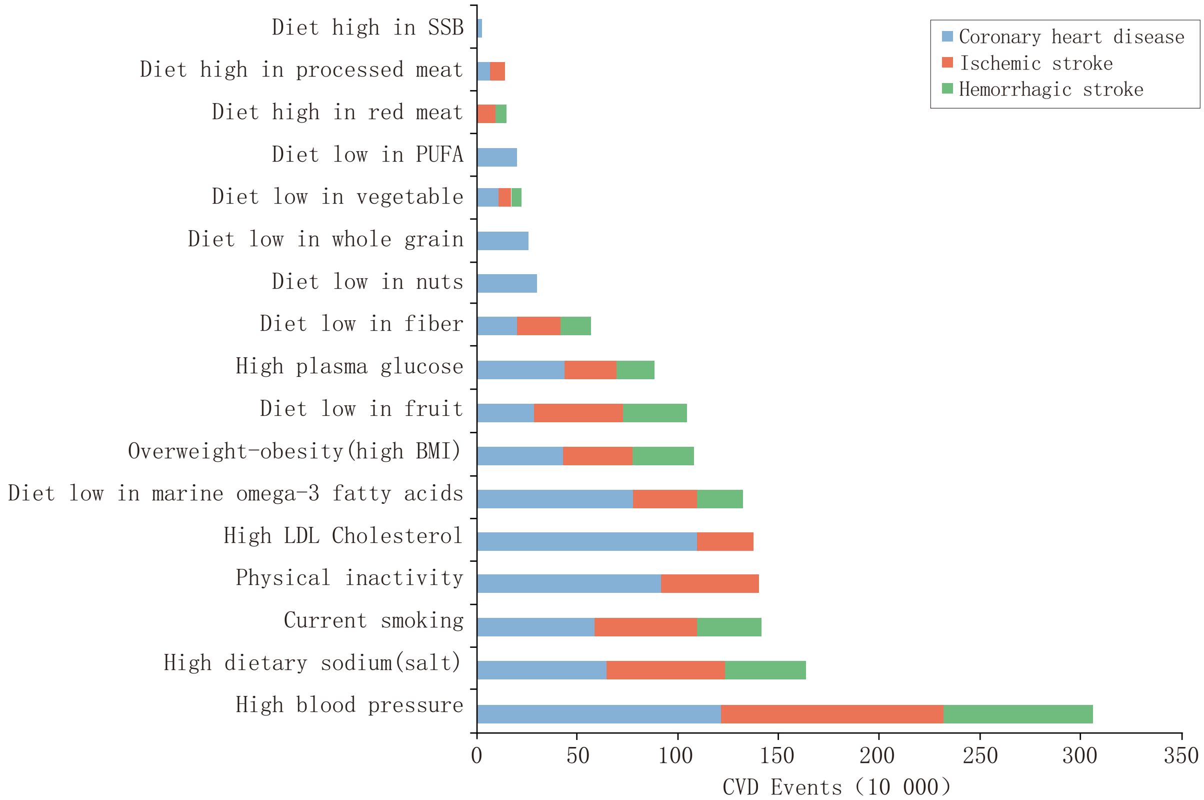

Figure 2-2-2 CVD attributable to 17 individual risk factors in 2011

2.3 Dyslipidemia

Since the 1980s, with rapid development of economy, especially aging of population and acceleration of urbanization, the level of blood lipid and prevalence of dyslipidemia have elevated alarmingly in Chinese

[1] Li Y, Wang DD, Ley SH, et al. Potential Impact of Time Trend of Life-Style Factors on Cardiovascular Disease Burden in China. J Am Coll Cardiol, 2016,68 (8):818-833.

population. A series of large-scale epidemiological studies in China [1,2,3,4,5,6] indicated that levels of serum TC and LDL-C were increasing in the Chinese population, despite lower than those in the Westerners. The level of TC and prevalence of hypercholesterolemia varied significantly across regions and age groups. They were higher in the economically developed regions and in the middle-aged and elderly residents.[5,6,7] Dyslipidemia was manifested as low HDL-C and high TG in China [8] while as hypercholesterolemia and high LDL-C in the Western population.[9]

2.3.1 Blood Lipid Levels

China Chronic Disease and Risk Factor Surveillance (CCDRFS),[10] surveyed the blood lipid levels, prevalence of dyslipidemia, and achievement of LDL-lowering targets in Chinese adults from 298 surveillance centers (177 in rural areas and 121 in urban areas) in 31 provinces , autonomous regions and municipalities. Several large-scale surveys on blood lipid in Chinese adults during 2002-2014 are shown in Table 2-3-1. The TC level increased significantly during the 12-year period.

[1] Tao SC, Li YH, Xiao ZK, et al. Serum lipids and their correlates in Chinese urban and rural populations of Beijing and Guangzhou. Inter J Epidemiol,1992,21(5):893-903.

[2] The WHO MONICA Project. Geographical variation in the major risk factors of coronary heart disease in men and women aged 35-64 years. World Health Statistics,1988,41(3/4):115-140.

[3] Wu ZS, Yao CH, Zhao D, et al. Multi provincial monitoring of trends and determinants in cardiovascular diseases (Sino-MONICA project). Chinese J Cardiology, 1997,25(4):255-259.

[4] Zhou BF, Zhang HY, Wu YF, et al.Ecological Analysis of the association between incidence and risk factors of coronary heart disease and stroke in Chinese populations. CVD Prevention,1998,1(3):207-216.

[5] He J, Gu D, Reynolds K et al. Serum total and lipoprotein cholesterol levels and awareness, treatment, and control of hypercholesterolemia in China. Circulation, 2004,110(4):405-411.

[6] Yang WY, Xiao JZ, Yang ZJ, et al. Serum lipids and lipoproteins in Chinese men and women. Circulation, 2012,125: 2212-2221.

[7] The Collaborative Study Group on Trends of Cardiovascular Diseases in China and Preventive Strategy. Current status of major cardiovascular risk factors in Chinese population and their trend in the past two decades. Chinese J Cardiology, 2001,29(2):74-79.

[8] Pan L, Yang Z, Wu Y, et al.The prevalence, awareness, treatment and control of dyslipidemia among adults in China. Atherosclerosis, 2016,248:2-9.

[9] Tóth PP1, Potter D, Ming EE. Prevalence of lipid abnormalities in the United States: the National Health and Nutrition Examination Survey 2003-2006. J Clin Lipidol, 2012,6(4):325-330.

[10] Zhang M, Deng Q, Wang L, et al. Prevalence of dyslipidemia and achievement of low-density lipoprotein cholesterol targets in Chinese adults: A nationally representative survey of 163,641 adults. Int J Cardiol, 2018,260:196-203.

Table 2-3-1 Average blood lipid levels in Chinese residents aged ≥18 years

Survey time	Project	Population	N	Average blood lipid levels (mmol/L)			
				TC	TG	HDL-C	LDL-C
2002[1]	CHNS	31 provinces, municipalities, and autonomous regions urban/rural	49 252	3.81	1.10	1.30	-
2010[2]	China Chronic Disease Surveillance	31 provinces, municipalities, and autonomous regions 161 surveillance centers, urban/rural	90 395	4.04	1.33	1.11	2.27
2012[3]	National survey	-	-	4.50	1.38	1.19	-
2014[4]	CCDRFS	31 provinces, municipalities, and autonomous regions 298 surveillance centers, urban/rural	163 641	4.70	1.14	1.35	2.88

The blood lipid levels in the Chinese population varied across areas and genders. Table 2-3-2 shows the components of blood lipid by region (urban/rural) and gender in 2002 CHNS,[1] 2010 China Chronic Disease Surveillance,[2] 2012 National survey,[3] and 2014 CCDRFS.[4] The levels of TC, TG, and LDL-C were significantly higher in urban areas than in rural areas. The levels of TG and LDL-C were significantly higher in males than in females, while that of HDL-C was apparently lower in males than in females ($P<0.001$). CCDRFS demonstrated that the level of TC was significantly higher in males than in females ($P<0.001$), but other studies found no statistical difference between both genders.

Table 2-3-2 Components of blood lipids in Chinese residents aged≥18 years by region and gender during 2002-2014

Blood lipids (mmol/L)	2002				2010				2012				2014			
	Urban	Rural	Male	Female	Urban	Rural	Male	Female	Urban	Rural	Male	Female	Urban	Rural	Male	Female
TC	3.96	3.75	3.81	3.82	4.08	4.03	4.06	4.03	4.58	4.41	4.50	4.50	4.74	4.66	4.71	4.68
TG	1.16	1.07	1.13	1.05	1.34	1.33	1.45	1.21	1.42	1.33	1.51	1.25	1.20	1.11	1.22	1.08
HDL-C	1.30	1.30	1.26	1.33	1.11	1.11	1.08	1.14	1.19	1.18	1.14	1.23	1.33	1.37	1.29	1.41
LDL-C	-	-	-	-	2.33	2.24	2.30	2.24	-	-	-	-	2.93	2.84	2.89	2.87

[1] Zhang J, Man QQ, Wang CR, et al. Level and distribution characteristics of blood lipid among Chinese aged more than 18. Chinese J of Preventive Medicine, 2005,39(5):302-305.

[2] Li JH, Mi SQ, Li YC, et al. The levels and distribution of serum lipids in Chinese adults, 2010. Chinese J of Preventive Medicine, 2012,46(7):607-612.

[3] Bureau of Disease Prevention and Control of National Health and Family Planning Commission. Report on the Nutrition and Chronic Disease Status of Chinese Residents (2015). Beijing: People's Medical Publishing House. 2015.

[4] Zhang M, Deng Q, Wang L, et al. Prevalence of dyslipidemia and achievement of low-density lipoprotein cholesterol targets in Chinese adults: A nationally representative survey of 163,641 adults. Int J Cardiol, 2018,260:196-203.

CCDRFS showed that the levels of TC and LDL-C increased with age. TG peaked at the age of 50-59, and then declined. HDL-C increased with age (Figure 2-3-1).

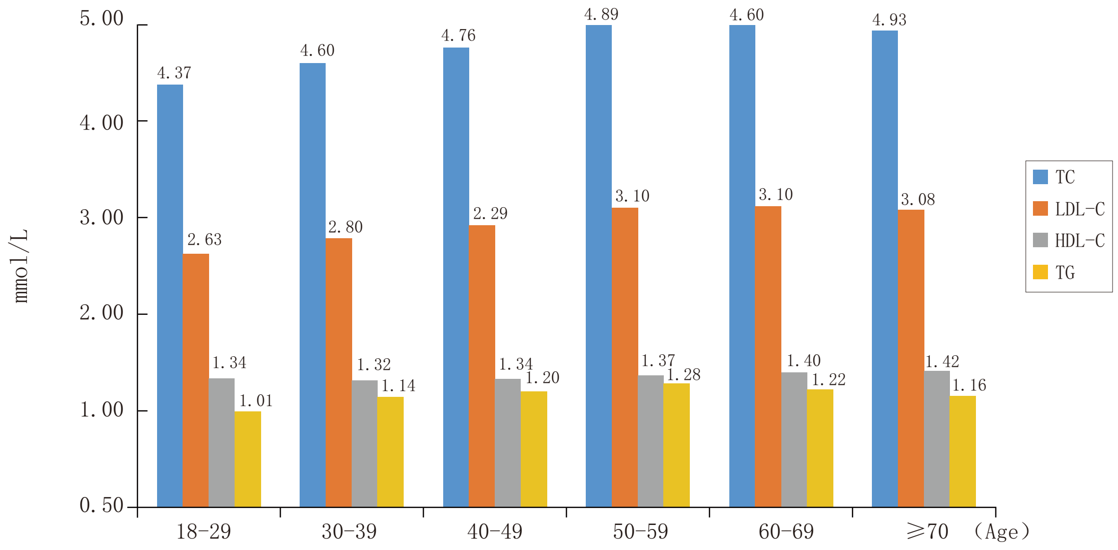

Figure 2-3-1 Blood lipid levels of Chinese adults by age in CCDRFS

Table 2-3-3 shows the average blood lipid levels in some regions of China in 2000-2001 International Collaborative Study of Cardiovascular Diseases in Asia (InterASIA),[1] 2007-2008 China National Diabetes and Metabolic Disorders Study (CNDMDS),[2] 2009-2017 Nanjing Retrospective Study,[3] and 2015-2017 Henan Rural Cohort Study.[4]

Table 2-3-3 Average blood lipid levels in some regions of China*

Survey time	Project	Population	N	Gender	Average blood lipid levels (mmol/L)			
					TC	LDL-C	HDL-C	TG
2000-2001	InterASIA [1]	10 provinces and cities, urban/ rural, aged 35-74 y	15 540	male	4.76	2.80	1.32	1.46
				female	4.86	2.86	1.36	1.43

[1] He J, Gu D, Reynolds K, et al. Serum total and lipoprotein cholesterol levels and awareness, treatment, and control of hypercholesterolemia in China. Circulation, 2004,110(4):405-411.
[2] Yang WY, Xiao JZ, Yang ZJ, et al. Serum lipids and lipoproteins in Chinese men and women. Circulation, 2012,125:2212-2221.
[3] Gu T, Zhou W, Sun J, et al. Gender and Age Differences in Lipid Profile Among Chinese Adults in Nanjing: a Retrospective Study of Over 230,000 Individuals from 2009 to 2015. Exp Clin Endocrinol Diabetes, Exp Clin Endocrinol Diabetes, 2018,126(7):429-436.
[4] Liu X, Yu S, Mao Z, et al. Dyslipidemia prevalence, awareness, treatment, control, and risk factors in Chinese rural population: the Henan rural cohort study. Lipids Health Dis, 2018 May 22;17(1):119. doi: 10.1186/s12944-018-0768-7.

Table 2-3-3 Average blood lipid levels in some regions of China* (Continued)

Survey time	Project	Population	N	Gender	Average blood lipid levels (mmol/L)			
					TC	LDL-C	HDL-C	TG
2007-2008	CNDMDS [1]	14 provinces and cities, urban/rural, aged ≥ 20 y	46 239	male	4.70	2.68	1.25	1.71
				female	4.73	2.69	1.35	1.42
2009-2015	Nanjing Research [2]	urban, ≥20 y	236 945	male	4.77	2.53	1.19	1.74
				female	4.79	2.44	1.46	1.21
2015-2017	Henan Rural Cohort [3]	rural, 18-79 y	39 207	male	4.63	2.81	1.26	1.66
				female	4.84	2.91	1.37	1.69

Note: *Standardized by age

2.3.2 Prevalence of Dyslipidemia

The prevalence of dyslipidemia in Chinese adults presented an upward trend. It was 18.6% in 2002 CHNS [4] , 34.0% in 2010 China Chronic Kidney Disease Survey [5], 39.9% in 2011 CHNS [6] and 40.4% in 2012 National survey [7] , showing a dramatic increase during the 10-year period (Figure 2-3-2).

[1] Yang WY, Xiao JZ, Yang ZJ, et al. Serum lipids and lipoproteins in Chinese men and women. Circulation,2012,125:2212-2221.

[2] Gu T, Zhou W, Sun J, et al. Gender and Age Differences in Lipid Profile Among Chinese Adults in Nanjing: a Retrospective Study of Over 230,000 Individuals from 2009 to 2015. Exp Clin Endocrinol Diabetes. 2017 Sep 11. doi: 10.1055/s-0043-117417.

[3] Liu X, Yu S, Mao Z, et al. Dyslipidemia prevalence, awareness, treatment, control, and risk factors in Chinese rural population: the Henan rural cohort study. Lipids Health Dis, 2018 May 22;17(1):119. doi: 10.1186/s12944-018-0768-7.

[4] Zhao WH, Zhang J, You Y, et al. Study on the prevalence of dyslipidemia in Chinese population aged 18 years and above. Chinese Journal of Preventive Medicine, 2005,39(5):306-310.

[5] Pan L, Yang Z, Wu Y, et al. The prevalence, awareness, treatment and control of dyslipidemia among adults in China. Atherosclerosis, 2016,248:2-9.

[6] Dai Jing, Min Jieqing,Yang Yunjuan. Astudy on the epidemic characteristics of dyslipidemia in adults of nine provinces of China. Chinese Journal of Cardiology, 2018,46(2):114-118.

[7] Bureau of Disease Prevention and Control of National Health and Family Planning Commission. Report on the Nutrition and Chronic Disease Status of Chinese Residents (2015). Beijing: People’s Medical Publishing House. 2015.

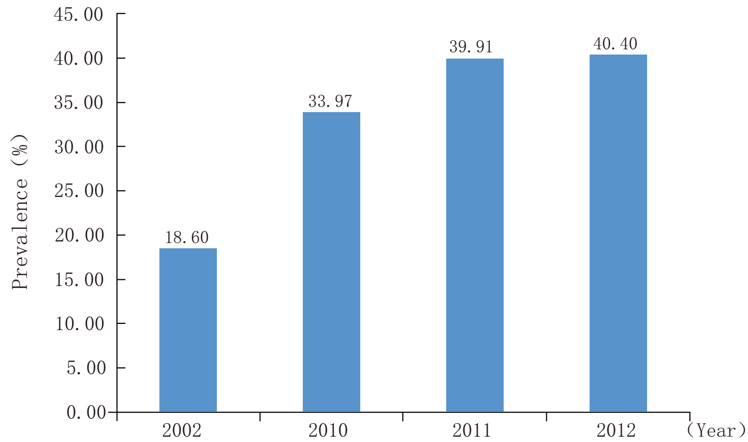

Figure 2-3-2 Prevalence of dyslipidemia in Chinese adults, 2002-2012

Note: In 2002, dyslipidemia was defined as the presence of at least one of the following conditions: TC ≥5.72 mmol/L was considered as hypercholesterolemia; HDL-C ≤0.91 mmol/L was considered as low high-density lipoprotein cholesterol; TG ≥1.70 mmol/L as hypertriglyceridemia. In 2010, 2011, and 2012, the definitionof dyslipidemia was: TC≥6.22 mmol/L, hypercholesterolemia; HDL-C ≤1.04 mmol/L, low high-density lipoprotein cholesterol; TG ≥2.26 mmol/L, hypertriglyceridemia, or LDL-C ≥4.14 mmol/L, high low-density lipoprotein cholesterol

The prevalence of dyslipidemia was higher in males than in females, and higher in urban areas than in rural areas. However, with the improvement of living conditions and the changes of lifestyle, the prevalence of dyslipidemia in rural areas has increased rapidly in recent years, and the difference between urban and rural areas has reduced. According to 2012 National survey,[1] the prevalence of dyslipidemia in rural areas exceeded that in urban areas (40.8% vs 39.9%). The prevalence of dyslipidemia during 2002-2012 in Chinese adults is shown by area (urban/rural) and gender in Figure 2-3-3 and Figure 2-3-4.

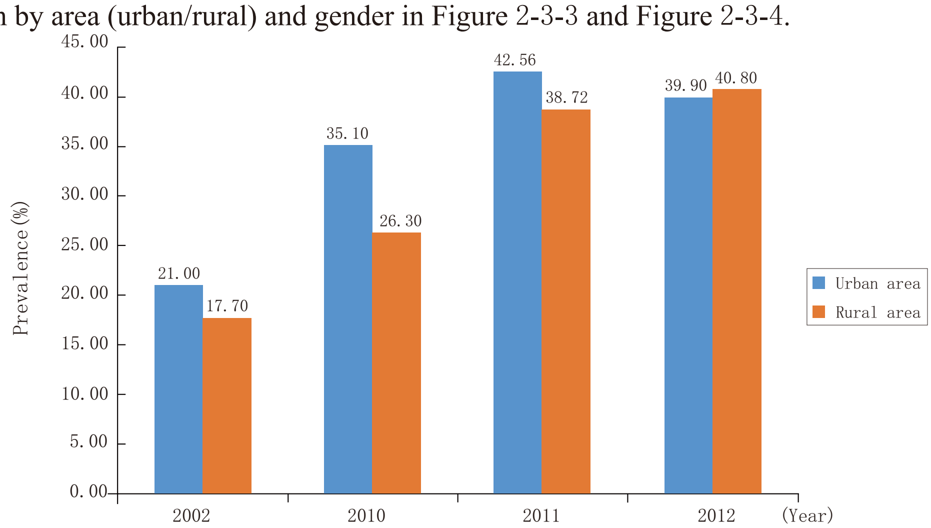

Figure 2-3-3 Prevalence of dyslipidemia in urban and rural Chinese residents aged ≥ 18 years, 2002-2012

[1] Bureau of Disease Prevention and Control of National Health and Family Planning Commission. Report on the Nutrition and Chronic Disease Status of Chinese Residents (2015). Beijing: People's Medical Publishing House. 2015.

Figure 2-3-4 Prevalence of dyslipidemia in male and female Chinese residents aged ≥ 18 years, 2002-2012

The prevalence of dyslipidemia increased with age and decreased slightly after 60 years of age. Figure 2-3-5 shows the prevalence of dyslipidemia in Chinese adults at different ages in 2002 CHNS,[1] 2011 CHNS,[2] and 2012 National survey.[3] In general, the prevalence of dyslipidemia was higher in males than in females. It increased rapidly in females after the age of 50 years and became higher in females than in males after the age of 60 [4] (Table 2-3-4).

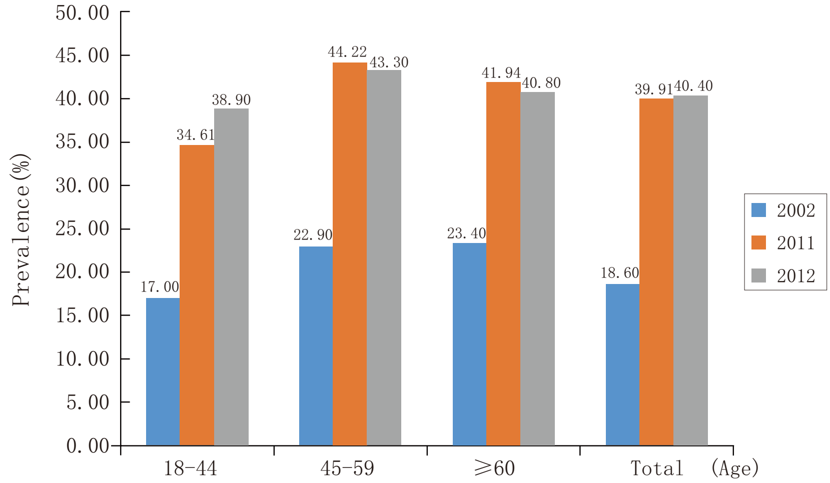

Figure 2-3-5 Prevalence of dyslipidemia in Chinese residents by age, 2002-2012

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[1] Zhao WH, Zhang J, You Y, et al. Study on the prevalence of dyslipidemia in Chinese population aged 18 years and above. Chinese Journal of Preventive Medicine, 2005,39(5):306-310.

[2] Dai J, Min JQ, Yang YJ, et al. A study on the epidemic characteristics of dyslipidemia in adults of nine provinces of China. Chinese Journal of Cardiology, 2018,46(2):114-118.

[3] Bureau of Disease Prevention and Control of National Health and Family Planning Commission. Report on the Nutrition and Chronic Disease Status of Chinese Residents (2015). Beijing: People's Medical Publishing House. 2015.

[4] Pan L, Yang Z, Wu Y, et al. The prevalence, awareness, treatment and control of dyslipidemia among adults in China. Atherosclerosis, 2016, 248:2-9.

Table 2-3-4 Prevalence of dyslipidemia in Chinese residents by age and gender in 2010 China Chronic Kidney Disease Survey (%)

Gender	18-29	30-39	40-49	50-59	60-69	≥70	Total
Male	27.66	38.11	43.61	46.81	45.25	42.88	41.92
Female	13.70	16.58	23.46	39.94	50.00	46.57	32.47

The prevalence of dyslipidemia in Chinese residents by age and gender in 2013-2014 CCDRFS is shown in Table 2-3-5. The prevalence of low HDL-C and high TG was higher in males than in females, while that of high TC and high LDL-C was lower in males than in females.

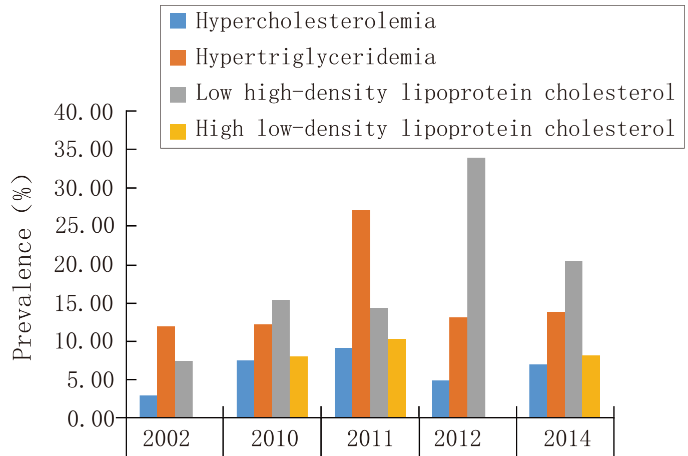
Table 2-3-5 Prevalence of dyslipidemia in Chinese residents by age and gender in 2013-2014

Characteristics	TC≥6.22 mmol/L	LDL-C≥4.14 mmol/L	HDL-C<1.04 mmol/L	TG≥2.26 mmol/L
	%（95%CI）	%（95%CI）	%（95%CI）	%（95%CI）
Overall	6.9 (6.5-7.4)	8.1 (7.5-8.6)	20.4 (19.5-21.3)	13.8 (13.2-14.3)
Gender				
Male	6.7 (6.2-7.2)	8.0 (7.3-8.6)	26.0 (25.0-27.1)	16.9 (16.2-17.6)
Female	7.1 (6.6-7.7)	8.2 (7.5-8.8)	14.6 (13.7-15.5)	10.7 (10.0-11.3)
Age				
18-29	3.8 (3.0-4.6)	4.7 (3.8.5.5)	19.6 (18.2-21.0)	9.6 (8.6-10.5)
30-39	5.5 (4.9-6.0)	6.2 (5.4-7.0)	22.2 (21.0-23.4)	14.6 (13.7-15.5)
40-49	7.0 (6.4-7.6)	7.9 (7.3-8.6)	21.8 (20.7-22.8)	16.5 (15.7-17.3)
50-59	10.3 (9.6-11.0)	12.0 (11.1-12.9)	20.4 (19.3-21.4)	17.2 (16.4-18.1)
60-69	10.7 (9.8-11.5)	12.3 (11.4-13.3)	18.3 (17.3-19.4)	13.9 (13.1-14.7)
≥70	9.5 (8.4-10.5)	11.7 (10.5-13.0)	16.5 (15.0-18.1)	10.5 (9.6-11.3)

Figure 2-3-6 shows the prevalence of hypercholesterolemia (TC≥6.22mmol/L), hypertriglyceridemia (TG≥2.26mmol/L), low high-density lipoprotein cholesterol (HDL-C<1.04 mmol/L), and high low-density lipoprotein cholesterol (LDL-C≥4.14 mmol/L) in 2010 China Chronic Kidney Disease Survey,[1] 2011

[1] Pan L, Yang Z, Wu Y, et al. The prevalence, awareness, treatment and control of dyslipidemia among adults in China. Atherosclerosis, 2016, 248:2-9.

CHNS,[1] 2012 National survey [2] and 2013-2014 CCDRFS.[3] Low HDL-C and hypertriglyceridemia are the major types of dyslipidemia in the Chinese population.



	2002	2010	2011	2012	2014
Hypercholesterolemia	2.90	7.50	9.01	4.90	6.90
Hypertriglyceridemia	11.90	12.17	27.02	13.10	13.80
Low high-density lipoprotein cholesterol	7.40	15.31	14.36	33.90	20.40
High low-density lipoprotein cholesterol		7.96	10.23		8.10

Figure 2-3-6 Prevalence of various dyslipidemia in Chinese adults, 2002-2014

Note: In 2002, dyslipidemia was defined as the presence of at least one of the following conditions: TC ≥5.72 mmol/L was considered as hypercholesterolemia; HDL-C ≤0.91 mmol/L, low high-density lipoprotein cholesterol; TG ≥1.70 mmol/L, hypertriglyceridemia. In 2010, 2011, and 2012, the definition of dyslipidemia was: TC≥6.22 mmol/L, hypercholesterolemia; HDL-C ≤1.04 mmol/L, low high-density lipoprotein cholesterol; TG ≥2.26 mmol/L, hypertriglyceridemia, or LDL-C ≥4.14 mmol/L, high low-density lipoprotein cholesterol

A cohort study recruited 39 207 rural residents aged 18-79 years during 2015-2017. [4] It demonstrated that low HDL-C and hypertriglyceridemia were also the major types of dyslipidemia in Chinese rural residents. The prevalence of dyslipidemia was 32.21%, and it was significantly higher in males than in females (42.85% vs 26.16%). The prevalence was 5.11%, 16.00%, 19.27%, and 4.76% for high TC (≥6.22mmol/L), high TG (≥2.26 mmol/L), low HDL-C (<1.04 mmol/L), and high LDL-C (≥4.14 mmol/L), respectively.

[1] Dai J, Min JQ, Yang YJ, et al. A study on the epidemic characteristics of dyslipidemia in adults of nine provinces of China. Chinese Journal of Cardiology, 2018,46(2):114-118.

[2] Bureau of Disease Prevention and Control of National Health and Family Planning Commission. Report on the Nutrition and Chronic Disease Status of Chinese Residents (2015). Beijing: People's Medical Publishing House, 2015.

[3] Zhang M, Deng Q, Wang L, et al. Prevalence of dyslipidemia and achievement of low-density lipoprotein cholesterol targets in Chinese adults: A nationally representative survey of 163,641 adults. Int J Cardiol, 2018,260:196-203.

[4] Liu X, Yu S, Mao Z, et al. Dyslipidemia prevalence, awareness, treatment, control, and risk factors in Chinese rural population: the Henan rural cohort study. Lipids Health Dis, 2018 May 22;17(1):119. doi: 10.1186/s12944-018-0768-7.

Table 2-3-6 Prevalence of dyslipidemia in some regions of China from recent studies

Studyv	Population	N	Prevalence of dyslipidemia (%)		
			Category (mmol/L)	Male	Female
CNDMDS 2007-2008[1]	14 provinces and municipalities, urban/rural, aged ≥20 y	46 239	TC≥6.22	8.7	9.3
			LDL-C≥4.14	3.5	3.5
			LDL-C≥4.92	3.1	3.0
			HDL-C≤1.04	27.1	17.5
CNSCKD 2009-2010[2]	13 provinces, municipalities, and autonomous regions, aged ≥18 y	43 368	TC≥6.22	8.2	10.5
			LDL-C≥4.14	9.3	10.7
			HDL-C≤1.04	20.0	10.1
Liaoning[3] 2013.1-2013.8	rural areas of Liaoning Province, aged ≥35 y	11 956	TC≥6.22	14.3	18.2
			LDL-C≥4.14	6.2	8.8
			HDL-C≤1.04	17.3	10.8

2.3.3 Prevalence of Dyslipidemia among Children and Adolescents

The prevalence of dyslipidemia in children and adolescents has been on an upward trend (Table 2-3-7). Obesity and family history of dyslipidemia are risk factors for dyslipidemia in children and adolescents [4] (Figure 2-3-7).

Table 2-3-7 Prevalence of dyslipidemia (%) in children and adolescents by region and survey time

Region	Published year	Age (y)	N	High TC	High TG	High LDL-C
CHNS[5]*	2002	3-18	-	0.8	2.8	-

[1] Yang WY, Xiao JZ, Yang ZJ, et al. Serum lipids and lipoproteins in Chinese men and women. Circulation, 2012,125:2212-2221.
[2] Pan L, Yang Z, Wu Y, et al.The prevalence, awareness, treatment and control of dyslipidemia among adults in China. Atherosclerosis, 2016,248:2-9.
[3] Sun GZ, Li Z, Guo L, et al. High prevalence of dyslipidemia and associated risk factors among rural Chinese adults. Lipids Health Dis, 2014 Dec 12;13:189. doi: 10.1186/1476-511X-13-189.
[4] Yan H, Mi J, Liu Y, et al. Screening for dyslipidemia based on family history combined with obesity in children. J of Peking University (Health Science), 2007, 39(6):591-594.
[5] Zhao WH. Report on the Nutrition and Health Status of Chinese Residents. VII. 2002, Blood Lipid. Beijing: People's Medical Publishing House.

Table 2-3-7 Prevalence of dyslipidemia (%) in children and adolescents by region and survey time (Continued)

Region	Published year	Age (y)	N	High TC*	High TG**	High LDL-C
Beijing 2004[1]**	2004	6-18	19 501	1.2	8.8	-
7 Provinces[2]***	2012	6-17	16 434	5.4	15.7	3.0
Beijing 2014[3]****	2014	6-18	3 249	10.7	16.1	5.8
Meta-analysis[4]	2001-2011	7-18	52 835	6.2	11.0	-

Note: The definition of dyslipidemia in each survey was listed as following.
*CHNS: TC≥5.72 mmol/L, TG≥1.70 mmol/L;
**Beijing 2004: TC≥5.20 mmol/L, TG≥1.70 mmol/L;
***7 Provinces: TC>5.18 mmol/L, TG>1.70 mmol/L, LDL-C≥3.37 mmol/L;
****Beijing 2014: TC≥5.18 mmol/L, LDL-C≥3.37 mmol/L, TG≥1.13 mmol/L (aged 6-9 years) or TG≥1.47 mmol/L (aged 10-19 years)

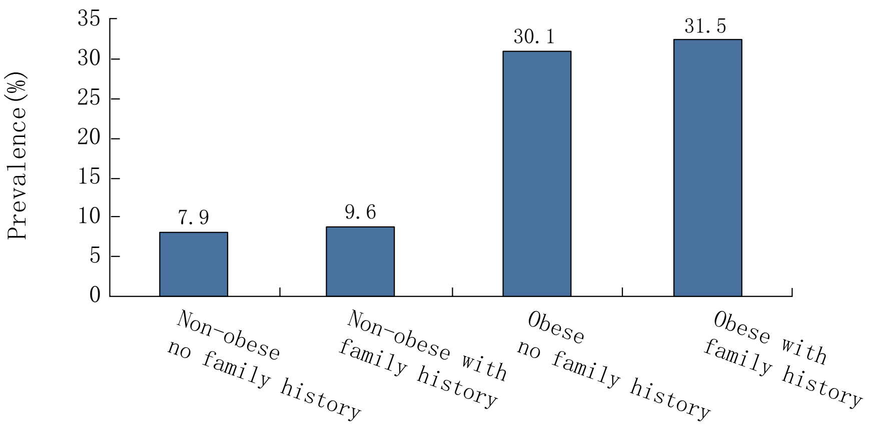


Figure 2-3-7 Prevalence of dyslipidemia in children by obesity and family history

2.3.4 Correlation between Dyslipidemia and Cardiovascular Diseases

Dyslipidemia is one of the most important risk factors for CVD in Chinese population. Several prospective cohort studies in China have shown that elevated serum TC and LDL-C or low HDL-C can

[1] Liu Y, Mi J, Du JB, et al. A survey on dyslipidemia of 6-18-year old children in Beijing area. Chinese Journal of Practical Pediatrics, 2007,22(2):101-102.
[2] Wang ZH, Zou ZY, Yang YD, et al. The epidemiological characteristics and related factors of dyslipidemia among children and adolescents aged 6-17 years from 7 provinces in China, 2012. Chin J Preventive Medicine, 2018,52(8):798-801.
[3] Ding W, Cheng H, Yan Y, et al. 10-year trends in serum lipid levels and dyslipidemia among children and adolescents from several schools in Beijing, China. J Epidemiol, 2016,26(12):637-645.
[4] Ding WQ, Dong HB, Mi J, et al. Prevalence of dyslipidemia in Chinese children and adolescents: a Meta-analysis. Chinese J of Epidemiology, 2015,36(1):71-77.

increase the risk of CVD. Additionally, other studies have proven that the increased non-HDL-C and TG may also be predictors for CVD (Table 2-3-8).

A study [1] based on 2009 CHNS, included almost 30 000 individuals in 15 provinces and municipalities, predicted that lipid lowering therapy could avert 9.7 million AMI, 7.8 million strokes and 3.4 million cardiovascular deaths during 2016-2030.

Table 2-3-8 Correlation between blood lipid levels and the risk of CVD in Chinese cohort studies (RR, 95%CI)

Study	N	Follow-up (y)	Endpoints	Blood lipid levels (mmol/L)			
Cohort study on CVD in multiple cities [2]	29 564	1992-2002		TC<5.18	5.18-5.67	5.70-6.19	≥6.22
			Ischemic CVD	1	1.3 (1.0-1.6)	1.3 (1.0-1.8)	1.6 (1.2-2.1)
				LDL-C <3.37	3.37-4.12	4.14-4.90	≥ 4.92
			Ischemic CVD	1	1.3 (1.0-1.6)	1.4 (1.0-2.0)	2.0 (1.4-2.9)
Prospective Collaborative cohort study (the China Cardiovascular Health Study and the China Multicenter Collaborative Study of Cardiovascular Epidemiology) [3]	27 020			LDL-C <2.59	2.59-3.37	3.37-4.14	≥ 4.14
		2001-2008	CVD	1	1.04 (0.85-1.27)	1.33 (1.07-1.66)	2.03 (1.58-2.01)
		1998-2008	CHD	1	1.13 (0.79-1.61)	1.65 (1.13-2.41)	3.12 (2.07-4.69)
			Stroke	1	1.05 (0.82-1.36)	1.29 (0.91-1.71)	1.67 (1.19-2.35)
Prospective cohort study on cardiovascular diseases in multiple cities [4]	30 378	1992-2002		HDL-C ≥1.0	< 1.0	—	—
			Acute coronary event	1	1.39 (1.00-1.92)	—	—
			Ischemic stroke	1	1.45 (1.15-1.83)	—	—
Prospective cohort study on cardiovascular diseases in multiple cities [5]	30 378	1992-2004		TG<0.81	0.81-1.14	1.15-1.59	≥1.60
			Acute coronary event	1	1.18 (0.74-1.87)	1.81 (1.18-2.78)	1.58 (1.03-2.45)

[1] Stevens W, Peneva D, Li JZ, et al. Estimating the future burden of cardiovascular disease and the value of lipid and blood pressure control therapies in China. BMC Health Services Research, 2016,16:175. doi:10.1186/s12913-016-1420-8.

[2] Wu YF, Zhao D, Zhou BF, et al. Cut offs and risk stratification of dyslipidemia in Chinese adults. Chin J Cardiol, 2007,35(05):428-433.

[3] Gu X, Yang X, Li Y, et al. Usefulness of Low-Density Lipoprotein Cholesterol and Non-High-Density Lipoprotein Cholesterol as Predictors of Cardiovascular Disease in Chinese. Am J Cardiol, 2015,116(7):1063-1070.

[4] Wang W, Zhao D, Sun GY, et al. Risk factors comparison in Chinese patients developing acute coronary syndrome, ischemic or hemorrhagic stroke: A multi-provincial study. Chinese J of Cardiology, 2006,34(12): 1133-1137.

[5] Wang M, Zhao D, Wang W, et al. Serum triglyceride is an independent risk factor for acute coronary heart disease events in 35-64 years old Chinese-Chinese provincial cohort study. Chinese Journal of Cardiology, 2008,36(10):940-943.

Table 2-3-8 Correlation between blood lipid levels and the risk of CVD in Chinese cohort studies (RR, 95%CI) (Continued)

Study	N	Follow-up (y)	Endpoints	Blood lipid levels (mmol/L)			
Sino-USA Collaborative study on epidemiology of cardiovascular diseases [1]	10 222	1983-2000		Non-HDL-C <3.88	3.88-4.38	4.39-4.90	≥4.91
			Ischemic CVD	1	1.44 (1.07-1.94)	1.81 (1.26-2.60)	1.53 (1.06-2.22)
Prospective cohort study on cardiovascular diseases in multiple cities [2]	29 937	1992-2004		Non-HDL-C <3.37	3.37-4.13	4.14-4.91	≥4.92
			Acute coronary event	1	1.24 (0.91-1.70)	1.78 (1.25-2.53)	2.23 (1.48-3.35)
			Ischemic stroke	1	1.34 (1.07-1.68)	1.38 (1.04-1.83)	1.38 (0.97-1.94)

2.3.5 Prevention and Control of Dyslipidemia in China

The awareness and treatment rates of dyslipidemia among community residents remained generally low, but the management and control rates of dyslipidemia have been improved in hospitalized patients.

The awareness rate of dyslipidemia refers to the proportion of people who measured their blood lipids and knew they had dyslipidemia among the total patients with dyslipidemia. The treatment rate is defined as the application of lipid-lowering interventions (including drugs and lifestyles) among the patients with dyslipidemia. The control rate is the proportion of patients with dyslipidemia who have previously taken measures to control blood lipids and keep blood lipids at normal levels.

2.3.5.1 Awareness, Treatment, and Control Rates of Dyslipidemia.

(1)"Three Rates"of Hypercholesterolemia

InterASIA [3] and CNDMDS [4] provided nationwide data on awareness, treatment, and control rates of hypercholesterolemia in China. The "three rates" from the studies among males and females in urban and rural areas are shown in Table 2-3-9.

[1] Li Y, Chen ZH, Zhou BF, et al. The predictive effects of lipids and lipoproteins on the incidence of ischemic cardiovascular disease in middle-aged Chinese population. Chinese J Cardiology, 2004,32(7):643-647.

[2] Ren J, Zhao D, Liu J, et al. Correlation between non-HDL-C level and risk of cardiovascular disease. Chinese J Cardiology, 2010,38(10):934-938.

[3] He J, Gu D, Reynolds K, et al. Serum total and lipoprotein cholesterol levels and awareness, treatment, and control of hypercholesterolemia in China. Circulation, 2004,110(4):405-411.

[4] Yang WY, Xiao JZ, Yang ZJ, et al. Serum lipids and lipoproteins in Chinese men and women. Circulation, 2012,125:2212-2221.

Table 2-3-9 Awareness, treatment and control rates of hypercholesteremia in China

Survey time	Study	Population		Male	Female
				TC≥6.22	TC≥6.22
2000-2001	InterAsia	aged 35-74 y; 15 540 participants	Awareness	21.3	18.1
			Treatment	14.0	11.6
			Control	11.3	9.5
2007-2008	CNDMDS	aged ≥20 y; 46 239 participants	Awareness	27.6	20.7
			Treatment	21.4	14.0
			Control	18.3	11.2
			Control among treatment	88.1	78.4

(2)"Three Rates"of Dyslipidemia

Data from 2002 CHNS [1] showed that the awareness rate of dyslipidemia in the population aged ≥18 years was only 3.2% (3.4% in males and 2.7% in females, 7.0% in urban and 1.5% in rural areas). The detection rate of blood lipids was 6.4% (6.9% in males and 6.0% in females, 16.5% for urban and 2.2% for rural areas).

2010 China National Survey of Chronic Kidney Disease (CNSCKD) ,[2] a cross-sectional study of 43 368 urban and rural residents in 13 provinces and municipalities, showed that the awareness, treatment, and control rates of dyslipidemia in adults (≥18 years) were 31.0%, 19.5%, and 8.9%, respectively. They were lower in males than in females (Figure 2-3-8).

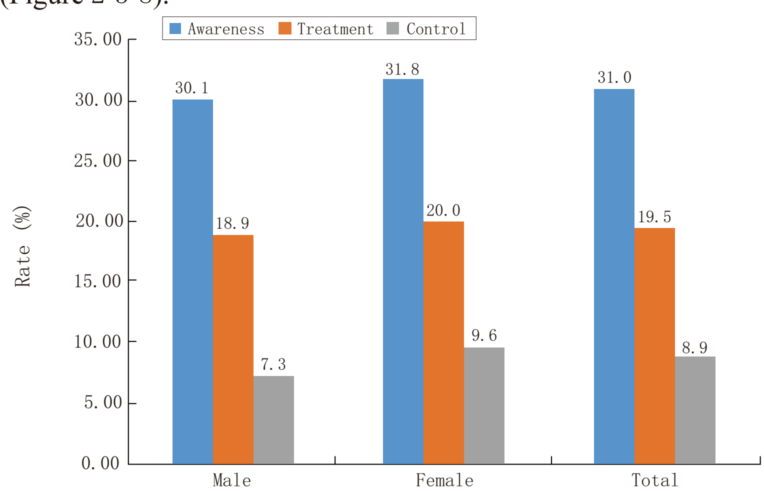


Figure 2-3-8 Awareness, treatment and control rates of dyslipidemia by gender in 2010 China National Survey of Chronic Kidney Disease

[1] Zhao WH. Report on the Nutrition and Health Status of Chinese Residents. VII. 2002, Blood Lipid. Beijing: People's Medical Publishing House.

[2] Pan L, Yang Z, Wu Y, et al. China National Survey of Chronic Kidney Disease Working Group. The prevalence, awareness, treatment and control of dyslipidemia among adults in China. Atherosclerosis, 2016,248:2-9.

China Chronic Disease Surveillance survey recruited 97 409 adults aged >18 years in 2010 from 162 monitoring sites around 31 provinces, municipalities, and autonomous regions in mainland China, applying multi-stage stratified cluster random sampling method.[1] The results showed that the awareness, treatment, and control rates of dyslipidemia in Chinese adults were comparatively low among Chinese adults, especially among population who were male, at age of <45 years or who were from rural areas or Western China (Table 2-3-10).

Table 2-3-10 Awareness, treatment and control rates of dyslipidemia among Chinese adults in 2010 (%)

Characteristics	Awareness (%)	Treatment (%)	Control (%)
Total	10.93	6.84	3.53
Gender			
Male	10.32	6.37	2.57
Female	11.71	7.43	4.75
Place of residence			
Urban	16.59	10.17	5.23
Rural	8.17	5.21	2.70
East	12.22	7.33	4.21
Central	11.75	7.52	3.89
West	8.26	5.41	2.71
Age			
18-44	6.00	3.55	1.64
45-59	16.75	10.73	5.49
≥60	18.74	12.05	6.94

China Noncommunicable Disease Surveillance [2] conducted a survey in 98 658 subjects aged ≥18 years from 162 study sites across 31 provinces, autonomous regions and municipalities in mainland China in 2010. The awareness, treatment, and control of dyslipidemia in Chinese adults by blood glucose status are shown in Table 2-3-11.

[1] Li JH, Wang LM, Mi SQ, et al. A survey on the awareness, treatment and control rate of dyslipidemia in adults in China. Chinese Journal of Preventive Medicine, 2012,46(8):687-691.

[2] Wang TG, Xu Y, Xu M, et al. Awareness, treatment and control of cardiometabolic disorders in Chinese adults with diabetes: a national representative population study. Cardiovasc Diabetol, 2015,14:28. doi: 10.1186/s12933-015-0191-6.

Table 2-3-11 Awareness, treatment, and control of dyslipidemia* in Chinese adults by blood glucose status (%)**

	Blood glucose status			
	Normal glucose regulation	Prediabetes	Newly-diagnosed diabetes	Previously-diagnosed diabetes
Prevalence	47.2 (46.5-47.9)	51.5 (50.9- 52.1)	63.2 (61.8-64.5)	70.0 (68.2- 71.7)[a]
Awareness	5.4 (5.0-5.8)	8.3 (7.9-8.7)	12.8 (11.7-13.9)	33.9 (31.8- 36.1)[a]
Treatment	2.3 (2.0-2.5)	3.7 (3.5-4.0)	5.4 (4.6-6.2)	18.9 (17.2- 20.7)[a]
Control	20.1 (15.8-25.2)	15.6 (13.1-18.5)	9.5 (6.4-13.8)	15.9 (12.3- 20.3)

Notes:
* Dyslipidemia was defined as taking lipid-lowering medications or increased lipid levels as TC ≥6.22 mmol/L, TG ≥1.70 mmol/L, HDL-C <1.04 mmol/L, or high LDL-C defined according to group-specific threshold;
**Data are weighted percentages (95%CI);
[a]$P < 0.0001$, compared with newly-diagnosed diabetes

A total of 39 207 rural residents aged 18-79 years were recruited for the epidemiological research from the Henan Rural Cohort Study during 2015-2017. The awareness, treatment, and control of dyslipidemia (defined as TC ≥6.22 mmol/L, TG ≥1.70 mmol/L, HDL-C <1.04mmol/L, or LDL-C ≥4.14 mmol) were 15.07%, 7.23%, and 3.25%, respectively. The "three rates" increased steeply with age, and were consistently higher in females than in males, as 19.12% vs 11.32%, 9.58% vs 4.94%, and 4.59% vs 1.87%, respectively. [1]

In conclusion, the awareness, treatment, and control of dyslipidemia in Chinese adults are still at a low level, but they have increased compared to those in 2002. The awareness of prevention and control of dyslipidemia was better in residents with older age and those living in economically developed regions.

2.3.5.2 Achievement of LDL-C Targets in Population with Different Stratification of Cardiovascular Risks

(1) Contemporary Management and Attainment of Cholesterol Targets for Patients with Dyslipidemia in China [2]

A sample of 12 040 patients with dyslipidemia from 19 provinces and 84 hospitals across China were enrolled in 2011. Risk stratification and individual cholesterol target was established for all participants. This survey showed that 39% of all participants received lipid-lowering medications and 94.5% of them had statins. However, the overall attainment for LDL-C target was only 25.8%. It was especially lower in females (22.2%) and in patients with increased BMI. The attainment was lower for patients in higher risk category. It

[1] Liu X, Yu S, Mao Z, et al. Dyslipidemia prevalence, awareness, treatment, control, and risk factors in Chinese rural population: the Henan rural cohort study. Lipids Health Dis. 2018,17(1):119. doi: 10.1186/s12944-018-0768-7.
[2] Gao F, Zhou YJ, Hu DY, et al. Contemporary management and attainment of cholesterol targets for patients with dyslipidemia in China. PLoS One, 2013,8(4): e47681.

was 38.1%, 29.7%, 19.9%, and 21.1% in the low-, moderate-, high-, and very high-risk category, respectively (According to the 2004 US NCEP ATPIII guidelines, the individualized LDL-C targets for low-, moderate-, high-, and very high-risk categories were less than 4.14 mmol/L, 3.37 mmol/L, 2.59 mmol/L, and 1.81 mmol/L, respectively). BMI, gender, CHD, blood pressure, hypertension, family history of premature CHD, and current smoking were identified as independent predictors of LDL-C attainment.

(2) Dyslipidemia International Study in China (DYSIS-China) [1]

DYSIS-China investigated the type of persistent lipid profile abnormalities and the predictors of failure in attaining lipid goals among outpatients. This cross-sectional study included 25 317 patients aged ≥45 years treated with lipid-lowering agents for at least 3 months from 122 centers in 27 provinces between April 2012 and October 2012. It showed that 98.0% of the patients were treated with single agent, and 88.9% of them had statins. Although all the respondents were treated with lipid-lowering agents for more than 3 months, only 29.1% of them had no lipid abnormalities, and 38.5% of patients did not achieve the therapeutic goal for LDL-C. Subjects with high cardiovascular risk were more likely than those with low risk to fail lipid goals (Table 2-3-12). Diabetes was shown to be a strong predictor of failure in attaining LDL-C goal.

Table 2-3-12 Patients with failing lipid goals by cardiovascular risk in DYSIS-China

	All patients	Very high risk	High risk	Moderate risk	Low risk
TC not at goal	12 960 (51.2%)	2 601 (84.1%)	8 640 (57.9%)	1 175 (42.2%)	544 (12.0%)
LDL-C not at goal	9 746 (38.5%)	1 866 (60.3%)	6 742 (45.2%)	741 (26.6%)	397 (8.8%)
TG>1.7mmol/L	10 594 (41.8%)	1 237 (40.0%)	5 925 (39.7%)	1 320 (47.4%)	2 112 (46.7%)
HDL-C<1.0mmol/L (male) or <1.2mmol/L (female)	8 082 (31.9%)	1 263 (40.8%)	4 945 (33.2%)	681 (24.5%)	1 193 (26.4%)
Non-HDL-C not at goal	9 081 (35.9%)	1 607 (52.0%)	6 142 (41.2%)	862 (31.0%)	470 (10.4%)
Both LDL-C and non-HDL-C not at goal	7523 (29.7%)	1480 (47.9%)	5 238 (35.1%)	551 (19.8%)	254 (5.6%)

Note: According to the Guideline for the Prevention and Treatment of Dyslipidemia in Chinese Adults (2007), for the individuals with very high-, high-, moderate-, and low-cardiovascular risk, the goal of LDL-C was less than 2.0 mmol/L, 2.6 mmol/L, 3.4 mmol/L, and 4.1 mmol/L, respectively, that of TC was less than 6.2 mmol/L, 5.2 mmol/L, 4.1 mmol/L, and 3.1 mmol/L, respectively, and that of non-HDL-C was less than 0.78 mmol/L plus the goal of LDL-C for each risk category

[1] Zhao S, Wang Y, Mu Y, et al. Prevalence of dyslipidemia in patients treated with lipid-lowering agents in China: results of the DYSlipidemia International Study (DYSIS). Atherosclerosis, 2014,235(2):463-469.

(3) China Chronic Disease and Risk Factor Surveillance (CCDRFS) [1]

CCDRFS recruited 163 641 adults aged ≥18 years during 2013-2014 and found that approximately 11.2% of Chinese were at high- or very-high ASCVD risk (1.8% at very-high risk and 9.4% at high risk). For very-high-risk individuals, 93.2% did not achieve their LDL-C-lowering goals (<1.8mmol/L) and 14.5% of them were treated. Among individuals with high ASCVD risk, 74.5% had uncontrolled LDL-C levels (<2.6mmol/L) and 5.5% of them were treated. The treatment rate was higher in urban residents than in their rural counterparts. Since the study population was from the general community, which included patients who were or were not treated with lipid-lowering agents, this could be the main reason for the lower achievement of LDL-C target compared to the 2 studies mentioned above.

2.4 Diabetes

2.4.1 Prevalence and Ethnic Pattern of Diabetes and Prediabetes

A large-sample epidemiological study was conducted to provide more recent estimates of the prevalence of diabetes and prediabetes in China and to investigate their ethnic pattern, using a nationally representative survey conducted in 2013 [2] .

The study enrolled 170 287 participants aged ≥18 years from 1 176 rural townships or urban subdistricts in 31 provinces, autonomous regions and municipalities. Analyses by ethnic groups were restricted to those with at least 1 000 participants, resulting in inclusion of Tibetan (Zang), Zhuang, Manchu (Man), Uygur (Wei), and Muslim (Hui) ethnic groups. HbA1c was directly measured from venous blood samples. Diabetes was defined as: ① a self-reported diagnosis that was determined previously by a health care professional; ② fasting plasma glucose (FPG) level ≥126 mg/dl; ③ 2-hour plasma glucose (PG) level ≥200 mg/dl; ④ HbA1c level ≥6.5%. Prediabetes was defined as any participants who did not have diabetes but who had a HbA1c level of 5.7% - 6.4%, FPG level of 100 - 125 mg/dL (5.6-6.9 mmol/L), or 2-hour PG level of 140 - 199 mg/dL (7.8-11.0 mmol/L). Awareness was defined as the proportion of individuals with physician-diagnosed diabetes among all patients with diabetes. Treatment was defined as the proportion of individuals receiving diabetes medications among all patients with diabetes. Control among treatment was defined as the proportion of individuals with an HbA1c concentration of less than 7.0% among patients with diabetes who were taking medication.

The mean age at baseline was 43.5±16.2 years, BMI was 24.0 kg/m^2, and 57% were females. The mean FPG level was 100.5 mg/dL (5.9 mmol/L), and the 2-hour PG level was 114.2 mg/dL (6.3 mmol/L). The overall standardized prevalence of diabetes in Chinese adults was estimated as 10.9% (95%CI: 10.4%-11.5%), with 10.2% (95%CI: 9.7%-10.7%) in females and 11.7% (95%CI: 10.9%-12.4%) in males (Table

[1] Zhang M, Deng Q, Wang L, et al. Prevalence of dyslipidemia and achievement of low-density lipoprotein cholesterol targets in Chinese adults: A nationally representative survey of 163,641 adults. Int J Cardiol, 2018,260:196-203.

[2] Wang L, Gao P, Zhang M, et al. Prevalence and Ethnic Pattern of Diabetes and Prediabetes in China in 2013. JAMA, 2017;317(24):2515-2523.

2-4-1). 4% (95%CI: 3.6%-4.3%) of Chinese adults had previously received a diagnosis of diabetes; 6.9% (95%CI: 6.7%-7.2%) of the population had received a new diagnosis. Hemoglobin A1c concentration added an additional 0.5% to the total diabetes group. The prevalence of diabetes was higher in the older population (P<0.001), urban residents (P<0.001), participants living in economically developed areas (P=0.003), and overweight and obese participants (P<0.001).

The estimated prevalence of prediabetes was 35.7% (95%CI: 34.1%-37.4%) in the overall population, 35.0% (95%CI: 33.4%-36.7%) in females and 36.4% (95%CI: 34.6%-38.2%) in males. The prevalence of prediabetes was higher in the older population (P<0.001; for males, P=0.008), overweight and obese participants (P<0.001), and rural residents (P=0.02) (Table 2-4-1).

The overall proportion of patients who were aware of their diabetes condition was 36.5% (95%CI: 34.3%-38.6%), and it was 39.8% (95%CI: 37.5%-42.2%) for females and 33.5% (95%CI: 31.2%-35.9%) for males. Of all patients with diabetes, 32.2% (95%CI: 30.1%-34.2%) were receiving antidiabetic medication. Among patients treated, 49.2% (95%CI: 46.9%-51.5%) had their HbA1c levels controlled. The proportion of patients who were aware of their diabetes and treated for it was higher in the older population, females, and urban residents. The proportion of patients who controlled their HbA1c levels well was higher in younger individuals and in urban residents.

Compared with Han participants, whose crude diabetes prevalence was 14.7% (95%CI: 14.6%-14.9%), the crude prevalence of total diabetes was lower among Tibetan (4.3% [95%CI: 3.5%-5.0%]) and Muslim adults (10.6% [95%CI: 9.3%-11.9%]) (Table 2-4-2). For prediabetes, Tibetan and Muslim adults had a similar crude prevalence that was significantly lower than that of Han participants (31.3% [95%CI: 29.7%-32.9%] for Tibetan, 31.9% [95%CI: 29.9%-33.9%] for Muslim, and 38.8% [95%CI: 38.5%-39.0%] for Han; Tibetan and Muslim P<0.001 compared with Han). Manchu participants had a significantly higher prevalence of prediabetes than did Chinese Han (43.4% [95%CI: 41.3%-45.5%]; P<0.001).

In the fully adjusted multivariable logistic models, the adjusted ORs compared with Han participants were 0.42 (95%CI: 0.35-0.50) for diabetes and 0.77 (95%CI: 0.71-0.84) for prediabetes for Tibetan Chinese, and 0.73 (95%CI: 0.63-0.85) for diabetes and 0.78 (95%CI: 0.71-0.86) for prediabetes for Muslim Chinese.

With approximately 1.09 billion adults in mainland China in 2013, it is projected that 388 million Chinese adults may have had prediabetes, considerably reduced from the projected number of 493 million individuals in 2010. Overall, 47% of the Chinese adult population was estimated to have either diabetes or prediabetes, slightly lower than the 49% - 52% estimate in the US population.

The 2010 and 2013 surveys were conducted under the same study protocol and followed identical, strict strategies for quality control. The most likely reason for the discrepancy in prediabetes prevalence was a difference in HbA1c measurement between the 2 surveys. Hemoglobin A1c level was calculated in 2010 by converting capillary HbA1c with a formula derived from an internal validation study, whereas HbA1c was directly measured from venous blood samples in the 2013 survey.

The 2010 and 2013 surveys both used the FPG>5.6 mmol/L as a diagnostic cutoff for prediabetes, which is in accordance with the American Diabetes Association criteria. WHO and Chinese Diabetes Society proposed the diagnostic criteria for prediabetes as a FPG>6.1 mmol/L. This survey did not indicate that how many prediabetic patients had their FPG between 5.6 and 6.1 mmol/L. More convincing studies are needed to demonstrate whether these patients would have a higher risk of diabetes or more risk factors and events of CVD, in order to further determine the necessity, efficacy and cost-effectiveness of interventions for these patients with prediabetes or impaired fasting glucose.

Table 2-4-1 Weighted prevalencea of diabetes and prediabetes among Chinese adults in 2013

	N	% （95%CI）				
		Total diabetes	Diagnosed diabetes	Undiagnosed diabetes based on FPG, 2-Hour PG, and HbA1c	Diabetes based on information with diagnosed diabetes, FPG, and PG	Prediabetes
Overall	170 287	10.9(10.4-11.5)	4.0(3.6-4.))	6.9（6.7-7.2)	10.4(9.8-10.9)	35.7(34.1-37.4)
Age group, y						
<40	35 466	5.9(5.1-6.6)	1.3(1.0-1.7)	4.5(4.1-4.9)	5.4(4.7-6.0)	28.8(26.8-30.9)
40-59	85 279	12.9(12.3-13.5)	5.0(4.7-5.4)	7.8(7.5-8.1)	12.3(11.7-12.9)	39.5(37.8-41.2)
≥60	49 542	20.2(19.1-21.2)	8.8(8.0-9.5)	11.4(10.8-12.0)	19.4(18.3-20.4)	45.8(44.3-47.2)
Gender						
Female	97 551	10.2(9.7-10.7）	4.1(3.7-4.4)	6.1(5.9-6.4)	9.6(9.1-10.1)	35.0(33.4-36.7)
Male	72 736	11.7(10.9-12.4)	3.9(3.5-4.3)	7.7(7.4-8.1)	11.1(10.4-11.7)	36.4(34.6-38.2)
Location						
Urban	78 317	12.6(11.7-13.6)	5.4(4.8-6.1)	7.1(6.8-7.5)	12.0(11.1-13.0)	34.3(32.3-36.3)
Rural	91 970	9.5(9.0-10.1)	2.8(2.5-3.0)	6.8(6.4-7.1)	8.9(8.4-9.5)	37.0(35.0-38.9)
Economic development						
Under developed	47 683	9.6(8.3-10.8)	3.2(2.6-3.8)	6.3(5.9-6.8)	9.0(7.7-10.3)	34.3(31.1-37.5)
Intermediately developed	48 111	10.2(9.4-10.9)	3.5(3.0-3.9)	6.7(6.3-7.1)	9.7(8.9-10.5)	36.2(33.1-39.3)
Developed	74 493	11.8(11.0-12.7)	4.5(4.0-5.1)	7.3(6.9-7.6)	11.2(10.4-12.0)	36.0(33.7-38.3)
BMI						
<25 (Normal)	103 072	7.8(7.3-8.4)	2.8(2.5-3.1)	5.0(4.8-5.3)	7.4(6.9-7.9)	32.6(30.8-34.4)
25-30 (Overweight)	55 785	15.4(14.6-16.2)	5.8(5.3-6.3)	9.5(9.0-10.0)	14.7(13.9-15.4)	40.7(38.9-42.4)
≥30 (Obese)	11 430	21.1(19.5-22.7)	7.2(6.0-8.3)	13.9(12.8-15.0)	19.6(18.0-21.2)	43.6(41.5-45.6)
BMI (Asian-specific cutoffs)						
<23 (Normal)	65 829	6.4(5.8-7.0)	2.3(1.9-2.6)	4.1(3.7-4.6)	6.0(5.5-6.6)	30.7(28.7-32.7)
23-25 (Overweight)	37 243	10.8(10.1-11.5)	3.9(3.6-4.3)	6.8(6.2-7.4)	10.2(9.5-10.8)	36.5(34.8-38.3)
≥25 (Obese)	67 215	16.4(15.5-17.2)	6.1(5.5-6.6)	10.3(9.7-10.8)	15.5(14.7-16.3)	41.2(39.5-42.8)

Abbreviations: BMI, body mass index; FPG, fasting plasma glucose; HbA1c, hemoglobin A1c; PG, plasma glucose.
Plasma glucose 1mg/dL = 0.0555 mmol/L

Table 2-4-2 Unweighted prevalence of diabetes by ethnic group (%)

Ethnicity	Overall	P value vs Han ethnicity	Age Groups			Gender	
			<40	40-59	≥60	Male	Female
Chinese Han							
No. of cases/ participants	22 220/150 766		1 767/29 785	10 398/75 618	10 055/45 363	9 758/64 012	12 462/86 754
Prevalence, (95%CI)	14.7 (14.6-14.9)		5.9 (5.7-6.2)	13.8 (13.5-14.0)	22.2 (21.8-22.5)	15.2 (15.0-15.5)[a]	14.4 (14.1-14.6)
Tibetan (Zang)							
No. of cases/ participants	132/3 103		22/1 151	95/1 652	15/300	62/1 328	70/1 775
Prevalence, (95%CI)	4.3 (3.5-5.0)	<0.001	1.9 (1.1-2.7)[b]	5.8 (4.6-6.9)[b]	5.0 (2.5-7.5)[b]	4.7 (3.5-5.8)	3.9 (3.0-4.8)
Zhuang							
No. of cases/ participants	250/2 081		24/368	115/1 038	111/675	117/798	133/1 283
Prevalence, (95%CI)	12.0 (10.6-13.4)	<0.001	6.5 (4.0-9.1)	11.1 (9.2-13.0)[b]	16.4 (13.6-19.2)[b]	14.7 (12.2-17.1)[a]	10.4 (8.7-12.0)
Manchu (Man)							
No. of cases/ participants	315/2 106		33/429	179/1 211	103/466	141/893	174/1 213
Prevalence, (95%CI)	15.0 (13.4-16.5)	0.78	7.7 (5.2-10.2)	14.8 (12.8-16.8)	22.1 (18.3-25.9)	15.8 (13.4-18.2)	14.3 (12.4-16.3)
Uygur (Wei)							
No. of cases/ participants	236/1 929		37/743	109/779	90/407	119/1 029	117/900
Prevalence, (95%CI)	12.2 (10.8-13.7)	0.002	5.0 (3.4-6.5)	14.0 (11.6-16.4)	22.1 (18.1-26.2)	11.6 (9.6-13.5)	13.0 (10.8-15.2)
Muslim (Hui)							
No.of cases/ participants	221/2 085		16/620	112/981	93/484	106/990	115/1 095
Prevalence, (95%CI)	10.6 (9.3-11.9)	<0.001	2.6 (1.3-3.8)[b]	11.4 (9.4-13.4)[b]	19.2 (15.7-22.7)	10.7 (8.8-12.6)	10.5 (8.7-12.3)

[a]P<0.001 in Chinese Han; P=0.003 in Zhuang

[b]P<0.001 for Tibetan vs Han in those aged <40, 40-60, ≥60 years; P=0.01 and <0.001 for Zhuang vs Han in those aged 40-60 and ≥60 years, respectively; P<0.001 and 0.03 for Muslim vs Han in those aged <40 and 40-60 years, respectively

2.4.2 Association between Diabetes and Cause-specific Mortality in Rural and Urban Areas of China

CKB survey assessed the correlation between diabetes and the cause-specific mortality in rural and urban areas of China. [1]

[1] Fiona Bragg, Michael V Holmes, Andri lona, et al. Association between diabetes and cause-specific mortality in rural and urban areas of China. JAMA, 2017,317(3):280-289.

This 7-year nationwide prospective study investigated 512 869 adults aged 30-79 years from 10 (5 rural and 5 urban) local sites across China, who were recruited from June 2004 to July 2008 and followed until January 2014. All-cause and cause-specific mortality rates were collected through established death registries. Cox regression was used to estimate the adjusted mortality rate ratio (RR), comparing individuals with versus without diabetes at baseline.

Overall, the mean (SD) age was 51.5±10.7 years, 59% (n=302 618) were female, and 5.9% (n=30 280) had diabetes (rural 4.1%, urban 8.1%, males 5.8%, females 6.1%, previously diagnosed 3.1%, screen-detected 2.8%). During 3.64 million person-years of follow-up, there were 24 909 deaths, including 3 384 among individuals with diabetes. Compared with adults without diabetes, individuals with diabetes had a significantly increased risk of all-cause mortality (1 373 vs 646 deaths per 100 000; adjusted RR=2.00 [95%CI: 1.93-2.08]), which was higher in rural than in urban areas (RR=2.17 [95%CI: 2.07-2.29] vs RR=1.83 [95%CI: 1.73-1.94]). Presence of diabetes was associated with increased mortality from IHD (3 287 deaths; RR=2.40 [95%CI: 2.19-2.63]) and stroke (4 444 deaths; RR=1.98 [95%CI: 1.81-2.17]). Likewise, diabetes was associated with an increased RR for mortality from chronic liver disease, infections, and cancer of the liver, pancreas, female breast, and female reproductive system.

The increase of mortality from CVD was most salient, and it was higher in rural areas than in urban areas. Besides the low treatment and control rates of diabetes, low use of cardio-protective medications (e.g., aspirin, statins, and blood pressure lowering agents) also contributed to excess cardiovascular mortality in patients with diabetes. In the present study, only 1.3%, 4.7%, and 16.8% of the patients with diabetes took statins, aspirin, and blood pressure lowering agents, respectively. Unlike previous foreign reports, about 75% of stroke deaths were due to intracerebral haemorrhage (RR=1.87 [95%CI: 1.67-2.09]). The RR for vascular mortality was greater at younger than older ages (age 35-59 RR=2.62 [95%CI: 2.28-3.02] vs [age 70-79 RR=1.98, 95%CI: 1.83-2.15]) and in females than males (RR=2.36 [95%CI: 2.18-2.56] vs RR=1.93 [95%CI: 1.77-2.10]), but did not differ significantly between rural and urban areas. This study estimated that there was a loss of a median of 9 (rural 10, urban 8) years of life for individuals with diabetes diagnosed below age 50.

2.4.3 China Da Qing Diabetes Prevention Study

The China Da Qing Diabetes Prevention Study is the earliest and longest-running study in the world adopting lifestyle intervention for diabetes prevention. It followed-up participants for 20 years and found that during the 6-year active intervention period, the incidence of diabetes was reduced by 51% in the intervention group. Additionally, lifestyle intervention had a long-term impact on diabetes prevention. During the 20-year follow-up period, the cumulative incidence of diabetes was 80% in the intervention group and 93% in the control group. After adjustment of age and clustering by clinic, the incidence in the intervention group was still lower than that in the control group by 43% (HR=0.57, 95%CI: 0.41-0.81). Participants in the intervention group spent an average of 3.6 fewer years with diabetes than those in the control group.[1] Furthermore, lifestyle intervention was associated with a 47% reduction in the incidence of severe retinopathy (need for laser treatment and blindness) .[2]

Six years of active lifestyle intervention reduced the CVD mortality during the 23-year follow-up.[3] Compared with the control group, the CVD mortality decreased by 41% (11.9% vs 19.6%), all-cause mortality decreased by 29% (28.1% vs 38.4%), and the incidence of diabetes decreased by 45% (72.6% vs 89.9%) in the intervention group. All the differences were statistically significant. Lifestyle intervention not only reduced the long-term incidence of diabetes, but also decreased the risk of life-threatening CVD events and death.

To clarify the extent to which diabetes leads to excess CVD mortality and all-cause mortality, Da Qing IGT and Diabetes Study compared death rates and causes of death among 630 people with newly diagnosed diabetes (NDD) and 519 with normal glucose tolerance (NGT) who, in 1986, were identified as a result of screening 110 660 adults aged 25-74 years for diabetes in Da Qing.[4] During 23 years of follow-up, 338 (56.5%) participants with NDD and 100 (20.3%) with NGT died. CVD was the predominant cause of death in those with diabetes (47.5% in males and 49.7% in females), almost half of which was due to stroke (52.3% in males and 42.3% in females). The age-standardized incidence of all-cause death was three times as high in those with NDD as in those with NGT with incidences (per 1000 person-years) of 36.9 (95%CI: 31.5-42.3) vs 13.3 (10.2-16.5) in men ($P<0.0001$) and 27.1 (22.9-31.4) vs 9.2 (7.8-10.6) in females ($P<0.0001$). The cumulative incidence of deaths from CVD was higher in NDD group than in NGT group, and it increased more steeply in females with NDD than in males with NDD(HR=6.9, 95%CI: 3.3-14.2 vs HR=3.5, 95%CI: 2.3-5.3) (Figure 2-4-1).

In addition, the incidence of CVD deaths in males and females with NDD (17.5 [13.8-21.2] vs13.5 [10.5-16.5] per 1 000 person-years) did not differ significantly. Significantly higher death rates attributable to renal disease and infection were also found in the NDD group.

[1] Li GW, Zhang P, Wang J, et al. Long-term effect of lifestyle interventions to prevent diabetes in the China Da Qing Diabetes Prevention Study: a 20-year follow-up study. Lancet, 2008,371:1783-1789.

[2] Gong Q, Gregg EW, Wang J, et al. Long-term effects of a randomized trial of a 6-year lifestyle intervention in impaired glucose tolerance on diabetes-related microvascular complications: the China Da Qing Diabetes Prevention Outcome Study. Diabetologia, 2011,54(2):300-307.

[3] Li GW, Zhang P, Wang JP, et al. Cardiovascular mortality, all-cause mortality, and diabetes incidence after lifestyle intervention for people with impaired glucose tolerance in the Da Qing Diabetes Prevention Study: a 23-year follow-up study. Lancet Diabetes Endocrinol, 2014,2(6):474-480.

[4] An YL, Zhang P, Wang JP, et al. Cardiovascular and All-Cause Mortality Over a 23-Year Period Among Chinese With Newly Diagnosed Diabetes in the Da Qing IGT and Diabetes Study. Diabetes Care, 2015, 38(7):1365-1371.

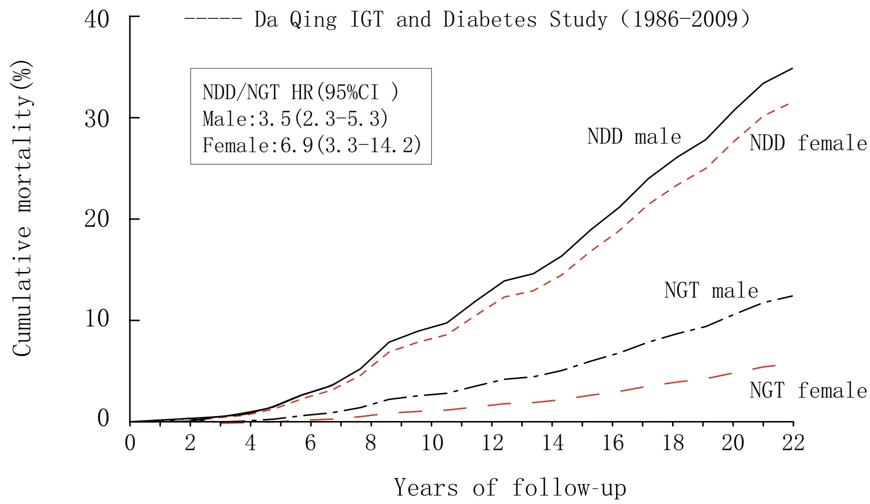


Figure 2-4-1 Cumulative incidence and HR of death from CVD in participants with NGT and NDD

2.4.4 Effect of Interventions on Prediabetes

The prediabetic population are susceptible to developing diabetes and at a high-risk of CVD. They develop diabetes at an annual speed of 5-10%. Currently, there are at least 92 million diabetic patients and 148 million prediabetic individuals in China. This suggests that China is and will remain a country with the largest number of diabetic patients worldwide in the foreseeable future.

Da Qing Diabetes Prevention Study investigated the long-term effect of intensive lifestyle interventions on cardiovascular events and mortality in people with prediabetes. In 1986, 519 subjects with normal glucose tolerance (NGT) and 577 subjects with impaired glucose tolerance (IGT) were recruited. The IGT subjects were randomly assigned to either the no-intervention group or one of three lifestyle intervention groups (diet, exercise, or diet plus exercise) for 6 years. The primary outcomes of cardiovascular events (myocardial infarction or stroke) and CVD mortality were followed up for 23 years.

The results showed that the subjects in IGT no-intervention group had the highest incidences of cardiovascular events (44.44%) and CVD mortality (20.00%), while those in NGT group had the lowest incidences of cardiovascular events (29.59%) and CVD mortality (7.52%). The incidences of cardiovascular events and CVD mortality in IGT intervention subjects were between those of above two groups, at 37.84% and 12.53%, respectively. The multivariable analyses showed that, after controlling of age, gender, BMI, smoking, blood pressure and cardiovascular event at baseline, the CVD mortality and incidence of cardiovascular events in IGT no-intervention group was 1.89 (HR=1.89, 95%CI: 1.11-3.22) and 1.38 (HR=1.38, 95%CI: 1.01-1.90) times of those in NGT group. However, the CVD mortality and incidence of cardiovascular events were not different in the IGT intervention group compared with those in the NGT group (HR=1.39, 95%CI: 0.89-2.18 and HR=1.25, 95%CI: 0.98-1.59, P=0.07, respectively). It suggested that although subjects with IGT were at high risk for cardiovascular events and mortality, lifestyle intervention for years in this population can reduce both the incidence of cardiovascular events and CVD mortality. [1]

Further study showed that during the 23-year follow-up, 174 (32.1%) of 542 persons with IGT died, with an overall death rate of 15.9 per 1 000 person-years. Participants who developed type 2 diabetes within the first 10 years of follow-up were older, had higher BMI, FPG, and SBP than those who developed it later. During 23 years of follow-up, 79.0% of the participants (428 of 542) developed type 2 diabetes, and 174 died, with an overall death rate of 15.9 per 1000 person-years. This rate was 70% higher than that of a comparison group of similar age and sex with NGT (9.3 per 1 000 person-years). Most of the deaths (130 of 174; 74.7%) in the cohort occurred after the development of diabetes. Those who developed type 2 diabetes during first 10 years of follow-up had the highest cumulative mortality (37.8%; 95%CI: 33.1%-42.2%), followed by those who developed it after 10-20 years (28.6%; 95%CI: 21.6%-35.0%) and those who never developed diabetes or developed it after 20 or more years of follow-up (13.9%; 95%CI: 7.0%-20.3%). The HR was significantly higher for those who developed diabetes in the first 10 years (HR=3.87; 95%CI: 2.13-7.02) and between 10 and 20 years (HR=2.50; 95%CI: 1.30-4.81) compared with those who did not develop diabetes or developed it later, after adjusting for age, sex, and intervention. Time-dependent multivariate Cox proportional hazards analyses, with adjustment for baseline age, sex, intervention, and other potential confounding risk factors, showed that the development of type 2 diabetes was associated with a 73% higher risk of death (HR=1.73). In conclusion, IGT is associated with increased risk of mortality in China, but much of this excess risk is attributable to the development of type 2 diabetes. Preventing or delaying the development of diabetes is likely to reduce mortality among people with IGT.[2]

2.5 Overweight and Obesity

2.5.1 Prevalence of Overweight and Obesity

With rapid development in economy and changes in lifestyle since the reform and opening up in China, the prevalence of overweight (BMI: 24.0-27.9 kg/m^2) and obesity (BMI≥28.0 kg/m^2) in Chinese residents has continuously increased, especially in recent years. Data from the *Report on the Nutrition and Chronic Disease Status of Chinese Residents (2015)* demonstrated that in 2012, 30.1% of Chinese residents aged ≥18 years were overweight and 11.9% were obese, with an increase of 7.3% and 4.8%, respectively, as compared with the prevalence in 2002 (Figure 2-5-1) .[3]

[1] Chen YY, Wang JP, An YL, et al. Effect of lifestyle interventions on reduction of cardiovascular disease events and its mortality in pre-diabetic patients: long-term follow-up of Da Qing Diabetes Prevention Study. Chin J Intern Med, 2015,54(1):13-17.

[2] Gong Q, Zhang P, Wang J, et al. Changes in Mortality in People with IGT Before and After the Onset of Diabetes During the 23-Year Follow-up of the Da Qing Diabetes Prevention Study. Diabetes Care,2016,39:1550-1555.

[3] Bureau of Disease Prevention and Control of National Health and Family Planning Commission. Report on the Nutrition and Chronic Disease Status of Chinese Residents (2015). Beijing: People's Medical Publishing House. 2015.

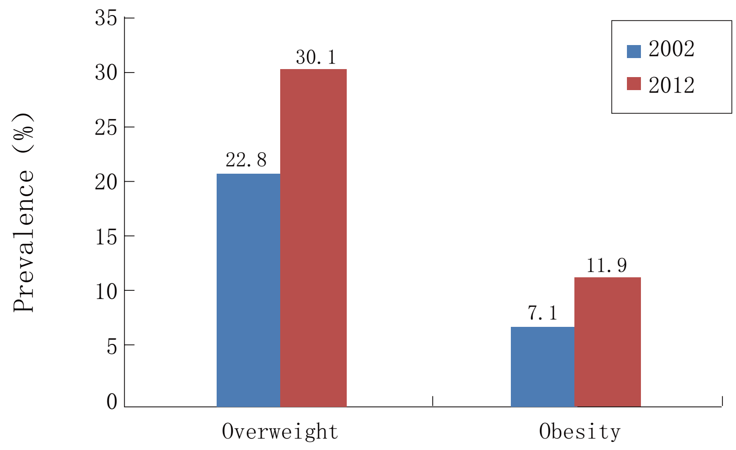


Figure 2-5-1 Prevalence of overweight and obesity in Chinese residents aged ≥ 18 years in 2002 and 2012

Results from 2002 and 2012 CHNS also indicated that the prevalence of abdominal obesity and mean waist circumference (WC), an index for abdominal obesity, had increased among Chinese adults. The increase was greater in rural residents than in urban residents, indicating a decrease in the disparity between the two populations (Table 2-5-1). [1]

Table 2-5-1 Waist circumference among Chinese adults in 2002 and 2012

	2002	2012	Absolute change (cm)	Relative change (%)
Male				
Total	80.0	82.7	+2.7	3.4
Urban	82.7	84.1	+1.4	1.7
Rural	77.3	81.4	+4.1	5.3
Female				
Total	76.4	78.5	+2.1	2.8
Urban	77.6	78.7	+1.1	1.4
Rural	75.2	78.3	+3.1	4.1

National Physical Fitness and Health Surveillance of Chinese School Students was conducted 6 times during 1985-2014. More than 200 000 students aged 7-18 years were enrolled in each survey. The prevalence

[1] Zhai Y, Fang HY, Yu WT, et al. Changes in Waist Circumference and Abdominal Obesity among Chinese Adults over a Ten-year Period. Biomed Environ Sci, 2017,30(5):315-322.

of overweight and obesity among Chinese adolescents was also on the rise (Figure 2-5-2). [1,2] It was 11 and 56 times, respectively, in 2014 of that in 1985.

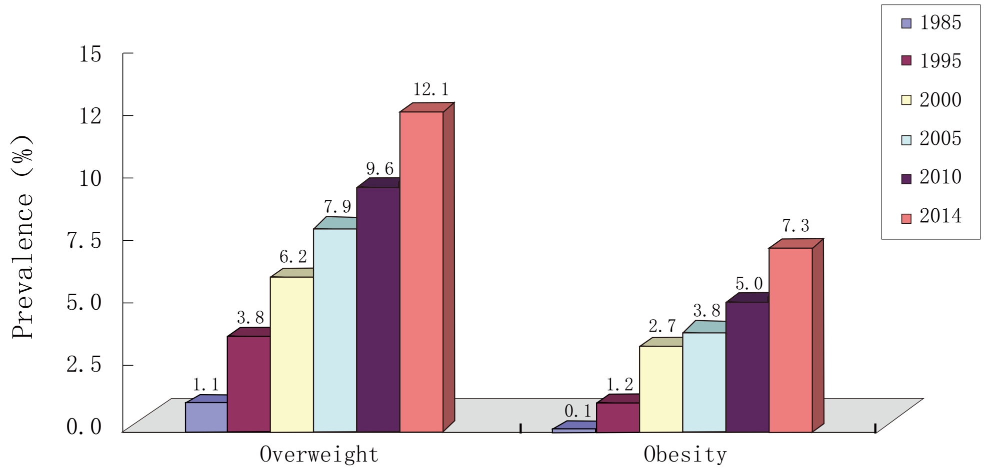


Figure 2-5-2 Trends in overweight and obesity among Chinese children aged 7-18 years

An analysis of the data from 2002 and 2012 Status of Nutrition and Health among Chinese Residents also demonstrated a significant increase in the prevalence of overweight and obesity in Chinese children and adolescents aged <6 and 7-17 years (Figure 2-5-3). [3]

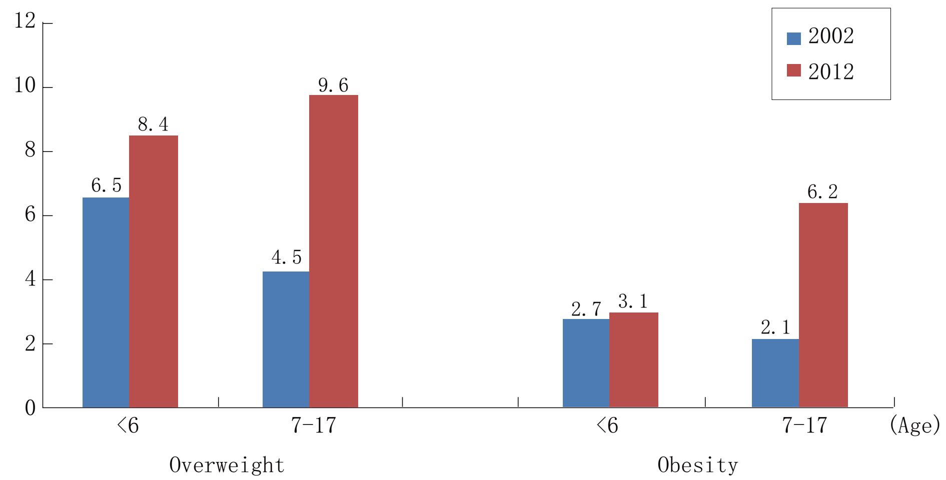


Figure 2-5-3 Prevalence of overweight and obesity among Chinese children by age in 2002 and 2012

[1] Ma J, Cai CH, Wang HJ, et al. The trend analysis of overweight and obesity in Chinese students during 1985-2010. Chinese Journal of Preventive Medicine, 2012,46(9):776-780.

[2] Wang S, Dong YH, Wang ZH, et al. Trends in overweight and obesity among Chinese children of 7-18 years old during 1985-2014. Chinese Journal of Preventive Medicine, 2017,51(4):300-305.

[3] Bureau of Disease Prevention and Control of National Health and Family Planning Commission. Report on the Nutrition and Chronic Disease Status of Chinese Residents (2015). Beijing: People's Medical Publishing House. 2015.

To revise the National Student Physical Fitness Standard in 2013, more than 120 000 primary and middle school students aged 7-18 years were selected from 7 major geographic areas in China by stratified random cluster sampling. The results showed that the prevalence of overweight and obesity in Chinese children and adolescents was 12.2% and 7.1%, respectively. There were differences between genders, urban/rural areas, and ethnic groups (Table 2-5-2). The prevalence of overweight and obesity was also significantly uneven among different geographic areas (Figure 2-5-4). [1]

Table 2-5-2 Prevalence of overweight and obesity in Chinese children and adolescents in 2013 (%)

		Overweight	Obesity
Gender			
	Male	14.6	9.1
	Female	9.8	5.2
Region			
	Urban	14.5	9.4
	Rural	9.6	4.6
Ethnic			
	Han	12.7	7.5
	Others	9.5	5.2
Overall		12.2	7.1

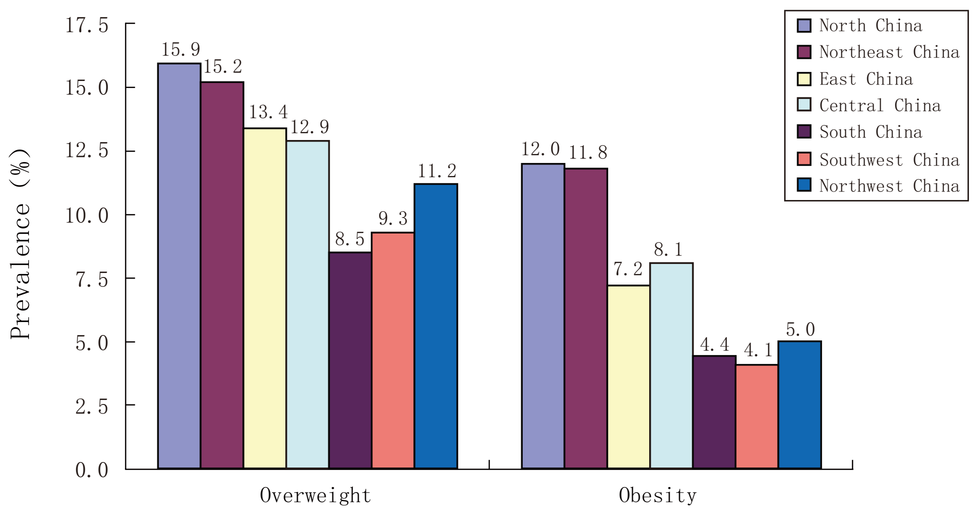


Figure 2-5-4 Prevalence of overweight and obesity in children and adolescents aged 7-18 years by geographic area of China in 2013 (%)

[1] Chen YS, Zhang YM, Kong ZX, et al.The current prevalence status of body overweight and obesity in Chinese children and adolescents. Chinese Journal of disease control & prevention, 2017,21(9):866-869.

To examine the status and trends of overweight and obesity in children and adolescents aged 6-18 years in Shenzhen, almost 20 000 students were enrolled each year from 2013 to 2017 through stratified cluster sampling method. Results showed that the prevalence rates of overweight and obesity were on the decline in both boys and girls (Table 2-5-3) [1] . This might be related to the prevention and control measures widely carried out in children and adolescents in recent years, but still need further surveillance evidences.

Table 2-5-3 Prevalence of overweight and obesity in children and adolescents aged 6-18 years in Shenzhen (%), 2013-2017

Survey time	Overweight		Obesity	
	Male	Female	Male	Female
2013	18.4	10.9	13.4	6.6
2014	18.3	10.7	13.2	6.1
2015	16.5	9.9	12.1	6.1
2016	17.4	9.5	11.7	5.5
2017	17.3	10.4	11.7	5.4

2.5.2 Hazard of Overweight and Obesity

The China Kadoorie Biobank (CKB) enrolled more than 500 000 adults aged 30 to 79 years from 10 areas in China during 2004-2008. Analysis was conducted among participants without previous CVD with a median 9 years of follow-up. Results showed that BMI was positively associated with the incidence and risk of ischemic stroke (Table 2-5-4). Other adiposity measures, e.g., body fat percentage and waist circumference, showed similar associations with stroke types. [2] Adiposity had association with ischemic stroke mainly through its effect on blood pressure. Each 5 kg/m² higher BMI was associated with 8.3 mmHg higher SBP.

Table 2-5-4 Standardized stroke incidence rates and adjusted HR by baseline BMI

BMI (kg/m^2)	Incidence (/10 000 person-year)†	HR (95%CI)‡
<18.0	49.3	1.00 (0.92-1.09)
18.0-20.4	50.4	1.10 (1.05-1.14)
20.5-22.9	59.6	1.33 (1.29-1.36)

[1] Li YY, Wang Y, Chen DY, et al. Prevalence and trends of overweight and obesity in children and adolescents from 2013 to 2017 in Shenzhen. Chinese Journal of Epidemiology, 2018,39(6):728-731.
[2] Chen ZM, Iona A, Parish S, et al. Adiposity and risk of ischemic and haemorrhagic stroke in 0.5 million Chinese men and women: a prospective cohort study. Lancet Glob Health, 2018,6(6):e630-e640.

Table 2-5-4 Standardized stroke incidence rates and adjusted HR by baseline BMI (Continued)

BMI (kg/m^2)	Incidence (/10 000 person-year)†	HR (95%CI)‡
23.0-24.9	67.5	1.51 (1.47-1.55)
25.0-27.4	78.6	1.75 (1.70-1.79)
27.5-29.9	86.6	1.90 (1.84-1.97)
⩾30.0	96.7	2.03 (1.92-2.13)
P for trend		<0.0001

Note:

† Standardized to age, sex, and study area structure

‡ Stratified by age, sex, and study area and adjusted for education, smoking, alcohol consumption, physical activity, and self-rated health status

According to an analysis on more than 53 000 people in the CKB study from Tongxiang city of Zhejiang Province, with a follow-up of median 7.3 years, the incidence and risk of diabetes increased significantly with the baseline BMI and WC in both genders (Table 2-5-5) [1] . Another cohort study in Guangzhou investigated more than 15 000 people aged ⩾50 years from 2003 to 2008, and followed them up from 2008 to 2012. During the follow-up of mean 3.6 years, 11.3% developed incident diabetes. Multivariate analysis revealed that BMI and WC were positively associated with incident diabetes. Compared with non-obesity, general obesity (BMI ⩾28 kg/m^2) was associated with an increased odds of incident diabetes by 76% (OR=1.76, 95%CI: 1.50-2.06). For abdominal obesity (WC ⩾90cm in male and ⩾80cm in female), the OR was 1.93 (95%CI: 1.71-2.17). [2]

Table 2-5-5 Incidence and HR of diabetes by BMI and waist circumference

	Male		Female	
	Incidence (%)†	HR (95%CI)‡	Incidence (%)†	HR (95%CI)‡
BMI (kg/m^2)				
Low weight	0.23	0.63 (0.42-0.96)	0.40	0.86 (0.67-1.09)
Normal weight	0.35	1.00 (0.90-1.12)	0.47	1.00 (0.92-1.08)
Overweight	1.00	2.72 (2.47-2.99)	1.04	2.19 (2.04-2.36)
Obesity	2.36	6.27 (5.33-7.36)	2.28	3.78 (3.36-4.26)

[1] Wang H, Hu RY, Qian YJ, et al. Prospective study on the effect of BMI and waist circumference on diabetes of adults in Zhejiang province. Chinese Journal of Epidemiology, 2018,39(6):810-815 .

[2] Xu L, Lam TH, Jiang CQ, et al. Adiposity and incident diabetes within 4 years of follow-up: the Guangzhou Biobank Cohort Study. Diabet Med, 2017,34(10):1400-1406.

Table 2-5-5 Incidence and HR of diabetes by BMI and waist circumference (Continued)

	Male		Female	
	Incidence (%)†	HR (95%CI)‡	Incidence (%)†	HR (95%CI)‡
Waist circumference (cm)				
Normal	0.38	1.00 (0.91-1.10)	0.49	1.00 (0.93-1.08)
Abdominal obesity class I	0.99	2.56 (2.22-2.95)	0.97	1.99 (1.80-2.21)
Abdominal obesity class II	1.85	4.66 (4.14-5.24)	1.97	3.16 (2.90-3.44)

Note:
† incidence was adjusted for age.
‡，HR was stratified by age and adjusted for education, income, occupation, smoking, alcohol consumption, physical activity, and family history of diabetes.
Low weight: BMI<18.5 kg/m^2; Normal weight: BMI 18.5-23.9 kg/m^2; Overweight: BMI 24.0-27.9 kg/m^2; Obesity: BMI ⩾28.0 kg/m^2
Normal waist circumference (WC): <85 cm for male and <80 cm for female; Abdominal obesity class I: WC 85-89 cm for male and 80-84 cm for female; Abdominal obesity class II: WC ⩾90 cm for males and ⩾85 cm for females

Although some areas have reported an improvement in the prevalence of obesity among children and adolescents, the problem of overweight and obesity among Chinese residents is still serious. Prevention and control of obesity should be continually strengthened to curb the increasing trend of obesity as soon as possible.

2.6 Physical Inactivity

2.6.1 Current Status, Trends and Influencing Factors of Physical Activity

The 1991-2011 CHNS in 9 provinces and municipalities, demonstrated a significant decline in overall physical activity (PA) in Chinese residents aged 18-60 years, which was largely driven by occupational PA reduction. PA fell from 382 MET-h/week in 1991 to 264 MET-h/week in 2011 among adult males (an decrease of 31%). Active leisure (i.e. exercise) stayed consistently low, which was 6 MET-h/week in 2011. These patterns were similar among females [1] .

Results from 2014 National Physical Fitness Surveillance indicated that 22.8% of adults aged 20-59 years met the minimum leisure-time physical activity (LTPA) recommendation (minimum 150 min of moderate or 75 min of vigorous exercise per week), which was slightly increased as compared with those in the previous surveys (Figure 2-6-1) .[2] However, other measures of physical fitness, such as resting heart rate, forced vital capacity, sit and reach distance, hand grip strength, and time standing on one leg, deteriorated over time.

［1］Ng SW, Howard AG, Wang HJ, et al. The physical activity transition among adults in China: 1991-2011. Obesity Reviews, 2014,15(S1):27-36.
［2］Tian Y, Jiang C, Wang M, et al. BMI, leisure-time physical activity, and physical fitness in adults in China: results from a series of national surveys, 2000-14. Lancet Diabetes Endocrinol, 2016,4(6):487-497.

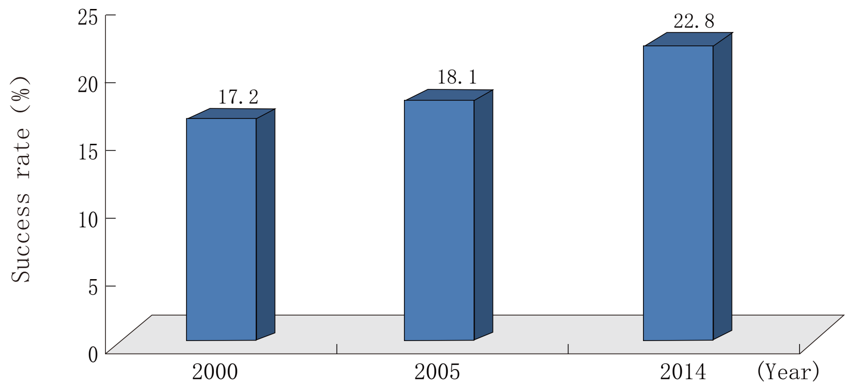


Figure 2-6-1 Proportion of Chinese adults aged 20-59 years who met LTPA recommendations (%)

In 2014, about 33.9% of people (including children and adolescents) participated in regular physical activity, which increased by 5.7% as compared with that in 2007. People aged ≥20 years accounted for 14.7% of the population doing regular activity, while urban and rural residents accounted for 19.5% and 10.4%, respectively. Compared with the profile in 2007, regular physical activity among urban and rural residents increased by 48.0% and 154.0%, respectively [1,2,3] . The rate of regular physical activity increased among all age groups, but it was still low among young adults aged 20-49 years (Figure 2-6-2) [2,3] .

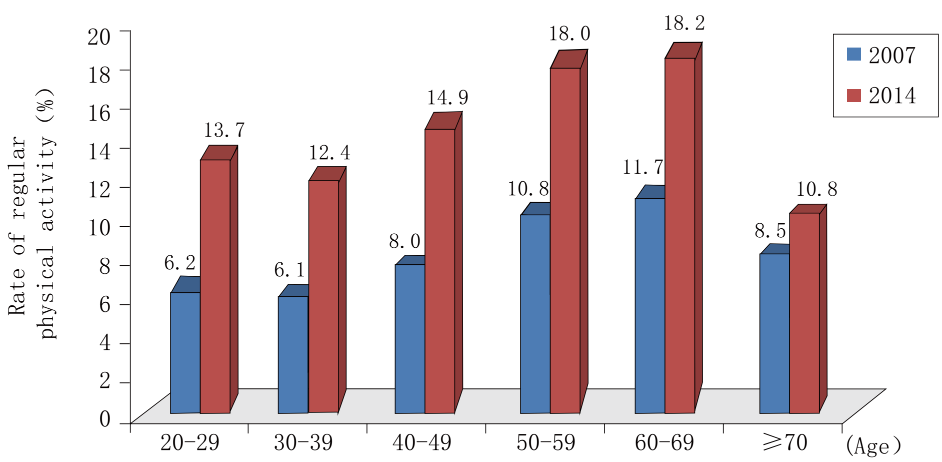


Figure 2-6-2 Participation rates for regular physical activity among Chinese adults aged ≥ 20 years

Note: Regular physical activity is defined as engaging in moderate-intensity physical activity for ≥30 min/day and ≥3 days/week

An investigation was conducted in more than 20 000 Beijing residents aged 18-79 years in 2011. Results

[1] Tian Y, Jiang C, Wang M, et al. BMI, leisure-time physical activity, and physical fitness in adults in China: results from a series of national surveys, 2000-14. Lancet Diabetes Endocrinol, 2016,4(6):487-497.

[2] National Department of Sport. The Third National Mass Sports Report: Beijing: People 's Sports Publishing House. 2010.

[3] National Department of Sport. Bulletin of Survey on National Fitness Activities in 2014. [2015-11-16]http://www.sport.gov.cn/n16/n1077/n1422/7300210.html.

showed that the rate of regular physical activity was 31.5% [1] , higher than that from the national survey in 2014. Compared with middle and elderly adults, young adults (aged 18-44 years) had the lower rate of regular physical activity (Figure 2-6-3).

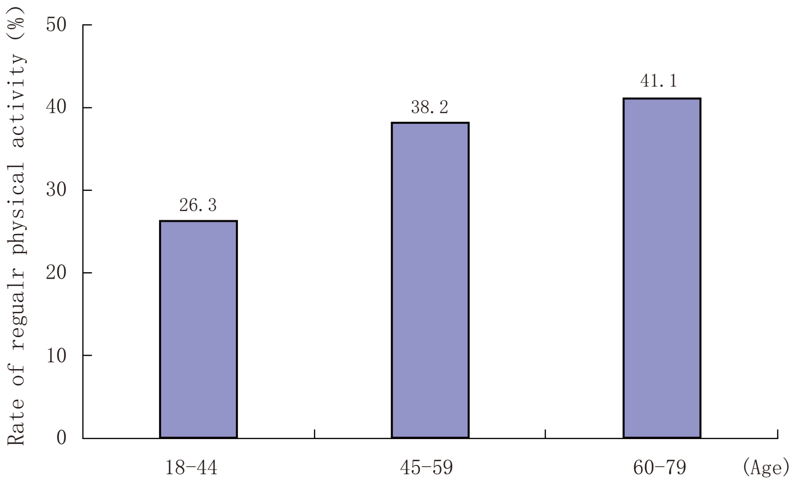


Figure 2-6-3 Rate of regular physical activity among Beijing residents by age in 2011

Note: Regular physical activity is defined as engaging in moderate-intensity physical activity for ⩾30 min/day and ⩾3 days/week

The 6th National Physical Fitness and Health Surveillance of Chinese School Students was conducted among more than 220 000 students aged 9-22 years in 2014. Results showed that the prevalence of physical activity time <1 hour was 73.3% in boys, and even higher in girls (79.1%). The prevalence of inactivity increased with age for both genders (Figure 2-6-4) [2] .

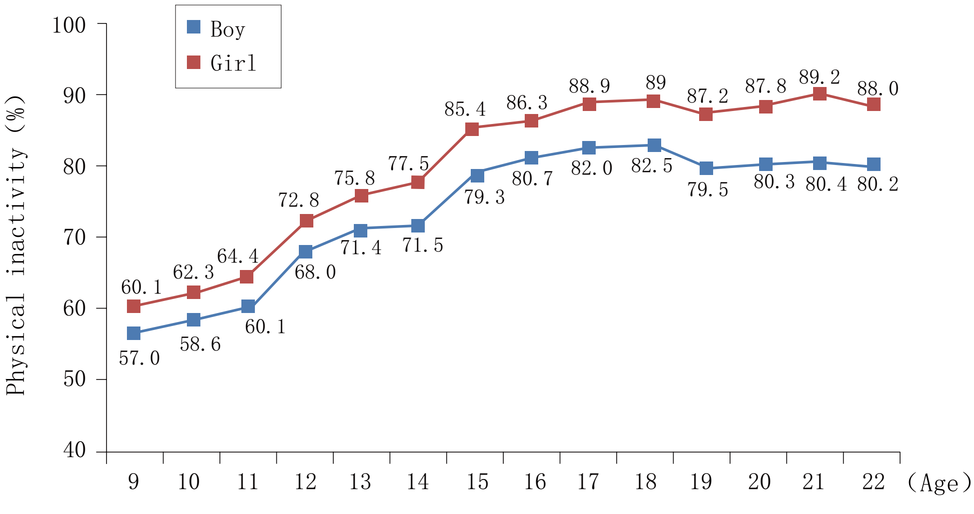


Figure 2-6-4 Physical inactivity among Chinese students by age in 2014

[1] Luo FJ, Cao J, Dong Z, et al. 2011 Status Survey for Physical Activity and Regular Exercise in Adult Residents of Beijing. Chinese Circulation Journal, 2018,33(1):73-78.

[2] Wang ZH, Dong YH, Song Y, et al. Analysis on prevalence of physical activity time <1 hour and related factors in students aged 9-22 years in China, 2014. Chinese Journal of Epidemiology, 2017,38(3):341-345.

The 2016 Physical Activity and Fitness in China-The Youth Study employed a multistage cluster sampling design and surveyed more than 120 000 students from 1 204 schools across 32 administrative provinces and regions in Mainland of China. Valid data from more than 90 000 students (aged 9-17 years) from Grade 4 of primary school to Grade 3 of junior high school were included in the analysis. The results showed that 29.9% of participants met the recommendations of 60 min/day of moderate-to-vigorous physical activity, with a higher percentage of boys than girls. Similar to the findings from the 6th National Physical Fitness and Health Surveillance of Chinese School Students in 2014, the compliance to recommendations of physical activity decreased with age (Table 2-6-1) .[1]

Table 2-6-1 Prevalence estimates of meeting PA recommendations among students in 2016 (%)

	Grades 4-6 of primary school (aged 9-11)	Junior middle school (aged 12-14)	Junior high school (aged 15-17)	Total
Boy	34.1	34.1	27.8	31.8
Girl	33.0	31.2	21.3	28.2
Total	33.5	32.5	24.4	29.9

The 2014 National Physical Fitness Surveillance uncovered that the main reason for physical inactivity in children and adolescents was "the concerns of less time for school work", followed by "lack of interest or a dislike of physical activities". Additionally, "lack of athletic skills" and "lack of space/facilities" were also the obstacles to regular physical activity (Figure 2-6-5) [2] .

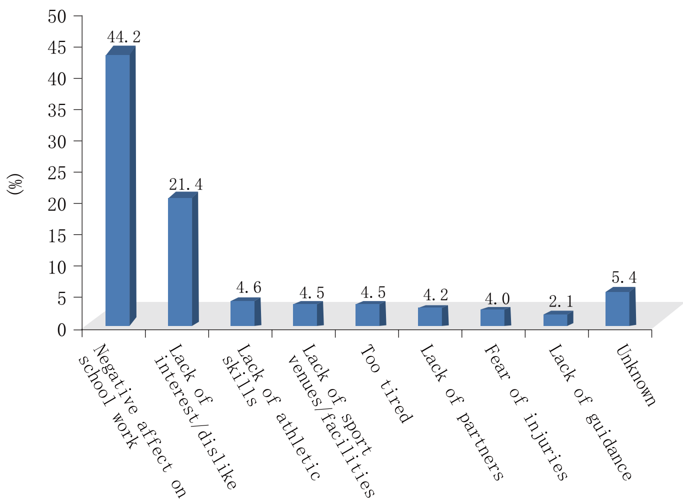


Figure 2-6-5 Common reasons for not taking part in physical exercise among children and adolescents aged 6-19 years in China in 2014(%)

[1] Fan X, Cao ZB. Physical activity among Chinese school-aged children: National prevalence estimates from the 2016 Physical Activity and Fitness in China—The Youth Study. J Sport Health Sci, 2017,6(4):388-394.

[2] National Department of Sport. Bulletin of Survey on National Fitness Activities in 2014. [2015-11-16]http://www.sport.gov.cn/n16/n1077/n1422/7300210.html

For the adults, the main reasons for physical inactivity were "lack of time" (30.6%), followed by "lack of interest" (11.6%) and "lack of convenient sports venues" (10.0%), etc.; which remained the same top three reasons as in 2007.[1,2] The survey showed that not recognizing the importance of physical activity and lack of necessary facilities were the major factors that prevented residents from exercising.

2.6.2 Physical Inactivity and CVD

The Community Intervention of Metabolic Syndrome in China & Chinese Family Health Study (CIMIC) was a large community-based cohort survey. It started in rural areas of 4 provinces in China during 2007-2008 and the follow-up was performed during 2012-2015. A total of more than 41 000 participants aged ⩾18 years and free from CVD and hypertension at baseline were divided into 4 groups according to their level of PA at baseline. There was a significantly negative association between PA and incident hypertension (P for trend <0.001). Compared with participants in the first (or lowest) quartile of PA, the risk of incident hypertension decreased with the level of PA by 8%, 28%, and 30% for the 2nd, 3rd, and 4th quartile, respectively (Table 2-6-2). [3]

Table 2-6-2 Hazard ratios for incident hypertension by volume of physical activity in rural areas

	Volume of physical activity			
	Q1	Q2	Q3	Q4
No. of cases	1 813	1 748	1 591	1 628
Follow-up(person-year)	58 102	59 116	62 601	61 962
Annual incidence (%)	3.12	2.96	2.54	2.63
HR(95%CI)	1.00	0.92 (0.86-0.99)	0.72 (0.67-0.77)	0.70 (0.65-0.75)

Note: Cox regression model was used for adjustment of age, sex, BMI, region (south/north), education, alcohol drinking, smoking, fasting plasma glucose, total cholesterol, and systolic blood pressure at baseline. The 1st quantile of physical activity was regarded as the reference

To evaluate the effects of habitual leisure-time physical activity (LTPA) on incident type 2 diabetes among Chinese adults with impaired fasting glucose (IFG, defined as fasting plasma glucose 5.6-6.9mmol/L), a prospective cohort study was conducted among more than 44 000 participants aged 20-80 years with IFG in Taiwan. [4] After 214 148 person-years of follow-up, 4 420 participants developed incident diabetes. A

［1］National Department of Sport. The Third National Mass Sports Report: Beijing: People 's Sports Publishing House. 2010.
［2］National Department of Sport. Bulletin of Survey on National Fitness Activities in 2014. [2015-11-16] http://www.sport.gov.cn/n16/n1077/n1422/7300210.html.
［3］Gong XY, Chen JC, Li JX, et al. The relationship between physical activity and incident hypertension in rural Chinese. Chinese Journal of Preventive Medicine, 2018,52(6):615-621.
［4］Lao XQ, Deng HB, Liu X, et al. Increased leisure-time physical activity associated with lower onset of diabetes in 44828 adults with impaired fasting glucose: a population-based prospective cohort study. Br J Sports Med, 2018 Jan 13. Epub ahead of print.

significantly inverse dose-response relationship (P for trend<0.001) was observed between baseline LTPA and diabetes risk in IFG subjects after adjustment of multiple confounders. Compared with inactive participants (<3.75 MET-h/week), diabetes risk in individuals reporting high volume LTPA (15.0 MET- h/week) was reduced by 25% (Table 2-6-3).

Table 2-6-3 Hazard ratios for incident diabetes by volume of LTPA in subjects with IFG in Taiwan

	Volume of LTPA			
	Inactive (n=24 469)	Low (n=8 450)	Moderate (n=5 328)	High (n=6 581)
No.of cases	2 535	731	542	612
Incidence (%)	10.4	8.7	10.2	9.3
HR(95%CI)	1.00	0.88(0.80-0.98)	0.80 (0.71-0.90)	0.75 (0.67-0.83)

Note: Cox regression model was used for adjustment of age, sex, marital status, education, physical labor at work, alcohol drinking, smoking, sleep duration, vegetable intake, systolic blood pressure, heart rate, and total cholesterol at baseline. Inactive (<3.75 MET-h/week; reference category), low (3.75 to <7.5 MET-h/week), moderate (7.5 to <15.0 MET-h/week) and high (15.0 MET-h/week)

Data from two large prospective cohort studies, Shanghai Male Health Study and Shanghai Female Health Study, were analyzed to evaluate the association of leisure-time physical activity (LTPA) with CVD mortality among more than 120 000 participants aged 40-74 years, with an average follow-up of 9.2 years for males and 14.7 years for females. Compared with those who reported no exercise, a reduction in CVD mortality by 14% (HR=0.86, 95%CI: 0.80-0.93) was observed in those who regularly engaged in moderate-intensity LTPA (such as Tai Chi, dancing, brisk walking, and so forth), even those who reported a LTPA level lower than the minimum amount recommended by the current physical activity guidelines (150 min or 7.5 MET-h/week). The association between moderate-intensity exercise and mortality followed a dose-response pattern until the amount of LTPA was greater than 5 times (⩾37.5 MET-h/week) the recommended minimum level (Table 2-6-4) [1] . A similar pattern of association was observed for overall mortality and cancer-specific mortality.

Table 2-6-4 Hazard ratios for CVD mortality by volume of moderate-intensity LTPA

Volume of LTPA (MET-hours/week)	Number of death	HR (95%CI)
None	1 216	1.00 (Reference)
0.1-7.4	249	0.75 (0.65-0.86)
7.5-	287	0.85 (0.75-0.97)
15.0-	145	0.71 (0.60-0.85)
22.5-	134	0.68 (0.57-0.82)
⩾37.5	99	0.79 (0.64-0.97)
P for trend	—	<0.001

Note: Cox regression model was used for adjustment of age, sex, education, family income, marital status, alcohol drinking,

[1] Liu Y, Wen W, Gao YT, et al. Level of moderate-intensity leisure-time physical activity and reduced mortality in middle-aged and elderly Chinese. J Epidemiol Community Health, 2018,72(1):13-20.

smoking, diabetes, hypertension, respiratory diseases, chronic hepatitis, and non-leisure physical activity at baseline, after excluding participants who had a history of cancer, coronary heart disease or stroke at baseline, or who died within the first 3 years after study enrolment

The CKB study conducted an average 7.5 years of follow-up among more than 487 000 subjects with no prior CVD history at baseline. Total physical activity was inversely associated with the risk of CVD death, which was decreased by 41% (HR=0.59, 95%CI: 0.55-0.64) in the top quintile of baseline total physical activity (33.8 MET-h/d) as compared with that in the bottom quintile (9.1 MET-h/d) (Table 2-6-5). Each 4 MET-h/d in physical activity (approximately 1 hour of brisk walking per day) was associated with a 12% lower risk of CVD death. In addition, higher occupational or non-occupational physical activity (including commuting, household tasks, and leisure time activities) was associated with significantly lower risks of CVD death. The study also found that higher occupational, non-occupational, and total physical activity was associated with a lower risk of intracerebral hemorrhage, ischemic stroke, and major coronary events. [1]

Table 2-6-5 Associations of total, occupational and non-occupational physical activity with CVD mortality

Physical activity at baseline (MET-hours/day)	No. of death	Mortality rate (1/1 000 person-year)	HR (95%CI)
Total PA			
≤9.1	3 611	3.12	1.00 (0.96-1.04)
9.2-14.7	1 830	2.10	0.75 (0.72-0.79)
14.8-22.4	1 206	1.84	0.67 (0.63-0.71)
22.5-33.7	1 061	1.63	0.60 (0.56-0.64)
≥33.8	729	1.69	0.59 (0.55-0.64)
Occupational PA			
0	4 164	3.13	1.00 (0.95-1.05)
0.1-5.9	1 276	1.91	0.75 (0.70-0.80)
6.0-13.8	1 260	1.73	0.66 (0.62-0.69)
13.9-25.7	1 054	1.79	0.61 (0.58-0.66)
≥25.8	683	2.20	0.59 (0.55-0.65)
Non-occupational PA			
0-3.9	2 047	3.30	1.00 (0.95-1.05)
4.0-6.5	1 685	2.39	0.89 (0.85-0.93)
6.6-8.4	1 795	2.28	0.85 (0.81-0.89)
8.5-11.6	1 485	2.03	0.78 (0.74-0.82)
≥11.7	1 425	1.92	0.71 (0.67-0.75)

Note: Mortality was the annual rate (1/1 000 person-years) after adjustment of age, gender and region. Cox model was stratified by

[1] Bennett DA, Du H, Clarke R, et al. Association of Physical Activity With Risk of Major Cardiovascular Diseases in Chinese Men and Women. JAMA Cardiol, 2017,2(12):1349-1358.

gender and region and used for adjustment of income, education, BMI, alcohol drinking, smoking, SBP, consumption of fresh fruit, sedentary time, and self-reported health status. occupational and non-occupational physical activity. Analyses of occupation and non-occupation physical activity levels also included additional mutual adjustment for each other

The CKB study also performed a prospective cohort study in more than 150 000 hypertensive participants. During a median 7.1 years of follow-up, a total of 9 716 participants died. Total physical activity was inversely associated with the risks of all-cause mortality and death due to IHD and cerebrovascular disease. Compared with hypertensive participants in the lowest quartile of total physical activity, those in the highest group showed a 33% reduction in the risk of death from IHD (HR=0.67, 95%CI: 0.55-0.83) and a 35% reduction in the risk of death from cerebrovascular disease (HR=0.65, 95%CI: 0.57-0.74), which was shown in Table 2-6-6. High levels of low-intensity, moderate-intensity, and vigorous-intensity physical activity were associated with lower risk of all-cause and cardiovascular mortality. So did being active in occupational, domestic, and leisure time. [1] In conclusion, among Chinese hypertensive adults, a higher level of physical activity reduces all-cause and cardiovascular mortality, independent of intensities and types of physical activity.

Table 2-6-6 Associations between total physical activity and all-cause and cardiovascular mortality among hypertensive participants

Level of total physical activity	No. of death	Mortality rate (1/1 000 person-year)	HR (95%CI)
All-cause mortality			
Q1	3 993	15.33	1.00 (reference)
Q2	2 369	8.87	0.80 (0.76-0.84)
Q3	1 913	7.06	0.69 (0.65-0.73)
Q4	1 431	5.28	0.67 (0.62-0.72)
P for trend			<0.001
IHD mortality			
Q1	694	2.66	1.00 (reference)
Q2	369	1.38	0.78 (0.68-0.88)
Q3	222	0.82	0.68 (0.57-0.80)
Q4	149	0.55	0.67 (0.55-0.83)
P for trend			<0.001
Cerebrovascular mortality			
Q1	1 152	4.42	1.00 (reference)
Q2	656	2.46	0.76 (0.69-0.84)
Q3	545	2.01	0.64 (0.58-0.72)
Q4	405	1.49	0.65 (0.57-0.74)
P for trend			<0.001

Note: Cox model was used for adjustment of age, gender, education, marital status, alcohol consumption, smoking, red meat intake,

[1] Fan M,Y Yu CQ, Guo Y, et al. Effect of total, domain-specific, and intensity-specific physical activity on all-cause and cardiovascular mortality among hypertensive adults in China. J Hypertens, 2018,36(4):793-800.

fruit intake, vegetable intake, BMI, SBP, diabetes, menopause (female) and average daily meditation time; additionally family history of heart disease or stroke was also adjusted when analyzing mortality due to IHD or cerebrovascular disease
Q is short for Quartile

According to the data from 2013 national survey on risk factors of chronic disease, the overall population attributable fraction (PAF) for all-cause death due to physical inactivity in adults aged ≥25 years was 4.24%, which was significantly higher than that in 1990. In 2013, the most attributed death was CVD, and the attribution of death due to IHD and ischemic stroke on physical inactivity was about 339 000. [1] The aforementioned studies indicate that physical activity among Chinese residents is still on a significant decline, particularly for occupational physical activities. Active physical exercise is an effective way to increase the amount of physical activity. However, the proportion of active physical activity by exercise or other ways remains low, which has increased the burden of CVD in China. The 13th China Five-Year Plan underlined that the country should strive to improve the health of whole nation, promote "Healthy China" program, and carry out a wide range of national physical fitness campaigns. The National Fitness Program (2016-2020), launched by the State Council, stressed that public health was an important manifestation of comprehensive national power and a symbol of socio-economic development. By 2020, the number of people regularly participating in physical activities should reach 435 million. Under the support and guidance of national policies, the public should respond actively to promote the development of popular sports, arouse the enthusiasm of residents for physical exercise, and make a better environment for residents to do physical exercise, which will be helpful to reduce the prevalence of CVD and other chronic diseases and improve people's health.

2.7

2.7.1 Current Status and Trends in Nutrition

CHNS had been conducted four times during 1982-2012. The results showed that the dietary patterns in China had changed significantly over the past 30 years. As far as the 3 major caloric nutrients were concerned, the intake of protein barely changed, but that of fat increased significantly, and carbohydrate declined greatly. In general, the total calorie intake decreased substantially. In addition, the consumption of vitamin C, calcium, and potassium also declined. The dietary sodium intake reduced dramatically, but it remained high in 2012 (5 702 mg/day, which corresponds to salt intake of 14.5g/day), more than twice the recommended amount (China: <6 g/day, World Health Organization: <5 g/day) (Table 2-7-1). [2, 3] The

[1] Liu JM, Liu YN, Zeng XY, et al. Effects of insufficient physical activity on mortality and life expectancy in adult aged 25 and above among Chinese population. Chinese Journal of Epidemiology, 2017,38(8):1033-1037.
[2] Zhai FY, Yan XG. Survey Report on the Status of Nutrition and Health of the Chinese People in 2002: Series Two, Status of Diet and Nutrients consumption. Beijing: People's Medical Publishing House, 2006.7.
[3] Bureau of Disease Prevention and Control of National Health and Family Planning Commission. Report on the Nutrition and Chronic Disease Status of Chinese Residents (2015). Beijing: People's Medical Publishing House. 2015.

changes in calorie and nutrients intake in China over the past 10 years (2002-2012) are less substantial than the previous 20 years (1982-2002).

Table 2-7-1 Average dietary intake of calorie and nutrients among residents in China, 1982-2012 (per day)

Nutrient	1982	1992	2002	2012
Calories (kcal)	2 491	2 328	2 251	2 172
Protein (g)	66.7	68.0	65.9	64.5
Fat (g)	48.1	58.3	76.3	79.9
Carbohydrate (g)	444	378	321	301
Dietary fiber (g)	8.1	13.3	12.0	10.8
Vitamin C (g)	129	100	88.4	80.4
Calcium (mg)	695	405	389	366
Potassium (mg)	—	1 871	1 700	1 617
Sodium (mg)	—	7 116	6 268	5 702
Salt (g)*	—	18.1	15.9	14.5

Note: *1 g salt = 393 mg sodium

The calories from dietary fat had increased substantially during 1992-2012 in Chinese residents, and reached 32.9% on average in 2012, exceeding the recommended upper limit of 20%-30% by Dietary Guidelines for Chinese Residents. The calories from carbohydrates was on a significant decline and decreased to a nationwide average of 55% in 2012, which was the recommended lower limit of 55%-65% (Figure 2-7-1). The imbalanced calories intake from dietary nutrients was more serious in urban residents than in rural ones.[1, 2]

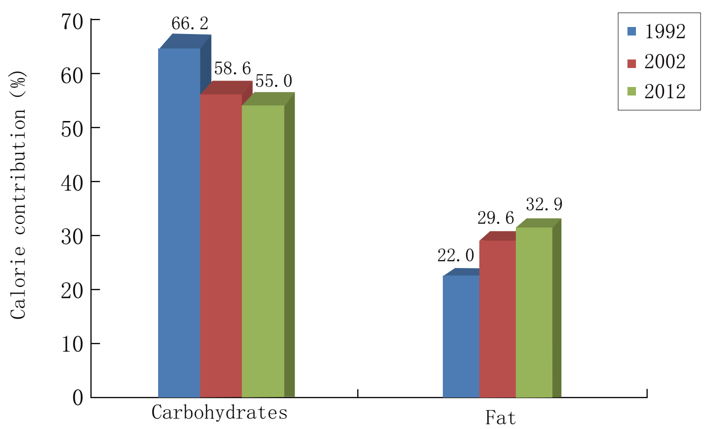


Figure 2-7-1 Calorie contribution from carbohydrates and fat among residents in China (%), 1992-2012

[1] Zhai FY, Yan XG. Survey Report on the Status of Nutrition and Health of the Chinese People in 2002: Series Two, Status of Diet and Nutrients consumption. Beijing: People's Medical Publishing House, 2006.7.

[2] Bureau of Disease Prevention and Control of National Health and Family Planning Commission. Report on the Nutrition and Chronic Disease Status of Chinese Residents (2015). Beijing: People's Medical Publishing House. 2015.

The CHNS conducted a long-term monitoring of the nutrition and health status in Chinese residents from multiple provinces. The results showed that during 1991-2015, a significant increase in percentages of energy from fat (Figure 2-7-2) and a decrease in percentages of energy from carbohydrate (Figure 2-7-3) were seen among all age adult females. The proportion of females with more than 30% of energy from fat increased from 31.8% in 1991 to 66.9% in 2015, and those consuming a diet with less than 50% of energy from carbohydrates increased from 14.1% to 45.5%,[1] indicating that the trend of an imbalanced dietary pattern in the Chinese residents persisted.

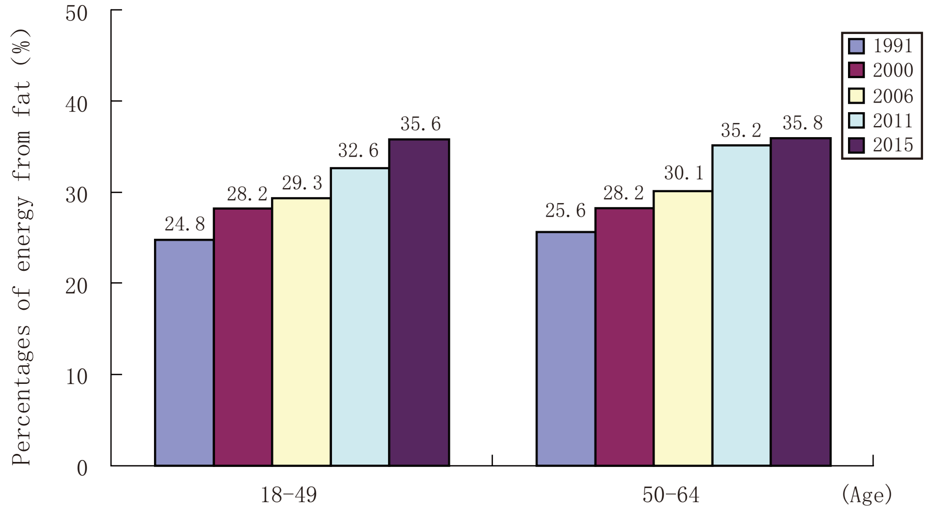


Figure 2-7-2 Percentages of energy from fat by age among females in multiple China provinces (%), 1991-2015

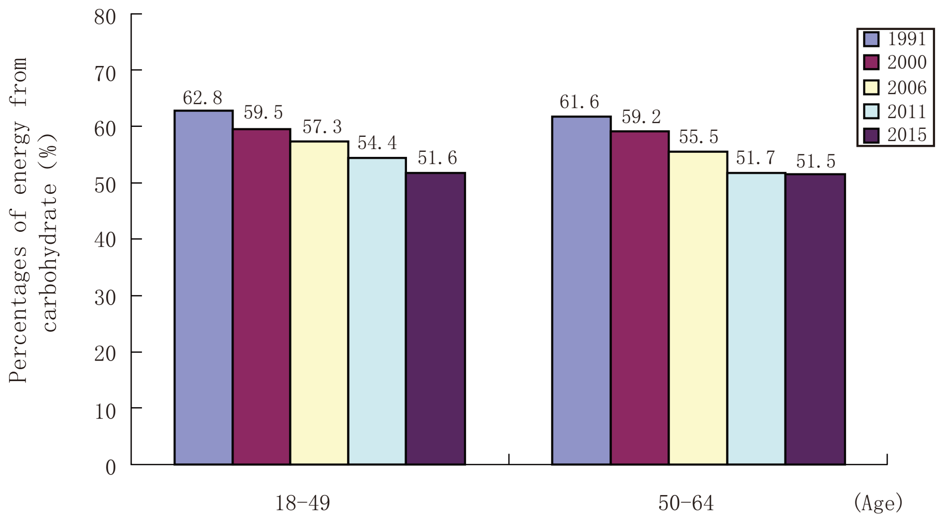


Figure 2-7-3 Percentages of energy from carbohydrates by age among females in multiple China (%) provinces, 1991-2015

[1] Zhao J, Su C, Wang H, et al. Secular Trends in Energy and Macronutrient Intakes and Distribution among Adult Females (1991-2015): Results from the China Health and Nutrition Survey. Nutrients, 2018 Jan 24;10(2). pii:E115.

Results from the CHNS indicated a significant change in food intake over the past 30 years (from 1982 to 2012), as shown in Table 2-7-2.[1,2] The change manifested itself as significant reduction in cereals and tubers remarkable increase in animal foods and edible oil, and decrease in cooking salt and soy sauce. But salt intake was still high (up to 10.5 g/day). The consumption of fresh vegetables decreased over time. Fruit intake in 2012 was higher than that in 1982, but still lower than 1992 and 2002, with a current average intake less than 50 g/day.

Table 2-7-2 Major food intake among Chinese residents (g/day), 1982-2012

Category	1982	1992	2002	2012
Cereals and tubers	690	527	452	370
Rice, flour	406	405	379	309
Potatoes	180	87	49	36
Others	104	35	24	25
Beans and products	13.4	11.2	16.0	14.2
Animal food	60.7	117.3	158.5	162.4
Poultry	34.2	58.9	78.6	89.7
Fish and shrimp	11.1	27.5	29.6	23.7
Eggs	7.3	16.0	23.7	24.3
Milk and products	8.1	14.9	26.6	24.7
Vegetable oil	12.9	22.4	32.9	37.3
Animal oil	5.3	7.1	8.7	4.8
Fresh vegetables	316	310	276	269
Fruit	37.4	49.2	45.0	40.7
Cooking salt	12.7	13.9	12.0	10.5
Soy sauce	14.2	12.6	8.9	7.9

Results from the CHNS showed that the daily intake of vegetables declined among Chinese adults aged 18-44 years in 9 provinces and autonomous regions during 1991-2011, and it was only 322 g in 2011.

[1] Zhai FY, Yan XG. Survey Report on the Status of Nutrition and Health of the Chinese People in 2002: Series Two, Status of Diet and Nutrients consumption. Beijing: People's Medical Publishing House, 2006.7.
[2] Bureau of Disease Prevention and Control of National Health and Family Planning Commission. Report on the Nutrition and Chronic Disease Status of Chinese Residents (2015). Beijing: People's Medical Publishing House. 2015.

Although the daily intake of fruit kept increasing, it was still less than 100 g in 2011(Figure 2-7-4). [1]

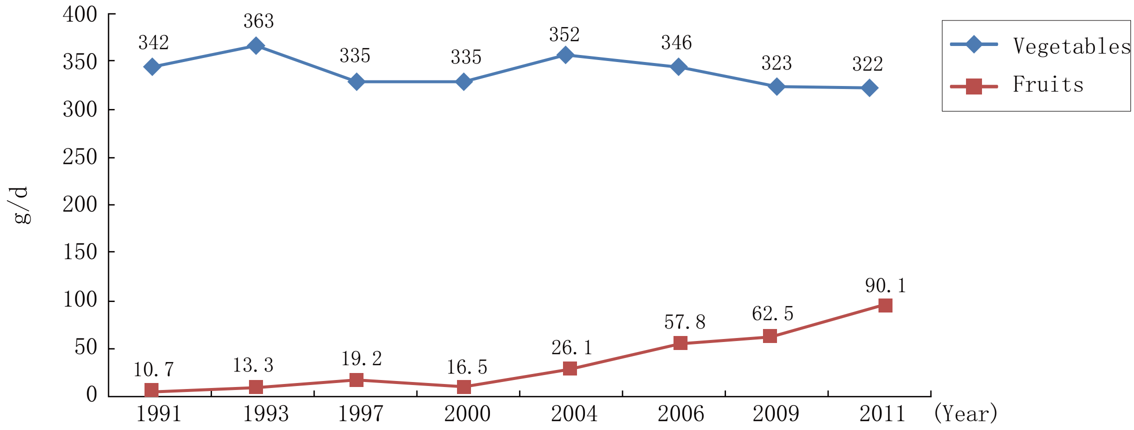


Figure 2-7-4 Vegetables and fruits consumption among Chinese adults aged 18-44 years in 9 provinces and autonomous regions (g/day), 1991-2011

Further analysis on the data from 2012 CHNS showed that more than 99% of adults consumed vegetables daily, while the proportion of adults whose consumption of vegetables reached Chinese dietary guidelines recommended level (300 g/day) were merely around 25% in urban areas and less than 20% in rural areas (Figure 2-7-5) .[2]

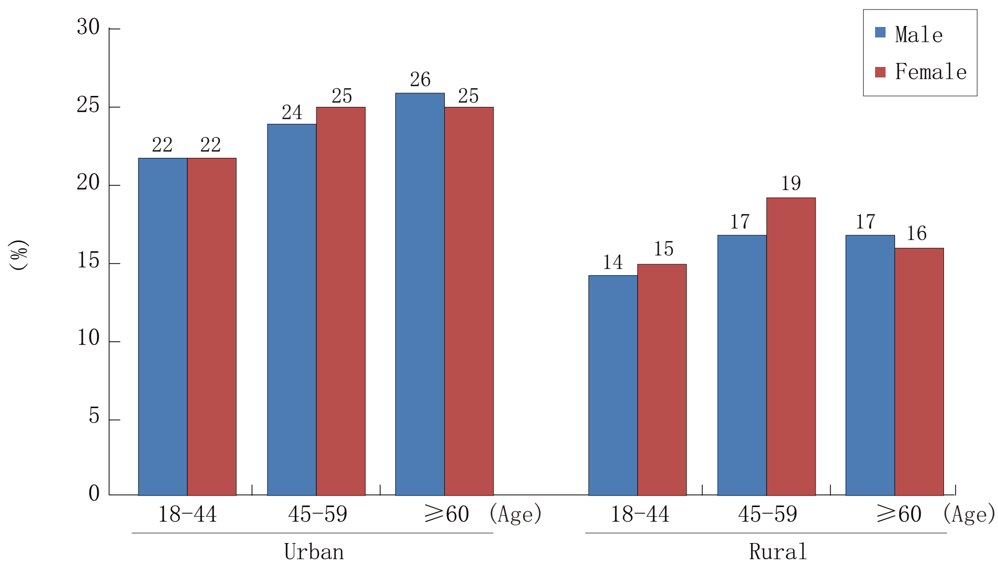


Figure 2-7-5 Proportion of adults whose consumption of vegetables reached Chinese dietary guidelines recommended level by age, gender and region in 2012 (%)

[1] Zhao J, Su C, Wang H, et al. Secular Trends in Energy and Macronutrient Intakes and Distribution among Adult Females (1991-2015): Results from the China Health and Nutrition Survey. Nutrients, 2018 Jan 24;10(2). pii:E115.

[2] He YN, Zhao LY, Yu DM, et al. Consumption of fruits and vegetables in Chinese adults from 2010 to 2012. Chinese Journal of Preventive Medicine, 2016,50(3):221-224.

Rates on intake of fruits among urban residents in 2012 were about 50% in females and 40% in males. They were even lower among rural males and females (Figure 2-7-6). The proportion of adults whose consumption of fruits reached Chinese dietary guidelines recommended level (200g/day) were only 2%-5% in urban areas, and was even lower in rural areas [1] (Figure 2-7-7).

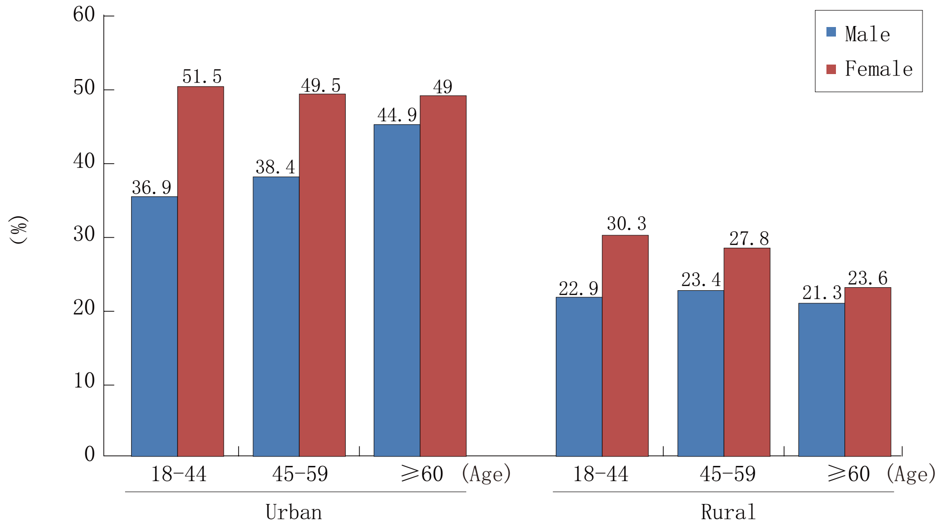
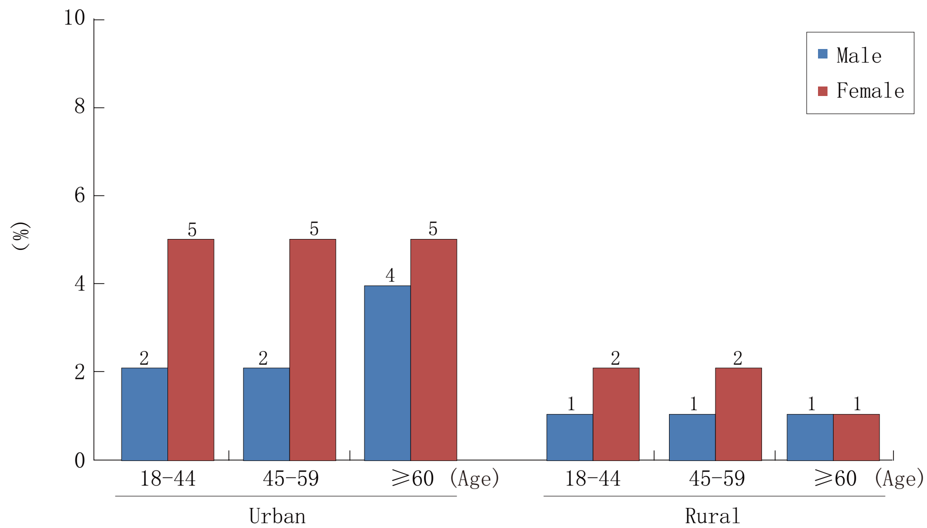


Figure 2-7-6 Rates on regular intake of fruits among Chinese residents by age, gender and region in 2012 (%)



[1] He YN, Zhao LY, Yu DM, et al. Consumption of fruits and vegetables in Chinese adults from 2010 to 2012. Chinese Journal of Preventive Medicine, 2016,50(3):221-224.

Figure 2-7-7 Proportion of adults whose consumption of fruits reached Chinese dietary guidelines recommended level by age, gender and region in 2012 (%)

Consumption of vegetables and fruits is even less optimistic among Chinese children and adolescents. Results from 2012 CHNS involving more than 29 000 children aged 6-17 years [1] showed that the median intake of vegetables and fruits was 121.7 g/day and 97.9 g/day, respectively. The proportion of children whose consumption less than once per day was 18.1% for vegetables and 59.2% for fruits. There was merely 14.0% of participants whose consumption of vegetables reached Chinese dietary guidelines recommended level (300 g/day), which was significantly lower than that of the adult population.Although the proportion of children whose consumption of fruits reached recommended level(150 g/day) was significantly higher than that of adults, it was only 32.5%. In addition, the younger the children, the lower the proportion meeting the recommended consumption level of vegetables and fruits (Figure 2-7-8).

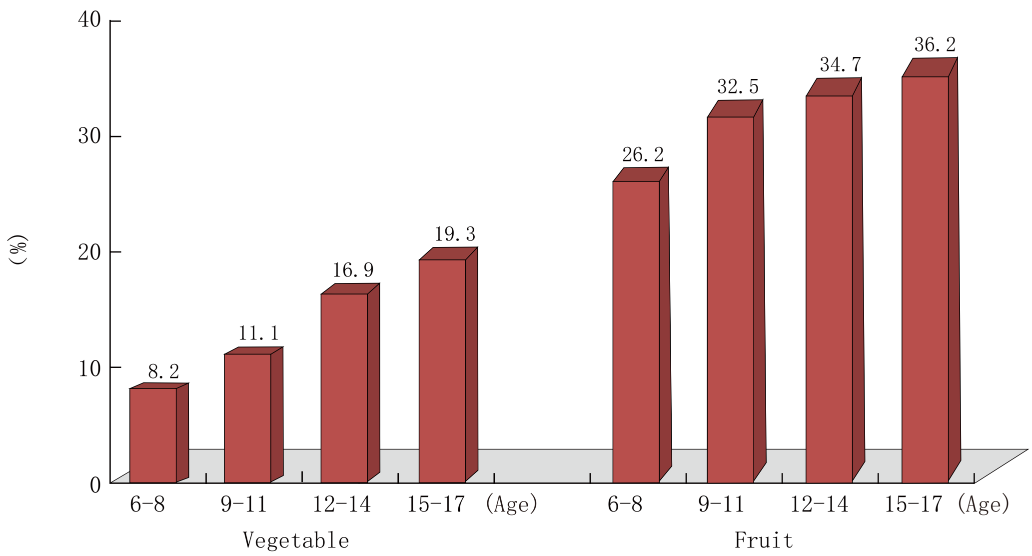


Figure 2-7-8 Proportion meeting the recommended consumption level of vegetables and fruits by Chinese dietary guidelines among Chinese children aged 6-17 years in 2012

2.7.2 Association of Dietary Nutrition with CVD and Associated Risk Factors

Analyses were conducted in 2011 on the data of 5 659 participants aged 18-64 years (free of hypertension, CVD and cancer at baseline) in the 2006 wave of CHNS. Results showed an inverse association of vegetable and fruit intake with incident hypertension (Table 2-7-3). Compared with the relative risk of hypertension in the lowest quintile group of vegetable and fruit intake, that in the highest quintile group was reduced by 27% (HR=0.73, 95CI: 0.53-0.99) .[2]

[1] Xu BB, Hu XQ, Pan H, et al.The status of vegetables and fruits consumption of children aged 6 to 17-year-old from 2010 to 2012, China. Chinese Journal of Preventive Medicine, 2018,(5):552-555.

[2] Liu MW, Yu HJ, Yuan S, et al. Association between fruit and vegetable intake and the risk of hypertension among Chinese

Table 2-7-3 Association of vegetable and fruit intake with incident hypertension

	Quintile group of vegetable and fruit intake*					P for trend
	1st quintile (n=1 312)	2nd quintile (n=1 304)	3rd quintile (n=1 286)	4th quintile (n=1 323)	5th quintile (n=1 301)	
Incidence (%)	16.5	15.6	14.5	15.2	14.7	
HR	1.00	0.74	0.65	0.68	0.73	0.055
95%CI	-	0.55-0.99	0.48-0.88	0.50-0.92	0.53-0.99	

Note: *The cutoff of vegetable and fruit intake for classification of each quintile group was 243.33, 326.67, 405.00 and 520.83 g/day, respectively.

Cox regression analysis was used for adjustment of age, gender, area (rural/urban), total calories at baseline, smoking, alcohol consumption, leisure-time physical activity, and intake of grain, red meat and sugar-sweetened beverages

Large cohort studies, such as CKB,[1] Shanghai Male Health Study, and Shanghai Female Health Study,[2] confirmed that increase of vegetable and fruit intake was associated with a reduction of CVD. According to the data from China Chronic Disease and Risk Factors Surveillance (CCDRFS) in 2013, the number of deaths attributable to low fruit intake was 1.3484 million among people ⩾aged 25 years in China, accounting for 15% of the total deaths, and 79.4% of the deaths (1.0703 million) were caused by IHD and stroke .[3] Therefore, changing the current status of inadequate intake of vegetables and fruits in Chinese residents is one of the key measures to prevent CVD.

A study that included 954 participants aged 35-59 years explored the relationship between dietary sodium and potassium and the risk of CVD. Each participant collected their overnight urine for 6 times, and the average urinary sodium and potassium were calculated for 8 hours excretion to estimate the intake. After a median of 18.6 years of follow-up, data showed that high urinary sodium excretion was significantly associated with an increased risk of CVD (including CHD and stroke events) (Table 2-7-4). The hazard ratio for CVD events in the highest sodium excretion tertile was 3 times of that in the lowest tertile (HR=3.04, 95%CI: 1.46-6.34) .[4]

adults: a longitudinal study. Eur J Nut, 2018,57(7):2639-2647.
[1] Du H, Li L, Bennett D, et al. Fresh fruit consumption and major cardiovascular disease in China. N Engl J Med, 2016,374(14):1332-1343.
[2] Yu D, Zhang X, Gao YT, et al. Fruit and vegetable intake and risk of CHD: results from prospective cohort studies of Chinese adults in Shanghai. Br J Nutr, 2014,111(2):353-362.
[3] Qi JL, Liu YN, Zhou MG, et al. Mortality attributable to inadequate intake of fruits among population aged 25 and above in China,2013. Chin J Epidemiol, 2017,(8):1038-1042.
[4] Liu H, Gao X, Zhou L, et al. Urinary sodium excretion and risk of cardiovascular disease in the Chinese population: a prospective study. Hypertens Res, 2018,41(10):849-855.

Table 2-7-4 Association of overnight urinary sodium excretion with cardiovascular events

	Tertiles of urinary sodium excretion			P for trend
	T1 (N=318)	T2 (N=318)	T3 (N=318)	
No. of events	12	23	46	
Incidence (1/1 000-person year)	2.21	4.26	8.75	
HR(95%CI)	1.00 (Ref)	1.66 (0.79-3.47)	3.04 (1.46-6.34)	<0.001

Note: The cutoff of overnight urinary sodium excretion for classification of each tertile group was 44.52 mmol/8h and 66.70 mmol/8h, respectively.
Cox regression analysis was used for adjustment of age, gender, area (urban or rural), region (north or south), educational level, type of work, smoking, alcohol consumption, BMI, SBP, antihypertension, and percentage of energy from saturated fat at baseline

This study also found that overnight urinary sodium to potassium ratio was positively associated with the risk of cardiovascular events (Table 2-7-5) [1] . High sodium and low potassium intake were both independent risk factors of CVD. In 2013, 1.43 million deaths in China were attributable to diet high in sodium, accounting for 15.6% of all-cause deaths in China [2] .

Table 2-7-5 Association of overnight urinary sodium to potassium ratio with cardiovascular events

	Tertiles of overnight urinary sodium to potassium ratio			P for trend
	T1 (N=318)	T2 (N=318)	T3 (N=318)	
No. of events	13	32	36	
Incidence (1/1 000-person year)	2.37	6.00	6.84	
HR(95%CI)	1.00 (Ref)	2.04 (1.06-3.95)	2.07 (1.07-4.03)	0.058

Note: The cutoff of overnight urinary sodium to potassium ratio for classification of each tertile group was 6.6 and 8.9, respectively.
Cox regression analysis was used for adjustment of age, gender, area (urban or rural), region (north or south), educational level, type of work, physical activity, smoking, alcohol consumption, BMI, serum cholesterol, and SBP at baseline

A study examined the association between the dietary cholesterol intake and stroke incidence. The data were from 5 805 non-stroke participants aged ≥30 years in 1997 and more than one repeated measurements in the following five waves of CHNS. During the mean 11.3 years follow-up, 198 stroke events were ascertained. Multivariate analysis showed that the mean cholesterol intake was insignificantly associated with

[1] Liu HH, Gao XM, Li Y, et al. Relationship between overnight urinary sodium to potassium ratio and the risk of cardiovascular disease. Chin J Cardiol, 2018,46(3):218-223.
[2] Liu SW, Cai Y, Zeng XY, et al. Deaths and life expectancy losses attributable to diet high in sodium in China. Chin J Epidemiol, 2017,(8):1022-1027.

stroke (Table 2-7-6). So did the baseline cholesterol intake or time-dependent cholesterol intake.[1] Another prospective cohort study analyzed the data from CHNS and did not find any association between cholesterol intake and incidence of MI either [2] .

Table 2-7-6 Effect of dietary cholesterol intake on stroke incidence

	Quintile group of mean cholesterol intake (mg/d)				
	1st quintile	2nd quintile	3rd quintile	4th quintile	5th quintile
Intake (median)	70.1	146.9	218.3	397.8	425.9
No. of events	43	35	32	50	38
Incidence (%)	3.3	2.6	2.4	3.7	3.2
RR (95%CI)	1.00	0.81 (0.50-1.31)	0.64 (0.39-1.07)	0.91(0.58-1.45)	0.69 (0.42-1.15)

Note: Cox regression analysis was used for adjustment of age, gender, area (rural/urban), smoking, alcohol drinking, waist circumference, prevalent hypertension, diabetes mellitus, and total energy intake

In addition, two studies explored the association of egg intake and the risk of CVD. One study included more than 28 000 participants aged ≥50 years without CVD at baseline in Guangzhou Biobank Cohort Study. During an average of 9.8-year follow-up, the study found that egg consumption at baseline was not associated with increase in CVD or all-cause mortality (Table 2-7-7) .[3]

Table 2-7-7 Association of egg consumption with CVD or all-cause mortality (n=28 024)

	Egg consumption (per week)					P for trend
	<1	1-2	3-4	5-6	≥7	
All-cause						
Mortality	106.5	92.6	95.0	92.0	109.2	
HR (95%CI)	1.00	0.99 (0.90-1.10)	0.99 (0.89-1.10)	0.89 (0.73-1.07)	1.08 (0.93-1.24)	0.73
CVD						
Mortality	35.0	30.7	30.3	29.0	34.0	
HR (95%CI)	1.00	0.92 (0.77-1.10)	0.96 (0.80-1.14)	0.81 (0.58-1.14)	0.99 (0.76-1.27)	0.99

[1] Huang FF, Zhang J, Wang HJ, et al. Effect of dietary cholesterol intake on stroke incidence among Chinese adults: evidence from China Health and Nutrition Survey. J Hygiene Res, 2016,45(3):383-387.

[2] Jiang HR, Zhang J, Huang FF, et al. Effect of dietary cholesterol intake on myocardial infarction incidence among people above 30 years old. Chinese Journal of Public Health Management, 2016,32(6):866-869.

[3] Xu L, Lam TH, Jiang CQ, et al. Egg consumption and the risk of cardiovascular disease and all-cause mortality: Guangzhou Biobank Cohort Study and meta-analyses. Eur J Nutr, 2019,58(2):785-796.

Table 2-7-7 Association of egg consumption with CVD or all-cause mortality (n=28 024) (Continued)

	Egg consumption (per week)					P for trend
	<1	1-2	3-4	5-6	≥7	
IHD						
Mortality	14.5	13.7	14.8	11.6	14.8	
HR (95%CI)	1.00	0.86 (0.66-1.13)	1.03 (0.79-1.34)	0.75 (0.44-1.27)	0.92 (0.63-1.36)	0.88
Stroke						
Mortality	14.6	12.1	11.3	11.6	11.6	
HR (95%CI)	1.00	0.99 (0.75-1.30)	0.90 (0.68-1.20)	0.81 (0.47-1.38)	0.88 (0.57-1.35)	0.38
Ischemic stroke						
Mortality	3.5	4.3	4.4	2.2	3.1	
HR (95%CI)	1.00	0.72 (0.43-1.21)	0.94 (0.59-1.52)	0.43 (0.13-1.38)	0.63 (0.28-1.41)	0.54
Hemorrhagic stroke						
Mortality	4.5	2.9	3.9	2.9	3.6	
HR (95%CI)	1.00	1.18 (0.70-1.99)	1.37 (0.81-2.30)	0.95 (0.34-2.68)	1.31 (0.60-2.84)	0.67

Note: Mortality is expressed as per 10 000 person-years.
Cox regression analysis was used for adjustment of age, gender, educational level, occupation, household income, smoking, alcohol consumption, physical activity, self-assessed health status, diabetes mellitus, prevalent hypertension and dyslipidemia

Another study used the data from CKB study and documented more than 460 000 participants aged 30-79 years free of prior CVD. After a median follow-up of 8.9 years, results showed that daily egg consumption was negatively associated with risk of CVD (P for linear trend <0.001) (Table 2-7-8). Each one egg increment per week was associated with a reduction of CVD risk by 3% (HR=0.97, 95%CI: 0.96-0.98) .[1] Both above studies concluded that eating one egg daily (a 60-gram egg contains about 300 mg of cholesterol) would not increase the risk of CVD events or deaths.

［1］Qin C, Lv J, Guo Y, et al. Associations of egg consumption with cardiovascular disease in a cohort study of 0.5 million Chinese adults. Heart, 2018,104(21):1756-1763.

Table 2-7-8 Association of egg consumption with CVD events (n=461 213)

	Egg consumption					P for trend
	Never/rarely	1-3 days/ month	1-3 days/week	4-6 days/week	7 days/week	
CVD						
Incidence	227	219	208	208	236	
HR (95%CI)	1.00	0.97 (0.95-1.00)	0.92 (0.90-0.94)	0.90 (0.87-0.93)	0.89 (0.87-0.92)	<0.001
IHD						
Incidence	77	67	70	71	97	
HR (95%CI)	1.00	0.95 (0.91-0.99)	0.92 (0.88-0.96)	0.86 (0.81-0.91)	0.88 (0.84-0.93)	<0.001
Ischemic stroke						
Incidence	76	67	65	60	77	
HR (95%CI)	1.00	0.98 (0.94-1.03)	0.95 (0.91-1.00)	0.95 (0.90-1.00)	0.90 (0.85-0.95)	<0.001
Haemorrhagic stroke						
Incidence	25	19	16	17	13	
HR (95%CI)	1.00	0.86 (0.79-0.93)	0.82 (0.76-0.88)	0.77 (0.70-0.86)	0.74 (0.67-0.82)	<0.001

Note: Incidence is expressed as per 10 000 person-years.
Stratified Cox proportional models were used with stratification on survey site and birth cohort.
Multivariate models were adjusted for age at baseline, sex, education level, household income, marital status, alcohol consumption, tobacco smoking, physical activity, BMI, waist to hip ratio, prevalent hypertension, use of aspirin, family history of CVD, intake of multivitamin supplementation, and dietary pattern (traditional northern, traditional southern and new model of affluence)

The latest dietary guidelines in China and some other countries have withdrawn the recommendation of daily cholesterol intake not more than 300mg due to insufficient evidence supporting this restriction, but it does not mean that dietary cholesterol is irrelevant to our health. More high-quality studies are needed to explore its impact on CVD. Dietary guidelines should pay more attention to the rationality of the overall dietary pattern. Considering the complexity of daily meals, the impact of diet on CVD should be assessed from a more comprehensive perspective.

2.8 Multiple Risk Factors for Cardiovascular Diseases

CVD is the synergetic result of multiple risk factors, and the clustering of multiple risk factors in the Chinese population is very common. Therefore, prevention and treatment of CVD should focus on the comprehensive control of multiple risk factors. Metabolic syndrome (MS) is a pathological condition in which a variety of metabolic components are abnormally gathered, including central obesity, hyperglycemia, hypertriglyceridemia, and hypertension. Each component of MS is a risk factor for CVD, and their combined effects are more harmful. The burden of CVD would be alleviated as the healthy lifestyle factors increased.

At present, the guidelines for diagnosing MS include the China Diabetes Society (CDS) for MS, the Joint Committee for Developing Chinese Guidelines on Prevention & Treatment of Dyslipidemia in Adults (GCDCJ), the National Cholesterol Education Program's Adult Treatment Panel III (NCEP-ATP III) on Monitoring, Evaluation & Treatment of Dyslipidemia in Adults, the guidelines from the International Diabetes Federation (IDF), and International Federation of Societies (JIS) Statement on Diagnostic Criteria.

According to the American Heart Association's suggestion,[1] the concept of ideal cardiovascular health is characterized by 7 metrics: including 3 ideal health factors (total cholesterol <200 mg/dL, blood pressure <120/<80 mmHg, and fasting blood glucose <100 mg/dL, in the absence of drug treatment), and 4 health behaviors (not smoking, normal body weight, sufficient physical activity and healthy diet pattern). Based on the recommendation from Chinese guidelines, ideal cardiovascular health includes: the ideal BMI is defined as BMI <24 kg/m^2; the ideal smoking status is defined as never smoking or quit-smoking for over 1 year; the ideal physical activity is defined as at least 150 minutes of moderate-intensity aerobic exercise or 75 minutes of high-intensity aerobic exercise per week; the ideal diet pattern is defined as meeting more than four dietary standards of dietary guidelines.

2.8.1 Metabolic Syndrome

2.8.1.1 Prevalence of Metabolic Syndrome in Adults

The 2002 CHNS reported that the prevalence of MS in adults aged ≥18 years, based on the criteria from the CDS and the NCEP-ATP III, was 6.6% and 13.8%, respectively. China National Health and Nutrition Surveillance Project (2010-2012) is a cross-sectional study, a total of 104 098 participants aged ≥18 years were recruited from 150 monitoring sites across 31 provinces, municipalities, and autonomous regions in China. The overall prevalence of MS was 11.0% based on the diagnostic criteria of CDS.[2] Another study included 98 658 Chinese adults aged ≥18 years from 31 provinces, municipalities, and autonomous regions in China. The prevalence of MS was 33.9% according to the ATP III criteria.[3] The prevalence of MS in different regions by different diagnostic definitions is listed in Table 2-8-1.

[1] Lloyd-Jones DM, Hong Y, Labarthe D, et al. Defining and setting national goals for cardiovascular health promotion and disease reduction: the American Heart Association's strategic Impact Goal through 2020 and beyond. Circulation, 2010,121:586-613.

[2] He YN, Zhao WH, Zhao LY, et al. Prevalence of metabolic syndrome in Chinese adults in 2010-2012. Chinese Journal of Epidemiology, 2017,38:212-215.

[3] Lu J, Wang L, Li M, et al. Metabolic Syndrome among Adults in China-The 2010 China Noncommunicable Disease Surveillance. J Clin Endocrinol Metab, 2017,102:507-515.

Table 2-8-1 Prevalence of MS in adults aged ≥18 years in different regions (%)

Region	Year	N	Prevalence (%)		
			CDS/GCDCJ	IDF	JIS
Nationwide[1]	2007-2008	46 239	17.89		
33 communities[2]	2009	15 477			30.37
Ningxia[3]	2013	10 639	17.4/14.7*		46.2
Jiangxi[4]	2013-2014	5 959	9.95*（CDS）	19.85*	

*standardized rate

2.8.1.2 Prevalence of Metabolic Syndrome among Children and Adolescents

The 2010-2012 Chinese Nutrition and Health Surveillance included 16 872 children and adolescents aged 10-17 years in 150 monitoring sites across 31 provinces, municipalities, and autonomous regions in Mainland China. According to the diagnostic criteria proposed by the Chinese Medical Association Pediatrics Branch (the Chinese criteria), the weighted prevalence of MS was 2.4%. The prevalence in urban areas was higher than that in rural areas (2.8% vs 1.9%). The prevalence rates in boys and girls were 2.7% and 2.0%, respectively. Based on the Cook criteria, the weighted prevalence was 4.3%.[5]

Another study investigated the prevalence of MS among 9 296 children and adolescents aged 10-16 years in 7 provinces in China (Guangdong, Hunan, Liaoning, Shanghai, Chongqing, Tianjin, and Ningxia). According to the metabolic syndrome standards for Chinese children and adolescents, the prevalence of MS was 4.1%. The prevalence of MS in boys was 5.0%, which was significantly higher than that in girls (3.2%). The standardized prevalence of MS was the highest in Tianjin (9.2%) and the lowest in Hunan province (0.8%)[6].

2.8.1.3 Metabolic Syndrome Risk Factors

Air pollution and metabolic syndrome: 33 Communities Chinese Health Study involving a total of

[1] Xing Y, Xu S, Jia A, et al. Recommendations for revision of Chinese diagnostic criteria for metabolic syndrome: A nationwide study. J Diabetes, 2018,10(3):232-239.

[2] Yang BY, Qian ZM, Li S, et al. Long-term exposure to ambient air pollution (including PM1) and metabolic syndrome: The 33 Communities Chinese Health Study (33CCHS). Environmental Research. 2018,164:204-211.

[3] Wang T, Zhang HD, Lu QL. The prevalence of metabolic syndrome among adults in rural areas of Ningxia Hui autonomous region. Chin J Intern Med, 2017,56(6):409-413.

[4] Cheng L, Yan W, Zhu L, et al. Comparative analysis of IDF, ATPIII and CDS in the diagnosis of metabolic syndrome among adult inhabitants in Jiangxi Province, China. PLoS One, 2017,12(12):e0189046.

[5] He N, Zhao W, Zhao L, et al. The epidemic status of metabolic syndrome among Chinese adolescents aged 10-17 years in 2010-2012. Chin J Prev Med, 2017,51:513-518.

[6] Wang Z, Zou Z, Wang S.Analysis of the epidemiological characteristics of metabolic syndrome among 10-16 adolescents in 7 provinces in China 2012. Chin J Prev Med, 2017,51:295-299.

15 477 subjects showed that the prevalence of MS was 30.37%. The adjusted odds ratio of MS for each 10 μg/m^3 increase in PM_1, $PM_{2.5}$, PM_{10}, SO_2, NO_2, and O_3 were 1.12 (95%CI: 1.00-1.24), 1.09 (95%CI; 1.00-1.18), 1.13 (95%CI: 1.08-1.19), 1.10 (95%CI: 1.02-1.18), 1.33 (95%CI: 1.12-1.57), and 1.10 (95%CI: 1.01-1.18), respectively [1] .

Uric acid and metabolic syndrome: A study involving 1 903 Yi ethnic residents from the Liangshan region showed that the level of uric acid was positively correlated with metabolic syndrome. After adjusting for various risk factors, the relative risk of MS increased with uric acid level. For each 1 mg/dl increase in uric acid level, the risk of metabolic syndrome increased by 41% and 62% in males and females, respectively.[2]

Famine in early life and metabolic syndrome: A cohort study involving 7 915 participants showed that exposure to famine in early life was associated with the risk of metabolic syndrome in adulthood. The metabolic syndrome prevalence rates in non-, fetal- (born in 1959.10.1-1961.9.30), early-childhood- (born in 1956.10.1-1958.9.30), mid-childhood- (born in 1954.10.1-1956.9.30), and late-childhood- (born in 1952.10.1-1954.9.30) famine groups were 25.2%, 26.9%, 30.3%, 32.7%, and 32.7%, respectively. Compared with the non-famine group, the relative risk of MS for participants exposed to famine in the fetal, early-childhood, mid-childhood, and late-childhood groups were 0.96 (95%CI: 0.77-1.20), 1.24 (95%CI: 1.01-1.52), 1.39 (95%CI: 1.13-1.72), and 1.33 (95%CI: 1.08-1.63), respectively.[3]

2.8.2 Ideal Cardiovascular Health

2.8.2.1 Healthy Behaviors and Healthy Factors

The CKB cohort was established in China during 2004 to 2008. Of 461 211 participants aged 30 to 79 years, 1.0%, 13.7% and 41.3% had at least 5, 4, and 3 low-risk lifestyle factors, respectively.[4]

2.8.2.2 Healthy Lifestyle and CVD

The CKB cohort included 461 211 adults between 30 to 79 years of age .[4] During a median of 7.2 years of follow-up, the study documented 3 331 incident major coronary events (including 2 179 IHD deaths and 1 152 non-fatal myocardial infarction), 19 348 ischemic stroke cases. The study showed that the risk would decrease by 58% for major coronary event, 43% for IHD, and 39% for ischemic stroke if participants had 4 or more low-risk factors including non-smoker or quit-smoking, alcohol intake <30 g/day, diet rich in vegetables and fruits, limited in red meat, and normal weight. The risks of major coronary event, IHD, and

[1] Yang B, Qian Z, Li S, et al. Long-term exposure to ambient air pollution (including PM1) and metabolic syndrome: The 33 Communities Chinese Health Study (33CCHS). Environmental Research, 2018,164:204-211.

[2] Huang S, Liu X, Li H, et al. Sex difference in the association of serum uric acid with metabolic syndrome and its components: a cross-sectional study in a Chinese Yi population. Postgrad Med, 2017,129(8):828-833.

[3] Yu C, Wang J, Wang F, et al. Victims of Chinese famine in early life have increased risk of metabolic syndrome in adulthood. Nutrition, 2018,53:20-25.

[4] Lv J, Yu C, Guo Y, et al. Adherence to Healthy Lifestyle and Cardiovascular Diseases in the Chinese Population. J Am Coll Cardiol, 2017,69:1116-1125.

ischemic stroke decreased significantly with an increasing number of any low-risk factors in the whole cohort (Figure 2-8-1).

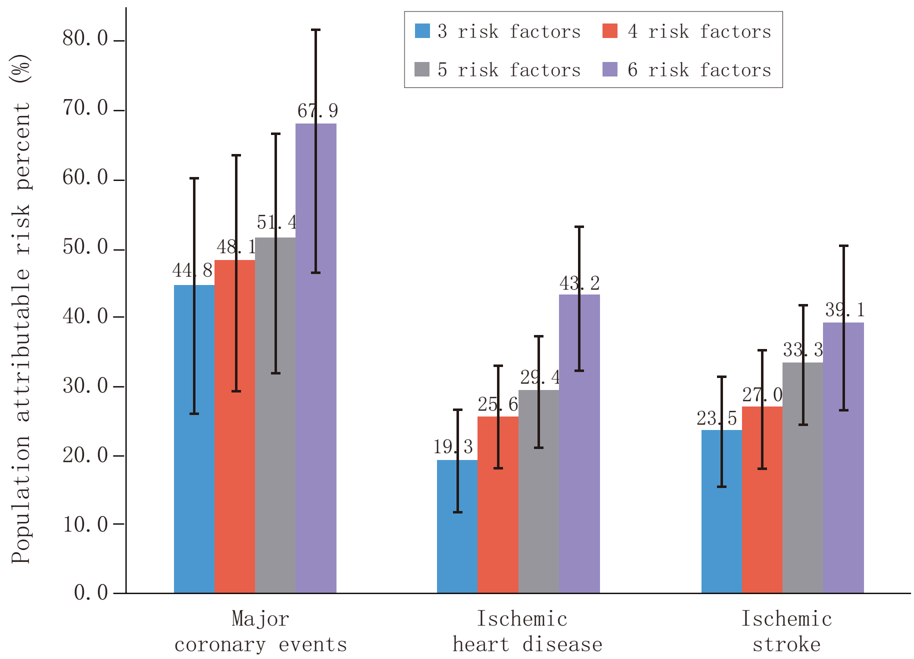


Figure 2-8-1 Healthy lifestyle and cardiovascular diseases in China

The China-PAR project was conducted among 93 987 adults with the longest follow-up of 17 years. Compared with participants having ≤2 ideal cardiovascular health metrics, the risk of atherosclerotic CVD (ASCVD) events among participants with 3, 4, 5, 6, and 7 ideal metrics decreased by 17%, 34%, 45%, 56%, and 76%, respectively. If the Chinese can achieve the ideal cardiovascular health metrics, approximately 62.1% of total ASCVD could be prevented, including 38.7% of CHD, 66.4% of stroke, and 60.5% of ASCVD deaths.[1]

2.9 Air Pollution

The findings from the GBD 2010 for China showed that ambient air pollution and household air pollution ranked the fourth and fifth leading risk factors for burden of disease in China, the attributable DALY was 25 227 000 and 21 292 000, respectively.[2] Air pollutants can be classified as particulate matter (PM) or gaseous pollutants. According to the diameters of particles, pollutants with the diameters of 2.5-10.0 μm are coarse particulate matter, and those with the diameters ≤ 2.5 μm are fine particulate matter. Gaseous

[1] Han C, Liu F, Yang X, et al. Ideal cardiovascular health and incidence of atherosclerotic cardiovascular disease among Chinese adults: the China-PAR project. Sci China Life Sci, 2018,61:504-514.

[2] Yang G, Wang Y, Zeng Y, et al. Rapid health transition in China, 1990-2010: findings from the Global Burden of Disease Study 2010. Lancet, 2013,381(9882):1987-2015.

pollutants include oxynitride (NOx), sulfur dioxide (SO_2), carbon monoxide (CO) and ozone (O_3), etc. Numerous studies have indicated that air pollution is a modifiable risk factor for CVD, and $PM_{2.5}$ has significant association with CVD .[1] The fuels leading to household air pollution mainly include biomass fuels (animal waste, wood, charcoal, firewood, and crop waste), coal, kerosene and paraffin, etc.

2.9.1 Air Pollution in China

Based on data from 945 monitoring sites in 190 cities in 2014, researchers estimated the $PM_{2.5}$ exposure level using statistical data model and showed that the spatial distribution characteristics of $PM_{2.5}$ concentration in China in 2014. The results identified that air pollution was more severe in the eastern region than the western region, and more severe in the northern region than the southern region.[2]

Study on seasonal variation and influencing factors of air pollution: The results of a study based on air quality data from 361 cities in 2016 showed a U-shaped monthly variation of air quality, which means that air is less polluted in the summer but more polluted in the winter, witnessing a trend of decline in spring while increase in autumn. In addition, population agglomeration, industrialization and enormous energy consumption obviously aggravate air pollution. Moreover, the population density, energy consumption, proportion of secondary industries, and the number of civil motor vehicles have negative influence on air quality.[3]

Study on the use of household polluting fuels: A study analyzed the use of household polluting fuels using data from 75 075 residents aged ≥40 years. In 2014, the proportion of Chinese families using polluting fuels for cooking or heating was 59.9%, the proportion using only biomass fuels was 25.9%, the proportion using only coal fuel was 18.9% and the proportion of using both biomass and coal fuels was 15.1%.[4]

2.9.2 Short-Term Effects of Air Pollution on CVD

Short-term effects of air pollution are defined as the effects of air pollution on CVD within several hours or days.

［1］Brook RD, Rajagopalan S, Pope CA 3rd, et al. Particulate matter air pollution and cardiovascular disease: An update to the scientific statement from the American Heart Association. Circulation, 2010,121(21):2331-2378.

［2］Ayubi E, Safiri S. Assessment of population exposure to $PM_{2.5}$ for mortality in China and its public health benefit based on BenMAP: Biases due to spatial auto correlation and the modifiable areal unit problem (MAUP). Environ Pollut, 2017,223:635. doi:10.1016/j.envpol.2017.01.069.

［3］Y Xiao, YZ Tian, WX Xu, et al. Study on the spatio temporal characteristics and socioeconomic driving factors of air pollution in China. Ecology and Environmental Sciences, 2018,27(3):518-526.

［4］YJ Feng, J Fan, S Cong, et al. Current status of household polluting fuel use in adults aged 40 years and older in China, 2014. Chinese Journal of Epidemiology, 2018,39(5):569-573.

2.9.2.1 The Relationship between $PM_{2.5}$ Concentration and CVD Mortality

The dose-response relationship between $PM_{2.5}$ and daily CVD mortality was assessed in multiple cities in China by using average daily $PM_{2.5}$ concentrations and death surveillance data. The study results are summarized in Table 2-9-1.

Table 2-9-1 Relationship between $PM_{2.5}$ concentrations and CVD mortality

Monitoring time	Region	Average daily $PM_{2.5}$ (μg/m^3)	Outcome indicator/N	Increase of CVD mortality with every 10 μg/m^3 elevation in $PM_{2.5}$ (95%CI)
2006-2011	Shanghai[1]	55	Mortality of out-of-hospital coronary heart diseases /18 202	0.68% (0.14%-1.21%)
2009-2011	Guangzhou[2]	41.4	CVD mortality/33 721	With every IQR (31.5 μg/m^3) increase, CVD mortality increases 6.11% (1.76%-10.64%)
2010-2012	Beijing[3]	96.2	Mortality of IHD/53 247	0.25% (0.10%-0.40%).
2009-2012	Beijing[4]	84.9	IHD AMI Cerebrovascular disease CVD	Mortality risk increases 0.39% (0.21% - 0.59%) 0.46% (0.19% - 0.72%) 0.41% (0.07% - 0.75%) 0.35% (0.1% - 0.75%)
2013-2015	7 cities[5] Shijiazhuang Harbin Shanghai Wuhan Guangzhou Chengdu Xi' an	 117.99 72.75 56.38 79.55 46.25 72.49 78.68	CVD mortality	 0.285% (0.102%-0.468%) 0.136% (-0.049%-0.321%) 0.294% (0.041%-0.548%) 0.442% (0.053%-0.832%) 1.422% (0.846%-1.999%) 0.135% (-0.149%-0.419%) 0.170% (-0.076%-0.417%)
2013-2015	272 Cities[6]	56 (18-127)	CVD mortality CHD mortality Stroke mortality	0.27% (0.18%-0.36%) 0.30% (0.19%-0.40%) 0.23% (0.13%-0.34%)

[1] Dai J, Chen R, Meng X, et al. Ambient air pollution, temperature and out-of-hospital coronary deaths in Shanghai. China. Environ Pollut, 2015,203:116-121.

[2] Lin H, Tao J, Du Y, et al. Particle size and chemical constituents of ambient particulate pollution associated with cardiovascular mortality in Guangzhou, China. Environ Pollut, 2016,208:758-766.

[3] Xie W, Li G, Zhao D, et al. Relationship between fine particulate air pollution and ischemic heart disease morbidity and mortality. Heart, 2015,101:257-263.

[4] Li T, Yan M, Sun Q, et al. Mortality risks from a spectrum of causes associated with wide-ranging exposure to fine particulate matter: A case-crossover study in Beijing, China. Environ Int, 2018,111:52-59.

[5] Liang RM, Yin P, Wang LJ, et al. Acute effect of fine particulate matters on daily cardiovascular disease mortality in seven cities of China. Chinese J Epidemiol, 2017,38(3):283-289.

[6] Chen R, Yin P, Meng X, et al. Fine particulate air pollution and daily mortality: A nationwide analysis in 272 Chinese cities. Am J Respir Crit Care Med, 2017,196(1):73-81.

Table 2-9-1 Relationship between $PM_{2.5}$ concentrations and CVD mortality (Continued)

Monitoring time	Region	Average daily $PM_{2.5}$ ($\mu g/m^3$)	Outcome indicator/N	Increase of CVD mortality with every 10 $\mu g/m^3$ elevation in $PM_{2.5}$ (95%CI)
2013-15	Beijing[1]	76.0 (5.0-476.0)	Out-of-hospital cardiac arrest/4 720	risk of cardiac arrest increases 0.7% (0.4%-1.0%)
2013-15	30 districts/ counties in major cities[2]	71.67	CVD mortality/164 061 CHD mortality/69 041 AMI mortality/26 089 Stroke mortality/49 669	Mortality risk increases 0.12% (0.001-0.25) 0.17% (−0.04-0.40) 0.42% (0.03-0.81) 0.13% (−0.12-0.33)

2.9.2.2 Relationship between $PM_{2.5}$ Concentration and CVD Incidence/ClinicVisits

The majority of CVD patients survive due to prompt treatment in the acute phase of their disease. Therefore, in comparison with CVD mortality, CVD incidence can reflect the short-term effects of air pollution on CVD more comprehensively. Study results displaying the correlation between an increase of 10$\mu g/m^3$ in average daily $PM_{2.5}$ concentrations and CVD incidence/clinic visits are summarized in Table 2-9-2.

Table 2-9-2 Relationship between $PM_{2.5}$ concentrations and CVD incidence/clinic visits

Monitoring time	Region	$PM_{2.5}$ ($\mu g/m^3$)	Outcome indicator/N	Increase of CVD risk (95%CI) with every 10$\mu g/m^3$ elevation in $PM_{2.5}$
2010-2012	Beijing[3]	Mean 96.2	IHD incidence/369 469	0.27% (0.21%-0.33%)
2005-2012	Shanghai[4]	Mean 38.61	CHD incidence/619 928	A 10 $\mu g/m^3$ increase in the 2-day $PM_{2.5}$, CHD incidence increased 0.74% (0.44%-1.04%)
2013-2014	Shanghai[5]	Maximum 167.0	AMI Hospitalizations/972	OR for AMI was 1.16 (1.03-1.29) for every IQR increased
2013	Beijing[6]	Mean 102.1	CVD emergency visits/ 56 221 IHD Arrhythmia Heart failure	Daily CVD emergency visits increase 0.30% (0.09%-0.52%) 0.56% (016%-0.95%) 0.81% (0.05%-1.57%) 1.21% (0.27%-2.15%)

[1] Xia R, Zhou G, Zhu T, et al. Ambient Air Pollution and Out-of-Hospital Cardiac Arrest in Beijing, China. Int J Environ Res Public Health, 2017 Apr 14;14(4). pii: E423. doi: 10.3390/ijerph14040423.

[2] Chen C, Zhu P, Lan L, et al. Short-term exposures to $PM_{2.5}$ and cause-specific mortality of cardiovascular health in China. Environ Res, 2018,161:188-194.

[3] Xie W, Li G, Zhao D, et al. Relationship between fine particulate air pollution and ischemic heart disease morbidity and mortality. Heart, 2015,101:257-263.

[4] Ye X, Peng L, Kan H, et al. Acute Effects of Particulate Air Pollution on the Incidence of Coronary Heart Disease in Shanghai, China. PLoS One, 2016,11 (3):e0151119.

[5] Wang XD, Zhang XM, Zhuang SW, et al. Short-term effects of air pollution on acute myocardial infarctions in Shanghai, China, 2013-2014. J Geriatr Cardiol, 2016,13(2):132-137.

[6] Xu Q, Wang S, Guo Y, et al. Acute exposure to fine particulate matter and cardiovascular hospital emergency room visits in Beijing, China. Environ Pollut, 2017,220:317-327.

Table 2-9-2 Relationship between $PM_{2.5}$ concentrations and CVD incidence/clinic visits (Continued)

Monitoring time	Region	$PM_{2.5}$ (μg/m^3)	Outcome indicator/N	Increase of CVD risk (95%CI) with every 10μg/m^3 elevation in $PM_{2.5}$
2013-2015	Guangzhou[1]	Median 41.0	Hospitalization for ischemic stroke/95 562	With every IQR increase, risk of hospitalization increased 2.72% (1.77%-3.68%).
2014-2015	26 cities[2]	Mean 63.5	Hospitalization for ischemic stroke/278 980	With every IQR (47.5 μg/m3) increase, risk of hospitalization increased 1.0% (0.7%-1.4%).
2014-2015	26 cities[3]	Mean 63.5	Hospitalization for heart failure/105 501	With every IQR increase, hospitalization for heart failure increased 1.2% (0.5%-1.8%).

2.9.2.3 The Relationship between Gaseous Pollutants and CVD

Studies on the relationship between gaseous pollutants [oxynitride (NOx), sulfur dioxide (SO_2), carbon monoxide (CO) and ozone (O_3), etc.] and CVD from 2006-2015 are summarized in Table 2-9-3.

Table 2-9-3 Studies on the relationship between gaseous pollutants and CVD

Monitoring time	Regions	Average concentrations	Outcome indicator/N	Increase of CVD risk with every 10μg/m^3 increase in SO_2 or NO_x (95%CI)
2006-2009	Wuhan[4]	SO_2 53.2μg/m^3 NO_2 53.1μg/m^3	CVD mortality/8 955	RR=1.01 (1.000-1.020); RR=1.019 (1.005-1.033).
2006-2011	Shanghai[5]	SO_2 53μg/m^3 NO_2 62μg/m^3	Mortality of out-of-hospital coronary heart diseases/18 202	0.88% (0.14%-1.62%); 1.60% (0.72%-2.48%).
2007-2011	Lanzhou[6]	SO_2 45.0μg/m^3 NO_2 42.7μg/m^3	In-hospital CVD/11 187	1.03% (0.96%-1.07%) 1.06% (1.02%-1.05%)
2009-2012	Beijing[7]	SO_2 26.6μg/m^3 NO_2 57.5μg/m^3	Emergency hospitalization for CVD/82 430	0.8% (-0.001%-1.8%) 1.4% (0.3%-2.4%)

[1] Guo P, Wang Y, Feng W, et al. Ambient Air Pollution and Risk for Ischemic Stroke: A Short-Term Exposure Assessment in South China. Int J Environ Res Public Health, 2017,14(9). pii: E1091. doi: 10.3390/ijerph14091091.

[2] Liu H, Tian Y, Xu Y, et al. Ambient Particulate Matter Concentrations and Hospitalization for Stroke in 26 Chinese Cities: A Case-Crossover Study. Stroke, 2017,48(8):2052-2059.

[3] Liu H, Tian Y, Song J, et al. Effect of Ambient Air Pollution on Hospitalization for Heart Failure in 26 of China's Largest Cities. Am J Cardiol, 2018,121(5):628-633.

[4] Yisi L, Xi C, Shuqiong H, et al. Association between Air Pollutants and Cardiovascular Disease Mortality in Wuhan, China. Int J Environ Res. Public Health, 2015,12:3506-3516.

[5] Dai J, Chen R, Meng X, et al. Ambient air pollution, temperature and out-of-hospital coronary deaths in Shanghai, China. Environ Pollut, 2015,203:116-121.

[6] Ma Y, Zhang H, Zhao Y, et al. Short-term effects of air pollution on daily hospital admissions for cardiovascular diseases in western China. Environ Sci Pollut Res Int, 2017,24(16):14071-14079.

[7] Ma Y, Zhao Y, Yang S, et al. Short-term effects of ambient air pollution on emergency room admissions due to cardiovascular causes in Beijing, China. Environ Pollut, 2017,230:974-980.

Table 2-9-3 Studies on the relationship between gaseous pollutants and CVD (Continued)

Monitoring time	Regions	Average concentrations	Outcome indicator/N	Increase of CVD risk with every 10μg/m^3 increase in SO_2 or NO_x (95%CI)
2010-12	Shanghai[1]	SO_2 30μg/m^3 NO_2 56μg/m^3	Number of emergency patients with coronary heart disease/47 523	0.90% (-0.14%-1.93%); 1.44% (0.63%-2.26%).
2013-14	Beijing[2]	SO_2 24.5μg/m^3 NO_2 52.5μg/m^3 CO 1.7mg/m^3 O_3 117.5μg/m^3	In-hospital stroke/147 624	0.73% (0.44%-1.03%) 0.82% (0.52%-1.13%) 1.35% (0.60%- 2.11%) 0.23% (0.08%-0.37%)
2010-15	Guangzhou[3]	SO_2 20.57 μg/m^3 NO_2 30.93μg/m^3	CVD mortality /21 816	5.26% (3.31%-7.23%) 2.71% (1.23%-4.22%)
2013-15	Guangzhou[4]	Median SO_2 15.0μg/m^3 NO_2 44.0μg/m^3 O_3 99.0μg/m^3	Hospitalization for ischemic stroke/95 562	With every IQR increase 3.44% (2.53%-4.35%) 4.23%(3.27%-5.20%) 1.73% (0.78%-2.69%)
2013-15	272 cities[5]	O_3 99.0 μg/m^3	CVD mortality Hypertension mortality CHD mortality Stroke mortality	0.27% (0.10%-0.44%) 0.60% (0.08%-1.11%) 0.24% (0.02%-0.46%) 0.29% (0.07%-0.50%)
2014-15	14 major cities[6]	SO_2 39.6μg/m^3 NO_2 46.6μg/m^3 CO 1.28mg/m^3 O_3 91.5μg/m^3	Hospitalization for ischemic stroke/200 958	2.6% (1.8%-3.5%) 1.6% (1.0%-2.3%) 0.5% (-0.2%-1.1%) 1.3% (0.2%-2.3%)
		SO_2 39.6 μg/m^3 NO_2 46.6μg/m^3 CO 1.28mg/m^3 O_3 91.5μg/m^3	Hospitalization for hemorrhagic stroke/41 746	1.4% (-0.4%-3.2%) 0.6% (-0.7%-2%) -0.8% (-2.2%-0.7%) 2% (-0.2%-4.3%)
2014-15	26 cities[7]	SO_2 29.6μg/m^3 NO_2 44.1μg/m^3 CO 1.15mg/m^3 O_3 — —	Hospitalization for heart failure/105 501	With every IQR increase, risk increase: 1.0% (0.2%-1.7%) 1.6% (0.6%-2.5%) 1.2% (0.5%-1.9%) 0.4% (-0.9%-1.7%)

[1] Xie J, He M, Zhu W. Acute effects of outdoor air pollution on emergency department visits due to five clinical subtypes of coronary heart diseases in Shanghai. Chinese J Epidemiol, 2014,24(6):452-459.

[2] Huang F, Luo Y, Tan P, et al. Gaseous Air Pollution and the Risk for Stroke Admissions: A Case-Crossover Study in Beijing, China. Int J Environ Res Public Health, 2017,Feb,14;14(2).pii:E189.doi: 10.3390/ijerph14020189.

[3] Lin H, Tao J, Du Y, et al. Particle size and chemical constituents of ambient particulate pollution associated with cardiovascular mortality in Guangzhou, China. Environ Pollut, 2016,208:758-766.

[4] Guo P, Wang Y, Feng W, et al. Ambient Air Pollution and Risk for Ischemic Stroke: A Short-Term Exposure Assessment in South China. Int J Environ Res Public Health, 2017,14(9).pii: E1091. doi: 10.3390/ijerph14091091.

[5] Yin P, Chen R, Wang L， et al. Ambient Ozone Pollution and Daily Mortality: A Nationwide Study in 272 Chinese Cities. Environ Health Perspect, 2017,125(11):117006. doi: 10.1289/EHP1849.

[6] Liu H, Tian Y, Xu Y， et al. Association between ambient air pollution and hospitalization for ischemic and hemorrhagic stroke in China: A multicity case-crossover study. Environ Pollut, 2017,230:234-241.

[7] Liu H, Tian Y, Song J, et al. Effect of Ambient Air Pollution on Hospitalization for Heart Failure in 26 of China's Largest Cities. Am J Cardiol, 2018,121(5):628-633.

2.9.3 Long-Term Effects of Air Pollution on CVD

It has been reported that long-term air pollution is more harmful than short-term air pollution to CVD. The long-term effects of air pollution on CVD should be evaluated via cohort studies, but domestic investigations are far from sufficient.[1]

24 845 individuals from three regions (Shenyang, Anshan and Jinzhou) were followed up for an average of 3 years in a cohort study. The results revealed that the prevalence of hypertension in males increased by 19% (OR=1.19; 95%CI: 1.05-1.34) for every 20μg/m^3 increase in baseline SO_2 concentrations. However, no statistically significant increase was found in females.[2]

A cohort study in Hong Kong included 66 820 participants aged ≥65 years and analyzed the relationship between baseline air pollution exposure and CVD mortality of follow-up for 10-13 years (from1998-2011). The results indicated that with every 10 μg/m^3 increase in $PM_{2.5}$, CVD mortality increased by 22% (HR=1.22, 95%CI:1.08-1.39), IHD mortality increased by 42% (HR=1.42, 95%CI: 1.16-1.73), and mortality from cerebrovascular disease increased by 24% (HR=1.24, 95%CI: 1.00-1.53) .[3]

This cohort study also evaluated the relationship between fine particles and first stroke incidence and its subtypes. Over a mean follow-up of 9.4 years, 6 733 cases of incident stroke were identified, of which 3 526 (52.4%) were ischemic and 1175 (17.5%) were hemorrhagic. The HR for every 10 μg/m^3 higher $PM_{2.5}$ concentration was statistically significant at 1.21 (95%CI: 1.04-1.41) for ischemic and non-statistically significant at 0.90 (95%CI: 0.70-1.17) for hemorrhagic stroke. The estimates for ischemic stroke were higher in older participants (>70 years), less educated participants, and in males for current smokers. [4]

2.9.4 Studies on Air Pollution and Blood Pressure

A study enrolled 12 655 participants aged ≥50 years in 8 cities (Shanghai, Guangdong, Hebei, Jilin, Shanxi, Shandong, Yunnan and Zhejiang) from 2007-2010, and analyzed the long-term association between ambient $PM_{2.5}$ and hypertension and blood pressure. Results of the multivariate logistic regression model indicated that with every 10μg/m^3 increase in $PM_{2.5}$, SBP and DBP increased by 1.30 mmHg (95%CI: 0.04-3.56) and 1.04 mmHg (95%CI: 0.31-1.78), respectively. The risk of hypertension increased by 14% (OR=1.14, 95%CI: 1.07-1.22), overweight or obese could enhance the association. [5]

[1] Qin G, Lv JY. Research progress of particulate matter air pollution and atherosclerosis. Chinese J Cardiol, 2011,39(3):282-284.

[2] Dong GH, Qian ZM, Xaverius PK, et al. Association between long-term air pollution and increased blood pressure and hypertension in China. Hypertension, 2013,61(3):578-584.

[3] Wong CM, Lai HK, Tsang H, et al. Satellite-Based Estimates of Long-Term Exposure to Fine Particles and Association with Mortality in Elderly Hong Kong Residents. Environ Health Perspect, 2015,123(11):1167-1172.

[4] Qiu H, Sun S, Tsang H, et al. Fine particulate matter exposure and incidence of stroke: A cohort study in Hong Kong. Neurology, 2017,88(18):1709-1717.

[5] Lin H, Guo Y, Zheng Y, et al. Long-Term Effects of Ambient PM2.5 on Hypertension and Blood Pressure and Attributable Risk Among Older Chinese Adults. Hypertension, 2017,69(5):806-812.

China Health and Retirement Longitudinal Survey (CHARLS) is a cohort study. Between June 2011 and March 2012, 13 975 adults aged ⩾ 35 years from 28 provinces were recruited. The study analyzed the associations of long-term exposure to $PM_{2.5}$ with the prevalence of hypertension and blood pressure by using a multivariate logistic regression model. The results indicated that with every IQR (IQR: 41.7 μg/m^3) increase in $PM_{2.5}$, SBP increased by 0.60 mmHg (95%CI: 0.05-1.15) and the prevalence of hypertension increased by 11% (OR=1.11; 95%CI: 1.05-1.17) .[1]

In a study conducted in 7 northeast cities in China, the relationship between gaseous pollutants and blood pressure was analyzed among 9 354 teenagers aged 5-17 years. The findings indicated that with every IQR increase in O_3 (IQR: 53.0 mg/m^3), SBP increased by 3.29 mmHg (95%CI: 2.86-3.72) on average.[2]

2.9.5 Household Air Pollution and CVD

Household air pollution caused by solid fuel is a major environmental factor of death and increases the disease burden in low and middle income countries.[3] A study compared the disease burden attributable to household air pollution in 1990 and 2013 in China. The results indicated that 807 000 deaths were attributable to solid fuel household pollution in 2013, including 169 000 from hemorrhagic stroke, 152 000 from ischemic heart disease, and 88 000 from ischemic stroke. Compared with 1990, the age-standardized mortality from solid fuel household pollution decreased by 24.5%, and the age-standardized DALY rate from solid fuel household pollution decreased by 42.4%.[4]

A prospective cohort study analyzed the relationship between solid fuel use in rural areas of China and the risk of CVD. Between June 2004 and July 2008, a total of 271 217 adults without a self-reported history of physician-diagnosed CVD at baseline were included. The mean follow-up time was 7.2 years. Among participants who reported regular cooking or winter heating, 84% and 90% used solid fuels, respectively. Compared with those not using solid fuels for cooking or heating, participants using solid fuels for cooking or heating had an 11% (HR=1.11; 95%CI:1.03-1.20) and 29% (HR=1.29; 95%CI: 1.06-1.55) increase in risk of CVD mortality, respectively. Among solid fuel users, the use of ventilated cook stoves was associated with an 11% lower risk of CVD mortality (HR=0.89; 95%CI: 0.80-0.99).[5]

[1] Liu C, Chen R, Zhao Y, et al. Associations between ambient fine particulate air pollution and hypertension: A nationwide cross-sectional study in China. Sci Total Environ, 2017, 584-585:869-874.

[2] Zeng XW, Qian ZM, Vaughn MG, et al. Positive association between short-term ambient air pollution exposure and children blood pressure in China-Result from the Seven Northeast Cities (SNEC) study. Environ Pollut, 2017,224:698-705.

[3] Gordon SB, Bruce NG, Grigg J, et al. Respiratory risks from household air pollution in low and middle income countries. Lancet Respir Med, 2014,2(10):823-860.

[4] P Yin, Y Cai, JM Liu, et al. Disease burden attributable to household air pollution in 1990 and 2013 in China. Chin J Prev Med, 2017,51(1):53-57.

[5] Yu K, Qiu G, Chan KH, et al. Association of Solid Fuel Use With Risk of Cardiovascular and All-Cause Mortality in Rural China. JAMA, 2018,319(13):1351-1361.

2.9.6 Randomized, Double-blinded, Crossover Trials on Household Particulate Matter Reduction

Short-term trial for household air purification: From November 2015 to December 2015, a randomized, double-blind crossover trial was conducted in Shanghai to explore biological mechanisms underlying the adverse health effects of particulate matter exposure by using metabolomics approach. A total of 55 healthy college students were randomized into two groups and alternated using real or sham air purifiers for 48 hours with a 12-day washout period. The average personal exposure to $PM_{2.5}$ was 24.3 μg/m^3 during the real purification and 53.1 μg/m^3 during the sham purification. Metabolomics analysis showed that higher exposure to $PM_{2.5}$ led to significant increases in cortisol, cortisone, epinephrine and norepinephrine. Between-treatment differences were also observed for glucose, amino acids, fatty acids, and lipids. With the increase in $PM_{2.5}$ exposure, blood pressure, hormones, insulin resistance, and biomarkers of oxidative stress and inflammation significantly increased. This study suggested that higher $PM_{2.5}$ may induce metabolic alterations that were consistent with activations of the hypothalamus pituitary-adrenal and sympathetic-adrenal-medullary axes.[1]

Long-term trial for household air purification: From 2013 to 2014, a randomized, double-blind crossover trial was conducted in Taiwan to study the effect of long-term indoor air conditioner filtration on the association between air pollution and cardiovascular health. This study recruited 200 homemakers (100 housewives and 100 househusbands) without history of smoking and CVD and randomly assigned 100 of them to air filtration or control intervention, six home visits were conducted per year from 2013-2014. An air conditioner with or without air purification was installed at home. The participants under air filtration intervention during 2013 were reassigned to control intervention in 2014. The results showed that the average $PM_{2.5}$ concentration was 12.8 μg/m^3 in the air filtration group and 21.4 μg/m^3 in the control group in the within-group comparisons; while the average $PM_{2.5}$ concentration was 12.5 μg/m^3 in the air filtration group and 22.0 μg/m^3 in the control group in the between-group comparisons, and the differences were statistically significant. The average SBP was 118.1 mmHg in the air filtration group and 125.8 mmHg in the control group in the within-group comparisons; while the average SBP was 117.8 mmHg in the air filtration group and 126.2 mmHg in the control group in the between-group comparisons, the differences were statistically significant. The average DBP was 69.8 mmHg in the air filtration group and 73.0 mmHg in the control group in the within-group comparisons; while the average DBP was 68.2 mmHg in the air filtration group and 72.7 mmHg in the control group in the between-group comparisons, and the differences were statistically significant. The average levels of several biological markers were lower in the air filtration group than in control group. This study indicated that air pollution exposure was associated with systemic inflammation, oxidative stress, and elevated blood pressure [2] .

[1] Li H, Cai J, Chen R, et al. Particulate Matter Exposure and Stress Hormone Levels: A Randomized, Double-Blind, Crossover Trial of Air Purification. Circulation, 2017,136(7):618-627.

[2] HC Chuang, KF Ho, LY Lin, et al. Long-term indoor air conditioner filtration and cardiovascular health: A randomized crossover intervention study. Environment International, 2017,106:91-96.

2.9.7 Development of National Air Quality Standards

The formulation and implementation of reasonable and scientific air quality standards is an important step to reduce air pollution. In 1982, the first national standards for atmospheric environment quality (GB3095-82) were issued and implemented in China. After several rounds of revision, atmospheric environmental quality standards (GB3095-1996) were issued in 1996.

In February 2012, Ministry of Ecology and Environment of the People's Republic of China released the ambient air quality standards (GB3095-2012), which were revised based on the standards in 1996. $PM_{2.5}$ was added to the list of air pollution monitoring indicators, while the threshold values for PM_{10} and NO_2 concentrations were raised. Additionally, a time schedule was arranged for the implementation of the standards 2012: municipalities and provincial capitals within the regions of Beijing-Tianjin-Hebei, Yangtze River Delta, and Pearl River Delta in 2012; 113 major cities and national model cities for environmental protection in 2013; all provincial-level cities in 2015 and nationwide by 1st January 2016.

In September 2013, the National Council issued the first air pollution prevention and control action program. By 2017, the concentration of PM_{10} was expected to decrease by 10% compared with that of 2012 in urban areas. The annual number of days with fairly good air quality was expected to gradually increase. Concentration of fine particulate matter ($PM_{2.5}$) in Beijing-Tianjin-Hebei, Yangtze River Delta, and the Pearl River Delta region was predicted to fall by around 25%, 20% and 15% from 2012 to 2017, respectively. The annual average $PM_{2.5}$ concentration was predicted to be controlled below 60 μg/m^3 in Beijing.

Part 3
Cardiovascular Diseases

3.1 Cerebrovascular Disease
3.1.1 Cerebrovascular Disease Epidemiology

3.1.1.1 Cerebrovascular Disease Mortality

(1) Cerebrovascular Disease Mortality in 2016

According to data from the *China Health and Family Planning Statistics Yearbook (2017)*,[1] the mortality rate of cerebrovascular disease for urban and rural residents in 2016 was 126.41/100 000 and 158.15/100 000, respectively. Based on data from the Sixth National Population Census, 841 500 urban residents and 1 065 300 rural residents died from cerebrovascular disease in 2016. In general, the mortality rate was higher in males than in females and higher in rural areas than in urban areas (Figure 3-1-1).

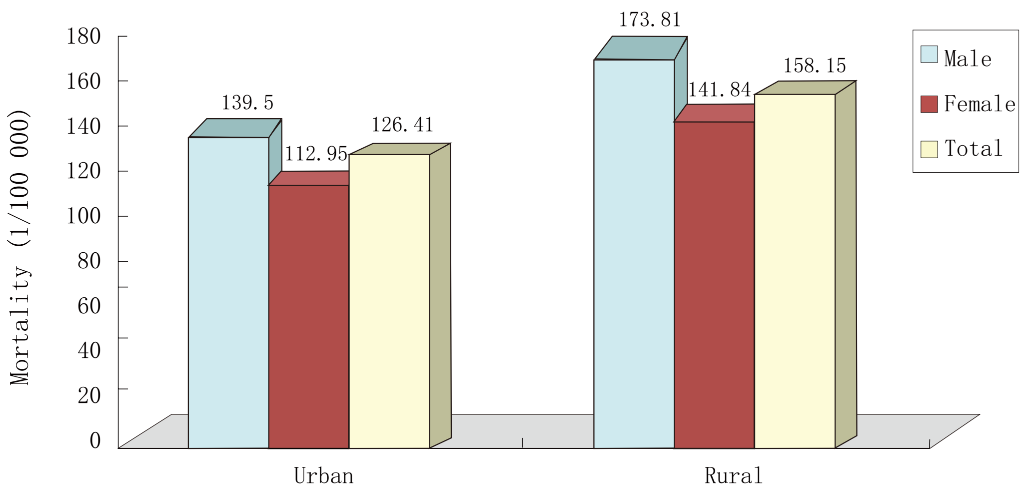


Figure 3-1-1 Cerebrovascular mortality by gender and region in 2016

[1] National Health and Family Planning Commission. China Health and Family Planning Statistics Yearbook (2017). Beijing: Peking Union Medical College Press, 2017.

(2) Cerebrovascular Disease Mortality by Gender and Age in Urban Areas in 2016 (1/100 000)

The mortality rate of cerebrovascular disease increased exponentially by age in urban areas. Mortality rates were higher for males than for females across all age groups (Figure 3-1-2, Table 3-1-1).

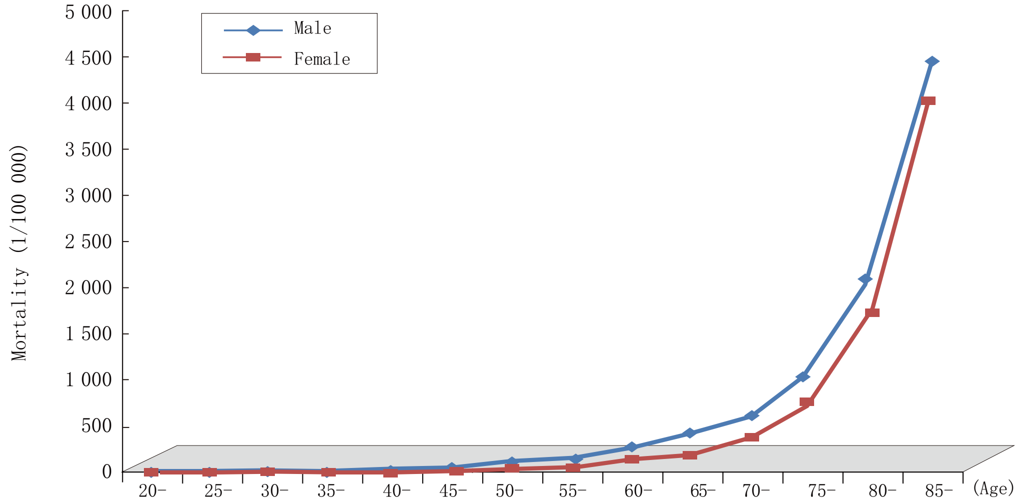


Figure 3-1-2 Cerebrovascular mortality of the urban population by gender and age in 2016

Table 3-1-1 Cerebrovascular mortality for the urban population by gender and age in 2016 (1/100 000)

	20-	25-	30-	35-	40-	45-	50-	55-	60-	65-	70-	75-	80-	85-
Male	0.93	2.83	6.10	10.24	22.09	35.25	99.73	103.8	236.41	410.96	634.07	1 038.71	2 122.02	4 502.7
Female	0.26	1.00	1.91	2.84	6.89	13.56	36.41	38.59	112.50	219.36	379.64	721.68	1 716.53	3 990.78

（3）Cerebrovascular Disease Mortality by Gender and Age in Rural Areas in 2016 (1/100 000)

The mortality rate of cerebrovascular disease also increased exponentially by age in rural areas. Mortality rates were higher in males than in females across all age ranges (Figure 3-1-3) and were higher in rural areas than in urban areas (Table 3-1-2).

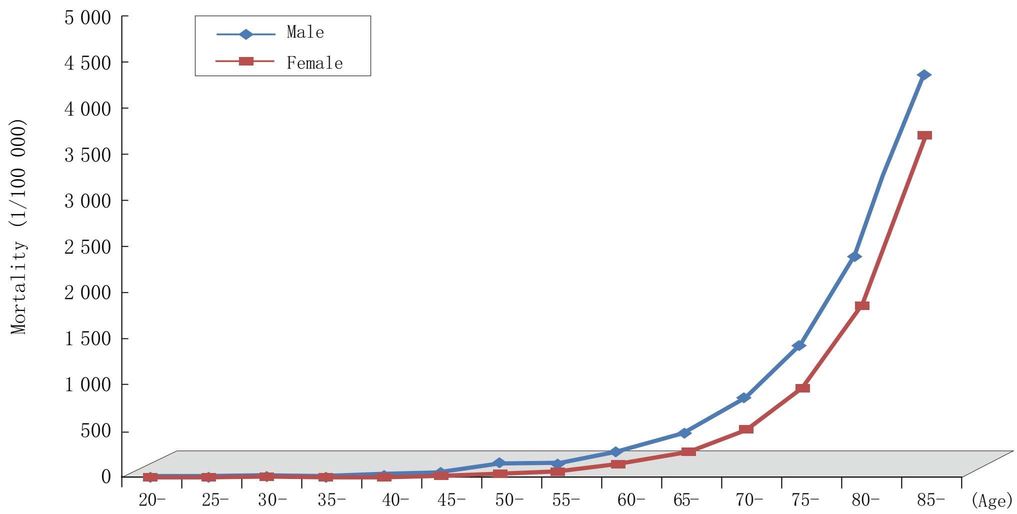


Figure 3-1-3 Cerebrovascular mortality of the rural population by gender and age in 2016

Table 3-1-2 Cerebrovascular mortality of the rural population by gender and age in 2016 (1/100 000)

	20-	25-	30-	35-	40-	45-	50-	55-	60-	65-	70-	75-	80-	85-
Male	2.18	5.15	10.97	14.96	29.7	52.08	127.46	129.92	292.04	503.51	837.54	1 413.04	2 420.83	4 457.67
Female	0.64	1.81	2.8	4.64	9.97	20.37	62.01	61.91	156.96	300.56	568.41	970.03	1 804.42	3 699.47

3.1.1.2 Trends in Cerebrovascular Disease Mortality from 2003 to 2016

Cerebrovascular disease mortality rates were higher in rural areas than in urban areas from 2003 to 2016. Compared with 2006, the cerebrovascular disease mortality rate in 2009 increased by 1.41 times in urban areas and 1.44 times in rural areas. It declined from 2009 to 2012 but increased slightly from 2013 to 2016, and the changes in rural areas were relatively more significant (Figure 3-1-4).

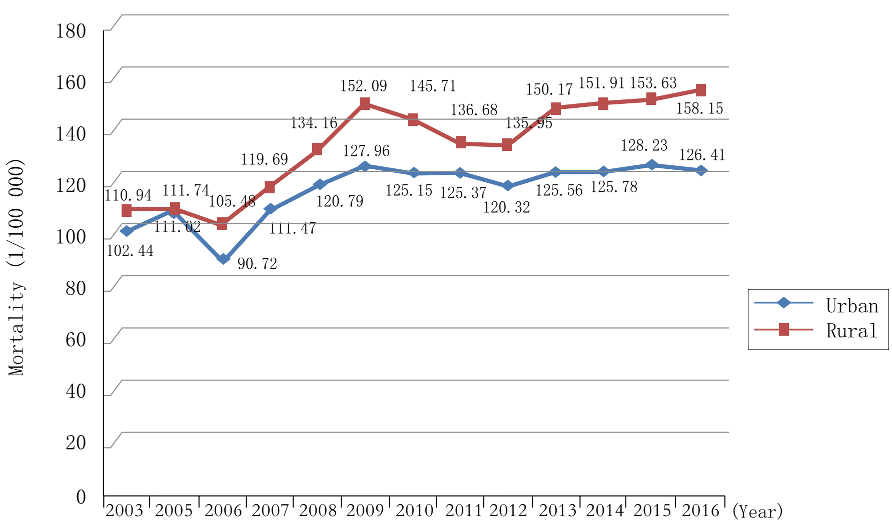


Figure 3-1-4 Trends in cerebrovascular mortality in China, 2003-2016

3.1.1.3 Studies on the Epidemiology of Stroke

(1) Prevalence, Incidence and Mortality of Stroke in China [1]

In 2013, a national cross-sectional survey was conducted among 480 687 adults aged ⩾20 years in 155 urban and rural centers from 31 provinces, municipalities, and autonomous regions in China. Among the participants, 7 672 (4 217 males and 3 455 females) were diagnosed with a stroke (1 596.0/100 000 people) and the average age was 66.4±10.6 years. First-ever strokes that occurred during 1 year preceding the survey point were 1 643 (345.1/100 000 person-years), 55% were males. The age-standardized prevalence, incidence, and mortality rates were 1 114.8/100 000 people, 246.8 and 114.8/100 000 person-years, respectively. The stroke incidence rate in rural areas (298.2/100 000 person-years) was significantly higher than that in urban areas (203.6/100 000 person-years).

(2) Trends of Stroke in China: 2002-2013 [2]

The China National Stroke Screening Survey (CNSSS) is an ongoing nationwide population-based program. A representative sample of 1 292 010 adults aged >40 years with 31 188 identified stroke cases were screened from the 2013-2014 CNSSS database. In addition, a retrospective evaluation of 12 526 first-ever stroke cases in 2002-2013 and stroke mortality data from the 2002-2013 China Health Statistics Yearbook was used to estimate the incidence rates. In 2014, the adjusted stroke prevalence was 2.06% in adults aged >40 years. The incidence of first-ever stroke in adults aged 40-74 years increased from 189/100 000 in 2002 to 379/100 000 in 2013; the overall annual increase was 8.3%. Stroke-specific mortality in adults aged 40-74 years has remained stable, at an approximate rate of 124 deaths/100 000 persons in both 2002 and 2013. After full adjustments, all risk factors assessed showed significant associations with stroke; the most significant contributor to stroke was hypertension, followed by family history, dyslipidemia, atrial fibrillation, diabetes, physical inactivity, smoking, and obesity.

(3) Prevalence and Incidence of Transient Ischemic Attacks [3]

In 2013, a nationally representative, door-to-door epidemiological survey was conducted on TIA in China. A total of 178 059 households were surveyed at 157 disease monitoring sites in 64 cities and 93 rural areas across China. Neurologists further examined residents with a transient ischemic attack (TIA) and stroke symptoms were screened and confirmed by medical history, physical examination, and CT/MRI results. Results showed that the weighted prevalence of TIA in China was 103.3/100 000, 92.4/100 000 among

［1］Wang W, Jiang B, Sun H, et al. Prevalence, Incidence and Mortality of Stroke in China: Results from a Nationwide Population-Based Survey of 480,687 Adults. Circulation, 2017,135(8):759-771.

［2］Guan T, Ma J, Li M, et al. Rapid transitions in the epidemiology of stroke and its risk factors in China from 2002 to 2013. Neurology, 2017,89(1):53-61.

［3］Jiang B, Sun H, Ru X, et al. Prevalence, incidence, prognosis, early stroke risk, and stroke-related prognostic factors of definite or probable transient ischemic attacks in China, 2013. Front Neurol, 2017,8:309.doi:10.3389.

males, and 114.7/100 000 among females. The incidence of TIA was 23.9/100 000, 21.3/100 000 among males, and 26.6/100 000 among females. Male patients with a history of TIA had a higher risk of stroke than their female counterpart (OR=2.469, 95%CI: 1.172-5.201, P=0.018). It was estimated that there were 1.35 million TIA patients nationwide, with 0.31 million new cases of TIA annually in China.

（4）Prevalence of Stroke among Middle-aged and Older Farmers in Western China（Qinling-Daba Mountains Region Stroke Study）[1]

A population-based stroke study was conducted from June 2014 to April 2015 in the Shanxi Qinling-Daba Mountains Region. 20 525 Chinese middle-aged and older farmers (≥40 years) were recruited. A structured questionnaire was used to collect data through face-to-face interviews. The results showed that the stroke prevalence rate was 1 380/100 000 in middle-aged and older farmers of western mountain area in China. The stroke risk factors included age, gender, hypertension, obesity and family history of stroke.

（5）Prevalence and Influential Factors of Stroke in Jiangxi Province [2]

Utilizing the simple random sampling method, this study selected 8 cities and counties, in each of them, 2 districts or townships were selected; and 3 communities or villages were chosen from each district and township, respectively. Subsequently, 15 269 subjects aged ≥15 years, living in Jiangxi province≥6 months, were randomly selected to participate in this survey from November 2013 to July 2014. Information on population characteristics, life behavior, and medical history was collected through a questionnaire survey. The results showed that the average age of participants was 53.04±17.91 years old; 226 stroke cases were identified with an average age of 67.76±9.74. The prevalence of stroke was 1 480.12/100 000, 1 866.92/100 000 in males and 1 210.84/100 000 in females, respectively. The prevalence of stroke increased with age, it was 413.79/100 000 among people aged 45-49 years, and 3 311.62/100 000 among people aged ≥75 years. Hypertension, drinking, age, body fat percentage, and sleep duration were risk factors of stroke.

3.1.2 Stroke Risk Factors

3.1.2.1 Atrial Fibrillation (AF)

Between 2013 and 2015, Beijing Tiantan Hospital conducted a prospective, multicenter cohort study. 1 511 patients within 7 days after acute ischemic stroke or TIA onset were enrolled at 20 sites in China. The mean age was 63 years, where 33.1% were females. 305 (20.2%) had either previously known (196, 13.0%) or AF newly-detected by electrocardiography (3.5%) or by 6-day Holter monitoring (4.4%). Advanced age, a history of heart failure, NIHSS at admission, and HDL-C were independently associated with newly-

［1］Zhang S, Liu Z, Liu YL, et al. Prevalence of stroke and associated risk factors among middle-aged and older farmers in western China. Environ Health Prev Med, 2017,22(1):6. doi: 10.1186/s12199-017-0621-z.
［2］Zhou W, Zhang B, Huang X, et al. Prevalence and influential factors of stroke in Jiangxi Province in 2014. Chinese Journal of Preventive Medicine, 2018,52(1):79-84.

detected AF. The study indicated that AF-associated stroke was relatively common in China. AF should be systemically sought once stroke or TIA occurred in order to initiate a timely and appropriate anticoagulant treatment. [1]

3.1.2.2 Adiposity

The CKB enrolled 512 891 adults aged 30-79 years from 10 areas (15 urban and 5 rural) during 2004-2008. During a median 9 years of follow-up, 32 448 strokes were recorded among 489 301 participants without previous cardiovascular disease. Adiposity was strongly positively associated with ischemic stroke, with an increase of 30% for each additional 5 kg/m^2 of BMI (HR=1.30, 95%CI: 1.28-1.33), and the risk for intracerebral hemorrhage only increased 11% (HR=1.11, 95%CI: 1.07-1.16 per additional 5 kg/m^2 BMI). High adiposity (BMI >23 kg/m^2) accounted for 14.7% of total stroke (16.5% of ischemic stroke and 6.7% of intracerebral hemorrhage) .[2]

3.1.2.3 Marriage

The national stroke registry of China led by Beijing Tiantan Hospital included 12 118 patients with acute ischemic stroke with an average age of 67 years in 2007-2008. Among them, 1 220 were unmarried and 10 898 married. The primary outcomes included all-cause mortality, stroke recurrence, combined endpoint, and stroke disability at one year. The results showed that 1-year incidences of stroke outcomes in unmarried patients were approximately 1.5-2.0 times higher than those in married patients. Compared with being married, unmarried patients had a higher proportion of 1-year post-stroke events than married patients: 25.3% vs 12.3% for all-cause mortality (P <0.01), 28.5% vs 18.2% for stroke recurrence (P <0.01), 33.4% vs 21.4% for the combined endpoint (P <0.01), and 61.7% vs 42.6% for stroke disability (P <0.01), respectively. Marital status was associated with stroke outcomes in patients with ischemic stroke .[3]

3.1.3 Primary Prevention

A post hoc analysis of the China Stroke Primary Prevention Trial (CSPPT) was conducted by Peking University First Hospital. 8 384 hypertensive males were randomly assigned to combined enalapril and folic acid tablet or an enalapril tablet alone. The median treatment duration was 4.5 years. The study demonstrated that folic acid therapy significantly reduced the risk of the first-ever stroke in never smokers with folate deficiency (HR=0.36, 95%CI: 0.16-0.83) and in ever smokers with normal folate levels (HR=0.69, 95%CI:

[1] Yang X, Li S, Zhao X, et al. Atrial fibrillation in not uncommon among patients with ischemic stroke and transient ischemic stroke in China. BMC Neurol, 2017,17(1):207. DOI: 10.1186.

[2] Chen Z, Iona A, Parish S, et al. Adiposity and risk of ischemic and hemorrhagic stroke in 0.5 million Chinese men and women: a prospective cohort study. Lancet Glob Health, 2018,6(6):e630-e640.

[3] Liu Q, Wang X, Wang Y, et al. Association between marriage and outcomes in patients with acute ischemic stroke. J Neurol, 2018,265(4):942-948.

0.48-0.99). Baseline folate levels and smoking status can interactively affect the risk of first stroke. The data suggested that compared with never smokers, ever smokers may require a higher dosage of folic acid to achieve a greater beneficial effect on stroke prevention.[1]

3.1.4 Intervention Treatment

In a study conducted by Jinling Hospital, Medical School of Nanjing University, Nanjing, 698 acute stroke patients with anterior circulation occlusion and endovascular treatment were enrolled from 21 stroke centers in China. Of the 698 patients, 304 (43.6%) patients had functional independence at 90 days. The rate of symptomatic intracranial hemorrhage within 72h after thrombus aspiration was 15.5% (108) and the mortality rate at 90 days was 25.4%. The mortality rate at 90 days was 65.3% for patients with symptomatic intracranial hemorrhage, and 18.8% for patients without symptomatic intracranial hemorrhage. Multivariate analysis showed baseline neutrophils ratio >0.83 (OR=2.07), preoperative Alberta Stroke Program Early CT Score < 6 (OR=2.27), cardiogenic stroke (OR=1.91), poor collateral flow (OR=1.97), endovascular treatment delay (>4.5 hours from onset of symptoms to puncture), and passes of thrombectomy ≥3 (OR=2.55) were independent predictors of poor functional outcomes for those patients with symptomatic cerebral hemorrhage.[2]

3.2 Coronary Heart Disease

3.2.1 Epidemiology of Coronary Heart Disease

3.2.1.1 Trends in Mortality of Coronary Heart Disease in the Chinese Population [3]

(1) Coronary Heart Disease Mortality in 2016

According to the data from *China Health and Family Planning Statistics Yearbook (2017)*, the mortality of coronary heart disease in 2016 was 113.46/100 000 in urban areas and 118.74/100 000 in rural areas, which were higher than those in 2015 (110.67/100 000 and 110.91/100 000, respectively). Overall, coronary heart disease mortality is higher in rural than in urban populations, and higher in males than in females (Figure 3-2-1, Table 3-2-1).

[1] Zhou Z, Li J, Yu Y, et al. Effect of Smoking and Folate Levels on the Efficacy of Folic Acid Therapy in Prevention of Stroke in Hypertensive Men. Stroke, 2018,49(1):114-120.

[2] Zi W, Wang H, Yang D, et al. Clinical Effectiveness and Safety Outcomes of Endovascular Treatment for Acute Anterior Circulation Ischemic Stroke in China. Cerebrovasc Dis, 2017,44(5-6):248-258.

[3] National Health and Family Planning Commission. China Health and Family Planning Statistics Yearbook 2017. Beijing: Peking Union Medical College Press, 2017.

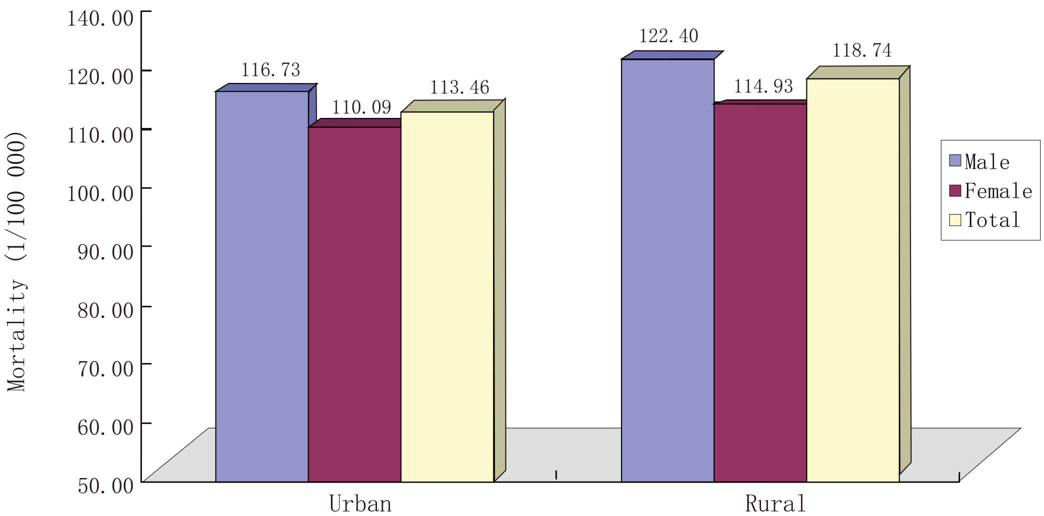


Figure 3-2-1 Coronary heart disease mortality in urban and rural populations by gender in 2016

Table 3-2-1 Coronary heart disease mortality in urban and rural populations by gender in 2016 (1/100 000)

	Urban			Rural		
	Total	Male	Female	Total	Male	Female
AMI	58.69	63.65	53.59	74.72	79.74	69.49
Coronary heart disease	113.46	116.73	110.09	118.74	122.40	114.93

(2) Trends for Coronary Heart Disease Mortality between 2002 and 2016

The mortality rates of coronary heart disease have increased continuously since 2012. It increased rapidly in rural areas and exceeded the mortality rate in urban areas in 2016 (Figure 3-2-2).

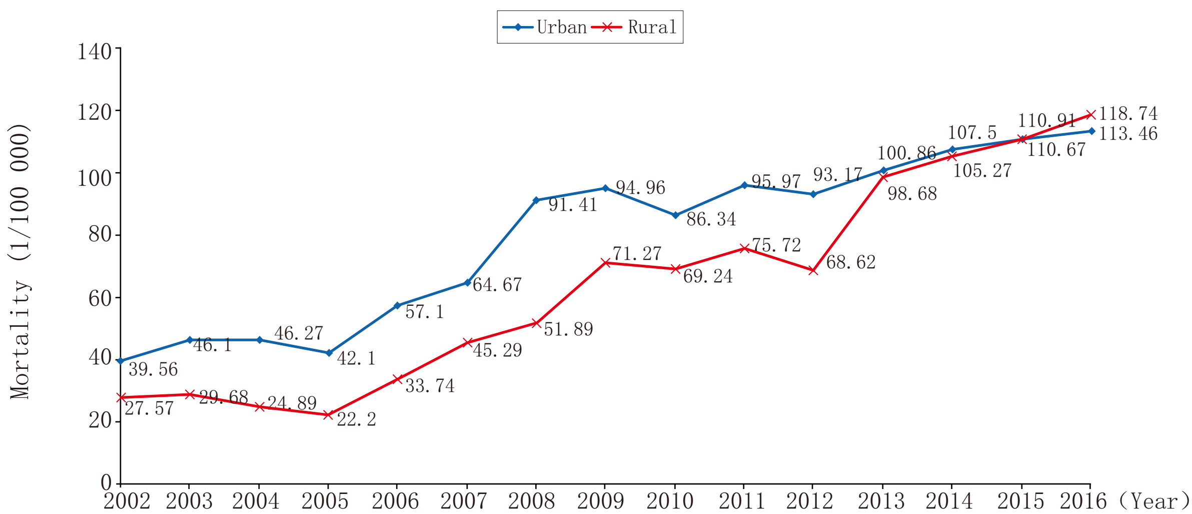


Figure 3-2-2 Coronary heart disease mortality trends in urban and rural areas, 2002-2016

(3) Acute Myocardial Infarction Mortality Trends between 2002 and 2016

Acute myocardial infarction mortality rate increased from 2002 to 2016, and had particularly accelerated since 2005. AMI mortality in rural areas exceeded that in urban areas in 2007, 2009 and 2011. It increased significantly in 2012, and exceeded that of urban areas from 2013 to 2016 (Figure 3-2-3).

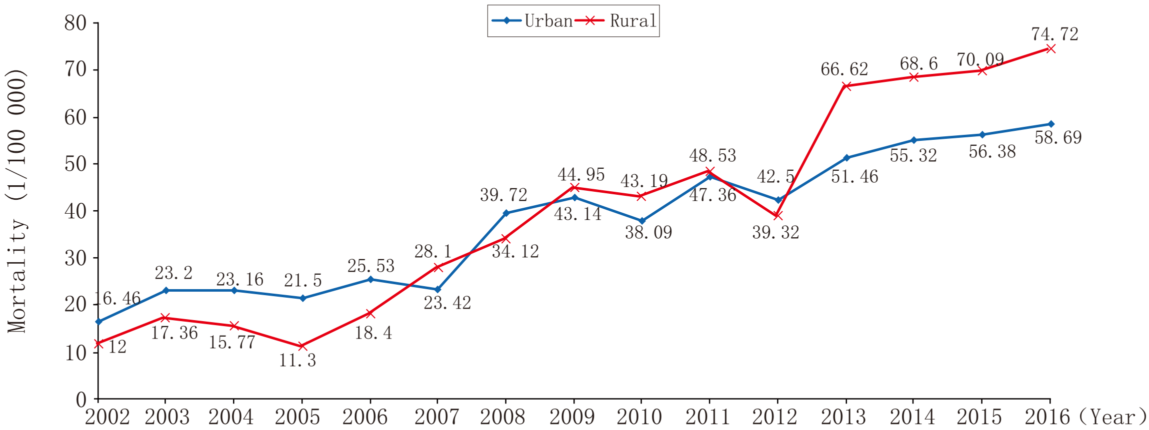


Figure 3-2-3 Acute myocardial infarction mortality trends in urban and rural areas, 2002-2016

(4) Acute Myocardial Infarction Mortality Rate by Age between 2002 and 2016 in Chinese Population (1/100 000)

AMI mortality rate increased with age; particularly, a distinct increase occurred after the age of 40 years. The increase approached an exponential relationship regardless of the gender or the urban/rural differences, which was persistently found between 2002 and 2016 (Figure 3-2-4, Figure 3-2-5, Figure 3-2-6, Figure 3-2-7).

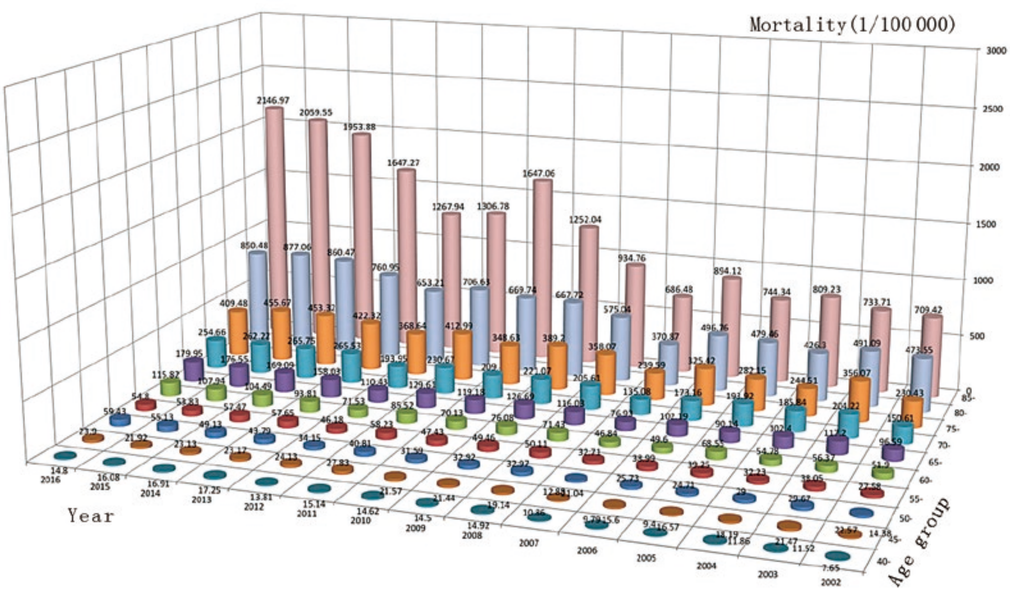


Figure 3-2-4 Trends in acute myocardial infarction mortality in males from urban areas by age, 2002-2016

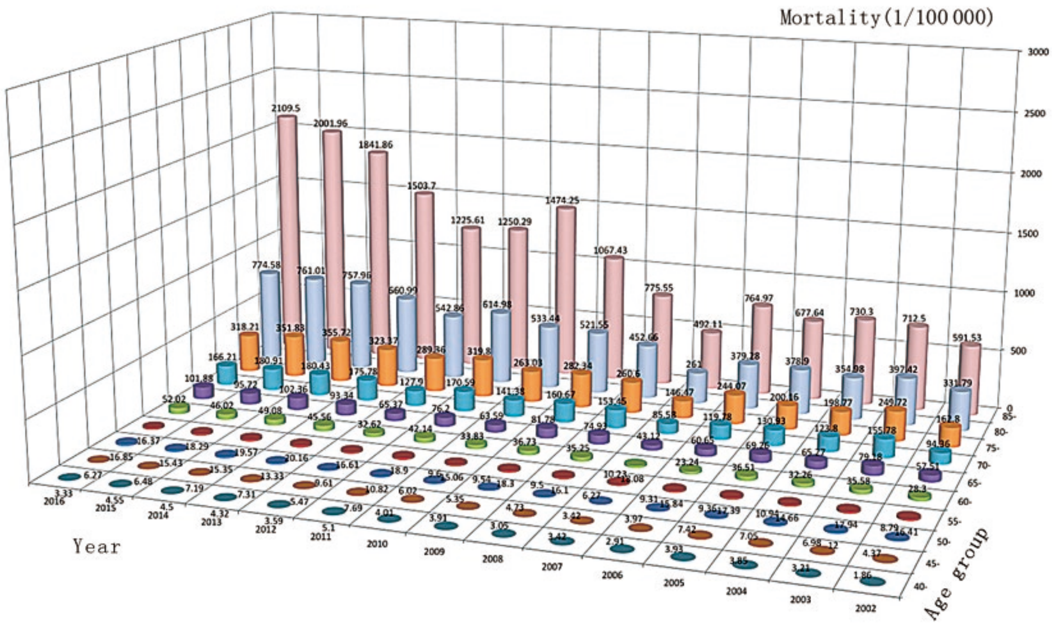


Figure 3-2-5 Trends in acute myocardial infarction mortality in females from urban areas by age, 2002-2016

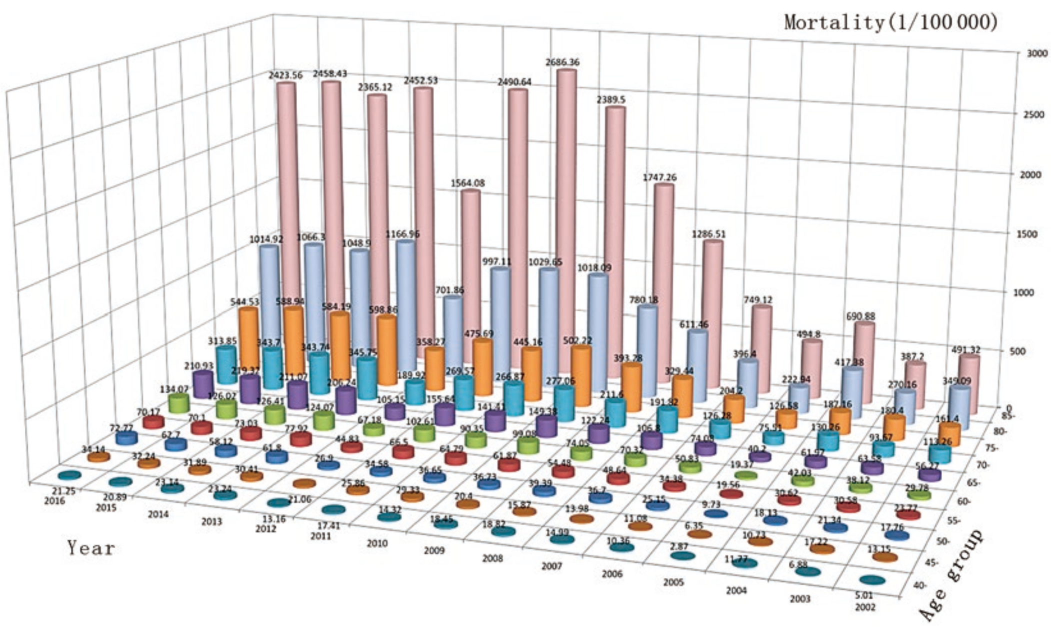


Figure 3-2-6 Trends in acute myocardial infarction mortality in males from rural areas by age, 2002-2016

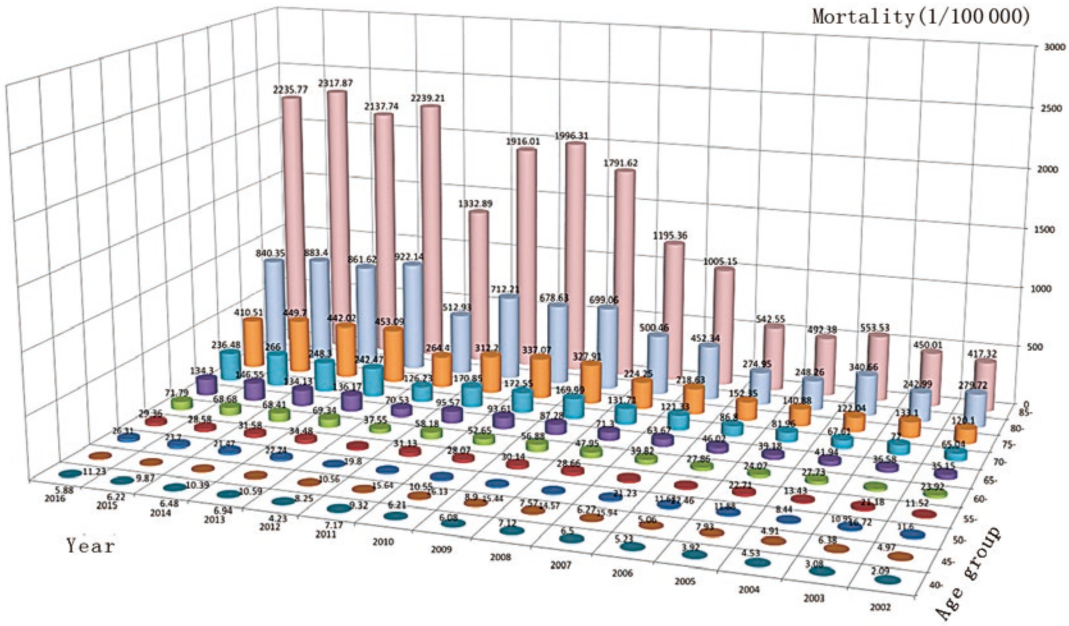


Figure 3-2-7 Trends in acute myocardial infarction mortality in females from rural areas by age, 2002-2016

3.2.1.2 Prevalence of Coronary Heart Disease [1]

Data from the 2013 5th Family Health Survey in National Health Service Survey showed that the prevalence of ischemic heart disease among people aged ≥15 years was 10.2‰, 12.3‰ in urban areas and 8.1‰ in rural areas. The overall prevalence of ischemic heart disease was 27.8‰ among people aged ≥60 years.

Compared with data from the 4th Family Health Survey in 2008, the 2013 data uncovered that prevalence of ischemic heart disease increased for the total population, but decreased for urban residents. The estimated prevalence in 2008 included all ages (>0 years), but only comprised people aged ≥15 years in 2013 (Figure 3-2-8).

[1] Ministry of Health Statistics Center. 2013 National Health Services Survey - 5th Family Health Survey. Beijing, Peking Union Medical College Press, 2016.

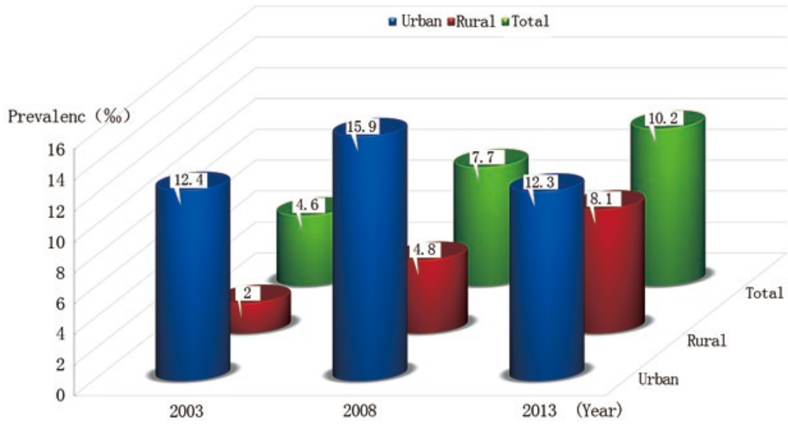


Figure 3-2-8 Prevalence of ischemic heart disease in three National Health Service Surveys (‰)

Note: Surveys in 2003 and 2008 included all ages. However, the survey in 2013 only included ages over 15 years;
Ischemic heart disease was defined as individuals diagnosed with ischemic heart disease within half a year of the study, or diagnosed with ischemic heart disease before half a year of the survey and experienced recurrence within half a year of the survey and received treatment

Based on existing data and the 2010 sixth national population census, the total population of China was about 1 340 million. The number of individuals aged over 15 years was 1.117 billion and accounted for 83.4% of the total population. The total number of patients with coronary heart disease in Mainland China was 11 396 104 in 2013. Based on the Fourth National Population Census in 2008, the total number of patients with coronary heart disease was 10 315 881 for all ages and increased by 1 080 223 between 2008 and 2013.

3.2.1.3 Studies on Epidemiology of Acute Myocardial Infarction in Chinese Population

(1) 15-year Trend in Incidence of Acute Myocardial Infarction in Tianjin [1]

AMI incidence data between 1999 (1st January) and 2013 (31st December) were obtained based on Tianjin CVD incidence surveillance registry established by the Centre of Disease Control and Prevention (CDC) in Tianjin, incidence rates of AMI were calculated and stratified by age, gender and rural/urban areas. Related information such as permanent residents′ population data were obtained from Tianjin Municipal Public Security Bureau. The 5th National Population Census data in 2000 were used for age-sex-standardized rates estimation.

AMI incidence rate in Tianjin declined from the year 1999 to 2013 with the rude incidence rate of

[1] Wang DZ, Shen CF, Zhang Y, et al. Fifteen-year trend in incidence of acute myocardial infarction in Tianjin of China. Chinese Journal of Cardiology, 2017,45(2):154-159.

80.46/100 000 to 81.29/100 000, and with the standardized incidence rate of 64.85/100 000 to 44.57/100 000 (Figure 3-2-9, Figure 3-2-10). AMI incidence decreased gradually in residents aged over 45 years old, but increased in residents younger than aged 45 years from 1999 to 2013.

The AMI incidence rate is consistently higher in male residents (rude incidence 99.89/100 000-102.98/100 000, standardized incidence rate 78.53/100 000-56.61/100 000) than in female residents (crude incidence 61.18/100 000-59.44/100 000, standardized incidence rate 50.31/100 000-31.76/100 000) and higher in urban residents (crude incidence rate 133.98/100 000-98.02/100 000, standardized incidence rate 99.89/100 000-50.12/100 000) than in rural residents (crude incidence rate 35.57/100 000-66.19/100 000, standardized incidence rate 32.68/100 000-43.51/100 000, Z=6.217, P<0.001).

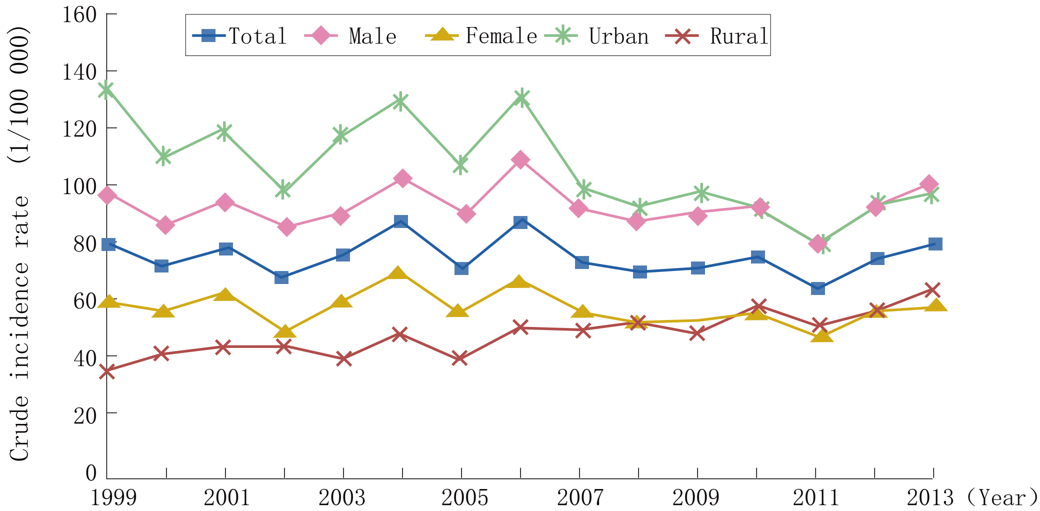


Figure 3-2-9 Crude incidence rate of AMI in Tianjin residents (1/100 000), 1999-2013

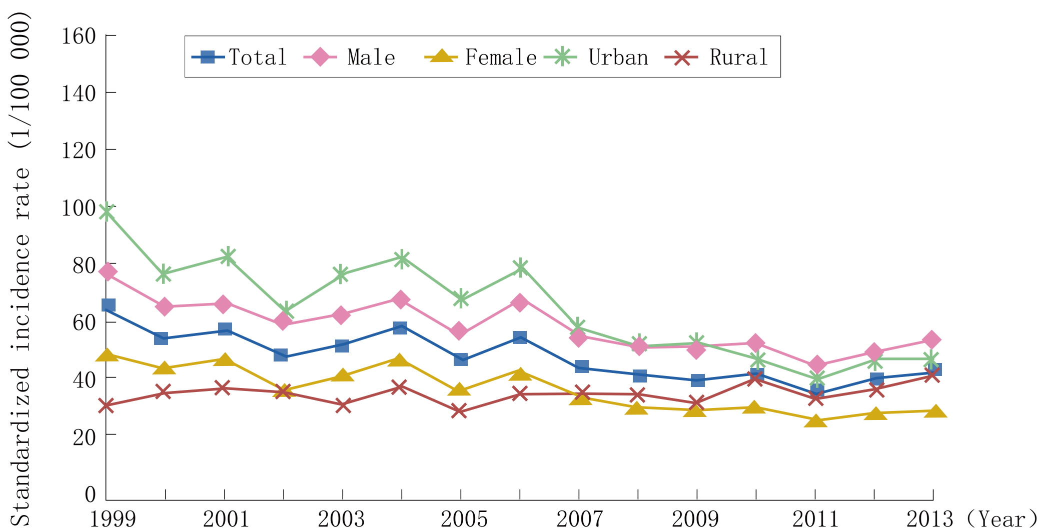


Figure 3-2-10 Standardized incidence rate of AMI in Tianjin residents (1/100 000), 1999-2013

(2) Dynamic Changes of Demographic Characteristics, Risk Factors, and Etiological Factors of AMI in the Past 40 Years in Beijing [1]

Data in the 1970s were collected from 1 314 AMI cases that were registered by the committee of prevention of coronary heart disease in Beijing between January 1972 and December 1973; while the data in the 2000s were based on 2 200 AMI cases of the China AMI registry data collected between January 2013 and September 2014 in Beijing. This study assessed the demographic characteristics (including sex, age and the proportion of farmers), risk factors, and etiological factors in all AMI cases. Results showed that prevalence of AMI who were older than 70 years old (25.6% vs 15.8%, P<0.001), the proportion of males (75.6% vs 68.3%, P＜0.001), and the proportion of farmers (14.5% vs 6.5%, P<0.001) were higher in the data from the 2000s than those from the 1970s. The proportion of registers who reported history of stroke (10.5% vs 6.2%, P<0.001), heart failure (11.9% vs 9.5%, P<0.05) and diabetes (27.6% vs 6.2%, P<0.001) was higher in 2000s than those in 1970s. The proportion of AMI cases due to mental stress decreased from 51.1% in the 1970s to 15.2% in the 2000s (P<0.001), while the proportion of AMI cases due to physical stress increased from 40.0% in the 1970s to 61.1% in the 2000s (p=0.007). The results reflected significant changes in recent 40 years for AMI patients in terms of age, gender, farmer proportion, previous histories of stroke, MI and diabetes. The characteristics of patients with AMI presented a trend towards being aging, males and farmers. The physical stress and unhealthy lifestyle became the major triggering factors for AMI.

(3) Changes of 30-day Mortality Rate in Patients Hospitalized with AMI from 2007 to 2012 in Beijing [2]

The research analyzed the distribution of population characteristics and trends of 30-day inpatient AMI mortality rate in Beijing. The clinical data of patients hospitalized due to AMI in Beijing from 1 January 2007 to 31 December 2012 were collected from "The Cardiovascular Disease Surveillance System in Beijing". After excluding duplicate records and validation for the completeness and accuracy of the records, a total of 77 943 Beijing residents aged ⩾25 years hospitalized with AMI were enrolled. The clinical characteristics of the patients and the trends in 30-day CHD mortality rate were analyzed with Poisson regression models. Results showed that the age-standardized 30-day CHD mortality rate was 9.7% , a decreasing trend was observed after adjusting for age and gender (P<0.001). The age-standardized 30-day CHD mortality rate decreased by 16.0%, from 10.8% in 2007 to 9.0% in 2012. The decreases of 30-day CHD mortality rates were noted in both males and females, and the mortality was higher in females (14.1%) than in males (7.6%) after adjusting for age. During this period, the proportion of ST-segment elevation myocardial infarction (STEMI) decreased, while the proportion of non-ST-segment elevation myocardial infarction (NSTEMI)

[1] Qinghao Zhao, Haiyan Xu, Yuejin Yang, et al. Variations of demography, risk factors and triggering factors for acute myocardial infarction patients in Beijing area over recent 40 years. Chinese Circulation Journal, 2018,(4):317-321.

[2] Sun Jiayi, Zhang Qian, Zhao Dong, et al. Trend in 30-day case fatality rate in patients hospitalized due to acute myocardial infarction in Beijing. Chinese Journal of Epidemiology, 2018,39(3):363-367.

increased. A significant decline (20.1%) in 30-day mortality rate of STEMI was found, but no decline was found for NSTEMI. The study demonstrated a decreasing trend in 30-day CHD mortality rate in the patients aged ≥25 years hospitalized due to AMI in Beijing during 2007-2012, indicating the improvement in short-term prognosis of patients hospitalized due to AMI. The findings highlight the urgent need to improve the treatment for females and NSTEMI patients.

3.2.2 Coronary Heart Disease Treatment

3.2.2.1 Current Status of Coronary Intervention Treatment in China

Based on the data registered at National Health Commission Coronary Heart Disease Intervention Treatment Quality Control Centre, the total number of PCI cases in Mainland China were 753 142 in mainland China in 2017 (Figure 3-2-11). Specifically, 615 984 cases were reported through the online reporting system; the military hospital reported 45 602 cases. 91 556 cases had been through data validation by quality control centers. The number of PCI cases increased by 13% in 2017 (Figure 3-2-12).

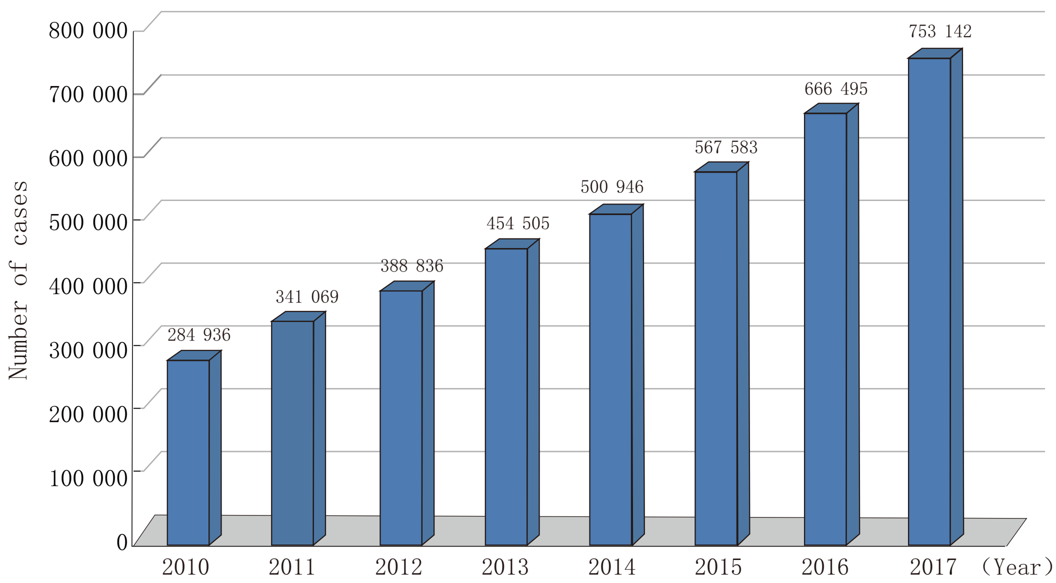


Figure 3-2-11 Number of PCI cases in China, 2010-2017

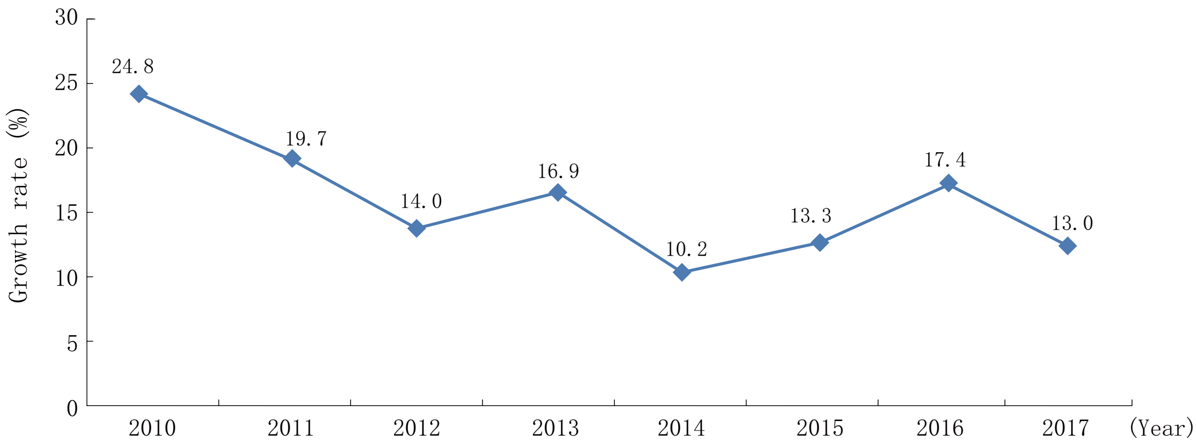


Figure 3-2-12 Annual growth rate of PCI in China, 2010-2017

(1) Overall Trends

The total number of PCI increased steadily in Mainland China in 2017. Indications for intervention treatment and instruments usage were relatively reasonable, and mortality of PCI remained at a low level. Emergency PCI for patients with STEMI had been increased, and the ability to apply PCI was increasing in district and county hospitals.

(2) Regional Difference

A substantial geographic difference had been found in the overall level of PCI. The top 10 provinces/cities of PCI procedures are listed in Table 3-2-2. The PCI completed in various regions remained dramatically different (Figure 3-2-13).

Table 3-2-2 Ranking of the total number of PCI in 2017

Rank	Area	N	Rank	Area	N
1	Beijing	61 709	6	Jiangsu	40 000
2	Shandong	58 024	7	Shanghai	38 109
3	Henan	44 000	8	Hubei	34 205
4	Guangdong	43 373	9	Zhejiang	33 772
5	Hebei	41 185	10	Liaoning	29 835

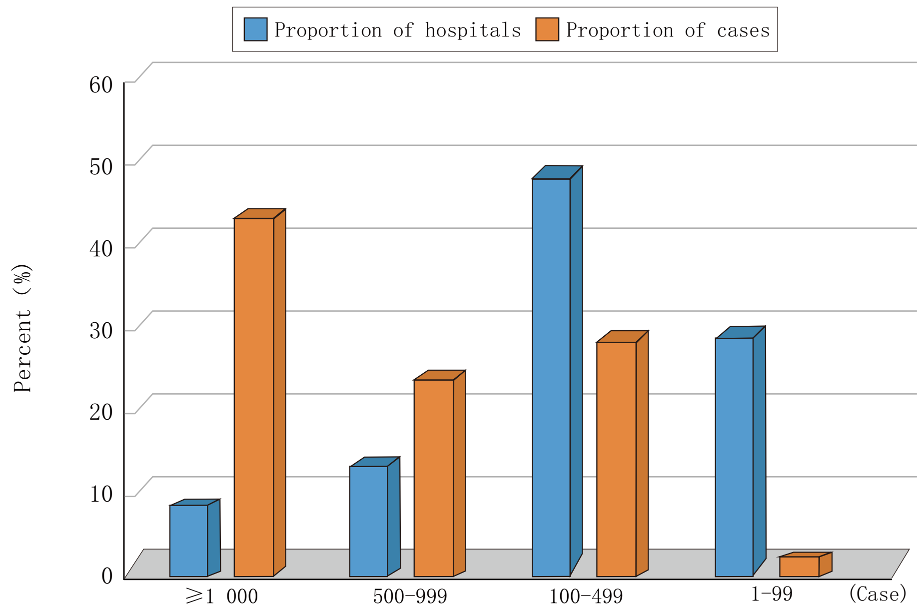


Figure 3-2-13 Number of hospitals with different PCI cases and the proportion of total PCI cases in 2017

(3) Clinical Characteristics

In 2017, 72.65% of patients with coronary heart disease were males. The mean age of patients was 62.43 years old. The main risk factors were hypertension, hyperlipidemia, smoking, and diabetes.

(4) The Number of Stents and Artery Access

The mean number of stents for each patient with CHD remained 1.5 between 2013 and 2016, and 1.47 in 2017. Intervention therapy through the radial artery still held the dominating position. The percentage of radial artery access accounted for 90.89% of all PCI cases with coronary heart disease in 2017.

(5) Clinical Diagnosis of PCI Cases

Unstable angina pectoris and STEMI accounted for the dominating proportions of patients with PCI (Figure 3-2-14).

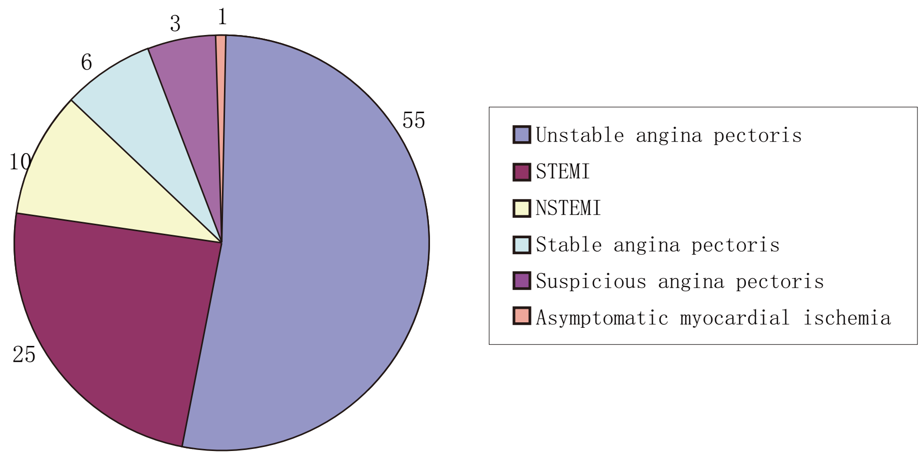


Figure 3-2-14 Proportion of diseases in PCI cases in 2017 (%)

(6) Quality Evaluation

The mortality rate was 0.23% in patients with PCI. The total number of STEMI patients were 165 613. Among them, the number of direct PCI was 69 889 (42.2%), which was higher than that in 2016 (38.91%). The missing report rate by website remained relatively high in 2017 (12.16%).

(7) County Hospitals

Of the data collected from 431 county hospitals, the total number of PCI cases were 66 029 in 2017. The ability to conduct urgent PCI reached 67%. The mortality of PCI was 0.29% in county hospitals, and 0.19% in non-county hospitals.

3.2.2.2 Clinical Researches in Coronary Heart Disease

(1) Coronary Artery Plaque Erosion and Related Factors in Patients with STEMI in China [1]

Chinese researchers investigated the plaque erosion in patients with STEMI through optical coherence tomography. They found that about 25.4% (209) had plaque erosion and 68.6% (564) had plaque rapture among 822 STEMI patients. The plaque rupture was equally distributed in both the left anterior descending artery (47%) and right coronary artery (43.3%). However, plaque erosion was more common in the left anterior descending artery (61.2%). Erosions and ruptures showed a similar distribution over the lengths of the coronary arteries, but the erosions were more likely to occur near the bifurcation of coronary arteries.

The multivariable analysis showed that age <50 years, current smoking, the absence of other coronary risk factors, single-vessel lesion, reduced lesion severity, larger vessel size, and bifurcation lesions were significantly associated with plaque erosion. Bifurcation lesions and current smoking were especially notable

[1] Dai J, Xing L, Jia H, et al. In vivo predictors of plague erosion in patients with ST-segment elevation myocardial infarction: a clinical, angiographical, and intravascular optical coherence tomography study. Eur Heart J, 2018,39(3):363-367.

in male patients; while age <50 years was most predictive in female patients.

(2) Treatment Strategy for Patients with Coronary Heart Disease - Thrombolytic Therapy and Primary PCI

The current therapies for STEMI include thrombolytic therapy and primary PCI (PPCI), while they cut both ways. The China PEACE study analyzed the data of 11 986 patients hospitalized with STEMI in China. The primary PCI increased from 10.2% in 2001 to 27.6% in 2011, but thrombolytic therapy decreased from 45.0% to 27.4%. The overall percentage of reperfusion and overall mortality did not change significantly.[1] Fast-MI study, which was conducted in 2012, suggested that for those STEMI patients who could not be offered timely PPCI, thrombolytic therapy has been proposed as a valuable alternative. Another recently conducted randomized non-inferiority clinical trial (Early-Myo) in China [2] compared the efficacy and safety of a pharmaco-invasive (PhI) strategy with half-dose fibrinolytic regimen versus PPCI in patients with STEMI aged 18 to 75 years presenting ≤6 hours after symptom onset but with an expected PCI-related delay. A total of 344 patients from 7 centers were randomized to PhI or PPCI group. Patients in PhI group received half-dose alteplase (8-mg bolus plus 42 mg in 90 minutes) followed by PCI after 3-24 hours. The PPCI group did not receive thrombolysis therapy. The study found that PhI was non-inferior (and even superior) to PPCI (34.2% versus 22.8%) for the primary endpoint of complete epicardial and myocardial reperfusion (thrombolysis in myocardial infarction flow grade 3, thrombolysis in myocardial infarction myocardial perfusion grade 3, ST-segment resolution ≥70%); no significant differences in the frequency of the individual components of the combined endpoint: thrombolysis in myocardial infarction flow 3 (91.3% vs 89.2%, P=0.580), thrombolysis in myocardial infarction myocardial perfusion grade 3 (65.8% vs 62.9%, P=0.730), and ST-segment resolution ≥70% (50.9% vs 45.5%, P=0.377). There were no significant differences in 30-day rates of total death (0.6% vs 1.2%, P=1.0), re-infarction (0.6% vs 0.6%, P=1.0), heart failure (13.5% vs 16.2%, P=0.545), major bleeding events (0.6% vs 0%, P=0.497), but minor bleeding (26.9% vs 11.0%, P<0.001) was observed more often in the PhI group. For patients with STEMI presenting ≤6 hours after symptom onset and with an expected PCI-related delay, a PhI strategy with half-dose alteplase and timely PCI offered more comprehensive epicardial and myocardial reperfusion when compared with PPCI and could benefit more patients.

[1] 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. Lancet, 2015,385(9966):441-451.

[2] Pu J, Ding S, Ge H, et al. Efficacy and Safety of a Pharmaco-Invasive Strategy With Half-Dose Alteplase Versus Primary Angioplasty in ST-Segment-Elevation Myocardial Infarction: EARLY-MYO Trial (Early Routine Catheterization After Alteplase Fibrinolysis Versus Primary PCI in Acute ST-Segment-Elevation Myocardial Infarction). Circulation, 2017,136(16):1462-1473.

(3) Efficacy and Safety of One-stop Composite Technique in the Treatment of Coronary Artery Disease [1]

The researchers in Fuwai hospital published an article in 2018 on the comparison of 30-day clinical outcome between one-stop composite coronary revascularization and off-pump coronary artery bypass grafting (OPCABG) in patients with multivessel coronary artery disease, exploring the efficacy and safety of one-stop composite technique in the treatment of coronary artery disease. The study recruited 533 patients with multivessel coronary artery disease who received one-stop composite tubular artery revascularization treatment between January 2009 and January 2017. It used 1:1 matching to select the patients who received the OPCABG treatment in the same period. The primary outcome was the recurrence rate of adverse cardiovascular events within 30 days of surgery, and the secondary outcomes were the hospitalization outcomes after surgery, including total post-operative drainage of blood from thoracic duct, the use rate of blood products, the time of postoperative ventilator, the residence time of intensive care unit (ICU), etc. The results showed that the total drainage volume of the thoracic tube [714 (523-971) ml vs 965 (716-1220) ml, $P<0.001$] and the use of blood products (19.7% vs 34.0%, $P=0.024$) were significantly reduced compared with the OPCABG group, ventilator use time (12.6h vs 16.0h, $P<0.001$) and ICU residence time (21.7h vs 41.6h, $P<0.001$) were significantly shortened. The all-cause mortality rate within 30 days of operation, occurrence rates of myocardial infarction, cerebrovascular events, revascularization, overall occurrence rates of cardiovascular and cerebrovascular events showed no statistically significant difference between the two groups. The study suggested that for patients with multiple coronary artery lesions, one-stop composite revascularization technology provided another safe and effective treatment option, with less trauma and similar early treatment efficacy in comparison with OPCABG.

(4) Strategy of Left Main Coronary Artery Percutaneous Coronary Intervention- Operator Experience and Volume were Associated with the Prognosis of Left Main Coronary Artery Percutaneous Coronary Intervention

The operator experience may have an impact on clinical outcomes after left main (LM) PCI. The study published in JACC Cardiovascular Interventions in 2016 [2] recruited a total of 1 948 patients who underwent unprotected LM PCI, and the results showed that the operator experience had an impact on the short- and long-term prognosis. The experienced operator was defined as an operator who performed at least 15 LM PCI per year for at least three consecutive years. Compared with the low-volume operators (who performed a mean of 4 LM PCI yearly), all-cause mortality at 30-day was lower for patients treated by high-volume operators (who performed a mean of 25 LM PCI yearly) (0.6% vs 2.1%, $P=0.008$); Being treated by a high-

[1] Shen LZ, Hu SS, Xu B, et al. 30-day prognosis for the patients with multivessel coronary artery disease who received one-stop composite tubular artery revascularization treatment. Chinese Circulation Journal, 2018,33:419-423.

[2] Xu B, Redfors B, Yang Y, et al. Impact of Operator Experience and Volume on Outcomes After Left Main Coronary Artery Percutaneous Coronary Intervention. JACC Cardiovasc Interv, 2016,9(20):2086-2093.

volume operator was also associated with lower risks for cardiac death both at 30-day (0.5% vs 2.1%, P=0.002) and 3-year (2.5% vs 4.6%, P=0.02); The adjusted 3-year mortality rate decreased by 51%. Based on this study, the newly released Guideline of Myocardial Revascularization by the European Society of Cardiology suggested an IIa level for that LM PCI operators should perform at least 25 operations per year.

PCI performed by experienced operator is a feasible and efficacy procedure for patients with LM disease who have low or intermediate SYNTAX (Synergy Between PCI With Taxus and Cardiac Surgery) scores. For patients with high-risk factors and not suitable for CABG, every measure should be taken into account and personalized treatment strategy should be made.

(5) Medication Treatment for Coronary Heart Disease

• Personalized Antiplatelet Treatment in China

Patients undergoing PCI react differently to antiplatelet drugs. Those with low responsiveness to clopidogrel have a higher risk of cardiac ischemic events. In order to find suitable intensified antiplatelet therapies in post-PCI patients in China, the CREATIVE study investigated the safety and effectiveness of intensified antiplatelet therapies (either double-dose clopidogrel [DOUBLE] or adjunctive cilostazol [TRIPLE]) and conventional strategy [STANDARD]) in patients after PCI.[1]

The CREATIVE study is a single-center, randomized, controlled trial. 1 076 patients undergoing PCI with low-responsiveness to clopidogrel were recruited. 362 patients were assigned to STANDARD group (clopidogrel 75 mg daily plus aspirin 100 mg daily), 359 to DOUBLE group (clopidogrel 150 mg daily plus aspirin 100 mg daily) and 355 to the TRIPLE group (clopidogrel 75 mg daily plus aspirin 100 mg daily plus cilostazol 100 mg bid). The study found that the TRIPLE group reduced the rate of adverse events significantly and improved platelet inhibition without increasing the risk of major bleeding. Decreased trend of negative outcomes could be observed in patients with double dosage of clopidogral, but the difference was not significant (Figure 3-2-15).

The CREATIVE study indicated in patients with low responsiveness to clopidogrel after PCI, the intensified antiplatelet strategies with adjunctive use of cilostazol significantly improved the clinical outcomes without increasing the risk of major bleeding.

[1] Tang Y, Wang W, Yang M, et al. Randomized Comparisons of Double-Dose Clopidogrel or Adjunctive Cilostazol versus Standard Dual Anti-platelet in Patients with High Post-Treatment Platelet Reactivity: Results of the CREATIVE Trial (Clopidogrel Response Evaluation and AnTi-platelet Inter VEntion in High Thrombotic Risk PCI Patients). Circulation, 2018,137(21):2231-2245.

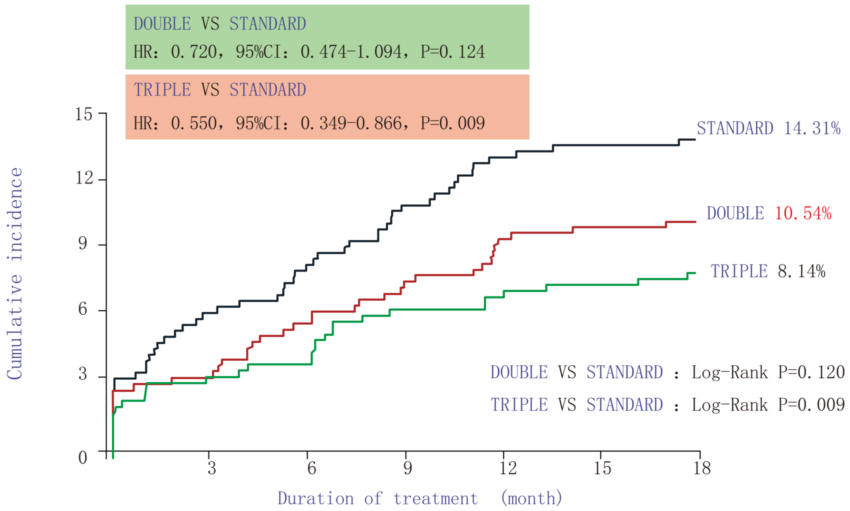


Figure 3-2-15 Cumulative Kaplan-Meier estimates of the time to the first adjudicated occurrence of primary endpoints (MACCE) and major bleeding endpoint.

Note: MACCE, major adverse cardiac and cerebrovascular events

• Dual Loading Antiplatelet Therapy after PCI in Elderly

The current guidelines suggested that a loading dose of dual antiplatelet therapy should be used as early as possible or at the time of PCI for all PCI patients with ACS. However, the latest research in China CCC-ACS (Improving Care for Cardiovascular Disease in China - Acute Coronary Syndrome) showed that a dual-loading dose of antiplatelet therapy increased risks of both in-hospital major adverse cardiovascular events and major bleeding among patients aged ≥75 years with ACS undergoing PCI in China. [1]

A total of 5 887 patients aged ≥75 years with ACS who had PCI and received dual antiplatelet thera py with aspirin and P2Y12 inhibitors (clopidogrel or ticagrelor) between November 2014 and June 2017 were enrolled. They were assigned into 4 groups according to the antiplatelet therapies: loading with neither aspirin nor P2Y12 receptor inhibitor (non-loading group, n=3 293); only loading with aspirin, but not with P2Y12 receptor inhibitor (only aspirin loading group, n=171); only loading with P2Y12 receptor inhibitor but not with aspirin (only P2Y12 receptor inhibitor loading group, n=526); and loading with both aspirin and P2Y12 receptor inhibitor (dual loading group, 1 897). The loading dose of aspirin was defined as ≥150 mg, and the loading dose of P2Y12 receptor inhibitor was defined as ≥300 mg of clopidogrel or ≥180 mg of ticagrelor. The non-loading dose of aspirin was defined as <150 mg, and the non-loading dose of P2Y12 receptor inhibitor was defined as 75-150 mg of clopidogrel or 90-135 mg of ticagrelor. The incidence of major adverse cardiovascular event (MACE) was higher in the dual loading group compared with other groups, especially with a higher proportion of cardiac death, in both the whole study population (A, C) and

[1] Zhao G, Zhou M, Ma C, et al. In - Hospital Outcomes of Dual Loading Antiplatelet Therapy in Patients 75 Years and Older With Acute Coronary Syndrome Undergoing Percutaneous Coronary Intervention: Findings From the CCC-ACS (Improving Care for Cardiovascular Disease in China - Acute Coronary Syndrome) Project. J Am Heart Assoc, 2018 Mar 30;7(7). pii: e008100. doi: 10.1161/JAHA.117.008100

the propensity score-matched population (B, D). The incidence of bleeding was also much higher in the dual loading group (Figure 3-2-16).

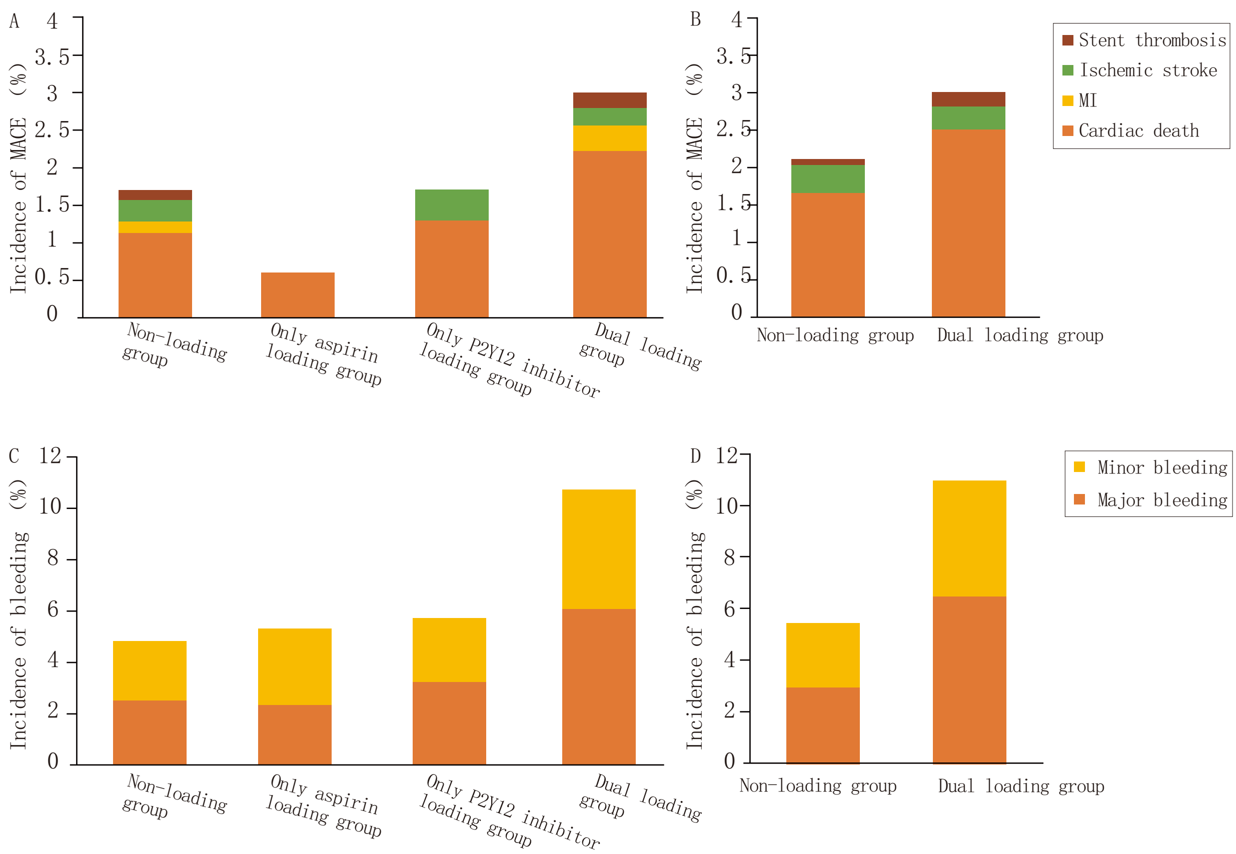


Figure 3-2-16 Incidence of MACE and bleeding in four antiplatelet strategy groups

The multivariate-adjusted analysis showed compared with the non-loading group, the dual loading group had higher risk of in-hospital MACE (HR=66, 95%CI: 1.13-2.44, P=0.010) and all-cause death (HR=1.78, 95%CI: 1.15-2.76, P=0.01), in-hospital major bleeding (HR=2.34, 95%CI: 1.75-3.13, P<0.001), and all bleeding events (HR=1.98, 95%CI: 1.59-2.47, P<0.001).

Among 3 284 propensity score-matched patients, a dual loading dose was associated with a 1.36-fold risk of MACE (HR=1.36, 95%CI: 0.88-2.11, P=0.168) and a 2.08-fold risk of major bleeding (HR=2.08, 95%CI: 1.47-2.93, P<0.001).

The researchers suggested that the potential risks and benefits regarding use of a dual loading dose of aspirin and P2Y12 receptor inhibitors should be carefully considered in patients aged ≥75 years with ACS undergoing PCI.

3.3 Disorders of Heart Rhythm

3.3.1 Atrial Fibrillation

3.3.1.1 Epidemiology of Atrial Fibrillation (AF)

Based on a survey conducted in 2004 in 10 different regions (4 urban and 6 rural areas), the estimated age-standardized prevalence of AF was 0.77% (0.78% in males and 0.76% in females). The prevalence of AF in participants aged 35-59 years was 0.42% and was 1.83% in participants aged ≥60 years. Age- and sex-adjusted multivariable logistic regression analysis revealed that myocardial infarction, left ventricular hypertrophy, obesity, and alcohol consumption were associated with a increased risk of AF.[1] Recently, analysis from a study among 3 922 cases of people aged >60 years showed that the baseline prevalence of AF was 2.0% in males and 1.6% in females. During 3 years of follow-up, the incidence of AF was 4.0/1 000 person-years. Only 1% of AF patients received warfarin anticoagulant treatment. Patients with AF had significantly higher risks of all-cause mortality (HR=1.87, 95%CI: 1.09-3.20), cardiovascular mortality (HR=3.78, 95%CI: 2.17-6.58) and stroke mortality (HR=6.31, 95%CI: 2.81-14.19) compared with those with sinus rhythm .[2] Recently, the 12th five-year plan research group of Fuwai Hospital conducted a stratified multistage random sampling study on 31 230 community residents in 31 provinces, municipalities, and autonomous regions of China. It showed that the prevalence of AF among residents ≥35 years in China was 0.71%, and 34% of AF patients were newly diagnosed in the survey and unaware of their pathological condition. [3] Another prospective observational study led by Fuwai Hospital [4] recruited 2 016 patients who were presented to an emergency department with AF or atrial flutter from 20 representative medical centers, 54.8% of them were females. Baseline data showed that 30.7% were diagnosed with paroxysmal atrial fibrillation, 22.4% with persistent AF, and 46.9% with permanent AF. The most common concomitant diseases were hypertension (55.5%), coronary heart disease (41.8%) and heart failure (37.4%). Analysis showed that patients aged ≥75 years [5,6] were more likely to have coronary heart disease, hypertension, previous stroke, cognitive dysfunction and chronic obstructive pulmonary disease (COPD). The older patients usually had higher $CHADS_2$ scores but were less likely to accept anticoagulant treatment. The risk of death or adverse events increased two-fold at

［1］Li Y, Wu Y, Chen K, et al. Prevalence of atrial fibrillation in China and its risk factors. Biome Environ Sci, 2013,26(9):709-716.

［2］Li LH, Sheng CS, Hu BC, et al. The prevalence, incidence, management and risks of atrial fibrillation in an elderly Chinese population: a prospective study. BMC Cardiovasc Disord, 2015 May 8;15:31.doi: 10.1186/s12872-015-0023-3.

［3］Wang Z, Chen Z, Wang X, et al. The Disease Burden of Atrial Fibrillation in China from a National Cross-sectional Survey. Am J Cardiol, 2018,2.pii: S0002-9149 (18) 31187-1.

［4］Zhang H, Yang Y, Zhu J, et al. Baseline characteristics and management of patients with atrial fibrillation/flutter in the emergency department: results of a prospective, multicenter registry in China. Intern Med J, 2014, 44(8): 742-748.

［5］Yang YM, Shao XH, Zhu J, et al. Risk factors and incidence of stroke and MACE in Chinese atrial fibrillation patients presenting to emergency departments: A national wide database analysis. Int J Cardiol, 2014,173(2):242-247.

［6］Shao XH, Yang YM, Zhu J, et al. Comparison of the clinical features and outcomes in two age-groups of elderly patients with atrial fibrillation. Clin Interv Aging, 2014,9:1335-1342.

1-year follow-up. COPD was an independent risk factor for adverse clinical events. [1]

3.3.1.2 Therapy for Atrial Fibrillation

(1) Anticoagulation Therapy for Atrial Fibrillation

Among AF patients in China, the proportion of patients receiving anticoagulation therapy is remaining low. One study has shown that among patients with AF, only 12.7% of those with $CHADS_2$ score≥2 received anticoagulation therapy.[2] A recent study analyzed 7 977 patients with AF who were enrolled from 20 tertiary and 12 non-tertiary hospitals in Beijing between 2011 and 2014. It demonstrated that oral anticoagulants were used in 36.5% (2 268/6 210), 28.5% (333/1 168), and 21.4% (128/599) of patients with CHA_2DS_2-VASc scores ≥2, 1, or 0, respectively.[3] In 2011, the Geriatrics Expert Group of the Chinese Medical Association published China's first Expert Opinion on the Treatment of Atrial Fibrillation for Elderly Patients, [4] and recently published Expert Consensus on Antithrombotic Therapy of elderly patients over 75 years old, [5] which presented the characteristics of older patients regarding stroke risk evaluation, ventricular rhythm, antiarrhythmic medications and antithrombotic therapies.

New oral anticoagulation (NOAC) medications, including direct thrombin inhibitors (dabigatran) and direct factor Xa inhibitors (rivaroxaban), have been used in China, but they are costly. Large clinical trials showed that new anticoagulation medications effectively prevented stroke and systemic embolism, and reduced the risk of major bleeding and intracerebral hemorrhage among nonvalvular atrial fibrillation patients.[6,7]

One small study on the clinical efficacy and safety of dabigatran for treating nonvalvular atrial fibrillation suggested little difference from general results.[8] Multiple centers in China observed the effectiveness

[1] Huang B, Yang Y, Zhu J, et al. Clinical characteristics and prognostic significance of chronic obstructive pulmonary disease in patients with atrial fibrillation: results from a multicenter atrial fibrillation registry study. J Am Med Dir Assoc, 2014,15(8):576-581.

[2] Zhang H, Yang Y, Zhu J, et al. Baseline characteristics and management of patients with atrial fibrillation/flutter in the emergency department: results of a prospective, multicenter registry in China. Intern Med J, 2014,44(8):742-748.

[3] Chang SS, Dong JZ, Ma CS, et al. Current Status and Time Trends of Oral Anticoagulation Use Among Chinese Patients With Nonvalvular Atrial Fibrillation: The Chinese Atrial Fibrillation Registry Study. Stroke, 2016,47(7):1803-1810.

[4] Expert Opinion on Treatment of Atrial Fibrillation for Elderly Patients, Writing Group. Expert Opinion on Treatment of Atrial Fibrillation for Elderly Patients. Chinese J Geriatrics, 2011,30(11): 894-908.

[5] Qian HY, Wang Z, He JF, et al. Expert consensus on the antithrombotic treatment of elderly patients over 75 years old. Chinese Journal of Cardiology, 2017, 3: 161-168.

[6] Patel MR, Mahaffey KW, Garg J, et al. Rivaroxaban versus warfarin in nonvalvular atrial fibrillation. N Engl J Med, 2011,365(10): 883-891.

[7] Granger GB, Alexander JH, McMurry JJ, et al. Apixaban versus warfarin in patients with atrial fibrillation. N Engl J Med, 2011,365(11):981-992.

[8] Yang GK, Xie B. Clinical observation of dabigatran in patients with non-valvular atrial fibrillation anticoagulation. Chinese J Cardiac Pacing and Electrophysiology, 2014,28(06):550.

and safety of dabigatran in anticoagulation treatment for AF in the perioperative period [1] and after ablation.[2] It proved that dabigatran and warfarin were equally effective and safe, and significantly reduced the hospital length of stay. The effectiveness and safety of rivaroxaban for people with AF in China (including perioperatively) were also verified. Meanwhile, another small study confirmed that rivaroxaban could be used in patients with non-valvular AF combined with left atrial thrombus, and the efficacy and safety were not inferior to warfarin.[3,4,5] In 2017, APHRS issued a consensus on stroke prevention in atrial fibrillation- 2017 Consensus of the Asia Pacific Heart Rhythm Society on Stroke Prevention in Atrial Fibrillation. The Asians are prone to bleeding when using warfarin. The consensus focused on the evidence for the use of NOAC in the Asia-pacific region and made clear recommendations. They analyzed the outcomes of randomized clinical trials including RE-LY, ROCKET AF, J-ROCKET AF, ARISTOTLE and ENGAGE AF in Asian subgroup populations, and found in comparison with low-dose NOAC, the risk of ischemic stroke significantly reduced with standard-dose NOAC, but the risk of bleeding indicated no statistically difference.[6]

(2) Catheter Ablation for Atrial Fibrillation

Since 2008, China has been building a national online platform for AF data collection. Statistics has shown that RFCA therapies for AF have increased steadily. Currently, circumferential pulmonary vein isolation is still the most commonly used RFCA technique for AF, accounting for 65.1% of all cases. The percentage of pulmonary vein ablations with complex fractionated atrial electrograms and with stepwise ablation reached 11.3% and 13.6%, respectively.[7] A recent study analyzed 1 946 cases of cerebrovascular complications occurring after catheter ablation in AF patients, and found that the risk of ischemic stroke was 0.36% and risk of hemorrhage stroke was 0.1%.[8] In recent years, the appliance of cryoballoon ablation in pulmonary vein

[1] Pan WQ, Hu WY, Lin ZJ, et al. Dabigatran in the atrial fibrillation ablation perioperative application. Chinese J of Cardiac Arrhythmias, 2015,19(2):104-107.

[2] Wang X, Wang ZL, Yang GT, et al. Dabigatran for atrial fibrillation after radiofrequency catheter anticoagulant therapy effectiveness and safety of ablation. J of Cardiac Arrhythmias, 2015,19(2):99-103.

[3] Zhong W, Wang L, Chen HS. Comparison of efficacy of oral anticoagulant rivaroxaban and warfarin in preventing thromboembolism in patients with non-valvular atrial fibrillation. Chinese Journal of Geriatrics, 2016,36:1094-1096.

[4] Lu C, He Y, Xu J, et al. Effect of rivaroxaban and warfarin on patients with atrial fibrillation and left atrial thrombosis. Chinese Circulation Journal, 2016, 31(11):1098-1101.

[5] Wang X, Liu J, Wang ZL, et al. The efficacy and safety of rivaroxaban in patients with atrial fibrillationafter radiofrequency ablation. Chinese Heart Journal, 2016,1:33-36.

[6] Chern-En Chiang, Ken Okumura, Shu Zhang, et al. 2017 consensus of the Asia Pacific Heart Rhythm Society on stroke prevention in atrial fibrillation. Journal of Arrhythmia, 2017,33:345-367.

[7] Huang CX, Zhang S, Ma CS, et al. National registry of catheter-guided ablation for atrial fibrillation-2008. Chinese J of Cardiac Arrhythmias, 2011,15(4):247-251.

[8] Liu Y, Zhan X, Xue Y, et al. Incidence and outcomes of cerebrovascular events complicating catheter ablation for atrial fibrillation. Europace, 2016,18(9):1357-1365.

isolation has gradually increased. In 2016, a randomized clinical trial in Europe indicated that [1] cryoballoon ablation was comparable to radiofrequency ablation in safety and efficacy. A recent study in China enrolled a total of 159 patients from a single center for treatment with first-generation cryoballoon ablation. After more than one year of follow-up, results showed that [2] 72.9% of patients maintained sinus rhythm after surgery, with a success rate of 77.7% and 61.1% for paroxysmal AF and persistent AF, respectively. The success rate can achieve 83.9% with the second operation. The incidence of postoperative complications was 2.5%, all of which were recovered after treatment without fatal complications. Cryoballoon ablation can be used effectively and safely in pulmonary vein isolation for AF, but the intermediate and long-term efficacy in Chinese population needs further verification by multicenter studies. Since 2013, China has started the preliminary application of left atrial appendage closure.[3] In 2015, China promoted the level of left atrial appendage closure to degree IIa and evidence degree to class B in knowledge and management recommendations for AF. The left atrial appendage closure procedure can be performed in patients who are not suitable for long-term anticoagulation, or in patients who are at high risk of stroke or hemorrhage with long-term standardized anticoagulation (HAS-BLED score >3) .[4] By 2017, China had implanted more than 2 000 cases of the left atrial appendage (including WATCHMAN and AMPLATZERTM ACPTM, etc.).

3.3.2 Pacemakers, Implantable Cardioverter-Defibrillators (ICD) and Cardiac Resynchronization Therapy (CRT)

The first application of artificial cardiac pacemaker in China was in 1962. The transvenous cardiac pacemaker was implanted for the first time in 1973.[5] Since then, the number of pacemaker implants has increased annually, and the proportion of physiological pacemakers has also increased. [6,7,8] According

[1] Kuck KH, Brugada J, Furnkranz A, et al. Cryoballoon or Radiofrequency Ablation for Paroxysmal Atrial Fibrillation. N Engl J Med, 2016,374(23):2235-2245.

[2] Lin YZ, Chen L, Lian L, et al. A one-year follow-up single-center study on treatment of atrial fibrillation by cryotherapy with first generation cryoballoon. Chinese Journal of Arrhythmia, 2017,21(1):58-62.

[3] Yao Y, Wu LM, Hou BB, et al. Three cases of the initial experience of percutaneous left atrial appendage closure in atrial fibrillation patients with high risk of stroke. Chinese Journal of Cardiac Arrhythmias, 2013,17(2):154-155.

[4] Huang X, Zhang S, Huang DJ, et al. Atrial fibrillation: current understanding and treatment recommendations -2015. Chinese Journal of Heart Pacing and Electro Cardiology, 2015,19(5):377-434.

[5] Huo JJ, Fang ZP, Wang WN, et al. The experiment study and preliminary clinical use of two cardiac pacemakers. Chinese JMedicine, 1964,50:219-224.

[6] Wang FZ, Hua W, Zhang S, et al. National investigation of the clinical use of pacemaker in 1998-1999. Chinese J Cardiac Arrhythmias, 2001,5(4):229-230.

[7] Wang F, Hua W, Zhang S, et al. National investigation of the clinical use of pacemaker in 2000-2001. Chinese J Cardiac Arrhythmias, 2003,7(3):189-191.

[8] Wang F, Hua W, Zhang S, et al. National investigation of the clinical use of pacemaker from 2002 to 2005. Chinese J Cardiac Arrhythmias, 2006,10(6):475-478.] [Chen YH, Chen H, Wu Y, et al. Cardiac electrophysiology in China. Heart Rhythm, 2007,4(6):862.

to the statistics from the National Health Commission's online registration system (excluding military hospitals), about 76 717 pacemakers were implanted in 2017: an increase of 4.98% compared with 2016 (Figure 3-3-1). Indications for cardiac pacing did not differ significantly as compared with 2016, and bradycardia still dominated as the primary indication: 47% were associated with the treatment of sick sinus syndrome (SSS) and 40% were related to atrioventricular block (Figure 3-3-2). Around 13% of pacemaker implantation patients had non-bradycardia adjustment syndrome, and the proportion of dual-chamber pacemaker implantation was nearly 73%, an increase of 4% compared with 2016. In recent years, there has been an improvement in the route of pacemaker venous puncture and position of pacemaker wire, and also breakthroughs in the age of implantation patients. From May 2013 to November 2015, a registry study of 5 467 cases across 20 hospitals showed that [1] the oldest patient to receive a pacemaker was 103 years old, and the youngest was only 6 years old. For the implantation route, 85% of doctors chose the subclavian vein, and less than 5% of doctors chose the cephalic vein. Because of the unique anatomical advantage of axillary vein puncture and the high puncture success rate, the proportion of axillary vein puncture has increased to about 10%. As to the position of the pacemaker wire, 92.6% of the atrial electrodes were implanted in the left atrium. Due to the weakness of the apical pacing, the placement of the ventricular electrode significantly changed, the proportion of septal pacing has gradually increased to 45.31% in recent years. In terms of the pacemaker selection, more than 90% chose imported pacemakers from 2013 to 2015, while domestic pacemakers were only accounted for a very minor proportion.

With the growing number of the pacemaker implantations, the clinical application of a remote monitoring system has a landmark significance. Clinicians can easily view the transmitted information through the system, which reduces the burden of outpatient follow-up. It may detect the abnormalities at the early stage for both disease- and device-related adverse events and is helpful for early treatment.[2] Many studies have confirmed the safety and effectiveness of pacemakers, and multiple guidelines and expert consensuses have recommended its application in CIED.[3] In November 2017, "Circulation" published the REHEARSE-AF study results of remote heart rhythm monitoring, showing that ECG monitoring in asymptomatic patients was significantly more likely to identify incident AF than routine care. Earlier identification of AF with appropriate anticoagulation may decrease stroke incidence .[4]

The pacemaker not only has a therapeutic effect but can also monitor the heart rate and rhythm, which can help diagnose occult arrhythmias. A multicenter registry study of remote monitoring pacemakers selected 628 cases across 97 hospitals from March 1st 2009 to December 30th 2010. Results showed that

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[1] Chen RH, Chen KP, Hua W, et al. Clinical application of cardiac pacemakers (20 hospitals registration research). Chinese Journal of Arrhythmia, 2017,21(1):22-25.

[2] Dai Y, Yang JF, Zhou YJ, et al. Multi-center registration study of home monitoring system in patients with dual-chamber pacemaker implantation. Chinese Circulation Journal, 2013,28 (1):29-32.

[3] David Slotwiner, Niraj Varma, Joseph G. Akar, et al. HRS Expert Consensus Statement on Remote Interrogation and Monitoring for Cardiovascular Electronic Implantable Devices. Heart Rhythm, 2015,12:e69-el00.

[4] Julian PJ Halcox, Kathie Wareham, Antonia Cardew, et al. Assessment of Remote Heart Rhythm Sampling Using the AliveCor Heart Monitor to Screen for Atrial Fibrillation: The REHEARSE-AF Study. Circulation, 2017,136(19):1784-1794.

22.9% of patients experienced at least one episode of AF at their six-month follow-up. The first AF detection occurred mostly on the second month of pacemaker implantation. After treatment, AF detection rate declined from 12% to 2.5% over six-month follow-up and AF burden decreased significantly. Remote monitoring pacemakers were helpful for the early diagnosis of AF (especially for asymptomatic AF) and could provide long-term benefits to patients. [1]

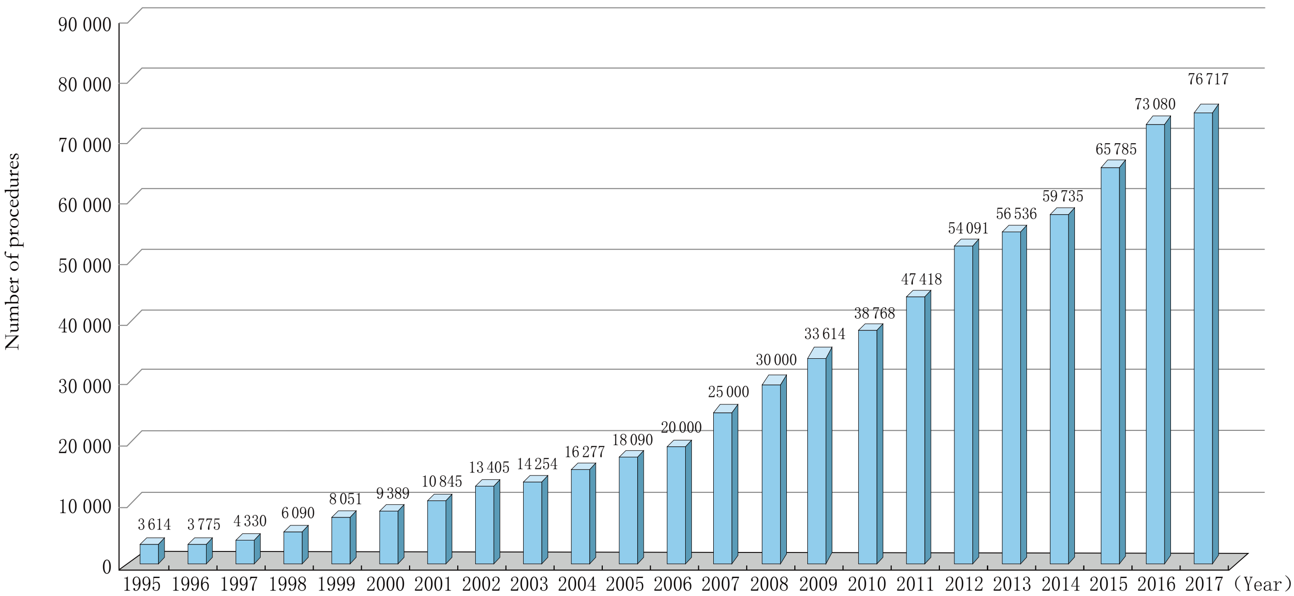


Figure 3-3-1 Pacemaker implantation volume in China, 1995-2017

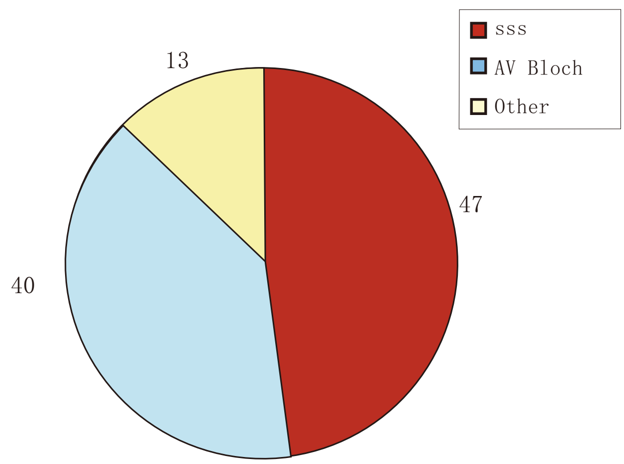


Figure 3-3-2 Indications for pacemaker implantation, 2017

[1] Chen KP, Dai Y, Hua W, et al. Reduction of atrial fibrillation in remotely monitored pacemaker patients: results from a Chinese multicentre registry. Chin Med J, 2013,126(22):4216-4221.

In 1996, the first trans-jugular implantable cardioverter-defibrillator (ICD) placement was performed in China. A study in 31 hospitals showed that 85.2% of the patients met Class I indication (2002 ACC/AHA/NASPE guideline) of ICD implantation for secondary prevention, and only 10.6% met Class IIa indication for primary prevention. [1] Not all the patients who were eligible for ICD received implantation. A recent study showed that among 497 patients who fulfilled Class I indication for ICD implantation, only 22.5% accepted ICD implantation, the remaining 77.5% patients refused to receive ICD therapy. During a mean follow-up of 11±3 months, the mortality rates were 1.8% in ICD group and 9.4% in non-ICD group. The incidence of sudden cardiac death was 6.7% in non-ICD group, which was significantly higher than that in ICD group. [2] According to the online registration system of the National Health Commission of the People's Republic of China, a total of 4 092 ICD implantations were conducted in 2017 (CRT-D was analyzed in the section of "cardiac resynchronization therapy (CRT)," and only ICD data was used). The number of implanted ICD has increased steadily in recent years. The annual growth rate has remained over 10%, with 22.2%, 16.3% and 23.4% in 2015, 2016 and 2017, respectively (Figure 3-3-3). The proportions of single-chamber and dual-chamber ICD implantation in 2017 were 37.7% and 62.3%, respectively, almost the same as in 2016. ICD implantation used for secondary prevention and primary prevention was 55.5% and 44.5%, respectively. From 2013 to 2015, there were 440 ICD implantations conducted in 20 hospitals across China. The study results showed [3] that about 75% fulfilled the class I recommendation, indicating appropriate grasp of ICD indications in China. For the ICD implantation route, 96.3% of patients chose the left subclavicular vein route, and 87.9% had their ICD implanted bag located on the left side. Most defibrillation wires located in the apex of the heart (89.3%), and less than 7% located in the ventricular septum.The proportion of primary prevention in southern patients was substantially higher than that in the north (58.9% vs 41.1%). Recently, European DANISH Study revealed [4] that there was a limited benefit of ICD implantation for primary prevention in older patients with nonischemic cardiomyopathy. Although there is no similar domestic research at present, ICD should be implanted with cautions when applying to more people.

[1] Hua W, Zhang S, Niu HX, et al. Primary and secondary prevention of sudden cardiac death with implantable cardioverter defibrillator: Analysis the indications of ICD in 31 hospital patients. Chinese J Cardiac Arrhythmias, 2010,14(1):9-11.

[2] Hua W, Niu H, Fan X, et al. The preventive effectiveness of implantable cardioverter defibrillator in reducing sudden cardiac death in the Chinese population: a multicenter trial of ICD therapy versus no-ICD therapy. J Cardiovasc Electrophysiol, 2012,23Suppl 1:S5-9.

[3] Dai Y, Chen KP, Hua W, et al. Clinical application of implantable cardioverter defibrillator (20 hospital registration studies). Chinese Journal of Arrhythmia, 2017,21(1):26-30.

[4] Kober L, Thune JJ, Nielsen JC, et al. Defibrillator Implantation in Patients with Nonischemic Systolic Heart Failure. N Engl J Med, 2016,375(13):1221-1230.

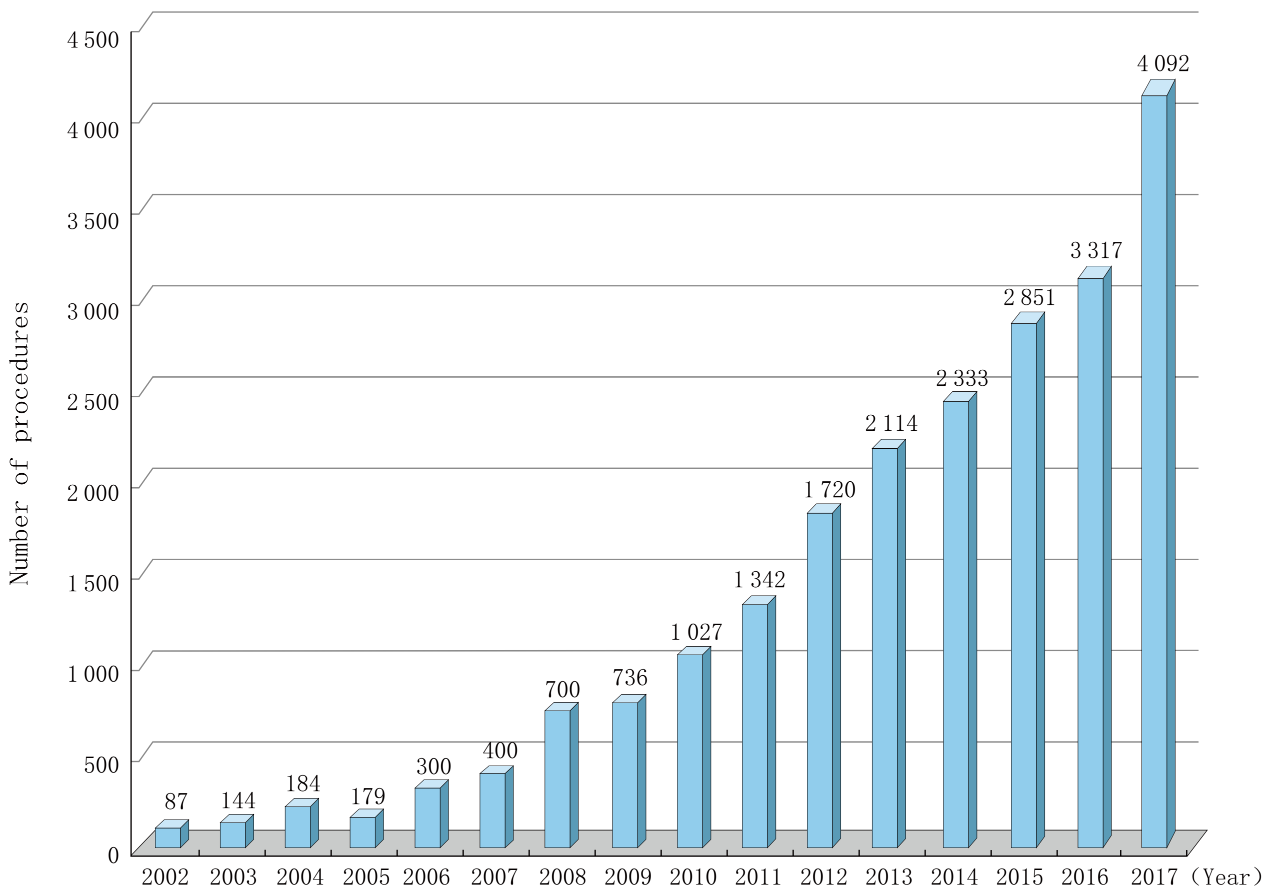


Figure 3-3-3 ICD implantation volumes in China, 2002-2017

Since 1999, Chinese physicians have started to use biventricular pacing to treat heart failure. From 2002 to 2007, the number of cardiac resynchronization therapy (CRT) implantations increased by at least 30% each year. According to statistics from the online enrollment system of the National Health Commission of the People's Republic of China (excluding some military hospitals), the rate in 2017 increased by 16.2% and 29.3% as compared with 2015 and 2016, respectively (Figure 3-3-4). The proportion of CRT-D implantation increased year by year as patients who met CRT-P indications also fulfilled CRT-D indications. From 2013 to 2015, one study included a total of 454 cases of CRT-P/D across 22 centers in China,[1] of which 52.2% patients chose CRT-D. The proportion of CRT-D in patients treated with CRT in 2017 was further increasing (61%). Elderly patients and patients with more clinical complications were more likely to choose CRT-P, whereas patients with a medical history of syncope or successful rescue of sudden death, lower ejection fraction, larger left ventricular diastolic dimension and who were taking more antiarrhythmic drugs, were more likely to choose CRT-D. Also, the level of hospitals and the regional economic development were

[1] Fan XH, Chen KP, Yan Q, et al. Analysis of the factors affecting pacemaker or defibrillator option in cardiac resynchronization therapy. Chinese Journal of Arrhythmia, 2017,21(1):31-36.

important factors for CRT selection: the ratio of CRT-D was higher in hospitals with an annual implant number of more than 40 cases, and it was lower in areas with a lower GDP.

Remote monitoring CRT has attracted increasing attention. A study conducted by Fuwai Hospital in 97 hospitals analyzed 73 CRT cases with remote monitoring function. The six-month follow-up showed that 92.7% of patients experienced abnormal events, 85% of which were disease-related (atrial arrhythmia events, ventricular arrhythmia events, low-frequency pacing, etc.) and 15% were device-related events (including conductor resistance disorder and sensory dysfunction). After implantation of CRT, it could detect adverse events earlier than the regular follow-up in three and six months after implantation. Furthermore, adverse disease-related events decreased over time, which suggested that remote monitoring was reliable for CRT implanted patients who had heart failure and lended long-term benefits. [1,2] Non-ischemic cardiomyopathy remained the most common indication for CRT. With stricter criteria for CRT, only heart failure patients with complete left bundle branch block are selected (76.3%), and the treatment brings more benefits to patients with high BMI. [3]

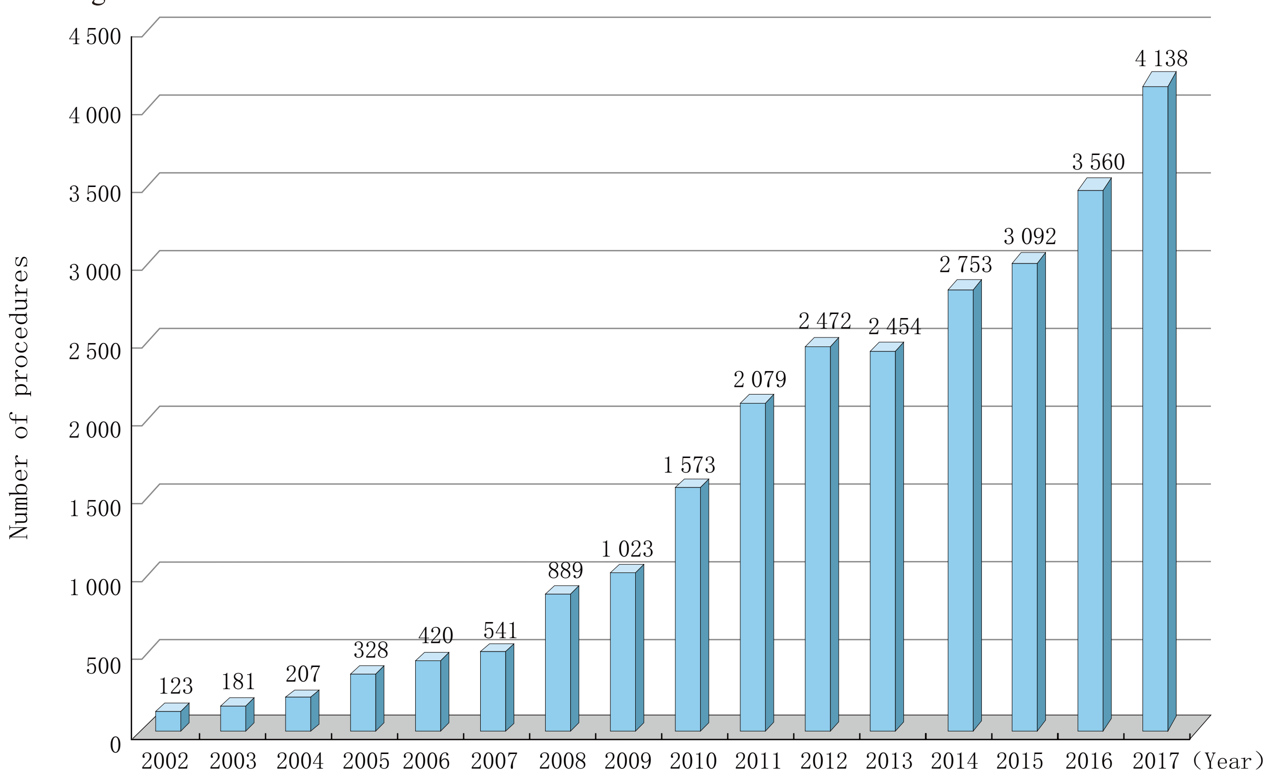


Figure 3-3-4 Trends in CRT procedures in China, 2002-2017

[1] Chen KP, Dai Y, Hua W, et al. Reduction of atrial fibrillation in remotely monitored pacemaker patients: results from a Chinese multicentre registry. Chin Med J, 2013,126(22):4216-4221.

[2] Chen KP, Hua W, Dai Y, et al. Cardiac resynchronization therapy in remotely monitored pacemaker patients: results from a Chinese multicentre registry. Chinese J Cardiac Arrhythmias, 2013,17(1):46-49.

[3] Cai C, Hua W, Ding LG, et al. Association of body mass index with cardiac reverse remodeling and long-term outcome in advanced heart failure patients with cardiac resynchronization therapy. Circ J, 2014,78(12):2899-2907.

3.3.3 Radiofrequency Catheter Ablation

China reported clinical practice of radiofrequency catheter ablation (RFCA) as early as in 1991 .[1,2] Currently, the application of RFCA for pre-excitation syndromes and supraventricular tachycardia is widely accepted in over 600 Chinese hospitals. Statistics from the National Health Commission's online enrollment system show that the application of RFCA has increased rapidly since 2010 (Figure 3-3-5), with annual growth rate between 13.2% and 17.5%. The number of RFCA was 133 900 in 2017. Out of all RFCA procedures, the proportion of RFCA for atrial fibrillation increased annually, from 21.0% in 2015, to 23.1% in 2016, and to 27.3% in 2017.

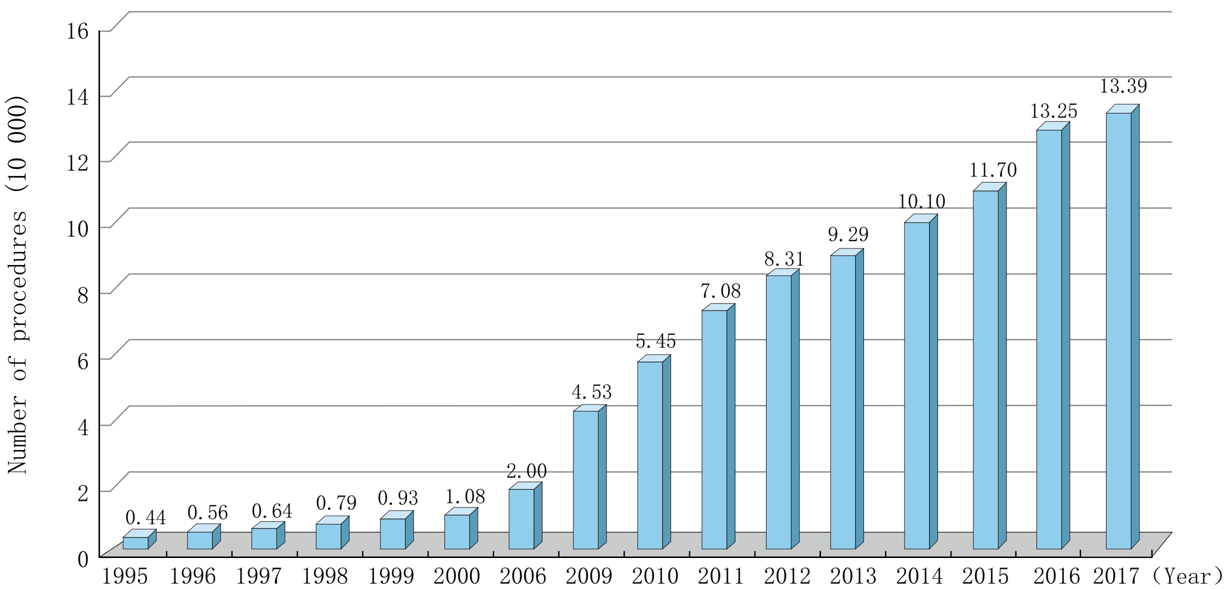


Figure 3-3-5 Number of RFCA in China, 1995-2017

At present, the disease distribution of RFCA tends to be stable, and there was no significant change from 2015 to 2017. The proportion of various diseases treated by RFCA was 50% for paroxysmal supraventricular tachycardia (SVT), 27.3% for atrial fibrillation (AF), 4.4% for atrial fluidity (AFL), 10% for premature ventricular contractions (PVC), 3.3% for ventricular tachycardia (VT), and 5% in total for atrial tachycardia (AT) and premature atrial contractions (PAC) (Figure 3-3-6).

[1] Li GS, Gao HN, Xu JL, et al. Treatment of pre-excitation syndrome through radiofrequency catheter ablation. Cardiac Pacing and Electrophysiology, 1991,5(2):57-59.

[2] Hu DY, Chen X, Ma CS, et al. National survey on radiofrequency catheter ablation in China. Chinese J Cardiac Arrhythmias, 2002,6(2):124-127.

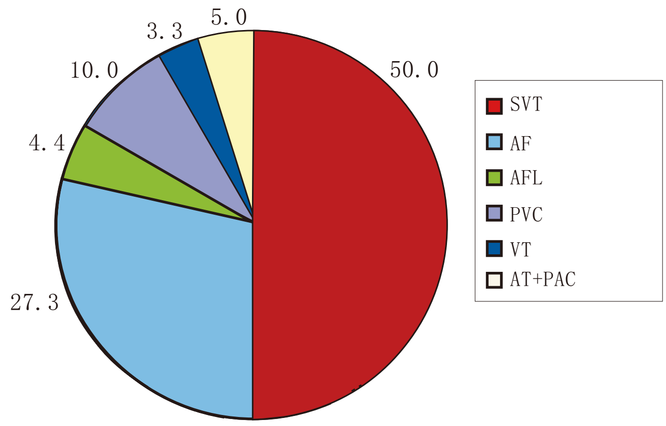


Figure 3-3-6 Proportion of diseases treated by RFCA in China (%), 2017

3.3.4 Sudden Cardiac Death (SCD)

A survey of one-year follow-up among 678 718 people from July 2005 to June 2006 uncovered that there were 2 983 deaths, with 9.5% (284 cases) attributed to sudden cardiac death (SCD). SCD occurred at a rate of 41.8/100 000 population and was more common in males than in females (44.6/100 000 vs 39.0/100 000). Most SCD cases occurred among people aged >65 years, and only 2 cases occurred in people aged <25 years. The estimated number of SCD cases across China was 544 000 per year [1,2] .

A prospective observational research was conducted in Fuwai Hospital [3] from 2004 to 2009. A total of 1 018 consecutive patients who had left ventricular ejection fraction (LVEF) ≤35% and New York Heart Association class II/III heart failure at least 40 days after myocardial infarction were enrolled. During a mean follow-up of 2.8 years for subjects who refused to have ICD implantation, the SCD rate was 5% (the annual incidence of SCD was 1.8%), and all-cause mortality rate was 7.4%. Independent predictors of SCD included age (HR=1.05, 95%CI: 1.02-1.09), LVEF ≤25% (HR=1.82, 95%CI: 1.04-3.21), and no history of revascularization therapy (HR=3.97, 95%CI: 2.15-7.31). Currently, LVEF <35% is the cutoff value used to identify patients at high risk of SCD. A recent study led by Fuwai Hospital analyzed the data of 853 patients from multiple centers who had ICD implantation with home monitoring between 2009 and 2014. Patients were divided into 4 groups according to their LVEF and left ventricular enddiastolic diameter (LVEDD). This study found that patients who had 35%<LVEF≤45% and LVEDD>60 mm were at high risk for ventricular arrhythmia and cardiac death during an average follow-up period of 30 months [4] . 2015 Diagnostic and

[1] Hua W, Zhang LF, Wu YF, et al. Incidence of sudden cardiac death in China: analysis of 4 regional populations. J Am Coll Cardiol, 2009,54:1110-1118.

[2] Zhang S. Sudden cardiac death in China. Pacing Clin Electrophysiol, 2009,32:1159-1162.

[3] Fan X, Hua W, Xu Y, et al. Incidence and predictors of sudden cardiac death in patients with reduced left ventricular ejection fraction after myocardial infarction in an era of revascularization. Heart, 2014,100(16):1242-1249.

[4] Zhao S, Chen K, Su Y, et al. High incidence of ventricular arrhythmias in patients with left ventricular enlargement and moderate left ventricular dysfunction. Clin Cardiol, 2016,39(12):703-708.

Therapeutic Guidelines for Acute ST-segment Elevation Myocardial Infarction(STEMI) released by the Chinese medical association proposed [1] that STEMI patients needed a second evaluation of cardiac function and sudden death risk at 40 days (not complete revascularization) or 90 days (revascularization) after myocardial infarction. Primary prevention for sudden cardiac death was recommended for patients who took the best medication treatment but still have heart failure (NYHA level II-III and LVEF≤35%) 40 days after STEMI, and with a life expectancy of more than 1 year; or for patients who took the best medication treatment but still have mild heart failure (NYHA level I and LVEF≤30%) 40 days after STEMI and have a life expectancy of more than 1 year. Because most underlying disease of SCD is coronary artery disease, SCD is still the critical challenge in the long-term management of ischemic heart disease after coronary revascularization. The EPCI expert consensus, Prevention of Sudden Cardiac Death After Revascularization For Coronary Heart Disease, was issued in 2017. The consensus introduced the risk assessment of sudden cardiac death at 48 hours after acute myocardial infarction and after stable coronary heart disease revascularization, as well as methods for secondary prevention and primary prevention.[2]

Although the implantation of ICD may prevent sudden death, the effect is limited. Patients with ICD may still experience repeated episodes of ventricular tachycardia, which reduces their quality of life. VANISH study in Europe suggested that for patients with ventricular tachycardia after myocardial infarction, such as ventricular tachycardia after ICD implantation, catheter ablation could be used to improve the treatment efficacy of antiarrhythmic medications. The Fuwai Hospital took the first lead to carry out ablation treatment for ventricular arrhythmia, and the success rate of ablation treatment on ventricular arrhythmias originating from the left ventricular anterobasal wall was up to 86%.[3]

3.3.5 New Technology in the Arrhythmia Field

Implanted pacemakers are currently the first-line treatment for bradyarrhythmias. However, the risks of lead displacements, lead fractures, venous thrombosis, and pacemaker pocket infection have led to more interest in leadless pacemakers in recent years. On February 10th 2015, Fuwai Hospital performed the first leadless pacemaker implantation in China. It initiated a new era in the treatment of bradyarrhythmia using leadless pacemakers.[4] Because normal electrical conduction can be obtained to maintain the synchronization of ventricular excitation, this bundle pacing is expected for good clinical effect, and it is the current hot spot in the field of pacing therapy. By using His-bundle pacing as intervention, original and innovative

[1] Chinese Society of Cardiology, Editorial Board of Chinese Journal of Cardiovascular Diseases. Diagnostic and therapeutic guidelines for acute ST-segment elevation myocardial infarction. Chinese Journal of Cardiovascular Diseases, 2015,43(5):380-393.

[2] Huang DJ, Huo YJ, Zhang S, et al. Prevention of sudden cardiac death after revascularization for coronary heart disease. Chinese Journal of Cardiac Arrhythmias, 2017,21(1):9-21.

[3] Ding L, Hou B, Wu L, et al. Delayed efficacy of radiofrequency catheter ablation on ventricular arrhythmias originating from the left ventricular anterobasal wall. Heart Rhythm, 2017,14(3):341-349.

[4] Chen KP, Dai Y, Zheng XL, et al. One case of leadless non-wire catheter pacemaker implantation. Chinese Journal of Cardiac Arrhythmias, 2015,19(2):145-146.

results were obtained from Chinese studies on the feasibility of correcting left bundle branch block (LBBB) in patients with heart failure and on their medium- and long-term prognosis, which has generated warm responses worldwide. It reported that the success rate of correcting LBBB by using His-bundle pacing is 96.6%, and 76.3% of patients have successfully performed permanent His-bundle pacing.[1,2]

Cardiac contractility modulation (CCM), also called absolute refractory period electrical stimulation or non-excitatory electrical stimulation, is mainly used in chronic heart failure patients with narrowed ECG QRS waves (<120ms). Fuwai Hospital successfully implanted the first CCM procedure in mainland China on December 30th 2014.[3]

As of May 2016, a total of 8 CCM had been implanted at 5 centers in China. The results of 6 months of follow-up showed that CCM was safe and reliable, and there was a significant improvement in the NYHA heart function classification and in the 6-minute walk test performance.[4] Fuwai Hospital implanted the first domestic station ICD (SICD) on December 23rd 2014.[5] As of December 2017, a total of 27 cases of SICD had been implanted in China. The 2017 AHA/ACC/HRS guidelines on ventricular tachycardia and sudden cardiac death suggested that SICD implantation could be a class I recommendation for those patients with ICD implantation indications, but without appropriate venous access or with high risk of infection; and for those who do not need or expect not to need bradycardia pacing or termination of VT pacing or CRT implantation.[6] SICD implantation provides a new, safe and effective treatment strategy for patients who are not suitable for traditional implantation of ICD through the venous route.

3.4 Heart Failure

3.4.1 Prevalence

A survey involving 15 518 people from 20 urban and rural areas in 10 provinces in China [7] found that the prevalence of chronic heart failure (CHF) among the Chinese population aged 35-74 years was 0.9% in

[1] Marwah Abdalla, Melissa C. Caughey, Rikki M. Tanner, et al. Associations of Blood Pressure Dipping Patterns With Left Ventricular Mass and Left Ventricular Hypertrophy in Blacks: The Jackson Heart Study. J Am Heart Assoc, 2017 Apr 5;6(4). pii: e004847. doi: 10.1161/JAHA.116.004847.

[2] Lan Su, Lei Xu, Sheng-jie Wu, et al. Pacing and sensing optimization of permanent His-bundle pacing in cardiac resynchronization therapy/implantable cardioverter defibrillators patients: value of integrated bipolar configuration. Europace, 2016,18 (9):1399-1405.

[3] Hua W, Fan XH, Wang J, et al. One case of implantable cardiac contractility modulation for treatment of chronic heart failure. J of Cardiac Arrhythmias, 2015,19(1):65-66.

[4] Hua W, Fan X, Su Y, et al. The efficacy and safety of cardiac contractility modulation in patients with no ischemic cardiomyopathy: Chinese experience. Int J Heart Rhythm, 2017,2:29-33.

[5] Hua W, Ding LG, Zheng LH, et al. Whole Subcutaneous Implantable Cardioverter Defibrillator Example. J of Cardiac Arrhythmias, 2014,18(6):469-470.

[6] Al-Khatib SM, Stevenson WG, Ackerman MJ, et al. 2017 AHA/ACC/HRS Guideline for Management of Patients With Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death. Heart Rhythm, 2017,26 pii:S1547-5271(17)31250-X.

[7] Gu DF, Huang GY, He J, et al. Investigation of prevalence and distributing feature of chronic heart failure in Chinese adult population. Chinese Journal of Cardiology, 2003,31(1):3-6.

2000. The prevalence was higher in females (1.0%) than in males (0.7%), higher in the north (1.4%) than in the south (0.5%), and higher in urban (1.1%) than in rural areas (0.8%). The prevalence of CHF increased significantly with age.

Studies conducted in different ethnicities (Han, Uygur, and Kazakh) of Xinjiang residents aged ≥35 [1] and ≥60 years [2] showed that the prevalence rates of CHF varied among different ethnicities, but all increased with age. A survey involving the people aged ≥50 in Beijing Chaoyang District also showed [3] that the prevalence of CHF increased with age.

A population-based study of 2 230 participants aged ≥35 years conducted in rural areas of Liaoning Province from January 2012 through August 2013 [4] showed that the overall prevalence of HF with preserved ejection fraction (HFpEF) was 3.5%. The prevalence of HFpEF increased with age in both genders and was higher in females than in males for every age group. The prevalence of HF in different studies in China is shown in Table 3-4-1.

Table 3-4-1 The prevalence of HF by study in China (%)

Study	Year	Age	N	HF Prevalence in male	HF Prevalence in female	Total
10 provinces[5]	2000	≥35	15 518	0.7	1.0	0.9
Xinjiang Province[6]	2007-2009	≥35	8 459	1.61	0.93	1.26
Xinjiang Province[7]	2007-2010	≥60	3 858	4.3	5.50	3.13
Beijing Chaoyang District[8]	2011-2012	≥50	1 540	5.3	4.3	4.6
Rural area of Liaoning Province[4]	2012-2013	≥35	2 230	1.80	4.90	3.5

[1] Yang YN, Ma YT, Liu F, et al. Prevalence and distributing feature of chronic heart failure in adult population of Xinjiang. Chinese Journal of Cardiology, 2010,38(5):460-464.

[2] Shan CF, Chen Y, Ma YT, et al. Prevalence and distribution of chronic heart failure in the elderly from Xinjiang. Chinese Journal of Epidemiology, 2014,35(9):1007-1010.

[3] Wang GL, Li RJ, Guo FS, et al. Investigation of prevalence and distributing feature of chronic heart failure in population aged >50 years in Beijing Chaoyang District. Chinese Journal of Medicine, 2015,50(11).54-57.

[4] Guo L, Guo X, Chang Y, et al. Prevalence and risk factors of heart failure with preserved ejection fraction: a population-based study in Northeast China. Int J Environ Res Public Health, 2016 Jul 29;13(8). pii: E770. doi: 10.3390/ijerph13080770.

[5] Gu DF, Huang GY, He J, et al. Investigation of prevalence and distributing feature of chronic heart failure in Chinese adult population. Chinese Journal of Cardiology, 2003,31(1):3-6.

[6] Yang YN, Ma YT, Liu F, et al. Prevalence and distributing feature of chronic heart failure in adult population of Xinjiang. Chinese Journal of Cardiology, 2010,38(5):460-464.

[7] Shan CF, Chen Y, Ma YT, et al. Prevalence and distribution of chronic heart failure in the elderly from Xinjiang. Chinese Journal of Epidemiology,2014,35(9):1007-1010.

[8] Wang GL, Li RJ, Guo FS, et al. Investigation of prevalence and distributing feature of chronic heart failure in population aged >50 years in Beijing Chaoyang District. Chinese Journal of Medicine, 2015, 50(11).54-57.

3.4.2 Demographic Characteristics

The latest analysis of China Heart Failure Registry Study (China-HF) [1] showed that the average age of hospitalized patients with HF in China was 65±15 years old, with males accounting for 59.1%. Compared with other studies on HF in China, the average age of hospitalized patients with HF has been rising (Table 3-4-2).

Table 3-4-2 The characteristics of HF patients by study

Study	Year	N	Subject	Age	Male (%)
42 hospitals[2]	1980	1 756	CHF	68±17	56.0
	1990	2 181	CHF	64±22	59.6
	2000	6 777	CHF	63±16	55.1
Shanghai[3]	1980	2 178	In-hospital HF	52	55.1
	1990			59	58.2
	2000			69	58.3
301 Hospital[4]	1993-1997	1 623	In-hospital HF	56±18	62.6
	1998-2002	2 444		58±18	60.4
	2003-2007	3 252		63±16	63.1
Hubei[5]	2000-2010	16 681	Chronic systolic HF	63±11	59.3
10 hospitals[6]	2005-2009	2 154		64±13	78.6
Xinjiang[7]	2004-2005	2 058	CHF	59±14	60.9

[1] Yang YN, Ma YT, Liu F, et al. Prevalence and distributing feature of chronic heart failure in adult population of Xinjiang. Chinese Journal of Cardiology, 2010,38(5):460-464.

[2] Chinese Society of Cardiology of Chinese Medical Association. Retrospective investigation of hospitalized patients with heart failure in some parts of China in 1980, 1990 and 2000. Chinese Journal of Cardiology, 2002,30(8):450-454.

[3] Shanghai Investigation Group of Heart Failure. The evolving trends in the epidemiologic factors and treatment of hospitalized patients with congestive heart failure in Shanghai during years of 1980, 1990, 2000. Chinese Journal of Cardiology, 2002,30(1):24-27.

[4] Pei ZY, Zhao YS, Li JY, et al. Fifteen-year evolving trends of etiology and prognosis in hospitalized patients with heart failure. Chinese Journal of Cardiology, 2011,39(5):434-439.

[5] Yu SB, Zhao QY, Cui HY, et al. Investigation on the prevalence and related factors of medicinal therapy in patients with chronic systolic heart failure. Chinese Journal ofEpidemiology, 2012,33(2):229-233.

[6] Liu X, Yu H, Pei J, et al. Clinical characteristics and long-term prognosis in patients with chronic heart failure and reduced ejection fraction in China. Heart Lung Circ, 2014,23:818-826.

[7] Zhang Y, Abelai B, Heliqiemu A, et al. Etiology and medication treatment of 2058 patients with chronic heart failure in Uygur district. Journal of Clinical Cardiology, 2016, 32 (10):1016-1020.

Table 3-4-2 The characteristics of HF patients by study (Continued)

Study	Year	N	Subject	Age	Male (%)
Xinjiang[1]	2011-2012	5 357	CHF	64±12	65.3
24 hospitals[2]	2012-2014	900		66±13	57.2
China-HF[3]	2012-2015	13 687	In-hospital HF	65±15	59.1

3.4.3 Etiology and Comorbidities

In recent years, the etiology of HF has changed significantly in China: the proportion of valvular disease (especially rheumatic valvular disease) has been decreasing year by year, while coronary heart disease, hypertension and dilated cardiomyopathy have become the main causes of HF in China. Diabetes mellitus has been increasing among patients with HF (Table 3-4-3).

Table 3-4-3 Etiology and comorbidities of patients with HF by study

Study	Year	N	CHD (%)	Hypertension (%)	VHD (%)	CM (%)	Diabetes (%)	AF (%)
42 hospitals[4]	1980	1 756	36.8	8.0	34.4[a]	6.4[b]	—	—
	1990	2 181	33.8	10.4	34.3[a]	7.4[b]	—	—
	2000	6 777	45.6	12.9	18.6[a]	7.6[b]	—	—
Shanghai[5]	1980	2 178	31.1	8.5	46.8[a]	6.0[b]	—	—
	1990		40.6	10.3	24.2[a]	6.9[b]	—	—
	2000		55.7	13.9	8.9[a]	7.5[b]	—	—

[1] Jiang H, Zhang HW, Zhou XH. Clinical Characteristics and Current Treatment Status in Patients with Chronic Heart Failure at Different Grade Hospitals in Xinjiang Area. Chinese Circulation Journal, 2015,30(12): 1186-1190.

[2] Liu SS, Yu LT, Tan HQ, et al. Clinical characteristics, treatment and prognosis of HF in different levels of hospitals. Molecular Cardiology of China, 2017,17 (2):2012-2016.

[3] Zhang Y, Zhang J, Butler J, et al. Contemporary Epidemiology, Management, and Outcomes of Patients Hospitalized for Heart Failure in China: Results from the China Heart Failure (China-HF) Registry. J Card Fail, 2017,23 (12):868-875.

[4] Chinese Society of Cardiology of Chinese Medical Association. Retrospective investigation of hospitalized patients with heart failure in some parts of China in 1980, 1990 and 2000. Chinese Journal of Cardiology, 2002,30(8):450-454.

[5] Shanghai Investigation Group of Heart Failure. The evolving trends in the epidemiologic factors and treatment of hospitalized patients with congestive heart failure in Shanghai during years of 1980, 1990, 2000. Chinese Journal of Cardiology, 2002,30(1):24-27.

Table 3-4-3 Etiology and comorbidities of patients with HF by study (Continued)

Study	Year	N	CHD (%)	Hypertension (%)	VHD (%)	CM (%)	Diabetes (%)	AF (%)
	1993-1997	1 623	37.2	23.3	35.2[a]	6.7	12.3	23.2
301 Hospital[1]	1998-2002	2 444	40.9	32.3	32.7[a]	5.7	15.9	23.0
	2003-2007	3 252	46.8	46.7	16.6[a]	8.2	21.1	20.6
Hubei[2]	2000-2010	16 681	—	47.6	—	—	16.2	40.8
10 hospitals[3]	2005-2009	2 154	64.4	56.7	—	35.6[b]	17.2	15.8
Xinjiang[4]	2004-2015	2 058	54.9	12.7	10.6[a]	10.9[b]	18.6	9.9
Xinjing[5]	2011-2012	5 357	50.8	31.8	2.3 [a]	7.2[b]	21.7	—
24 hospitals[6]	2012-2014	990	52.1	16.7	9.9	14.1[b]	—	—
China-HF[7]	2012-2015	13 687	49.6	50.9	15.5	16.0[b]	21.0	24.4

Notes: a: rheumatic valvular disease; b: dilated cardiomyopathy; CHD: coronary heart disease; CM: Cardiomyopathy; VHD: valvular heart disease; AF: atrial fibrilliation.

3.4.4 Inducing Factors for HF

The China-HF study [7] showed that infection was still the predominant inducing factor for HF, followed by myocardial ischemia and exertion or stress (Figure 3-4-1). A cross-sectional survey [8] in hospitalized HF patients in the year of 1980, 1990 and 2000 in Shanghai showed similar results. A retrospective analysis

[1] Pei ZY, Zhao YS, Li JY, et al. Fifteen-year evolving trends of etiology and prognosis in hospitalized patients with heart failure. Chinese Journal of Cardiology, 2011,39(5):434-439.

[2] Yu SB, Zhao QY, Cui HY, et al. Investigation on the prevalence and related factors of medicinal therapy in patients with chronic systolic heart failure. Chinese Journal of Epidemiology, 2012,33(2):229-233.

[3] Liu X, Yu H, Pei J, et al. Clinical characteristics and long-term prognosis in patients with chronic heart failure and reduced ejection fraction in China. Heart Lung Circ, 2014,23: 818-826.

[4] Zhang Y, Abelai B, Heliqiemu A, et al. Etiology and medication treatment of 2058 patients with chronic heart failure in Uygur district. Journal of Clinical Cardiology, 2016,32 (10):1016-1020.

[5] Jiang H, Zhang HW, Zhou XH. Clinical Characteristics and Current Treatment Status in Patients with Chronic Heart Failure at Different Grade Hospitals in Xinjiang Area. Chinese Circulation Journal, 2015,30(12): 1186-1190.

[6] Liu SS, Yu LT, Tan HQ, et al. Clinical characteristics, treatment and prognosis of HF in different levels of hospitals. Molecular Cardiology of China, 2017,17(2):2012-2016.

[7] Zhang Y, Zhang J, Butler J, et al. Contemporary Epidemiology, Management, and Outcomes of Patients Hospitalized for Heart Failure in China: Results from the China Heart Failure (China-HF) Registry. J Card Fail, 2017,23(12):868-875.

[8] Shanghai Investigation Group of Heart Failure. The evolving trends in the epidemiologic factors and treatment of hospitalized patients with congestive heart failure in Shanghai during years of 1980, 1990, 2000. Chinese Journal of Cardiology, 2002,30(1):24-27.

revealing 15-year trends of etiology and prognosis in hospitalized patients with chronic HF in PLA General Hospital showed that atrial fibrillation was the main inducing factor for HF.[1]

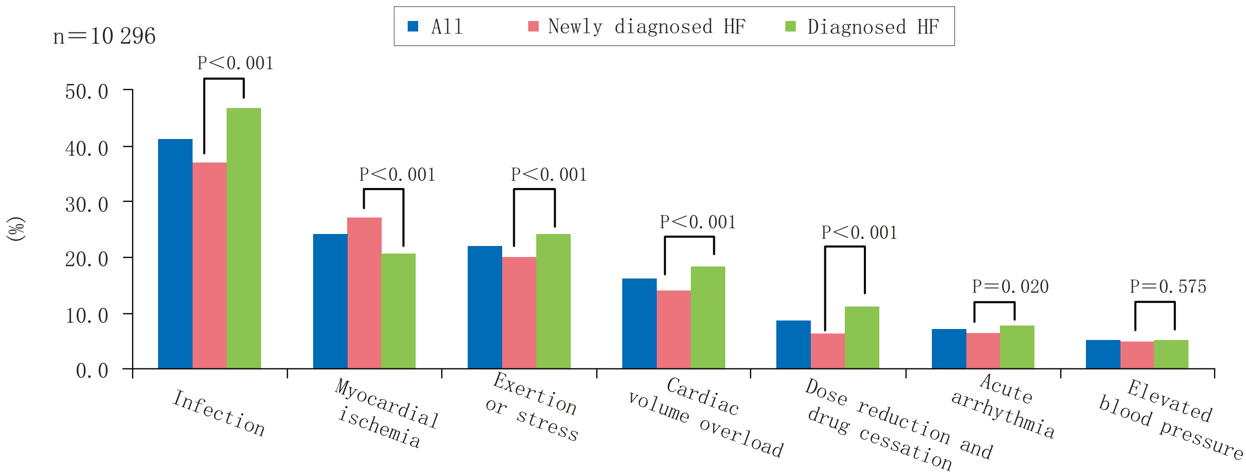


Figure 3-4-1 Inducing factors for HF

3.4.5 Pharmaceutical Treatment for HF

The China-HF study [2] and some other relevant studies in China showed that the proportion of patients treated with intravenous diuretics during hospitalization had not changed significantly in recent years. The use of digoxin had witnessed a downward trend due to the influence of international clinical studies. The use of ACEI, ARB, mineralocorticoid receptor antagonists (MRA), and beta-receptor blockers (BB) had increased significantly. The medication usage across different studies is shown in Table 3-4-4.

Table 3-4-4 Utilization of medications in HF (%)

Study	Year	N	Diuretics	Digoxin	ARB	ACEI	MRA	BB
	1973-1982	542	58.7	61.3	—	—	5.9	9.0
Tianjin[3]	1983-1992	1 253	67.8	71.6	—		10.1	8.3
	1993-2002	3 394	75.4	67.9	4.0	70.9	23.2	25.3

[1] Pei ZY, Zhao YS, Li JY, et al. Fifteen-year evolving trends of etiology and prognosis in hospitalized patients with heart failure. Chinese Journal of Cardiology, 2011,39(5):434-439.

[2] Zhang Y, Zhang J, Butler J, et al. Contemporary Epidemiology, Management, and Outcomes of Patients Hospitalized for Heart Failure in China: Results from the China Heart Failure (China-HF) Registry. J Card Fail, 2017,23(12):868-875.

[3] Ma JP, Wang L, Dang Q, et al. Retrospective analysis of drug treatment on inpatients with chronic heart failure. Chinese Journal of Epidemiology, 2007,28(1):78-82.

Table 3-4-4 Utilization of medications in HF (%) (Continued)

<table>
<tr><th>Study</th><th>Year</th><th>N</th><th>Diuretics</th><th>Digoxin</th><th>ARB</th><th>ACEI</th><th>MRA</th><th>BB</th></tr>
<tr><td rowspan="3">42 hospitals[1]</td><td>1980</td><td>1 756</td><td>63.7</td><td>51.7</td><td>0.4</td><td>14.0</td><td>10.0</td><td>8.5</td></tr>
<tr><td>1990</td><td>2 181</td><td>70.2</td><td>45.5</td><td>1.4</td><td>26.4</td><td>8.4</td><td>9.5</td></tr>
<tr><td>2000</td><td>6 777</td><td>48.6</td><td>40.3</td><td>4.5</td><td>40.4</td><td>20.0</td><td>19.0</td></tr>
<tr><td rowspan="3">Shanghai[2]</td><td>1980</td><td>2 178</td><td>77.1</td><td>60.0</td><td>—</td><td>0.6</td><td>—</td><td>6.8</td></tr>
<tr><td>1990</td><td></td><td>—</td><td>—</td><td>—</td><td>38.9</td><td>—</td><td>5.7</td></tr>
<tr><td>2000</td><td></td><td>—</td><td>—</td><td>11.5</td><td>70.8</td><td>—</td><td>25.0</td></tr>
<tr><td>Hubei[3]</td><td>2000-2010</td><td>16 681</td><td>69.1</td><td>46.2</td><td>18.7</td><td>51.6</td><td>—</td><td>46.6</td></tr>
<tr><td>10 hospitals[4]</td><td>2005-2009</td><td>2 154</td><td>74.4</td><td>—</td><td colspan="2">66.0</td><td>74.6</td><td>68.3</td></tr>
<tr><td>Xinjiang[5]</td><td>2004-2015</td><td>2 058</td><td>55.1</td><td>25.2</td><td colspan="2">74.5</td><td>30.9</td><td>65.3</td></tr>
<tr><td>Primary hospitals in 17 districts[6]</td><td>2006</td><td>2 100</td><td>90.0</td><td>60.0</td><td></td><td>5.8</td><td>50.0</td><td>40.0</td></tr>
<tr><td>Yunnan Province[7]</td><td>2008-2012</td><td>2 106</td><td>84.8</td><td>28.2</td><td colspan="2">82.8</td><td>76.6</td><td>72.2</td></tr>
<tr><td>Xinjiang[8]</td><td>2011-2012</td><td>5 357</td><td>45.5</td><td>26.8</td><td colspan="2">72.8</td><td>46.6</td><td>66.8</td></tr>
<tr><td>24 hospitals[9]</td><td>2012-2014</td><td>990</td><td>60.6</td><td>26.2</td><td colspan="2">65.9</td><td>54.1</td><td>59.9</td></tr>
<tr><td rowspan="2">China-HF[10]</td><td>2012-2015</td><td>13 687</td><td>72.2[a]</td><td rowspan="2">—</td><td colspan="2">67.5[a]</td><td>74.1[a]</td><td>70.0[a]</td></tr>
<tr><td></td><td></td><td>46.9[b]</td><td colspan="2">55.5[b]</td><td>48.7[b]</td><td>52.2[b]</td></tr>
</table>

Notes: a: Intravenous drugs during hospitalization; b: Oral medication after discharge

[1] Chinese Society of Cardiology of Chinese Medical Association. Retrospective investigation of hospitalized patients with heart failure in some parts of China in 1980, 1990 and 2000. Chinese Journal of Cardiology, 2002,30(8):450-454.

[2] Shanghai Investigation Group of Heart Failure. The evolving trends in the epidemiologic factors and treatment of hospitalized patients with congestive heart failure in Shanghai during years of 1980, 1990, 2000. Chinese Journal of Cardiology, 2002,30(1):24-27.

[3] Yu SB, Zhao QY, Cui HY, Et al. Investigation on the prevalence and related factors of medicinal therapy in patients with chronic systolic heart failure. Chinese Journal of Epidemiology, 2012,33(2):229-233.

[4] Liu X, Yu H, Pei J, et al. Clinical characteristics and long-term prognosis in patients with chronic heart failure and reduced ejection fraction in China. Heart Lung Circ, 2014,23:818-826.

[5] Zhang Y, Abelai B, Heliqiemu A, et al. Etiology and medication treatment of 2058 patients with chronic heart failure in Uygur district. Journal of Clinical Cardiology, 2016,32 (10):1016-1020.

[6] Cao YS, Hu DY, Wang HY, et al. A survey of medical therapies for chronic heart failure in primary hospitals in China. Chinese Journal of Internal Medicine, 2006,45(11):907-909.

[7] Yuan HY, Han MH. Analysis of drug therapy for patients with chronic heart failure. Journal of Kunming Medical University, 2015,36(8):61-64.

[8] Jiang H, Zhang HW, Zhou XH. Clinical Characteristics and Current Treatment Status in Patients with Chronic Heart Failure at Different Grade Hospitals in Xinjiang Area. Chinese Circulation Journal, 2015,30(12): 1186-1190.

[9] Liu SS, Yu LT, Tan HQ, et al. Clinical characteristics, treatment and prognosis of HF in different levels of hospitals. Molecular Cardiology of China, 2017,17 (2):2012-2016.

[10] Zhang Y, Zhang J, Butler J, et al. Contemporary Epidemiology, Management, and Outcomes of Patients Hospitalized for Heart Failure in China: Results from the China Heart Failure (China-HF) Registry. J Card Fail, 2017,23(12):868-875.

3.4.6 Mortality Rate

3.4.6.1 Mortality Rate of Patients with Chronic Heart Failure (CHF)

The mortality rate of hospitalized patients with CHF has decreased significantly along with the development of healthcare in China. A retrospective analysis of hospitalized patients with CHF from 42 hospitals in China,[1] and a cross-sectional survey of hospitalized patients with CHF from 12 hospitals in Shanghai in the year 1980, 1990 and 2000,[2] both demonstrated a declining trend of in-hospital mortality rate in patients with CHF. A retrospective study of hospitalized patients with CHF in Beijing 301 Hospital across three time periods (1993-1997, 1998-2002 and 2003-2007) [3] also showed a downward trend for the 30-day mortality rate in patients with CHF.

The average in-hospital mortality rate of patients with CHF among different ethnic groups (Han, Uygur and Hui) in Xinjiang was 4.9%, with a higher mortality rate in the Han ethnic group than in other ethnic groups [4] . Most recently, the China-HF study [5] showed that the mortality rate of HF patients in China was 4.1% (Table 3-4-5).

Table 3-4-5 The mortality rate of patients hospitalized for HF by study

Study	Year	N	Subjects	Age	In-hospital mortality
42 hospitals[1]	1980	1 756	Chronic HF	68±17	15.4
	1990	2 181	Chronic HF	64±22	12.3
	2000	6 777	Chronic HF	63±16	6.2
Shanghai[2]	1980	2 178	Inpatient HF	52	13.8
	1990			59	11.5
	2000			69	6.0

[1] Chinese Society of Cardiology of Chinese Medical Association. Retrospective investigation of hospitalized patients with heart failure in some parts of China in 1980, 1990 and 2000. Chinese Journal of Cardiology, 2002,30(8):450-454.

[2] Shanghai Investigation Group of Heart Failure. The evolving trends in the epidemiologic factors and treatment of hospitalized patients with congestive heart failure in Shanghai in the year 1980, 1990, 2000. Chinese Journal of Cardiology, 2002,30(1):24-27.

[3] Pei ZY, Zhao YS, Li JY, et al. Fifteen-year evolving trends of etiology and prognosis in hospitalized patients with heart failure. Chinese Journal of Cardiology, 2011,39(5):434-439.

[4] Zhang Y, Abelai B, Heliqiemu A, et al. Etiology and medication treatment of 2058 patients with chronic heart failure in Uygur district. Journal of Clinical Cardiology, 2016,32(10):1016-1020.

[5] Zhang Y, Zhang J, Butler J, et al. Contemporary Epidemiology, Management, and Outcomes of Patients Hospitalized for Heart Failure in China: Results from the China Heart Failure (China-HF) Registry. J Card Fail, 2017,23(12):868-875.

Table 3-4-5 The mortality rate of patients hospitalized for HF by study (Continued)

Study	Year	N	Subject	Age	In-hospital mortality
301 Hospital[1]	1993-1997	1 623	chronic HF	56±18	7.0[a]
	1998-2002	2 444		58±18	4.5[a]
	2003-2007	3 252		63±16	5.1[a]
Xinjiang[2]	2004-2015	2 058	chronic HF	59±14	4.9
China-HF[3]	2012-2015	13 687	inpatient HF	65±15	4.1
Fuwai Hospital HF Center[4]	2009-2013	793	dilated cardiomyopathy	49±13	4.4
Southern Hospital[5]	2011-2015	1 182	HF with various LVEF	65±15	4.7

Notes: [a], 30-day mortality rate
LVEF, Left Ventricular Ejection Fraction

3.4.6.2 Mortality Rate of HF in the Emergency Room

A retrospective study analyzed 1 198 cases admitted to the emergency room in Xuanwu Hospital due to acute heart failure (AHF) between 2005 and 2011.[6] It showed that 115 patients (9.6%) died in the emergency room, of which,73 (63.5%) died within 24 hours, and 93 (80.9%) died within 48 hours. Another retrospective study analyzed 1 190 patients of AHF admitted to the emergency room in Jiangsu Provincial People's Hospital and found that mortality rates from senile valvular disease, cardiomyopathy and rheumatic heart disease were all over 10%, higher than from other diseases; and mortality rates from hypertension, coronary heart disease and pulmonary heart disease were about 5%.[7]

［1］Pei ZY, Zhao YS, Li JY, et al. Fifteen-year evolving trends of etiology and prognosis in hospitalized patients with heart failure. Chinese Journal of Cardiology, 2011,39(5):434-439.

［2］Zhang Y, Abelai B, Heliqiemu A, et al. Etiology and medication treatment of 2058 patients with chronic heart failure in Uygur district. Journal of Clinical Cardiology, 2016,32(10):1016-1020.

［3］Zhang Y, Zhang J, Butler J, et al. Contemporary Epidemiology, Management, and Outcomes of Patients Hospitalized for Heart Failure in China: Results from the China Heart Failure (China-HF) Registry. J Card Fail, 2017,23(12):868-875.

［4］Zou CH, Huang Y, Zhou Q, et al. In-hospital and post-discharge prognosis and prediction scoring system for patients hospitalized with dilated cardiomyopathy. Chin J Heart Fail & Cardiomyopathy, 2017,1(2):93-97.

［5］Zhou HB, An DQ, Xu DL, et al. A retrospective analysis of clinical characteristics and outcomes of heart failure patients with various left ventricular ejection fractions. Chinese Journal of Internal Medicine, 2017,56(4):253-257.

［6］Li XY, Qin J, Liang X, et al. A retrospective analysis of 1198 patients with acute heart failure treated in emergency department. Chinese Journal of Geriatric Heart Brain and Vessel Diseases, 2012,14(10):1045-1047.

［7］Li CY, Jiang T, Wang WW, et al. Etiological analysis and treatment of heart failure patients in emergency room. Journal of Clinical Cardiology, 2016,32(10):1009-1012.

3.4.6.3 Long-term Mortality Rates in Patients with CHF

The long-term mortality rates of patients with CHF in different studies in China is shown in Table 3-4-6.

Table 3-4-6 Long-term mortality rate of patients with HF by study

Study	Year	N	Age	Subject	Follow-up time	In-hospital mortality (%)
Hubei Province[1]	2000-2010	16 681	63±11	chronic HF	5.8±1.6 years	38.7
10 provinces[2]	2005-2009	2 154	64±13	low ejection fraction HF	Median 52 months	39.5
Fuwai Hospital HF Center[3]	2009-2013	701	49±13	dilated cardiomyopathy HF	Median 34 months	19.5
Fuwai Hospital HF Center[4]	2009-2013	1 440	58±16	inpatient HF	Median 582 days	19.7
Southern Hospital[5]	2011-2015	1 182	65±15	HF with various LVEF	Median 24 months	20.6
24 hospitals[6]	2012-2014	990	66±13	HF in different levels of hospital	1 year	7.8

LVEF, Left Ventricular Ejection Fraction

3.4.7 Clinical Characteristics of Elderly Patients with HF

As China is embracing an aging society, the number of elderly patients with HF will increase over the years. Most studies on elderly patients with HF have suggested that coronary heart disease is the most common etiology in this subgroup, and the prevalence of hypertension and pulmonary heart disease increased with age among elderly patients with HF (Table 3-4-7). Common factors inducing HF in the elderly included

[1] Yu SB, Zhao QY, Cui HY, et al. Investigation on the prevalence and related factors of medicinal therapy in patients with chronic systolic heart failure. Chinese Journal of Epidemiology, 2012,33(2):229-233.

[2] Liu X, Yu H, Pei J, et al. Clinical characteristics and long-term prognosis in patients with chronic heart failure and reduced ejection fraction in China. Heart Lung Circ, 2014,23:818-826.

[3] Zou CH, Huang Y, Zhou Q, et al. In-hospital and post-discharge prognosis and prediction scoring system for patients hospitalized with dilated cardiomyopathy. Chin J Heart Fail & Cardiomyopathy, 2017,1(2):93-97.

[4] Zhang Y, Zhang R, An T, et al. The utility of galectin-3 for predicting cause-specific death in hospitalized patients with heart failure. J Card Fail, 2015,21(1):51-59.

[5] Zhou HB, An DQ, Xu DL, et al. A retrospective analysis of clinical characteristics and outcomes of heart failure patients with different Left ventricular ejection fractions. Chinese Journal of Internal Medicine, 2017,56(4):253-257.

[6] Liu SS, Yu LT, Tan HQ, et al. Clinical characteristics, treatment and prognosis of HF in different levels of hospitals. Molecular Cardiology of China, 2017,17(2):2012-2016.

infection, myocardial ischemia, arrhythmia, fatigue and emotional agitation.[1,2,3,4]

Table 3-4-7 Etiology of HF in the elderly

Study	Year	Age group	N	Coronary heart disease(%)	Hypertension (%)	Diabetes (%)	Valvular heart disease(%)	Pulmonary heart disease (%)
309 Hospital[1]	1996-2014	60-69	126	38.9	23.0	18.3	11.9	8.7
		70-79	258	52.7	38.0	30.6	26.4	7.0
		≥80	186	74.2	62.4	46.8	40.8	1.6
Jiangxi Provincial People's Hospital[2]	2003-2010	60-69	618	33.3	41.9	24.9	30.4	7.1
		70-79	682	48.8	52.9	29.2	10.9	12.0
		≥80	280	58.2	56.4	28.6	3.9	22.5
Shengjing Hospital[3]	2005-2012	60-85	1 378	48.6	27.6	28.1	11.3	-
		≥85	135	39.3	34.1	17.0	4.4	-
The General Hospital of Shenyang Military[4]	2008-2012	73±7	3 909	61.6	9.1	-	8.0	5.7

3.5 Pulmonary Vascular Disease

3.5.1 Pulmonary Arterial Hypertension

Pulmonary arterial hypertension (PAH) is defined as an increase in mean pulmonary arterial pressure ≥25 mmHg at rest as assessed by right heart catheterization (1 mmHg=0.125 kPa). PAH is clinically classified into 5 types. Type 1 is pulmonary arterial hypertension (PAH), including idiopathic pulmonary arterial hypertension (IPAH), pulmonary arterial hypertension associated with connective tissue disease (CTD-PAH), pulmonary arterial hypertension associated with congenital heart disease (CHD-PAH); Type 2 is pulmonary hypertension due to left heart disease; Type 3 is pulmonary hypertension due to lung disease and/or hypoxia; Type 4 is chronic thromboembolic pulmonary hypertension (CTEPH) and other pulmonary artery obstructions; Type 5 is pulmonary hypertension with unclear and/or multifactorial mechanisms.

[1] Su L, Guo XM, Yin HJ. Etiology and contributing factors of the elderly hospitalized with heart failure. Chinese Journal of Integrative Medicine on Cardio/Cerebrovascular Disease, 2015,13(3):361-362.

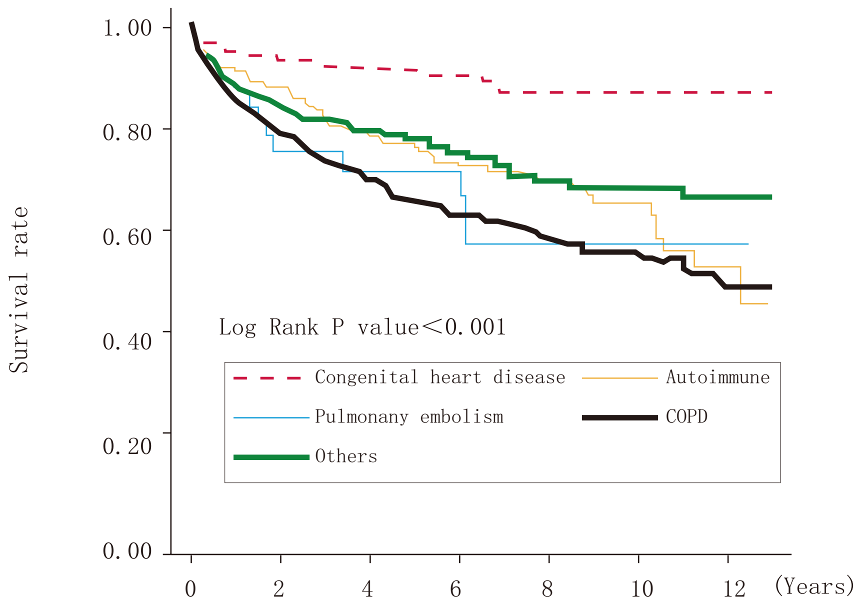
[2] Hu J, Qiu YZ, Peng L. Clinical features of elderly male and female chronic heart failure patients at different ages. Chinese Journal of Geriatric Heart Brain and Vessel Diseases, 2014,16(10):1019-1034.

[3] Yu TT, Wang CH, Wang QQ. Clinical characteristics of chronic heart failure in very elderly patients. China Journal of Modern Medicine, 2015,25(12):94-98.

[4] Tong CY, He R, Li CH, et al. Analysis of clinical characteristic and drug therapy in elderly chronic heart failure patients. China Medical Herald, 2014,11(9):57-69.

3.5.1.1 Proportion and Prognosis of Different Types of Pulmonary Arterial Hypertension

Based on Taiwan's National Health Insurance claims data, 1 092 patients with newly diagnosed PAH were identified between 1999 and 2011, including 550 patients with chronic obstructive pulmonary disease (COPD) related PAH (50.37%), 189 patients with IPAH(17.31%), 183 patients with CTD-PAH (16.76%), 129 patients with CHD-PAH (11.81%), and 41 patients with CTEPH (3.75%). The long-term survival rates of the PAH patients at 1, 5, and 10 years were 87.9%, 72.5%, and 62.6% (Figure 3-5-1), respectively. Among different types of PAH, COPD-related PAH (HR=3.2, 95%CI: 2.76-3.71) and CTEPH (HR=4.64, 95%CI: 2.74-7.87) had the highest mortality rates (Table 3-5-1) .[1]



Number at risk							
Congenital heart disease	129	102	93	84	60	48	21
Autoimmune	183	140	105	87	57	34	8
Pulmonary embolism	41	23	19	16	9	7	2
COPD	550	376	295	213	153	97	34
Others	189	131	105	78	56	37	13

Figure 3-5-1 Kaplan-Meier estimates of 12-year survival among patients with different types of PAH

[1] Chang WT, Weng SF, Hsu CH, et al. Prognostic Factors in Patients with Pulmonary Hypertension—A Nationwide Cohort Study. Journal of the American Heart Association, 2016, 5(9): pii: e003579. doi: 10.1161/JAHA.116.003579.

Table 3-5-1 Mortality rates of different types of PAH

PAH group	N	Death	PY	Mortality*	Crude HR (95%CI)	Adjusted HR† (95%CI)
Pulmonary embolism	41	14	189.13	74.02	3.91‡ (2.31－6.62)	4.64‡ (2.74-7.87)
CTD	183	55	1 030.41	53.38	2.85‡ (2.18－3.74)	2.76‡ (2.10－3.62)
CHD	129	14	931.9	15.02	0.82‡ (0.48－1.39)	4.45‡ (2.58－7.69)
COPD	550	209	2 841.98	73.54	3.91‡ (3.37－4.53)	3.20‡ (2.76－3.71)
Idiopathic	189	47	1 012.00	46.44	2.48‡ (1.85－3.31)	4.22‡ (3.15－5.67)

*1 000 person-years；† Adjusted by age, gender, hypertension, diabetes, hyperlipidemia and coronary heart disease ; ‡ P<0.05

3.5.1.2 Clinical Characteristics and Prognosis of Patients with CTD-PAH

A prospective cohort study enrolled 190 CTD-PAH patients who visited the referral center between May 2006 and December 2014, including 111 patients with systemic lupus erythematosus (SLE), 50 patients with systemic sclerosis (SSc), and 29 patients with primary Sjögren's syndrome (pSS). Mean pulmonary arterial pressure and mean right atrial pressure at baseline were significantly higher in pSS-PAH compared with SLE-PAH and SSc-PAH. The mean carbon monoxide diffusing capacity (DLCO) was markedly lower in SSc-PAH group than in other two groups. After an average 1.5 years of follow up, there were 41 deaths in the cohort, and the overall 1-, 3-, and 5-year survival rates from the time of diagnosis were 87.1%, 79.1% and 62.9%, respectively. SSc-PAH patients presented the most unfavorable prognosis among PAH patients with CTD (P<0.01) (Figure 3-5-2). Independent predictors of poor prognosis in CTD-PAH patients were six-minute walking distance ≤380 m (HR=3.222, 95%CI:1.485-6.987, P=0.003) and SSc as the underlying CTD (HR=1.86, 95%CI: 1.32-2.62, P=0.021) [1] . The 1-, 3-, and 5-year survival rates of pSS-PAH patients were 80.2%, 74.8% and 67.4%, respectively. Prognostic factors of mortality were time between pSS onset and PAH onset and cardiac index <2L/min/m^2. Use of immunosuppressants can significantly improve the prognosis of pSS-PAH [2] .

[1] Zhao J, Wang Q, Liu Y, et al. Clinical characteristics and survival of pulmonary arterial hypertension associated with three major connective tissue diseases: A cohort study in China. Int J Cardiol, 2017,236:432-437.

[2] Liu Z, Yang X, Tian Z, et al. The prognosis of pulmonary arterial hypertension associated with primary Sjögren's syndrome: a cohort study. Lupus, 2018,27(7):1072-1080.

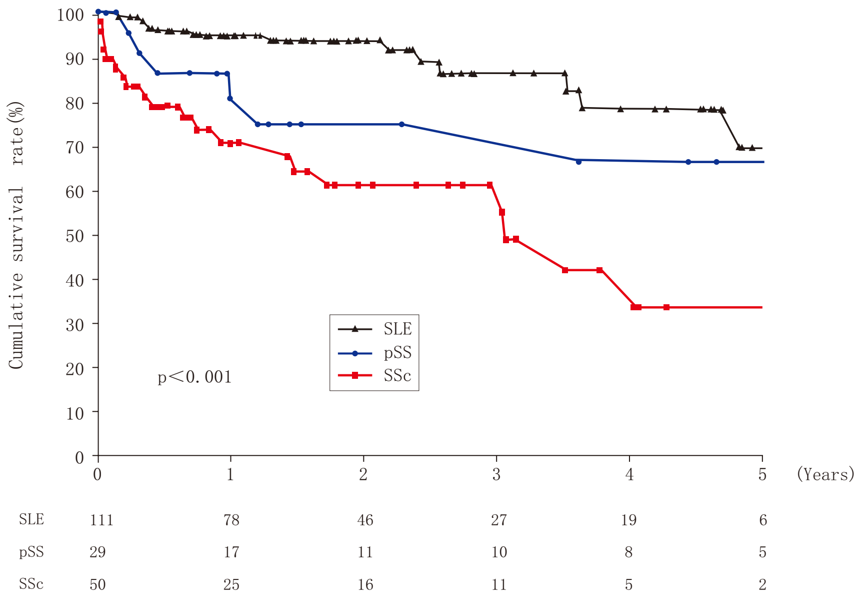


Figure 3-5-2 Survival curves of PAH patients with SLE, pSS, SSc

3.5.1.3 Long-term Survival Rate of Patients with CTEPH

A retrospective cohort study was conducted in 504 patients with CTEPH, who were treated surgically (n=360), or non-surgically (n=144) from 1989 to 2007. The patients in surgical group received a standard pulmonary thromboendarterectomy (PTE), while those in non-surgical group were given thrombolytic therapy. The in-hospital mortality for the surgery group and non-surgery group was 4.44% and 3.50%, respectively. Among patients with proximal type of CTEPH, those who underwent surgical intervention demonstrated significantly higher long-term survival rates than patients treated with the medical regimen (P=0.0004). In patients with distal type of CTEPH, there was no significant difference between these two groups (P=0.874) [1] . The long-term survival rates of patients with CTEPH are listed in Table 3-5-2. The long-term survival rates of CTEPH patients undergoing thromboendarterectomy from both domestic and international studies are presented in Table 3-5-3.

Table 3-5-2 Long-term survival rates of patients with CTEPH

Group	Proximal Type		Distal Type		P value
	10-year survival rate (%)	15-year survival rate (%)	10-year survival rate (%)	15-year survival rate (%)	
Surgery	94.60±2.38	90.96±4.24	71.78±4.66	29.57±15.10	<0.0001
Non-surgery	81.4±7.14	56.43±14.70	69.84±7.78	32.59±13.70	0.5

[1] Gan HL, Zhang JQ, Bo P, et al. The actuarial survival analysis of the surgical and non-surgical therapy regimen for chronic thromboembolic pulmonary hypertension. J Thromb Thrombolysis, 2010,29(1):25-31.

Table 3-5-3 Long-term survival rates of CTEPH patients undergoing thromboendarterectomy from both domestic and international studies

Country	Medical Center	Duration	N	In-hospital mortality(%)	Long-term survival rate of central type of CTEPH (%)
China	Beijng Anzhen Hospital	1989 - 2008	360	4.4	94.60 (10-year) 90.96 (15-year)
United States[1]	UCSD Medical Center	1997 - 2007	988	4.0	96 (1-year) 88 (5-year)
United Kingdom[2]	Papworth Hospital	2001 - 2006	236	16.0	98-99 (1-year) 93 -94 (3-year)
Japan[3]	Chiba University	1990 - 2010	77	9.0	84 (5-year) 82 (10-year)

3.5.2 Pulmonary Embolism (PE)

3.5.2.1 Incidence and Mortality of PE among Hospitalized Patients

A registration study of patients with suspected PE syndromes admitted to 60 tertiary hospitals involved in the National Cooperative Project for the Prevention and Treatment of Venous Thromboembolism (NCPPT) was conducted from January 1997 to December 2008. A total of 18 206 patients were confirmed with PE from 16 972 182 hospital admissions. The annual incidence of PE was 0.1%.[4] The incidence of PE in hospitalized patients stratified by age and gender is presented in Table 3-5-4. The trends of incidence and case fatality rates for PE in hospitalized adults from 1997 to 2008 are illustrated in Figure 3-5-3. The discrepancies between the North and the South in incidence and case fatality rates for PE in China from 1997 to 2008 are exhibited in Figure 3-5-4.

Table 3-5-4 Incidence of PE in hospitalized patients by age and gender (%), 1997-2008

Age	Total	Male	Female
≤30	0.07 (0.02−0.13)	0.12 (0.06−0.21)	0.05 (0.02−0.11)
31−40	0.06 (0.02−0.12)	0.14 (0.08−0.23)	0.03 (0.01−0.09)
41−50	0.13 (0.07−0.22)	0.16 (0.09−0.25)	0.10 (0.05−0.18)
51−60	0.12 (0.06−0.21)	0.14 (0.08−0.23)	0.10 (0.05−0.18)
61−70	0.14 (0.08−0.23)	0.19 (0.11−0.29)	0.12 (0.06−0.21)
70+	0.10 (0.05−0.18)	0.44 (0.32−0.59)	0.05 (0.02−0.11)
Total	0.11 (0.05−0.19)	0.18 (0.10−0.28)	0.07 (0.02−0.13)

［1］Thistlethwaite PA, Kaneko K, Madani MM, et al. Technique and outcomes of pulmonary endarterectomy surgery. Ann Thorac Cardiovasc Surg, 2008,14(5):274-282.
［2］Condliffe R, Kiely DG, Gibbs JS, et al. Improved outcomes in medically and surgically treated chronic thromboembolic pulmonary hypertension. Am J Respir Crit Care Med, 2008,177(10):1122-1127.
［3］Keiichi I, Masahisa M, Nobuhiro T, et al. Long-term outcome after pulmonary endarterectomy for chronic thromboembolic pulmonary hypertension. J Thorac Cardiovasc Surg, 2012,144(2):321-326.
［4］Yang Y, Liang L, Zhai Z, et al. Pulmonary Embolism Incidence and Fatality Trends in Chinese Hospitals from 1997 to 2008: A Multicenter Registration Study. PLoS One, 2011,6(11):e26861.

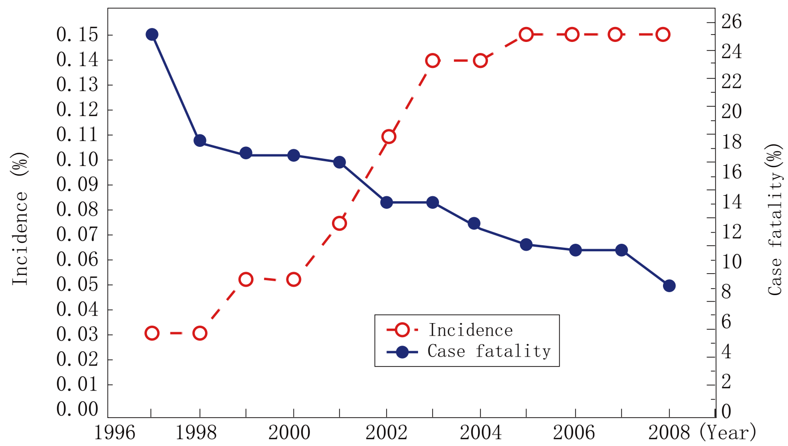


Figure 3-5-3 Incidence and case fatality rates for PE in hospitalized adults, 1997-2008

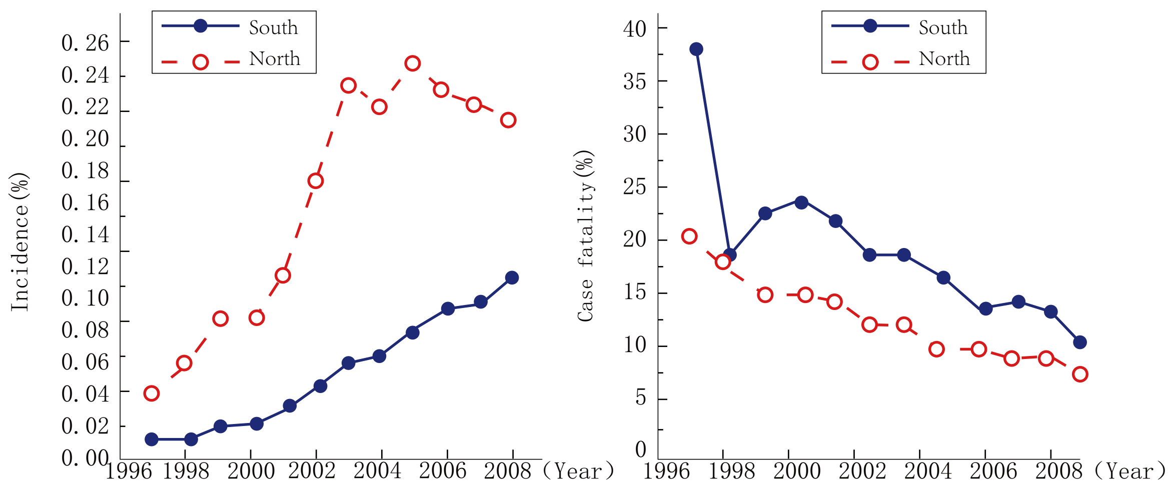


Figure 3-5-4 Discrepancies between the north and the south in incidence and case fatality rates for PE, 1997-2008

3.5.2.2 Incidence and Risk Factors of PE in Patients with Lung Cancer Surgery

A retrospective cohort study [1] enrolled 11 474 patients who underwent surgery for lung cancer during January 2012 to July 2015, with 1 748 (15.2%) patients receiving anticoagulant therapy during their hospitalization after surgery. The 30-day PE incidence with chemical prophylaxis was 0.34%, and the 30-day PE incidence without chemical prophylaxis was 0.57% (55/9 726). Age >66 years (OR=1.09, 95%CI: 1.05-1.12, P<0.001), more extensive surgery than lobectomy (OR=2.34, 95%CI: 1.28-4.25, P<0.006) and stage

[1] Li YP, Shen L, Huang W, et al. Prevalence and Risk Factors of Acute Pulmonary Embolism in Patients with Lung Cancer Surgery. Semin Thromb Hemost, 2018,44(4):334-340.

IV of lung cancer (OR= 4.22, 95%CI: 1.50-11.9, P<0.007) were associated with an increased risk of 30-day postoperative PE.

3.5.2.3 Incidence and Short-term Mortality of PE in Patients with End-stage Renal Disease Receiving Dialysis

A cohort study [1] identified 106 231 patients with end-stage renal disease undergoing dialysis in 1998-2010 from Taiwan Health Insurance claims data and randomly selected 106 231 comparison subjects without clinical kidney disease, frequency matched by age, sex and the index year. The incidence of PE was nearly 3-fold greater in dialysis patients (0.92/1 000 person-years) than in the comparison cohort (0.33/1 000 person-years) (HR=2.02, 95%CI: 1.63-2.50). Among dialysis patients, the incidence of PE in the propensity score-matched hemodialysis (HD) cohort of 7 340 patients was greater than that in the peritoneal dialysis (PD) cohort of 7 430 patients (HR=2.30, 95%CI:1.23-4.29). The incidence of PE was significantly greater in catheter users (1.83/1 000 person-years) than in non-users (0.75/1 000 person-years). The 30-day mortality rate for subjects who had developed PE (16.5%) was greater in the dialysis cohort than in the comparison cohort (9.77%) (OR=2.56, 95%CI: 1.32-4.95).

3.5.2.4 Incidence of Venous Thromboembolism (VTE)

A registry study in Hong Kong [2] enrolled 2 214 patients hospitalized with a new occurrence of VTE between January 2004 and December 2016. Among all patients, 1 444 patients (65.2%) had deep vein thrombosis (DVT), and 770 patients (34.8%) had PE. Over the 13-year period, there was an increasing trend in the incidence of VTE from 28.1/100 000 population per year in 2004 to 48.3/100 000 population per year in 2016. There was a difference in terms of the incidence of VTE by age and gender (Figure 3-5-5). The most common cause of VTE was active malignancy with an incidence that increased from 34.8% in 2005 to 60.9% in 2014 (Figure 3-5-6).

[1] Wang IK, Shen TC, Muo CH, et al. Risk of pulmonary embolism in patients with end-stage renal disease receiving long-term dialysis. Nephrol Dial Transplant, 2017,1;32(8):1386-1393.

[2] Huang D, Chan PH, She HL, et al. Secular trends and etiologies of venous thromboembolism in Chinese from 2004 to 2016. Thromb Res, 2018,166:80-85.

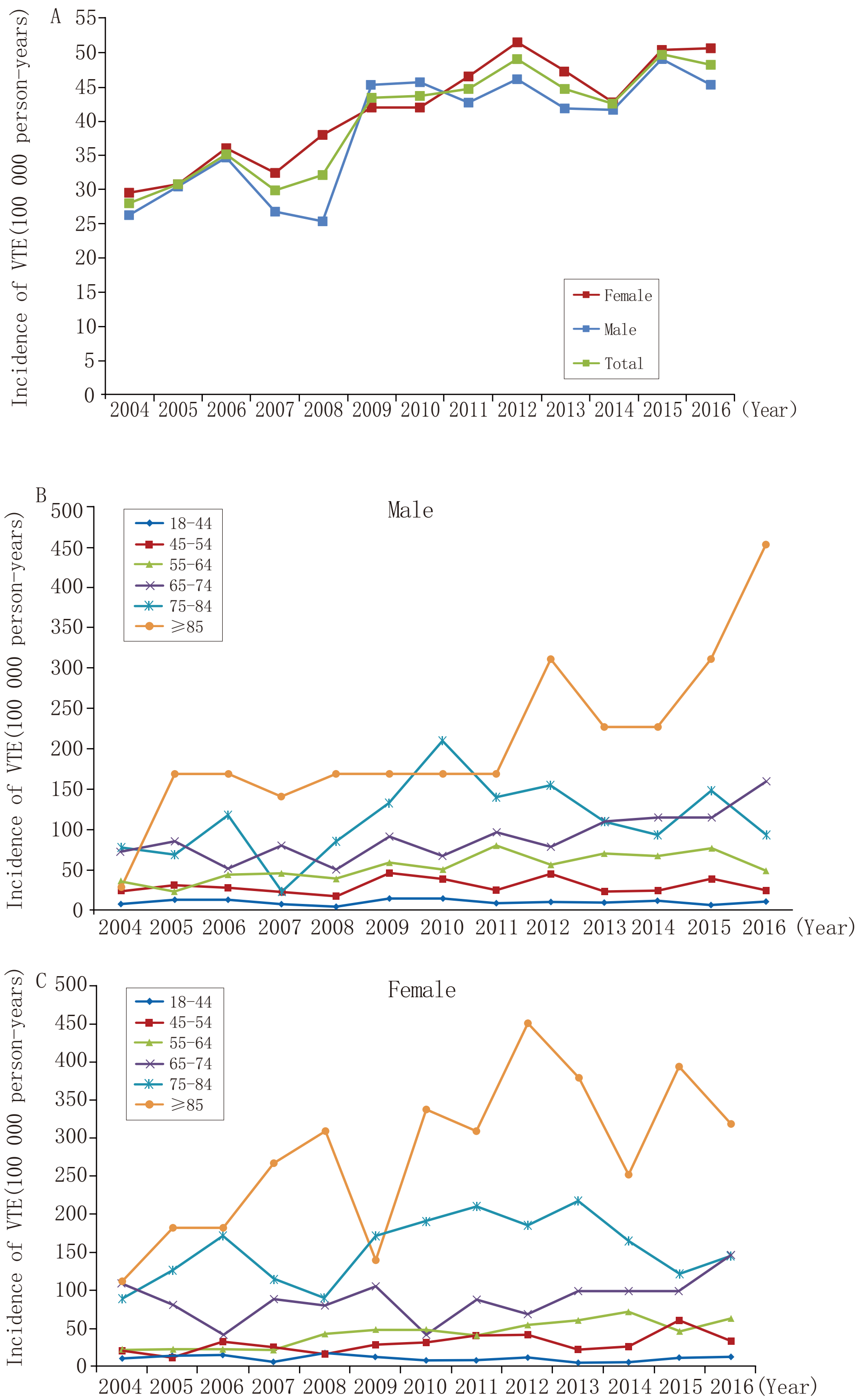


Figure 3-5-5 Annual incidence of VTE stratified by age and gender

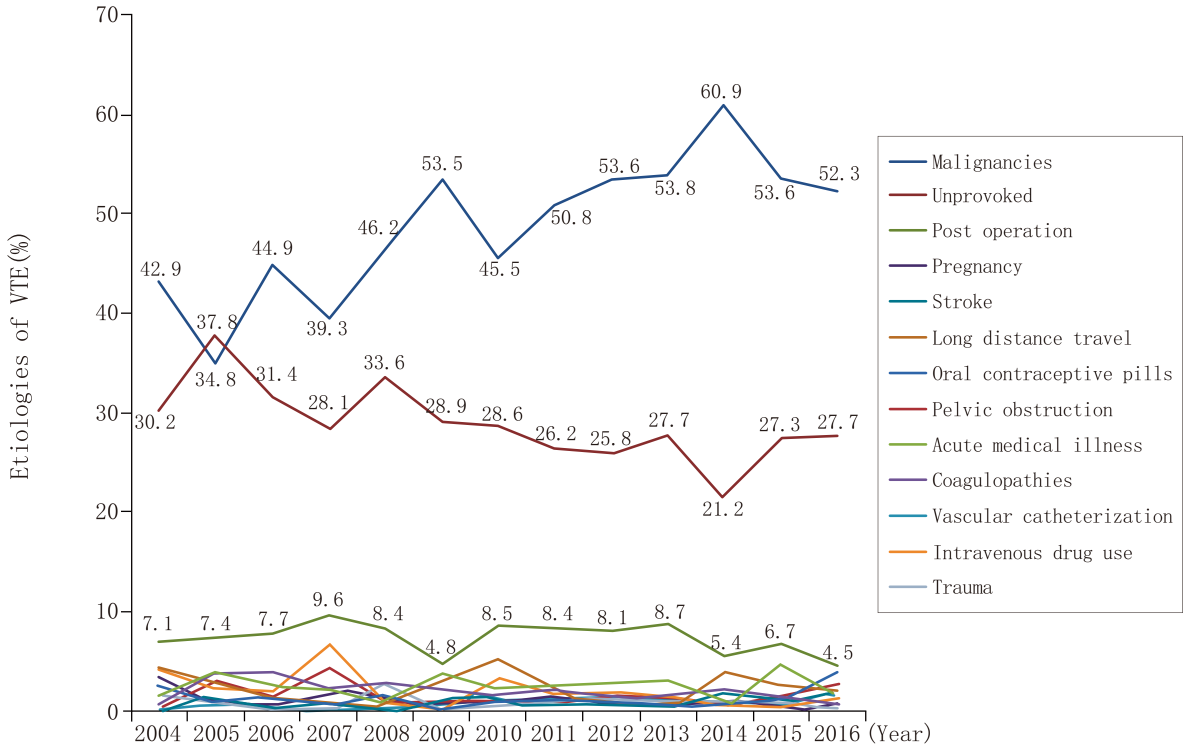


Figure 3-5-6 Secular trends of the etiologies of venous thromboembolism, 2004-2016

3.5.2.5 Incidence of VTE in Cancer Patients admitted to Intensive Care Unit for Post-Operative Care

A total of 2 127 consecutive patients with cancer admitted to an intensive care unit for postoperative care were included in this retrospective cohort study [1] during January 2013 to December 2016. There were a total of 32 patients with PE, 51 patients with DVT, and 17 patients with both conditions. The observed 30-day incidence rate of VTE in ICU was 3.1% (66/2 127). The percentage of postoperative patients receiving chemoprophylaxis was 16.8% (358/2 127), 20 of the 66 VTE patients (30.3%) received chemoprophylaxis before VTE was diagnosed. Among all the patients included, 99.5% scored in the highest risk category (Caproni score≥5), and the risk of developing VTE events were significantly higher among patients with Caprini score >10.

3.5.2.6 Perioperative Incidence of DVT Following Lower Extremity Fractures

A retrospective cohort study [2] enrolled 1 825 patients with isolated lower extremity fractures who

[1] Xu JX, Dong J, Ren H, et al. Incidence and risk assessment of venous thromboembolism in cancer patients admitted to intensive care unit for postoperative care. J BUON, 2018,23(1):248-254.

[2] Wang H, Kandemir U, Liu P, et al. Perioperative incidence and locations of deep vein thrombosis following specific isolated lower extremity fractures. Injury, 2018 May 22. pii: S0020-1383(18)30261-4.doi:10.1016/j.injury.2018.05.018.

underwent surgical treatment between September 2014 and September 2017. The incidence of symptomatic PE was 1.6%. Thromboprophylaxis regimen was applied to all patients during hospitalization. 547 preoperative patients (30.0%) were detected with DVT, with proximal DVT in 3.7% of patients. 792 patients (43.4%) were found to have DVT postoperatively, with proximal DVT in 6.2% of patients. Interestingly, the rate of DVT in an uninjured lower limb was significantly higher postoperatively compared with preoperatively (16.4% vs 4.9%).

3.5.3 Chronic Obstructive Pulmonary Disease

3.5.3.1 Prevalence and Mortality of COPD

Between June 2012 and May 2015, the China Pulmonary Health study [1] recruited 50 991 participants who had reliable post-bronchodilator results. The overall prevalence of COPD was 8.6% (95%CI:7.5-9.9), accounting for 99.9 (95%CI:76.3-135.7) million people with COPD in China. Prevalence was higher in males than in females, and also higher in people aged ≥40 years than in those aged 20-39 years. The prevalence of COPD by age and gender is presented in Table 3-5-5. Only 12.0% of people with COPD reported a previous pulmonary function test. Risk factors for COPD included smoking exposure of 20 pack-years or more (OR=1.95, 95%CI: 1.53-2.47), exposure to annual mean particulate matter with a diameter less than 2.5 μm of 50-74 μg/m^3 (OR=1.85, 95%CI: 1.23-2.77) or 75 μg/m^3 or higher (OR=2.00, 95%CI: 1.36-2.92), underweight (body-mass index <18.5 kg/m^2; OR=1.43, 95%CI: 1.03-1.97), sometimes childhood chronic cough (OR=1.48, 95%CI: 1.14-1.93) or frequent cough (OR=2.57, 95%CI: 2.01-3.29), and parental history of respiratory diseases (OR=1.40, 95%CI: 1.23-1.60). A lower risk of COPD was associated with middle or high school education (OR=0.76, 95%CI: 0.64-0.90), and college or higher education (OR=0.47, 95%CI: 0.33-0.66).

Table 3-5-5 Prevalence of COPD by age and gender

Age	Prevalence in entire population (95%CI)		
	Male	Female	Total
20–29	1.7% (0.7-0.9)	1.0% (0.6-1.8)	1.4% (0.7-2.8)
30–39	3.9% (2.0-7.4)	2.0% (1.2-3.3)	3.0% (1.9-4.5)
40–49	7.1% (5.1-9.8)	2.9% (2.1-4.1)	5.1% (3.8-6.7)
50–59	15.8% (12.7-19.6)	6.1% (5.1-7.4)	11.1% (9.1-13.4)
60–69	28.8% (24.3-33.7)	13.4% (10.3-17.4)	21.2% (17.9-25.0)
≥70	49.5% (41.0-58.0)	23.0% (19.8-26.4)	35.5% (29.9-41.5)
P value	<0.0001	<0.0001	<0.0001

[1] Wang C, Xu J, Yang L, et al. Prevalence and risk factors of chronic obstructive pulmonary disease in China (the China Pulmonary Health [CPH] study): a national cross-sectional study. Lancet, 2018,391(10131):1706-1717.

Data from China CDC [1] indicated that among 66 752 adults aged ≥40 years recruited between Dec 2014 and Dec 2015, the estimated standardized prevalence of COPD was 13.6% (95%CI: 12.0-15.2). The prevalence of COPD differed significantly between males and females (19.0%, 95%CI: 16.9-21.2 vs 8.1%, 95%CI: 6.8-9.3; P<0·0001), mainly because of a significant difference in smoking status between males and females (current smokers: 58.2% vs 4.0%) (Figure 3-5-7). The prevalence of COPD varied between geographic regions, with the highest prevalence in southwest China and the lowest in central China (Table 3-5-6).

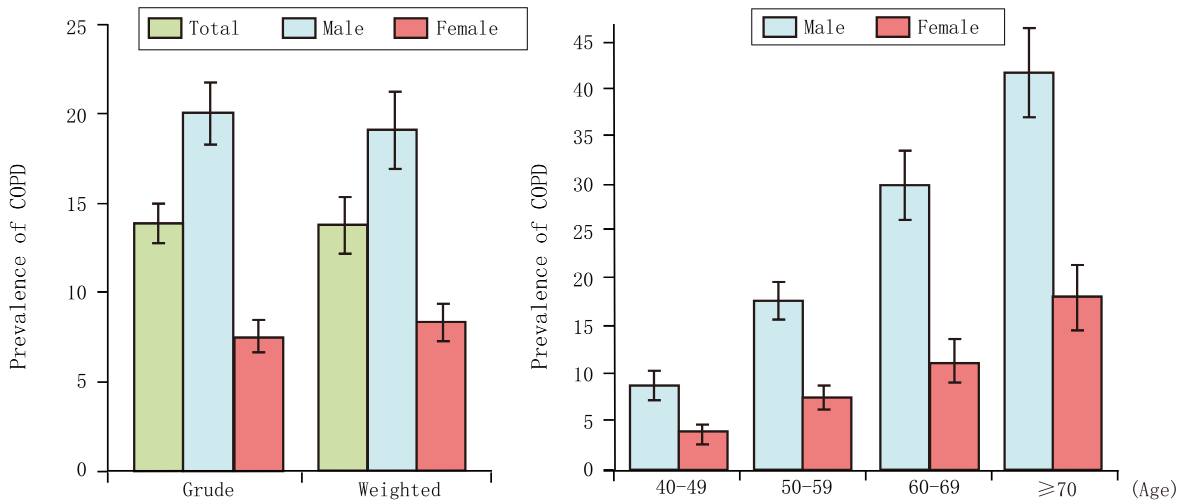


Figure 3-5-7 Prevalence of COPD by Age and Gender

Table 3-5-6 Prevalence of COPD by region in China

Region	Cases/total	Prevalence of COPD (95%CI)
Southwest China	1 798/10 887	20.2% (14.7—25.8)
Northeast China	1 004/6 980	15.6% (10.4—20.7)
North China	1 223/9 103	13.7% (7.2—20.2)
Northwest China	1 135/7 895	13.6% (9.5—17.6)
Esat China	2 324/17 716	12.1% (10.4—13.9)
South China	757/6 303	11.0% (9.8—12.2)
Central China	893/7 868	10.2% (8.2—12.2)

[1] Fang L, Gao P, Bao H, et al. Chronic obstructive pulmonary disease in China: a nationwide prevalence study. Lancet Respir Med, 2018,6(6):421-430.

3.5.3.2 Risk Factors of PE in Acute Exacerbation of COPD

A retrospective study [1] enrolled 522 patients who were admitted with acute exacerbation of COPD and received CT pulmonary angiography from November 2009 to May 2014. Among all patients, 54 had pulmonary embolism (10.3%). For patients admitted with acute exacerbation of COPD, immobilization ≥ 3 days (OR=25.36, 95%CI:7.42-86.69, P<0.001), D-dimmer ≥2 000 ug/L (OR=10.10, 95%CI: 2.25-45.42, P<0.05) and lower extremity edema (OR=7.34, 95%CI: 3.43-15.71, P<0.001) were risk factors of pulmonary embolism.

3.5.3.3 Incidence of DVT in Patients with COPD

A large-scale population-based retrospective cohort study was carried out by utilizing Taiwan Health Insurance claims data. The overall incidence rate of DVT in 8 810 patients with COPD aged >40 years was 18.78/10 000 person-years, and the adjusted hazard ratio of DVT in patients with COPD was 1.38, which was greater than patients without COPD after adjusting for age, sex, atrial fibrillation, hypertension, diabetes, hyperlipidemia, cerebrovascular accident, congestive heart failure and cancer (18.78 vs 13.3 per 10 000 person-years, 95%CI: 1.06-1.80) .[2] The cumulative incidence of DVT in patients with and without COPD is shown in Figure 3-5-8. The incidence of DVT stratified by gender and age in patients with or without COPD is shown in Table 3-5-7.

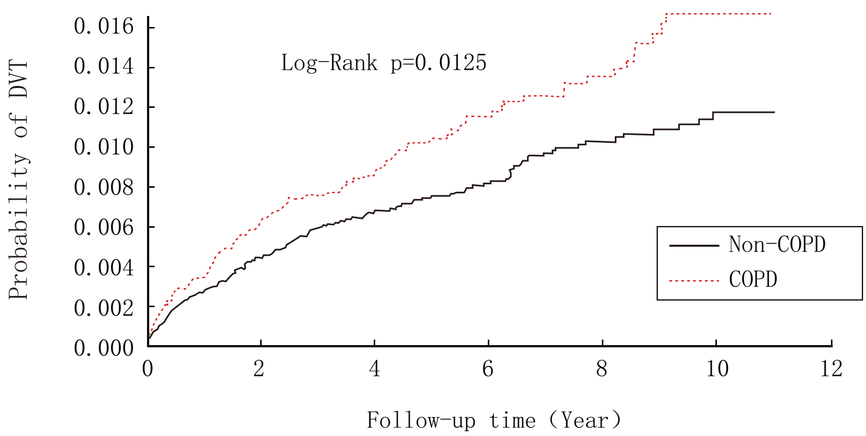


Figure 3-5-8 Cumulative incidence of DVT

[1] Li YX, Zheng ZG, Liu N, et al. Risk factors for pulmonary embolism in acute exacerbation of chronic obstructive pulmonary disease. Chinese Journal of Tuberculosis and Respiratory Diseases, 2016,39(4):298-303.

[2] Chen CY, Liao KM. The Incidence of Deep Vein Thrombosis in Asian Patients with Chronic Obstructive Pulmonary Disease. Medicine, 2015,94(44):e1741.

Table 3-5-7 Incidence of DVT stratified by gender and age in patients with and without COPD (1/10 000 person-year)

	Non-COPD		COPD		IRR (95%CI)	Adjusted HR (95%CI)
	DVT event	Incidence	DVT event	Incidence		
Male						
40-49	3	6.16	5	22.07	3.58(0.86-4.99)	6.53(1.37-31.11)
50-59	7	9.73	7	19.85	2.04(0.72-5.82)	1.96(0.67-5.68)
60-69	14	9.79	8	11.16	1.15(0.48-2.74)	1.08(0.45-2.61)
≥70	47	11.33	32	16.10	1.42(0.91-2.23)	1.32(0.84-2.08)
Female						
40-49	3	10.95	0	0.00	-	-
50-59	6	13.32	6	27.19	2.04(0.66-6.33)	1.48(0.44-5.03)
60-69	21	28.76	12	32.76	1.14(0.56-2.32)	1.11(0.54-2.29)
≥70	36	17.22	24	24.04	1.40(0.83-2.34)	1.40(0.83-2.38)

IRR: incidence rate ratio

3.6 Cardiovascular Surgery

3.6.1 Cardiac Surgery

In 2017, 228 938 cardiac surgeries were performed in mainland China, of which 162 597 were performed on-pump. 1 834 cardiac surgeries were performed in Hong Kong, China, of which 1 604 were on-pump. The number of cardiac surgeries in China (including Hong Kong) during the period of 2015-2017 is shown in Table 3-6-1.

Table 3-6-1 Number of cardiac surgeries in China, 2015-2017

Region	Province/City	2015		2016		2017	
		Total	On-pump	Total	On-pump	Total	On-pump
North China	Beijing	32 233	20 133	34 538	20 483	33 901	20 300
	Hebei	5 708	3 837	6 014	4 350	5 581	3 526
	Tianjin	4 303	2 285	5 156	2 688	5 275	2 891
	Shanxi	1 965	1 019	2 557	1 216	2 312	1 321
	Inner Mongolia	1 056	568	1 150	719	1 303	717

Table 3-6-1 Number of cardiac surgeries in China, 2015-2017 (Continued)

Region	Province/City	2015		2016		2017	
		Total	On-pump	Total	On-pump	Total	On-pump
Northeast	Liaoning	5 565	3 359	5 708	3 400	5 976	3 457
	Heilongjiang	3 068	1 870	3 142	1 833	3 298	1 856
	Jilin	2 510	1 846	2 326	1 627	2 310	1 478
East China	Shanghai	16 676	13 152	16 864	13 138	18 051	13 920
	Shandong	13 898	8 907	15 172	9 060	15 908	9 529
	Jiangsu	9 726	7 697	10 402	7 970	11 437	8 732
	Zhejiang	5 841	5 004	5 913	4 873	6 580	5 549
Central China	Henan	18 169	12 636	17 386	11 645	17 556	11 372
	Hubei	12 944	11 072	12 676	10 686	14 954	11 522
	Hunan	7 367	6 176	7 672	6 494	7 786	6 499
	Anhui	4 336	3 590	4 178	3 464	4 840	3 873
	Jiangxi	4 135	3 485	3 730	3 132	3 949	3 240
South China	Guangdong	15 459	13 510	15 577	13 406	17 205	14 514
	Fujian	5 442	3 865	5 425	3 864	5 885	4 197
	Guangxi	3 908	3 434	4 018	3 496	4 523	3 801
	Hainan	846	753	864	778	842	767
Northwest	Shaanxi	8 257	5 704	8 839	5 465	9 465	5 582
	Xinjiang	3 817	3 014	3 931	2 779	5 080	3 221
	Gansu	2 669	1 798	2 511	1 489	2 633	1 493
	Ningxia	906	554	931	650	860	572
	Qinghai	495	414	539	445	512	440
Southwest	Sichuan	7 156	6 139	7 017	5 783	7 447	6 328
	Chongqing	5 378	4 674	4 946	4 387	4 675	4 101
	Yunnan	4 624	4 499	4 879	4 683	5 639	4 945
	Guizhou	2 569	2 277	2 762	2 640	3 155	2 854
	Tibet	126	71	73	51	0	0
Hongkong		1 644	1 578	1 771	1 574	1 834	1 604
Total		212 795	158 920	218 667	158 266	230 772	164 201

Note：Data were cited from the Extracorporeal Cycle Branch of the Chinese Society of Biomedical Engineering

Since 2003, the number of cardiac surgeries in China has been increasing every year, and the annual growth rate in 2017 rebounded by a large margin compared with the rates from the previous four years (Figure 3-6-1, Figure 3-6-2).

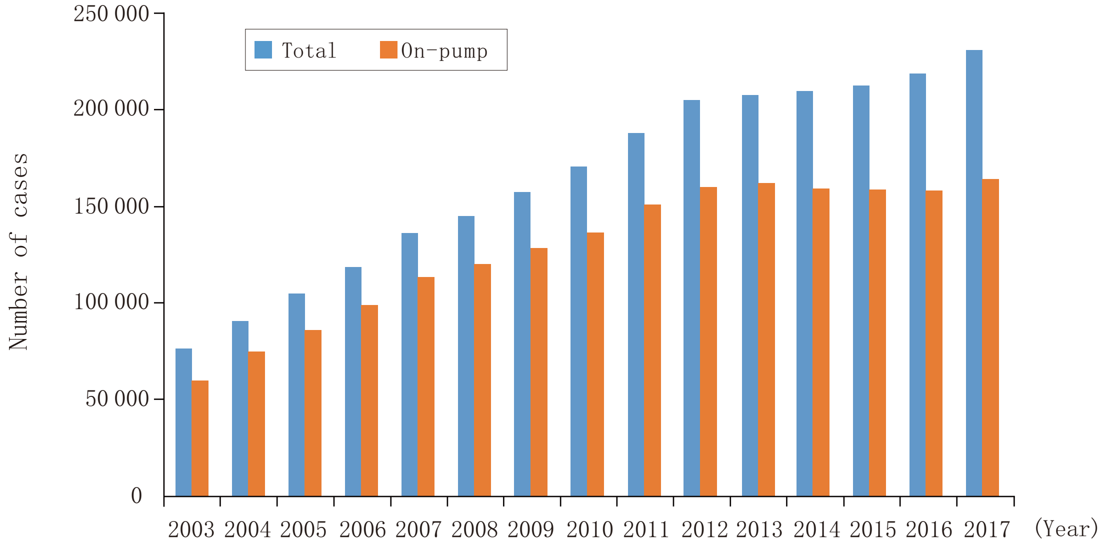


Figure 3-6-1 Number of cardiac surgeries in China, 2003-2017

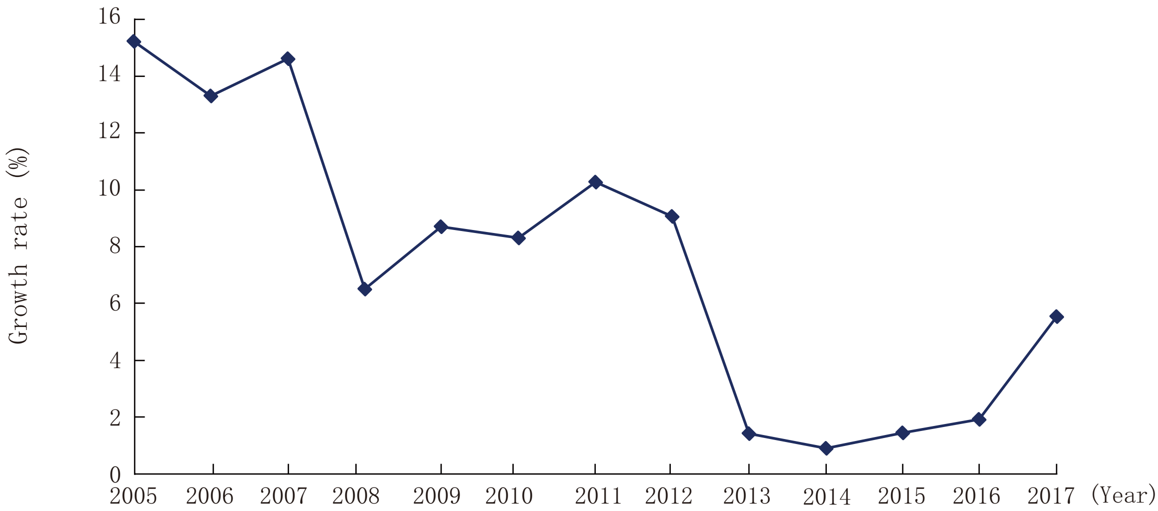


Figure 3-6-2 Annual growth rate of cardiac surgeries in China, 2005-2017

Along with the increase of the off-pump coronary artery bypass grafting (OPCABG) and the intervention treatment for various types of cardiac and aortic diseases, the growth rate of surgeries on-pump was significantly lower than that of total surgeries. The proportion of cardiac surgery on-pump has decreased since 2007, which accounted for 71.2% of total cardiac surgeries in 2017 (Figure 3-6-3).

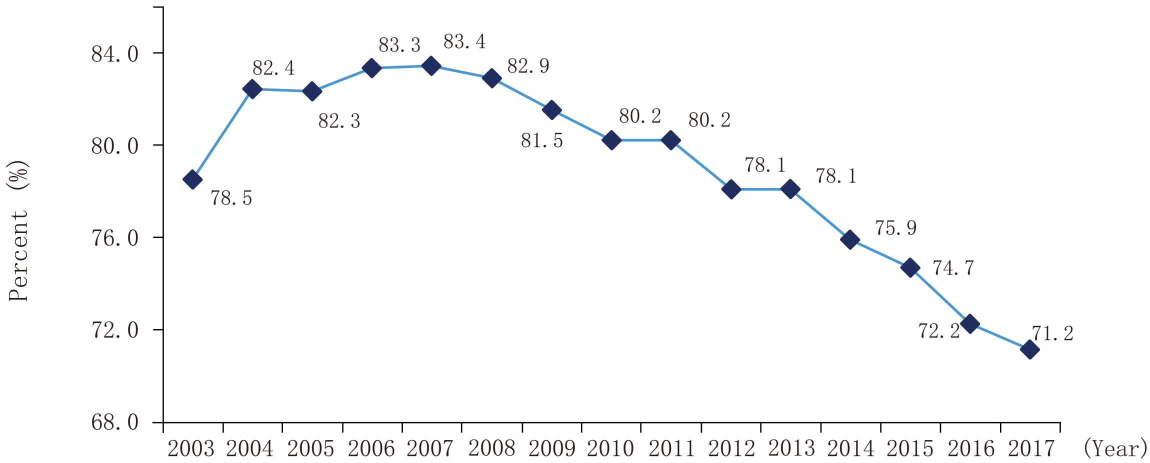


Figure 3-6-3 Proportion of on-pump surgery to total cardiac surgery, 2003-2017

In 2017, 77 305 congenital heart surgeries were performed in mainland China and Hong Kong, accounting for 33.5% of all cardiac surgeries, the proportion has decreased since 2013 (Figure 3-6-4). There were 65 749 heart valve surgeries, 45 455 CABG, 19 585 aortic surgeries and 2 002 ECMO adjuvant therapies carried out in 2017.

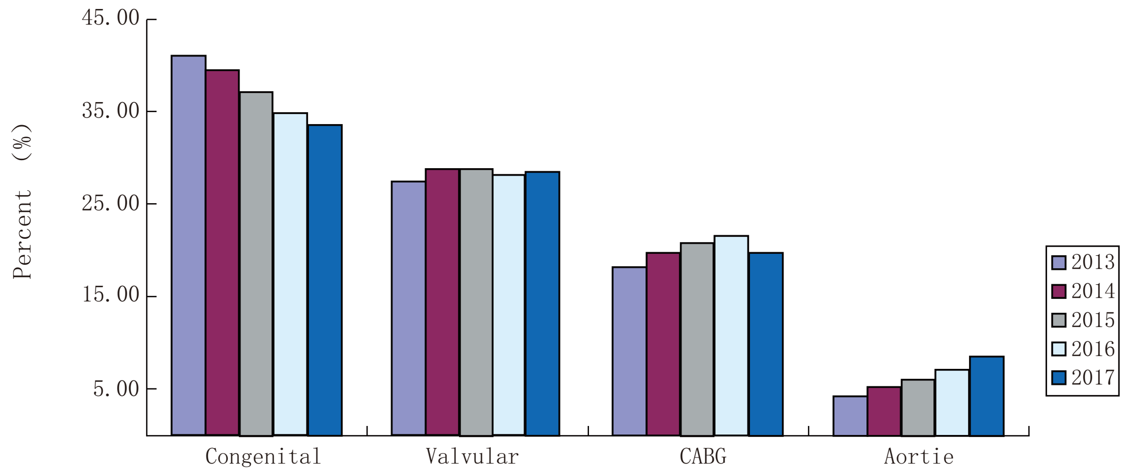


Figure 3-6-4 Percentage of major cardiovascular surgery in China, 2013-2017

The number of heart transplantations in China has increased since 2007; In 2017, 559 heart transplantations were performed in China (Figure 3-6-5).

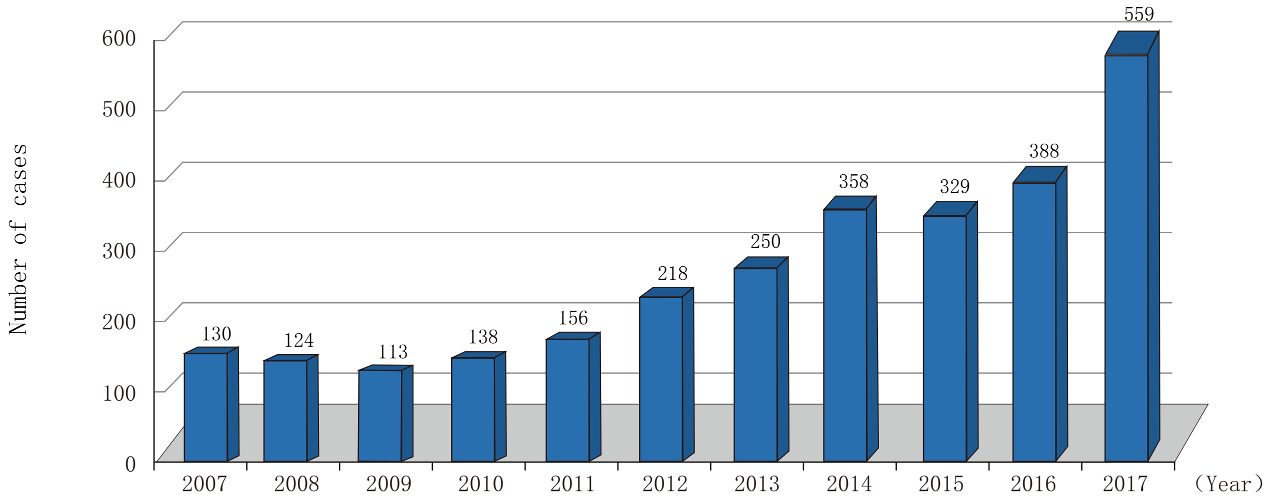


Figure3-6-5 Number of heart transplantations in China, 2007-2017

Table 3-6-2 Number of primary cardiac surgeries by procedure classification and region in mainland China and Hong Kong in 2017 (n)

Region	Province/City	Surgery Category				Auxiliary circulation		Transplantation	
		CHD	Valve	CABG	Aorta	IABP	ECMO	Heart	Heart & lung
North China	Beijing	9 345	5 797	11 022	2 998	1 264	319	96	
	Hebei	1 800	1 258	2 050	208	158	6	4	
	Tianjin	1 462	637	2 632	343	191	34	13	
	Shanxi	653	598	892	142	33	4		
	Inner Mongolia	263	306	264	117	25	1		
Northeast	Liaoning	1 018	1 910	2 481	424	235	29	11	
	Heilongjiang	1 000	732	821	306	165	15	4	
	Jilin	384	709	873	154	48	16	1	
East China	Shanghai	7 158	5 120	2 934	2 077	321	156	44	
	Shandong	3 785	4 185	5 039	902	968	39	37	2
	Jiangsu	2 878	4 169	1 930	1 556	217	124	14	1
	Zhejiang	1 950	2 765	701	551	25	196	13	
Central China	Henan	7 274	3 855	3 945	1 496	350	229		

Table 3-6-2 Number of primary cardiac surgeries by procedure classification and region in mainland China and Hong Kong in 2017 (n) (Continued)

Region	Province/City	Surgery Category				Auxiliary circulation		Transplantation	
		CHD	Valve	CABG	Aorta	IABP	ECMO	Heart	Heart & lung
	Hubei	4 304	4 004	2 421	1 934	312	73	127	3
	Hunan	3 300	2 725	794	616	121	47	4	
	Anhui	871	1 872	835	357	321	15	1	
	Jiangxi	1 534	1 457	283	275	9	30		
South China	Guangdong	7 718	6 269	1 078	1 118	345	300	65	1
	Fujian	1 862	1 755	292	544	106	68	73	
	Guangxi	1 791	1 916	247	189	83	31	7	
	Hainan	148	498	167	23	16			
Northwest	Shaanxi	4 786	1 740	778	1 175	37	56	21	
	Xinjiang	1 899	945	909	257	47	13	1	
	Gansu	1 240	477	153	245	12	7		
	Ningxia	354	264	71	48	24	2		
	Qinghai	310	100	48	25	4			
Southwest	Sichuan	2 297	3 888	512	423	69	16	2	4
	Chongqing	1 808	1 914	273	397	93	41		
	Yunnan	2 580	2 047	421	382	19	1		
	Guizhou	1 348	1 320	123	124	89	16	8	
	Tibet								
Hong Kong		185	517	466	179	89	118	13	13
Total		77 305	65 749	45 455	19 585	5 796	2002	559	24

Note: The data were cited from the Extracorporeal Cycle Branch of the Chinese Society of Biomedical Engineering.
IABP: Intra-aortic balloon pump; CHD: congenital heart disease; CABG: coronary artery bypass grafting; ECMO: extracorporeal membrane oxygenation

3.6.2 Congenital Heart Disease

Congenital heart disease is the major congenital malformation in mainland China. It is the most common cause of congenital disabilities of newborns in many regions. The prevalence of congenital heart disease differs from 5‰ to 14‰ in different regions. If 8‰ is taken as the prevalence of congenital heart disease, there will be 160 000 newborns with congenital heart disease each year in mainland China.

A lot of investigations have shown that ventricular septal defect, atrial septal defect and patent ductus arteriosus account for 75%-80% of the total number of congenital heart disease cases in many regions. The order of these three malformations varies from place to place.

3.6.2.1 Death from Congenital Heart Disease in Children Under 5 Years Old

Death surveillance data were collected from Beijing Death Monitoring Network of Children under 5 years old.[1] Beijing 16 districts (2 urban districts, 6 suburbs, and 8 outer suburbs) were all covered in the surveillance scope. Live births (had at least one of the four vital signs at birth: heartbeat, respiration, umbilical cord pulsation, and voluntary muscle contraction) from 2006-2015 with gestational age older than 28 weeks and died under the age of 5 were included in the study.

The study found that the total mortality rate of congenital malformation in children aged <5 years in Beijing decreased from 1.909‰ in 2006 to 0.703‰ in 2015 (χ^2=89.673, $P < 0.01$), with a decrease rate of 63.17%.

Although the mortality rate of congenital heart disease decreased from 1.087‰ in 2006 to 0.387‰ in 2015, it is still the leading death cause of congenital malformation in children, which accounts for 41%-64% of total deaths caused by congenital malformation in children aged <5 years (Table 3-6-3).

Table 3-6-3 Deaths from congenital heart disease in children aged <5 years in Beijing, 2006-2015

Year	No. of Death	Mortality rate (‰)	Ratio of death from congenital heart disease to death from total congenital malformation (%)
2006	69	1.087	57.02
2007	66	0.850	64.08
2008	53	0.654	51.46
2009	66	0.739	64.08
2010	51	0.563	57.95
2011	47	0.427	41.59
2012	51	0.386	50.50
2013	44	0.346	49.44
2014	60	0.392	50.85
2015	49	0.387	55.06
χ^2		70.868	13.478
P value		0.000	0.000

[1] Wang Jing, Li Dongyang, Zhang Wanxia, et al. Trend analysis of congenital malformation in children under 5 years old in Beijing from 2006 to 2015. Chinese Journal of Epidemiology, 2017,38(1):73-76.

The difference in the regional distribution of congenital heart disease mortality among children aged <5 years between urban and suburban areas was statistically significant (Table 3-6-4).

Table 3-6-4 Regional distribution of congenital heart disease mortality among children aged <5 years in Beijing, 2006-2015

Region	No. of deaths	Mortality (‰)	Constituent ratio (%)
Urban	95	0.443	17.09
Suburbs	230	0.429	41.37
Outer suburbs	231	0.769	41.55
Total	556	0.529	100
χ^2		45.783	
P value		0.000	

3.6.2.2 Epidemiological Investigation on Congenital Heart Disease

Birth defects have been being monitored in Mainland China. Congenital heart disease is one of the common congenital malformations, but the prevalence varies from region to region. In 2017, many large-scale birth defect monitoring results were published, providing data on the prevalence of congenital heart disease in different provinces and municipalities (Table 3-6-5).

Table 3-6-5 Prevalence of congenital heart disease from birth defect surveillance system in mainland China

Region	N	Survey year	Prevalence (‰)	Ranking in local birth defects
Jilin [1]	913 998	2006 - 2011	1.23	No.1
Jilin [2]	178 474	2016	1.87	No.1
Yanbian, Jilin [3]	110 635	2007 - 2015	5.37	No.1
12 Regions of Inner Mongolia [4]	62 544	2005 - 2008	1.71	No.2
Ningxia[5]	514 736	2004 - 2014	1.04	No.3

[1] Hao PK, Han JH, Zhang XQ, et al. Analysis of epidemiological characteristics of birth defects in Jilin Province from 2007 to 2011. Chinese Maternal and Child Health Care, 2014,29(35):5888-5890.

[2] Bing J, Jiang TT, Song P. Analysis of monitoring results of birth defects hospitals in Jilin Province in 2016. Chinese Maternal and Child Health Care, 2017,32(17):4017- 4019.

[3] Piao JL, Fu M, Lu YQ, et al. Monitoring and analysis of birth defects in Yanbian Korean Autonomous Prefecture, 2007-2015. Chinese Journal of Reproductive Health, 2017,28(2):123-126.

[4] Guo SY, Zhang XG. Investigation on the prevalence of birth defects in children in 12 regions of Inner Mongolia. Modern Preventive Medicine, 2013,40(21):3964-3973.

[5] Chen YX, Shen XP, Wang Li. Analysis of birth defects monitoring results of Ningxia Hospital from 2004 to 2014. Ningxia Medical Journal, 2017,39(1):74-76.

Table 3-6-5 Prevalence of congenital heart disease from birth defect surveillance system in mainland China (Continued)

Region	N	Survey year	Prevalence (‰)	Ranking in local birth defects
Beijing[1]	1 102 918	2007 - 2012	8.04	-
Chaoyang District, Beijing[2]	106 370	2013 - 2015	5.88	No.2
Hebei[3]	1 202 291	2001 - 2012	1.71	No.1
Shanxi[4]	363 363	2007 - 2012	0.96	-
Taiyuan, Shanxi[5]	35 949	2011 - 2016	5.67	No.1
Xinjiang Construction Corps[6]	147 160	2011 - 2015	0.50	No.2
Hunan[7]	714 071	2003 - 2012	4.36	No.1
Hunan[8]	293 053	2009 - 2011	5.57	No.1
Hunan[9]	1 177 050	2007 - 2016	5.92	No.1
Changsha, Hunan[10]	173 527	2001 - 2010	6.28	No.1
Changsha, Hunan[11]	192 113	2012 - 2015	16.46	No.1

[1] Liu KB, Zhang W, Xu HY, et al. Analysis of surveillance data of congenital heart disease in Beijing from 2007 to 2012. Chinese Journal of Birth Health and Genetics, 2013,21(12):127-128.

[2] Yuan L, Xia RM. Monitoring results and related factors of 106370 cases of perinatal birth defects in Chaoyang District, Beijing. Chinese Maternal and Child Health Care, 2017,32(1):81-85.

[3] Li JH, Zhang YK, Zhao LN, et al. Analysis of the incidence and trends of major birth defects in Hebei Province from 2001 to 2012. Chinese Journal of Maternal and Child Health, 2013,28(29):4767-4771.

[4] Zhang XJ, Zhao ZH, Huang J, et al. Analysis of monitoring data of perinatal congenital heart disease in Shanxi Province from 2008 to 2012. Chinese Journal of Reproductive Health, 2013,24(5):364-366.

[5] Zhen SP, Wu YL, Wang HM. Epidemiological survey of birth defects in 389 newborns in Taiyuan City. Chinese Maternal and Child Health Care, 2017,32(19):4791-4795.

[6] Liu LX, Jing W, Wang XR, et al. Retrospective analysis of birth defects in Xinjiang Production and Construction Corps from 2011 to 2015. Chinese Journal of Reproductive Health, 2017,28(1):75-77.

[7] Xie DH, Du QY, Wang H. Analysis of the trend of birth defects in Hunan Province from 2003 to 2012. Chinese Journal of Birth Health and Genetics, 2013,21(11):72-74.

[8] Wang AH, Du QY. Analysis of monitoring results of perinatal birth defects in Hunan Province from 2009 to 2011. Practical Preventive Medicine, 2013,20(1):78-80.

[9] Xie Q, Tan HZ, Qin JB, et al. Analysis of hospital-based birth defect monitoring in Hunan Province from 2007 to 2016. Practical Preventive Medicine, 2017,24(9):1031-1036.

[10] Zu YE, Zhu L, Zhou HN, et al. Analysis of birth defects monitoring results of hospitals in Changsha City from 2001 to 2010. Medical Clinical Research, 2013,30(12):2447-2450.

[11] Fan J, Yang LY. Analysis of monitoring results of birth defects hospitals in Changsha City from 2012 to 2015. Practical Preventive Medicine, 2017,24(10):1247-1249.

Table 3-6-5 Prevalence of congenital heart disease from birth defect surveillance system in mainland China (Continued)

Region	N	Survey year	Prevalence (‰)	Ranking in local birth defects
Sichuan[1]	648 465	2001 - 2010	0.88	No.4
Guangdong[2]	2 024 583	2006 - 2015	9.04	No.1
Shenzhen, Guangdong[3]	1 089 577	2008 - 2013	6.29	No.1
Ningbo, Zhejiang[4]	256 504	2011 - 2014	16.28	No.1

Note: The subjects were monitored according to the requirements of the China Birth Monitoring Program which includes perinatal infants from 28 weeks of pregnancy to 7 days postpartum (including live births, stillbirths, death neonates within 7 days, and perinatal infants scheduled for labor within 7 days)

Guangdong researchers believed that the current monitoring results about birth defects and congenital heart diseases in dead fetuses less than 28 weeks of pregnancy and newborns aged <7 days could be underestimated. They randomly chose several sub-districts or towns at three areas (Dongguan City, Guangdong Province, Nanhai District of Foshan City, and Huicheng District of Huizhou City) in Guangdong province to examine the situation of congenital heart diseases among 63 341 females with gestational age <12 weeks and children aged ≤5 years from January 2011 to December 2014 [5] . The prevalence of congenital heart disease was 6.93‰. The main types of congenital heart disease were complex cardiac anomalies (30.5%), ventricular septal defect (25.7%), atrial septal defect (24.8%) and patent ductus arteriosus (12.3%).

The survey also demonstrated that 21.6% of congenital heart disease that were diagnosed before 28 weeks of pregnancy were not recorded by perinatal monitoring system because of the termination of the pregnancy. Therefore, in order to reflect the actual prevalence of congenital heart disease, fetuses before 28 weeks of pregnancy need to be involved in the congenital heart disease screening for providing a reliable scientific support for birth defects prevention and intervention.

[1] Liu JT, Xu YZ, He LK, et al. Monitoring and analysis of birth defects in perinatal infants in Sichuan Province from 2001 to 2010. Journal of Practical Hospitals, 2013,10(6):63-65.

[2] Luo C, Xu HL, Chen TT, et al. Monitoring and analysis of birth defects in perinatal infants in Guangdong from 2006 to 2015. Chinese Public Health, 2017,33(11):1669-1672.

[3] Zhao J, Jin SY, Liu PH, et al. Analysis of birth defects monitoring data of perinatal infants in Shenzhen from 2008 to 2013. Chinese Journal of Birth Health and Genetics, 2015,23(3):71-72.

[4] Li J, Wu JH, Qiu HY. Analysis of neonatal birth defects monitoring results in Ningbo from 2011 to 2014. Chinese Journal of Preventive Medicine, 2017,18(5):334-340.

[5] Li Mingzhen, Wang Qiling, Gu Heng, et al. Congenital heart disease survey of 0–5 years old in some parts of Guangdong Province. Chinese Journal of Birth Health and Genetics, 2017,25(3):88-89.

3.6.2.3 Risk Factors of Congenital Heart Disease

Using the Guangdong Registry data of Congenital Heart Disease (2004-2014), a population-based, case-control matched study among 9 452 live-born infants and stillborn fetuses was conducted to analyze the risk factors for congenital heart disease [1] .

The results showed that pregnant females exposed to environmental tobacco smoke during the first trimester of pregnancy were more likely to have infants with congenital heart disease than mothers who did not (OR=1.44, 95%CI: 1.25-1.66); and a significant dose-response relationship was observed.

3.6.2.4 Intervention Treatment of Congenital Heart Disease

Based on the statistics from the National Health Commission's online enrollment system for Intervention Therapy Network and the Direct Intervention System for the Treatment of Congenital Heart Diseases, the number of intervention treatments for congenital heart disease in mainland China in the past 6 years is shown in Figure 3-6-6.

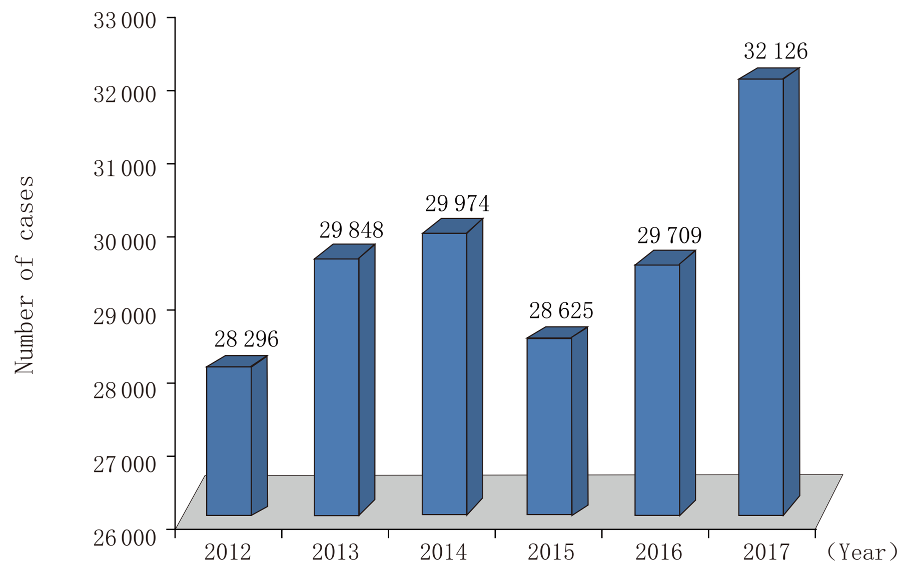


Figure 3-6-6 Number of intervention therapies for congenital heart disease, 2012-2017

In 2017, there were 366 hospitals performed intervention treatment for congenital heart disease in mainland China, and 717 physicians had the ability to perform intervention therapy for congenital heart disease, the total success rate was 98.6%, and the incidence of major complications was 0.12%. Primary indications of intervention treatment for congenital heart disease in mainland China in 2017 is shown in Figure 3-6-7.

[1] Liu X, Nie Z, Chen J, et al. Does maternal environmental tobacco smoke interact with social-demographics and environmental factors on congenital heart defects? Environ Pollut, 2018,234:214-222.

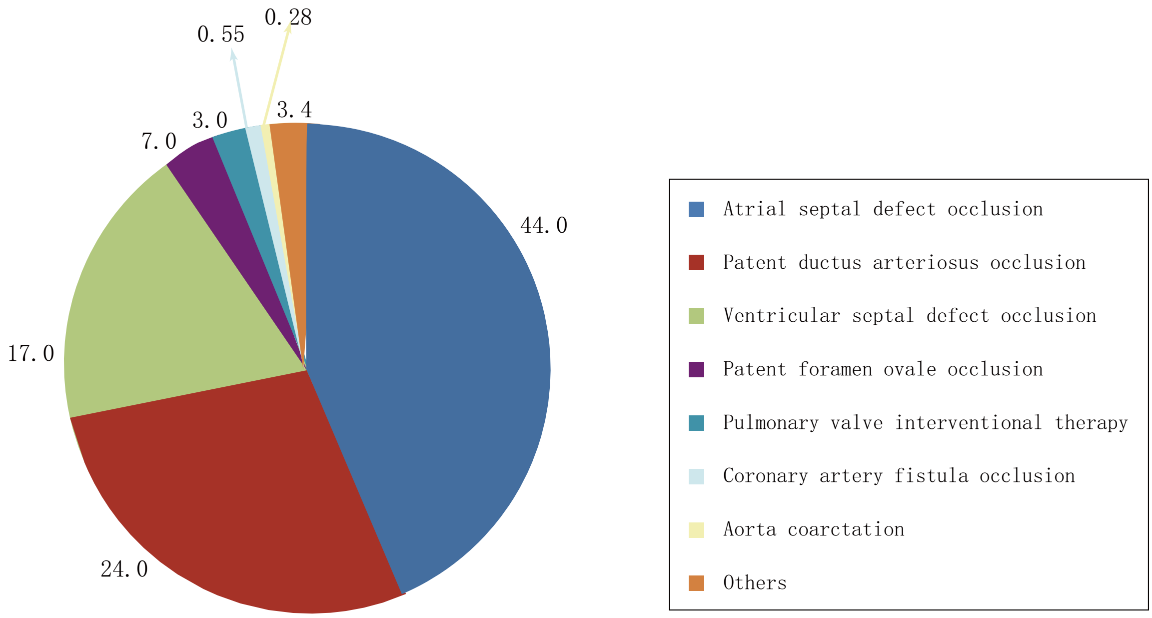


Figure 3-6-7 Primary indications for congenital heart disease intervention therapy, 2017

3.6.2.5 Open Surgical Treatment of Congenital Heart Disease

As the leading congenital cardiac centers in mainland China, the staff from Shanghai Children's Medical Center and Guangdong Provincial People's Hospital summarized the surgical strategies and experiences for treating total anomalous pulmonary venous connection (TAPVC) in a cohort of patients [1] .

This retrospective study included 768 patients operated on between 2005 and 2014. The mean surgical age and weight were 214.9±39.2 days and 5.4±3.6 kg, respectively. Surgical correction in patients with TAPVC with a biventricular anatomy can achieve an acceptable outcome. Sutureless technique was associated with a lower restenosis rate compared with conventional repair in patients with preoperative pulmonary venous obstruction. Risk factors such as a younger age at the time of repair, infracardiac and mixed TAPVC, and preoperative pulmonary venous obstruction were associated with a poorer prognosis.

3.6.3 Surgical Treatment of Coronary Artery Disease in China

3.6.3.1 Outcomes of CABG versus PCI in Young Coronary Artery Disease Patients with Diabetes

The long-term outcomes of CABG were compared with those of PCI during 2006-2016 among 2 018

[1] Shi G, Zhu Z, Chen J, et al. Total Anomalous Pulmonary Venous Connection: The Current Management Strategies in a Pediatric Cohort of 768 Patients. Circulation, 2017,135(1):48-58.

patients aged 18-45 years with diabetes mellitus. [1] Using propensity score matching, 406 patients were matched from each group.

The study found that the in-hospital mortality was higher in the CABG group than in the PCI group (1.2% vs 0.1%, P<0.0001). However, the 10-year follow-up showed that the CABG group was superior to the PCI group in long-term survival rate and free from major adverse events rate (97.3% vs 94.5%, P=0.0072; 93.2% vs 86.3%, P<0.0001). The preventing stroke rate was worse in the CABG group than in the PCI group (94.2% vs 97.5%, P=0.0059).

After propensity score-matched analysis, the long-term survival rate of the CABG group was superior to the PCI group (97.5% vs 94.6%, P=0.0403); the CABG group was also superior in preventing recurrent MI (95.6% vs 92.5%, P=0.0260). There was no significant difference between the two groups in preventing stroke (95.3% vs 97.3%, P=0.9385).

The study suggests that CABG has an advantage in cumulative survival rate and avoidance of recurrent MI in young patients with diabetes; PCI appears to be superior to CABG in prevention of stroke.

3.6.3.2 Risk Factors for the Survival of Patients Underwent CABG

Researchers from Beijing Anzhen Hospital conducted a retrospective analysis among 35 173 patients (26 926 males and 8 247 females) who underwent CABG from 2006 to 2011 [2] . They found that advancing age but not female gender, appeared to be an independent risk factor for post-CABG in-hospital and long-term mortality, and off-pump CABG may be associated with worse in-hospital mortality and better 3-year survival compared with on-pump CABG.

3.6.4 Valvular Heart Diseases

3.6.4.1 Prevalence of Valvular Heart Diseases

In 2007 and 2010, researchers from Xinjiang Autonomous Region of China used a four-stage stratified cluster random sampling method to extract a 14 618 sample population and used ultrasound to detect the condition of valvular heart diseases [3] .

The survey results showed that the prevalence of valvular heart diseases in Xinjiang was 9.65%; the prevalence increases with age; and the prevalence varies in different ethnic groups. The prevalence rates of valvular heart diseases in Han, Uygur and Kazak group were 13.51%, 2.71% and 12.29%, respectively (Figure 3-6-8).

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[1] Li Y, Dong R, Hua K, et al. Outcomes of coronary artery bypass graft surgery versus percutaneous coronary intervention in patients aged 18-45 years with diabetes mellitus. Chin Med J (Engl), 2017,130(24):2906-2915.

[2] Wang J, Yu W, Zhao D, et al. In-Hospital and Long-Term Mortality in 35,173 Chinese Patients Undergoing Coronary Artery Bypass Grafting in Beijing: Impact of Sex, Age, Myocardial Infarction, and Cardiopulmonary Bypass. J Cardiothorac Vasc Anesth, 2017,31(1):26-31.

[3] Wang YT, Tao J, Maimaiti A, et al. Prevalence of valvular heart diseases and associated risk factors in Han, Uygur and Kazak population in Xinjiang, China. PLoS One, 2017 Mar 29;12(3):e0174490. doi:10.1371/journal.pone.0174490. eCollection 2017.

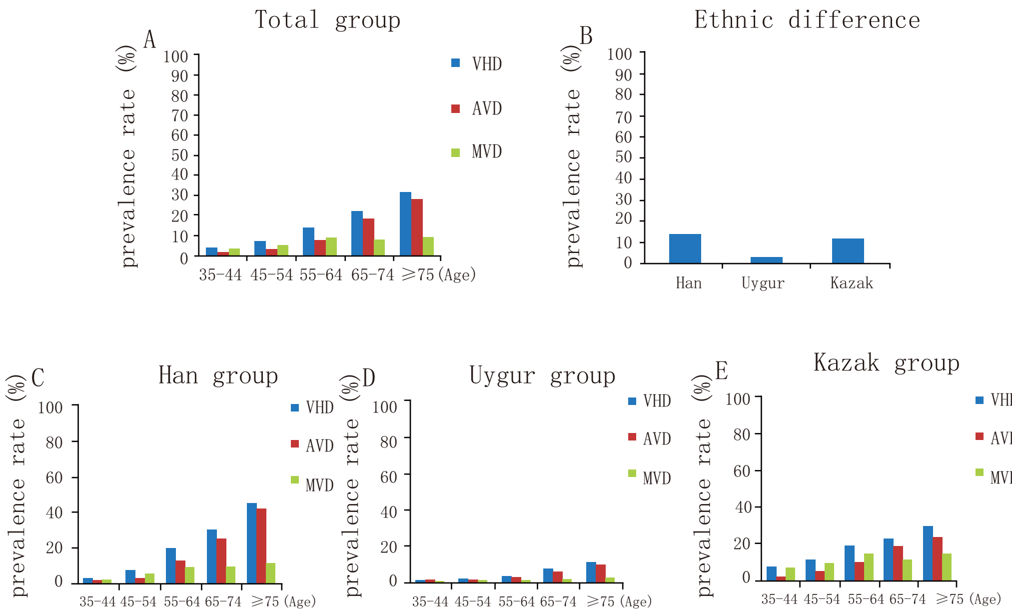

Figure 3-6-8 Prevalence of valvular heart diseases in Xinjiang Autonomous Region

Note:VHD, valvular heart disease; AVD, aortic valve disease; MVD, mitral valve disease

3.6.4.2 Prevalence of Bicuspid Aortic Valve

A retrospective analysis of 195 708 echocardiograms from 157 039 people in Huaxi Hospital from 2008 to 2012[1] showed that the prevalence of bicuspid aortic valve was 0.43%, which was close to 0.5%-2% reported in the western population.

The researchers found that:

(1) The prevalence of bicuspid aortic valve was significantly higher in males than in females (0.56% vs 0.29%);

(2) About half of patients with bicuspid aortic valve over 40 years old have various degree of aortic valve disease;

(3) In the bicuspid aortic valve, aortic valve stenosis or regurgitation accounted for 27.1% and 17.5% respectively, while 42.1% of patients had both conditions;.

(4) The number of patients with moderate to severe aortic valve stenosis and regurgitation increased significantly with age;

(5) The average age of infective endocarditis occurred was 42.96±11.25, and the incidence rate was about 0.68%/person year;

(6) The average age of aortic dissection occurred was 43.00±5.14, and the incidence rate was about 0.18%/person year.

[1] Li Y, Wei X, Zhao Z, et al. Prevalence and complications of bicuspid aortic valve in Chinese according to echocardiographic database. Am J Cardiol, 2017,120(2):287-291.

3.6.5 Aortic Dissection

According to the Taiwan Health Insurance claim data 2011 [1], the annual incidence of acute aortic dissection in mainland China was estimated to be 2.8/100 000 and was significantly higher in males than in females (3.7/100 000 vs 1.5/100000, P<0.001). The average age was 58.9±13.4, which was significantly younger than that reported by IRAD registry research from west countries.

Researchers in Taiwan, China identified cases of acute aortic dissection diagnosed during 2005 to 2012 in Taiwan Health Insurance claim data [2] and found that the average annual incidence of acute aortic dissection in Taiwanese was 5.6/100 000, and the average prevalence was 19.9/100 000.

3.7 Chronic Kidney Disease

3.7.1 Chronic Kidney Disease Prevalence

3.7.1.1 National Chronic Kidney Disease Prevalence Survey

A cross-sectional chronic kidney disease (CKD) prevalence survey was conducted between September 2009 and September 2010 in 13 provinces, autonomous regions, and municipalities in China.The overall prevalence of chronic kidney disease among 47 204 adults aged ⩾18 years was 10.8%. The adjusted prevalence of eGFR less than 60 ml/min/1.73m² was 1.7% and that of urinary albumin to creatinine ratio (ACR) >30mg/g was 9.4 %. Therefore, the number of patients with chronic kidney disease in China is estimated to be about 120 million. Factors independently associated with CKD were age, gender, hypertension, diabetes, history of cardiovascular disease, hyperuricemia, the area of residence and economic status [3].

3.7.1.2 Prevalence of Chronic Kidney Disease in the Tibetan Plateau

A cross-sectional study on the influence of different altitudes on the prevalence of CKD was conducted in Tibetan Plateau from 2014 to 2016. The results showed that, among 1 707 subjects aged ⩾35 years, the age-standardized prevalence of CKD at different altitude in Tibetan Plateau [Linzhi (2 900 m altitude), Lhasa (3 650 m) and Anduo (4 700 m)] was higher than that of the average level: the age-standardized prevalence of CKD in Linzhi, Lhasa, and Anduo was 27.7% (95%CI: 22.1-33.3%), 18.3% (95%CI: 12.7%-24.0%), and 30.4% (95%CI: 23.5%-37.3%) in males; and 37.7% (95%CI: 31.8%-43.6%), 29.5% (95%CI: 24.6%-34.4%), and 36.7% (95%CI: 29.0%-44.4%) in females, respectively. Tibetans in 3 regions accounted for 88%, 91% and 97%, respectively. CKD in the study was defined as eGFR <60ml/min/1.73 m^2 and/

[1] Xia L, Li JH, Zhao K, et al. Incidence and in-hospital mortality of acute aortic dissection in China: analysis of China Health Insurance Research (CHIRA) Data 2011. J Geriatr Cardiol, 2015,12:502-506.

[2] Yeh TY, Chen CY, Huang JW, et al. Epidemiology and medication utilization pattern of Aortic Dissection in Taiwan. Medicine, 2015,94(36):1-8.

[3] Zhang L, Wang F, Wang L, et al. Prevalence of chronic kidney disease in China: a cross-sectional survey. Lancet, 2012,379:815-822.

or urinary albumin/creatinine ratio (ACR) ≥30 mg/g). Like other studies, age, female gender, systolic blood pressure, fasting glucose and low education were risk factors for CKD [1]. This study suggested that a higher prevalence of CKD was found in the residents living in the Tibetan Plateau. However, for the highlanders living at higher altitude does not mean higher risk.

3.7.1.3 China Kidney Disease Prevalence among Hospitalized Patients

China CKD Monitoring Data System - China Kidney Disease Network (CK-NET) released its first annual report (CK-NET 2014 annual report). This report summarized the medical records of 19 518 990 hospitalized patients aged >18 years from 775 tertiary hospitals in 29 provinces and municipalities registered by national hospital quality monitoring system (HQMS) from July 2013 to June 2014. The international classification of diseases (ICD) code on the first page of the medical record was used to identify patients with CKD. The results showed that 4.5% of hospitalized patients were complicated with CKD. The proportion of hospitalized patients with CKD by disease was shown in Table 3-7-1 [2].

Table 3-7-1 Prevalence of CKD among different types of underlying diseases

Group	CKD (n)	HQMS (n)	CKD prevalence (%)
Diabetes	226 142	1 557 596	14.5
Hypertension	348 075	3 670 740	9.5
CVD	242 409	3 443 012	7.0
HQMS	871 742	19 518 990	4.5

Note: HQMS, hospital quality monitoring system

3.7.2 Cardiovascular Complications in Patients with CKD

3.7.2.1 CKD and Hypertension

Hypertension is an important risk factor for CVD in CKD patients. According to the annual report of CK-NET, among 871 742 hospitalized CKD patients, 434 292 patients were complicated with hypertension, and the prevalence of hypertension was 49.8% [1].

A cross-sectional survey for 6 079 CKD patients (mean age: 51.0±16.4 years) from 22 hospitals in China between June 30, 2012 and December 30, 2013 showed that the prevalence, awareness and treatment rates in hypertension patients with CKD were 71.2%, 95.4%, and 93.7%, respectively. 41.1% of patients had their blood pressure controlled <140/90 mmHg; and 15% below 130/80 mmHg. Patients were treated mostly with

[1] Zhang L, Wang Z, Chen Y, et al. Prevalence and risk factors associated with chronic kidney disease in adults living in 3 different altitude regions in the Tibetan Plateau. Clin Chim Acta, 2018,481:212-217.

[2] Zhang L, Wang H, Long J, et al. China Kidney Disease Network(CK-NET) 2014 Annual Data Report. Am J Kidney Dis, 2017 Jun;69(6S2):A4. doi: 10.1053/j.ajkd.2016.06.011.

monotherapy (37.7%) or 2-drug anti-hypertensive combination (38.7%). CCB was the most preferred drug class in China (77.6%), followed by ARB (52.9%), ACEI (24.0%) and β blocker (24.0%) [1] .

The PATRIOTIC study investigated the prevalence of refractory hypertension and related factors among CKD patients in China. A total of 4 435 CKD patients with hypertension were enrolled from 61 tertiary hospitals in 31 provinces, municipalities, and autonomous regions that met the eligibility criteria (independent nephrology department, number of beds >40, and monthly admission >50 CKD patients). Among them, the prevalence of refractory hypertension (defined as BP >140/90 mmHg with 3 antihypertensive drugs or achieving the target BP by using 4 or more antihypertensive drugs) was 11.1%. Multivariate logistic regression analysis showed that obesity, advanced CKD stages, urinary protein level ≥1.5g/24h, diabetes and CVD were associated with refractory hypertension in CKD patients ($P< 0.05$) [2] .

3.7.2.2 CKD and CVD

Data from China CKD cohort study (C-STRIDE) showed that among 3 168 patients with stage 1-4 CKD, the prevalence of CVD was 9.8%, and cerebrovascular disease accounted for 69.1% of CVD cases (Table 3-7-2). Age, low eGFR, hypertension, abdominal aortic calcification and diabetes were independently associated with higher CVD prevalence in patients with CKD [3] .

Table 3-7-2 CVD prevalence in different stages of CKD in C-STRIDE study

Variable	Total	eGFR (ml/min/1.73m^2)				P for trend
		>60	45-60	30-45	15-30	
	n=3 168	n=975	n=497	n=769	n=927	
Myocardial infarction*	64 (20.58)	6 (0.62)	9 (1.81)	22 (2.86)	27 (2.91)	0.001
Chronic heart failure*	28 (9.00)	3 (0.31)	5 (1.01)	9 (1.17)	11 (1.19)	0.14
Cerebrovascular disease*	215 (69.13)	22 (2.26)	44 (8.85)	58 (7.54)	91 (9.82)	<0.001
Peripheral arterial disease*	50 (16.10)	3 (0.31)	8 (1.61)	13 (1.69)	26 (2.81)	<0.001
Total VCD	311 (9.82)	31 (3.18)	59 (11.87)	86 (11.18)	135 (14.56)	

* as a percentage of CVD

According to the annual report from CK-NET, 27.8% of hospitalized CKD patients associated with CVD, higher than the prevalence of CVD (17.2%) in all hospitalized patients. Coronary heart disease was the

[1] Zhang W, Shi W, Liu Z, et al. A nationwide cross-sectional survey on prevalence, management and pharmaco epidemiology patterns on hypertension in Chinese patients with chronic kidney disease. Sci Rep, 2016,6:38768. doi: 10.1038/srep38768.

[2] Zheng Y, Tang L, Chen X, et al. Resistant and undertreated hypertension in patients with chronic kidney disease: data from the PATRIOTIC survey. Clin Exp Hypertens, 2018,6:1-8.

[3] Yuan J, Zou XR, Han SP, et al. Prevalence and risk factors for cardiovascular disease among chronic kidney disease patients: results from the Chinese cohort study of chronic kidney disease (C-STRIDE). BMC Nephrol, 2017,18(1):23. doi:10.1186.

most common disease in CKD patients, with the acute coronary syndrome (3.5%) and other coronary artery diseases (14.2%); followed by congestive heart failure (13.0%) and stroke (9.2%). The prevalence of CVD in stages 1-2, 3, 4 and 5 CKD was 29.6%, 33.9%, 34.7%, and 28.3%, respectively. The prevalence of CVD at different stages of CKD was shown in Table 3-7-3 [1] .

Table 3-7-3 CVD Prevalence by CKD stage in CK-NET study

	CKD Stage							
	1-2（n=16 570)		3 (n=21 780)		4 (n=15 935)		5 (n=69 493)	
	N	%	N	%	N	%	N	%
ACS	639	3.9	905	4.2	698	4.4	1 342	1.9
CHF	2 323	14	3 715	17.1	3 134	19.7	13 223	19
Stroke	1 635	9.9	2 359	10.8	1 509	9.5	3 604	5.2
Other CHD	2 644	16	4 288	19.7	2 897	18.2	7 482	10.8
Other heart disease	233	1.4	300	1.4	192	1.2	438	0.6
CVD	4 911	29.6	7 374	33.9	5 529	34.7	19 677	28.3

A cross-sectional study based on the "China CKD survey" conducted from 2007 to 2012 linked the survival status of 47 204 Chinese adults to the cause of death registration data by the end of December 2013 and conducted Cox multiple regression analysis on the relationship between CKD and all-cause mortality and cardiovascular mortality. The results showed that all-cause mortality and cardiovascular mortality increased with ACR values (Table 3-7-4). Decreased eGFR (<60ml/min/1.73m^2) was not associated with all-cause or cardiovascular mortality in the general population after multivariate adjustment but associated with all-cause mortality among participants aged less than 65 years [2] .

[1] Zhang L, Wang H, Long J, et al. China Kidney Disease Network (CK-NET) 2014 Annual Data Report. Am J Kidney Dis, 2017,Jun;69(6S2):A4.doi: 10.1053/j.ajkd.2016.06.011.

[2] Wang J, Wang F, Liu S, et al. Reduced Kidney Function, Albuminuria, and Risks for All-cause and Cardiovascular Mortality in China: A Population-based Cohort Study. BMC Nephrol, 2017,18(1):188. DOI 10.1186/s12882-017-0603-9.

Table 3-7-4 HR for all-cause mortality and cardiovascular mortality by ACR

	HR	95%CI
All-cause mortality		
ACR<30mg/g	1	
ACR 30-299 mg/g	1.26	1.04-1.53
ACR ⩾ 300 mg/g	2.07	1.40-3.04
Cardiovascular mortality		
ACR<30mg/g	1	
ACR 30-299 mg/g	1.08	0.77-1.50
ACR ⩾ 300 mg/g	2.32	1.31-4.12

The mortality of early diabetic kidney disease was assessed from a cohort of 512 700 adults in Taiwan Health Iusurance claims data from 1994 to 2008, of whom 50 977 were early CKD patients without diabetes. Of the 27 455 patients with diabetes, about one-third (9 067) had the early kidney disease (stages 1-3 CKD). The mortality rates in 3 groups (diabetes without CKD, early diabetic kidney disease, and early CKD without diabetes) were observed through the death registration system after an average follow-up of 8 years (Table 3-7-5) [1] . The results showed that mortality for early diabetic kidney disease was nearly twice as high as that for early CKD or diabetes without CKD. Diabetes with early kidney disease may shorten life expectancy by 16 years.

Table 3-7-5 HR for all-cause mortality and cardiovascular mortality by CKD and diabetes

	HR	95%CI
All-cause mortality		
Early CKD	1.58	1.5-1.7
Diabetes without CKD	1.76	1.6-1.9
Early diabetic kidney disease	3.16	3.0-3.4
Cardiovascular mortality		
Early CKD	1.74	1.6-1.9
Diabetes without CKD	1.40	1.2-1.7
Early diabetic kidney disease	2.78	2.4-3.2

[1] Wen CP, Chang CH, Tsai MK, et al. Diabetes with early kidney involvement may shorten life expectancy by 16 years. Kidney Int, 2017,92(2):388-396.

3.7.2.3 CKD and Vascular Calcification

Vascular/valvular calcification, especially coronary artery calcification, is closely associated with cardiovascular complications and poor prognosis in patients with CKD. The China Calcification Study was a national multicenter, observational, prospective cohort study. A total of 1 493 dialysis patients aged 18-75 years were enrolled from 24 centers in 9 cities, including 1 169 hemodialysis patients and 324 peritoneal dialysis patients. The study showed that at baseline the total prevalence of vascular/valvular calcification was 77.4% (80.8% in hemodialysis group, 65.1% in peritoneal dialysis group, $P<0.001$), the prevalence of coronary artery calcification was 68.3%, abdominal aortic calcification 46.8%, and valvular calcification 29%. Multivariate regression analysis showed that serum calcium ($OR=2.11$, $P=0.0354$) and parathyroid hormone ($OR=1.05$, $P=0.0129$) were correlated significantly with vascular/valve calcification [1] .

China CKD cohort study (C-STRIDE) enrolled 3 194 patients aged 18-74 years with stages 1-4 CKD from 39 hospitals in 28 cities from 22 provinces. Among 2 280 patients who performed lateral abdominal radiography, the prevalence of abdominal aortic calcification was 9.8%. Serum phosphorus level was an independent risk factor for abdominal aortic calcification [2] .

3.8 Peripheral Arterial Disease

Peripheral arterial disease (PAD) refers to arterial diseases other than coronary artery disease and cerebrovascular disease. This report only covers lower extremity atherosclerotic disease (LEAD), carotid atherosclerotic disease (CAD) and renal artery stenosis (RAS).

3.8.1 Lower Extremity Atherosclerotic Disease (LEAD)

3.8.1.1 Prevalence of LEAD

LEAD is common in the middle-aged and elderly population, and the diagnostic methods include intermittent claudication questionnaires, ankle-brachial index (ABI), pulse wave velocity (PWV), and other noninvasive measures. The results from epidemiological studies of LEAD have shown salient differences in the prevalence among different populations in China. The prevalence was about 16.4% in the elderly residents of Beijing Wanshoulu District,[3] and 19.4%-24.1% in the diabetic or metabolic syndrome

[1] Liu ZH, Yu XQ, Yang JW, et al. Prevalence and risk factors for vascular calcification in Chinese patients receiving dialysis: baseline results from a prospective cohort study. Curr Med Res Opin, 2018,3:1-10.

[2] Zhou C, Wang F, Wang JW, et al. Mineral and Bone Disorder and Its Association with Cardiovascular Parameters in Chinese Patients with Chronic Kidney Disease. Chin Med J (Engl), 2016,129(19):2275-2780.

[3] Li XY, Wang J, He Y, et al. The association between lower extremity atherosclerotic disease and cardiac vascular disease: survey in the elderly at Wanshoulu district, Beijing. Chinese Medical Journal, 2003,83(21):1847-1851.

population,[1,2,3] with the lowest prevalence in Zhejiang Zhoushan fishermen (2.1%) [4] .The prevalence of LEAD increased with age and most studies reported a higher prevalence in females than in males (Table 3-8-1).

Table 3-8-1 Epidemiological studies of LEAD in China

Program	N	Age	Prevalence（%）		
			Male	Female	Total
Elderly residents in Beijing Wanshoulu[5,6]	2 124	60-95	12.7	18.1	16.4
Zhejiang Zhoushan fishermen[4]	2 668	>35	3.0	1.2	2.1
Metabolic syndrome[1]	2 115	32-91	21.7	23.4	22.5
MUCA* [7]	18 140	>35	5.4	9.3	6.0
Diabetes[2]	1 347	>50	18.3	20.4	19.4
Hypertension[8]	3 047	>50	—	—	27.5
Community population[9]	21 152	>18	1.8	4.3	3.04
Elderly diabetes in Wuhan[3]	2 010	>60	—	—	24.1

Note: LEAD is diagnosed if ABI＜0.90;
MUCA: China Multicenter Collaborative Study of Cardiovascular Epidemiology

3.8.1.2 Risk Factors Associated with LEAD

Epidemiological studies showed that the prevalence of LEAD increased with age and the number of risk

［1］Wei YD, Hu DY, Zhang RF, et al. Clinical study of the patients with metabolic syndrome and peripheral arterial disease. Chinese Medical Journal, 2006,86(30):2114-2116.
［2］Guan H, Liu ZM, Li GW, et al. Peripheral arterial occlusive disease among patient aged 50 or older with diabetes and related factors. Chinese Medical Journal, 2007,87 (1):23-27.
［3］Wang L, Du F, Mao H, et al. Prevalence and related risk factors of peripheral arterial disease in elderly patients with type 2 diabetes in Wuhan, Central China. Chin Med J (Engl), 2011,124 (24):4264-4268.
［4］Liu CG, Ruan LS. Survey of peripheral arterial disease in Zhoushan fishing area. Chinese Medical Journal of Gerontology, 2005,24(11):863-865.
［5］Li XY, Wang J, He Y, et al. The association between lower extremity atherosclerotic disease and cardiac vascular disease: Survey of the elderly in Wanshoulu, Beijing. Chinese Medical Journal, 2003,83 (21):1847- 1851.
［6］Wang J, Li XY, He Y, et al. The cross-sectional study of the lower extremity atherosclerotic disease among the elderly in Wanshoulu, Beijing. Chinese Journal of Epidemiology, 2004,25 (3):221-224.
［7］An W, Li X, Wu YF, et al. Hypertension and peripheral arterial diseases. Journal of Peking University (Health Sciences), 2010,42(6):667-670.
［8］Li J. Serial of reports of the lower extremity arterial disease in China. All-cause of lower extremity arterial disease and the cardiovascular disease mortality among high-risk groups. Chinese Journal of Internal Medicine, 2006,26 (21):1685-1687.
［9］Wang Y, Li J, Xu YW, et al. The prevalence of peripheral arterial disease in the natural population and the associated risk factors in China. Chinese Journal of Cardiology, 2009,37 (12):1127-1131.

factors for atherosclerosis (AS). AS is the major cause for LEAD, and risk factors for AS such as smoking, diabetes, dyslipidemia, hypertension and hyperhomocysteinemia also increased the risk of LEAD. 30% of patients with cerebrovascular disease and 25% of patients with ischemic heart disease had LEAD as a complication.[1,2] Thus, LEAD primes systemic atherosclerotic diseases, early detection and treatment of LEAD have great value for the diagnosis and treatment of systemic atherosclerosis.

An epidemiological study among 2 127 community elders showed that the decrease of ankle-brachial index and the increase of brachial-ankle pulse wave velocity were independent risk factors for albuminuria.[3] One cohort study among the Chinese community-based population showed that the increased leucocyte counts could predict the risk of new onset peripheral arterial disease (PAD). After an average of 2.3 years follow-up with 3 555 subjects without PAD at baseline, it showed that when leucocyte count increases by 1×10^9, the risk of new onset PAD would increase by 27% (OR=1.27, 95%CI: 1.14-1.41, P<0.0001) .[4] In addition, one cross-sectional study involving 3 148 participants aged ≥40 years with normal thyroid function showed that FT3 levels and the FT3/FT4 ratio were negatively associated with the prevalence of PAD [5] .

3.8.1.3 Effects of LEAD on Mortality

The mortality rate of LEAD patients is significantly higher than that of non-LEAD people of the same age, and the mortality rate also increases as the value of ABI decreases. A 3-year follow-up study among 3 210 participants with a high risk of AS compared the mortality rates by ABI. The study revealed that patients with ABI ≤0.4 were 3 times (95%CI: 1.936-4.979) as likely to die as those with ABI in the range of 1.0-1.4; patients with ABI ≤0.4 were about five times (95%CI: 2.740-8.388) as likely to die of CVD as those with ABI in the range of 1.0-1.4 (Table 3-8-2) [6] .

Table 3-8-2 Mortality of patients with high risk of atherosclerotic diseases by ABI after 3-year follow-up (%)

Mortality rate	ABI≤0.4	0.41-0.9	0.91-0.99	1.0-1.4	Total	P value
All-cause mortality	37.7	24.4	13.2	12.1	15.7	<0.001
Cardiovascular mortality	27.5	14.5	8.1	6.3	8.9	<0.001

[1] Liu CG, Ruan LS. Survey of peripheral arterial disease in Zhoushan fishing area. Chinese Medical Journal of Gerontology, 2005,24(11):863-865.

[2] Wei YD, Hu DY, Zhang RF, et al. Study of the patients with metabolic syndrome and peripheral arterial disease. Chinese Medical Journal, 2006,86(30):2114-2116.

[3] Xu X, He J, Wang S, et al. Ankle-brachial index and brachial-ankle pulse wave velocity are associated with albuminuria in community-based Han Chinese. Clin Exp Hypertens, 2016,38(7):618-623.

[4] Li Y, Fan F, Jia J, et al. WBC count predicts the risk of new-onset peripheral arterial disease in a Chinese community-based population. Hypertens Res, 2017 May 11. doi:10.1038/hr.2017.64.

[5] Wang P, DU R, Lin L, et al. Association between Free Triiodothyronine Levels and Peripheral Arterial Disease in Euthyroid Participants. Biomed Environ Sci, 2017,30(2):128-133.

[6] Li X, Luo Y, Xu Y, et al. Relationship of ankle-brachial index with all-cause mortality and cardiovascular mortality after a 3-year follow-up: the China ankle-brachial index cohort study. J Hum Hypertens, 2010,24(2):111-116.

3.8.2 Carotid Arterial Disease

3.8.2.1 Prevalence and Risk Factors of Carotid Arterial Disease

Carotid atherosclerosis disease (CAD) is highly prevalent in the middle-aged and elderly population. The epidemiological diagnostic methods include atherosclerotic plaque detection and carotid intima-media thickness (IMT) measurements via carotid ultrasound. The epidemiological studies showed that the prevalence of CAD is associated with age, risk factors and underlying diseases.

A total of 107 095 residents aged ≥40 years from 31 provinces, municipalities, and autonomous regions were enrolled in the China National Stroke Prevention Project (CSPP) and underwent carotid ultrasound examination, and the data from 84 880 participants were included in the final analysis. The results showed that the overall prevalence of carotid atherosclerosis was 36.2%. Approximately 26.5% of participants had increased IMT (IMT≥1mm), and 13.9% presented carotid plaques.Multivariate regression analysis showed that age, male gender, residence in rural areas, smoking, alcohol consumption, physical inactivities, obesity, hypertension, diabetes mellitus, and dyslipidemia were associated with carotid atherosclerosis [1] .

The prevalence of carotid atherosclerosis disease in recent years is shown in Table 3-8-3.

Table 3-8-3 The prevalence of carotid atherosclerosis disease

Program	Survey year	Age	N	Prevalence	
				Carotid plaque	IMT≥1mm
CSPP[1]	2014-2015	≥40	84 880	13.9%	26.5%
CKB[2]	2013-2014	30-79	24 822	30.9%	--
Rural area in Tianjing[3]	2014-2015	≥45	3 789	40.3%	-

Note: CSPP, China National Stroke Prevention Project; CKB, China Kadoorie Biobank
Definition of carotid atherosclerosis disease in different studies:
CSPP, IMT≥1mm or atherosclerotic plaque;
CKB, atherosclerotic plaque detection via carotid ultrasound;
Rural area in Tianjing, atherosclerotic plaque detection via carotid ultrasound

3.8.2.2 Carotid Arterial Disease and the Risk of Ischemic Heart Disease

A 5-year follow-up study showed that baseline IMT was an independent predictor for ischemic cardiovascular disease in participants without carotid plaque (HR=1.59, 95%CI: 1.04-2.45). In patients with

[1] Wang X, Li W, Song F, et al. Carotid Atherosclerosis Detected by Ultrasonography: A National Cross-Sectional Study. J Am Heart Assoc, 2018,7(8):1-11.
[2] Clarke R, Du H, Kurmi O, et al. Burden of carotid artery atherosclerosis in Chinese adults: Implications for future risk of cardiovascular diseases. Eur J Prev Cardiol, 2017,24(6):647-656.
[3] Zhan C, Shi M, Yang Y, et al. Prevalence and risk factors of carotid plaque among middle-aged and elderly adults in rural Tianjin, China. Sci Rep, 2016,31,6:23870.

carotid plaque, the total area of plaques (HR=1.29, 95%CI: 1.08-1.55), the number of plaques (HR=1.14, 95%CI: 1.02-1.27) were all significantly associated with ischemic cardiovascular disease.[1]

3.8.3 Renal Vascular Disease

Renal artery stenosis (RAS), defined as a narrowing of the renal artery lumen ⩾50%, is a common atherosclerotic PAD in the middle-aged and elderly population. Although renal angiography is the gold standard for diagnosing RAS, MRA and CTA have been extensively applied in clinical settings due to technological advancement and the noninvasive advantages. Renal artery duplex ultrasonography is a more convenient method commonly used for screening. Since RAS is usually asymptomatic, its prevalence is often underestimated.

3.8.3.1 Incidence of Renal Vascular Disease

At present, the Taiwan Health Insurance program is the first population-based study describing the incidence of renal vascular disease among a whole population (23 million). From 2000-2008, a total of 14 025 patients were diagnosed as renal vascular disease. The overall incidence was 6.69/100 000 person-years. The incidence increased with age: it was 10.56/100 000 person-years in patients aged between 45 and 64 years, 27.03/100 000 person-years in patients aged ⩾65 years. The temporal trend in incidence decreased year by year from 2000, which was mainly attributed to the decline in the incidence of renal artery stenosis among the middle-aged and elderly population, and was consistent with the increased control rate of atherosclerosis disease in Taiwan.[2]

3.8.3.2 Etiology of RAS and Detection Rate among Risky Populations

According to the observation of 2 906 RAS patients during an 18-year period, the proportion of three major causes of renal artery stenosis (RAS) changed substantially. The proportion of atherosclerotic RAS gradually increased from approximately 50% in 1999-2000 to nearly 85% in 2015-2016; the proportion of RAS caused by Takayasu arteritis gradually decreased from 31% to 10%; and the proportion of RAS caused by fibromuscular dysplasia had almost no changes, fluctuating between 2.9% and 6.5%.[3]

The Chinese domestic data showed that the detection rate of RAS was between 9.7-18.4% in patients who underwent coronary angiography and renal artery angiography at the same time. The detection rate of RAS among people with normal coronary arteries was 1.5%-15.1%, and 8.2%-30.8% in people with coronary

[1] Xie W, Liang L, Zhao L, et al. Combination of carotid intima-media thickness and plaque for better predicting risk of ischaemic cardiovascular events. Heart, 2011,97(16):1326-1331.

[2] Fang CC, Chen WJ, Peng CL, et al. Renovascular disease in Taiwan: a long-term nationwide population study. Int J Cardiol, 2013,168(1):541-542.

[3] Xiong HL, Peng M, Jiang XJ, et al.Time trends regarding the etiology of renal artery stenosis: 18 years' experience from the China Center for Cardiovascular Disease. J Clin Hypertens (Greenwich), 2018,20(9):1302-1309.

heart disease [1,2,3,4,5] . Age, female gender, hypertension, peripheral vascular disease, renal insufficiency, and multivessel coronary artery disease are independent risk factors for RAS [6] . Other data showed that the prevalence of RAS was 12.7%-15.8% in patients with suspected renal vascular hypertension, 14.9%-25.1% in hypertensive patients complicated with diabetes mellitus, 45.7%-62.3% in patients with chronic heart failure, 23.6%-27.0% in patients with peripheral vascular disease, 27.4%-39.2% in patients with abdominal aortic aneurysm, and 27%-55.8% in patients with end-stage nephropathy.[7]

RAS is a major cause of secondary hypertension, and interventional angioplasty for atherosclerotic RAS was not superior to medical therapy in terms of the prevention of clinical events [6] . Renal artery stent combined with optimal medical treatment could confer a beneficial effect on blood pressure control and estimated glomerular filtration rate in patients with severe atherosclerotic RAS (83.1% stenosis) .[8]

3.9 Medical Care Quality Assessment on CVD

Prevention and treatment of CVD is essential to reduce premature death and improve health condition. The decline in CVD death depends on two aspects. First, take aggressive strategies and strengthen prevention to decrease the incidence of diseases. Second, provide reasonable and standardized treatment for high-risk population, and ensure that evidence-based medicine is transformed into good clinical practice, improve quality of healthcare, reduce medical waste, take full advantages of limited medical resources, and achieve the most favorable outcomes. In recent years, the researches on CVD medical quality have attracted widespread attention. Medical care quality indexes include two categories: patients' outcomes (including adverse events such as death and complications) and process indicators for diagnosis and treatment (including therapies specifically recommended or prohibited by guidelines). This section will summarize the research progress in this field.

[1] Yan JH, Sun LX, Zhao XY, et al.Prevalence and risk factors of atherosclerotic renal artery stenosis Chin Medical J, 2013,93(11):827-831.

[2] Liu BC, Tang RN, Feng Y, et al. A single Chinese center investigation of renal artery stenosis in 141 consecutive cases with coronary angiography. Am J Nephrol, 2004,24(6):630-634.

[3] Wang Y, Ho DS, Chen WH, et al. Prevalence and predictors of renal artery stenosis in Chinese patients with coronary artery disease. Intern Med J, 2003,33(7):280-285.

[4] Shen ZJ, Shang YP, Zhu WL, et al. The incidence of renal artery stenosis in patients with coronary heart disease. Chinese Journal of Internal Medicine, 2001,40(8):521-524.

[5] Yang JG, Hu DY, Liu KS. The incidence of renal artery stenosis in patients taken coronary angiography. Chinese Journal of Internal Medicine, 2002,41(1):24-27.

[6] Cooper CJ, Murphy TP, Cutlip DE, et al. Stenting and medical therapy for atherosclerotic renal-artery stenosis. N Engl J Med, 2014,370(1):13-22.

[7] de Mast Q, Beutler JJ. The prevalence of atherosclerotic renal artery stenosis in risk groups: a systematic literature review. J Hypertens, 2009,27(7):1333-1340.

[8] Jiang X, Peng M, Li B, et al. The efficacy of renal artery stent combined with optimal medical therapy in patients with severe atherosclerotic renal artery stenosis. Curr Med Res Opin, 2016,32(sup2):3-7.

3.9.1 Medical Care Quality Assessment on Coronary Heart Disease

The main medical care quality assessment researches on coronary heart disease include the Clinical Pathways for Acute Coronary Syndromes study (CPACS), the Improving Care for Cardiovascular Diseases in China (CCC), the China Patient-centered Evaluative Assessment of Cardiac Events (China PEACE), the China Acute Myocardial Infarction (CAMI), and the Bridging the Gap on Coronary Heart disease Secondary Prevention in China (BRIG). These studies are summarized in Table 3-9-1.

Table 3-9-1 Medical care quality assessment researches on coronary heart disease

Program	Year	Study design	Participants	Participated hospitals	N	Contents
CPACS	2007-2010	Cluster randomized control trial based on registry	Patients hospitalized with ACS aged ≥18 years	75 urban secondary or tertiary hospitals	15 141	Conduct intervention on clinical pathway according to the status quo and the gap, and evaluate its feasibility and effect
BRIG	2006-2012	Cross-sectional study, non-randomized two-stage sampling	Patients with discharge diagnosis of ACS aged ≥18 years	65 secondary or tertiary hospitals from 31 provinces, municipalities, and autonomous regions	3 323	Assess the status of diagnosis and secondary prevention for CAD in China, identify existing problems, obstacles and major influencing factors, develop targeted improvement measures and systematic intervention programs, and evaluate their rationality and sustainability
China PEACE	2001-2011	Cross-sectional study, generating national representative sample in 2001, 2006 and 2011 by randomized two-stage sampling	Patients hospitalized for AMI	162 hospitals (63 urban large hospitals and 99 county-level hospitals)	18 631	Quantitatively evaluate the trend of in-patient care pattern, in-hospital mortality and complications of AMI in China
CAMI	2013 till now	Registry study	Patients hospitalized for AMI	108 central hospitals in each administrative region (hospitals were categorized as provincial, municipal, and county-level)	50 000 till Nov, 2017	Evaluate the resource allocation, patient characteristics, risk factors, inducing factors and treatment, etc.
CCC-ACS	2014 till now	Registry study. The first 20-30 consecutive patients in each hospital each month were recruited	Patients hospitalized for ACS	150 hospitals were sampled according to economic-geographic regions	35 616 till Apr, 2016	Evaluate the adherence of cardiovascular diagnosis and treatment practice to various guidelines' recommendations

ACS, acute coronary syndrome.

3.9.1.1 Clinical Pathways for Acute Coronary Syndromes study (CPACS)

The CPACS study was conducted in 75 secondary or tertiary hospitals throughout China. Hospitals were assigned immediate implementation of the American Heart Association/American College of Cardiology guideline based clinical pathways or commencement of the intervention 12 months later. The key performance indicators were measured 12 months after commencement in intervention hospitals and compared with baseline data in control hospitals using data collected every 6 months from 50 consecutive patients in each hospital. The results showed that the pathway implementation was associated with an increased proportion of patients discharged on appropriate medical therapy, with no significant improvements or absence of effects on other key performance indicators (Table 3-9-2) [1] .

Table 3-9-2 Effects of the clinical pathway interventions on key performance indicators and clinical outcomes

	Control (n=1 900)	Intervention (n=1 600)	Average difference RR (95%CI)*	P value#
Length of stay (day)	11.31	12.05	-0.77 (-2.15-0.62)	0.278
Door-to-needle time (min)	99.00	79.06	18.06 (-13.4-49.54)	0.261
Door-to-balloon time (min)	130.09	141.09	-11.0 (-45.2-23.22)	0.528
Patients with final diagnosis (UAP or MI) consistent with biomarker findings	1 720/1 855 (92.7%)	1 398/1 568 (89.2%)	0.95 (0.89-1.02)	0.163
Low-risk patients undergoing functional testing	9/141 (6.4%)	1/90 (1.1%)	0.25 (0.03-2.07)	0.197
High-risk patients undergoing coronary angiography	689/1 504 (45.8%)	690/1 350 (51.1%)	1.02 (0.81-1.29)	0.849
Patients discharged on appropriate medical therapy	932/1 822 (51.2%)	976/1 555 (62.8%)	1.21 (1.06-1.37)	0.004
STEMI patients receiving appropriate reperfusion therapy	229/720 (31.8%)	290/679 (42.7%)	1.25 (0.98-1.59)	0.070
Clinical outcomes				
Death	78/1 900 (4.11%)	41/1 596 (2.57%)	1.78 (0.85-3.72)	0.128
Cardiac death	60/1 900 (3.16%)	35/1 596 (2.19%)	1.37 (0.67-2.80)	0.390
Major adverse cardiac events	122/1 900 (6.42%)	92/1 596 (5.76%)	1.59 (0.86-2.96)	0.142
Major bleeding	42/1 893 (2.22%)	19/1 596 (1.19%)	1.91 (0.59-6.15)	0.277

*Variables adjusted for hospital level, sex, main occupation (manual or business), insurance status, family history of premature coronary heart disease, previous diagnosed stroke or transient ischemic attack, and smoking history. #adjusted risk stratification according to GRACE risk model.

UAP, unstable angina pectoris

[1] Du X, Gao R, Turnbull F, et al. Hospital Quality Improvement Initiative for Patients with Acute Coronary Syndromes in China: A Cluster Randomised, Controlled Trial. Circ Cardiovasc Qual Outcomes, 2014,7(2):217-226.

In addition, the CPACS investigators analyzed the data at discharge and 6, 12, 18, and 24-month follow-up surveys of patients with ACS. They found that the usage of cardiovascular prevention treatments declined over time following discharge. The largest proportional decline was in the first six months (Table 3-9-3) [1] .

Table 3-9-3 Prevalence of preventive drug treatments among individuals at discharge and 24 months of follow-up.

Medication	At discharge (n=12 094)	At 6 months (n=11 400)	At 12 months (n=12 094)	At 18 months (n=8 593)	At 24 months (n=5 612)
Aspirin	11 524(95.3%)	10 523 (92.3%)	11 004 (91.0%)	7 662 (89.2%)	4 957 (88.3%)
Statins	11 124(92.0%)	9 108 (79.9%)	9 042 (74.8%)	5 913 (68.8%)	3 708 (66.1%)
β blockers	9 341 (77.2%)	8 228 (72.2%)	8 490 (70.2%)	5 785 (67.3%)	3 724 (66.4%)
ACEI/ARB	9 237 (76.4%)	7 507 (65.8%)	7 528 (62.2%)	5 059 (58.9%)	3 280 (58.4%)
Any BP-lowering	11 221 (92.8%)	9 996 (87.7%)	10 358 (85.6%)	7 088 (82.5%)	4 602 (82.0%)
All 3 in combination*	10 408 (86.1%)	8 439 (69.8%)	8 298 (68.6%)	5 334 (62.1%)	3 353 (59.7%)

* It indicates the combination of aspirin, statins and blood-pressure lowering medications

3.9.1.2 Improving Care for Cardiovascular Diseases in China Project (CCC)

The CCC study found that among patients with NSTE-ACS (including NSTEMI and unstable angina), the very-high -risk patients had the lowest proportion of PCI. The percentage of PCI performed within recommended time period was low in all the patients (it should be performed within 2 hours of admission for the very-high-risk patients, within 24 hours for the high-risk patients, and within 72 hours for the moderate-risk patients). 88.3% of patients received early dual antiplatelet therapy, and the rate of dual antiplatelet therapy in the PCI group was higher than that in the conservative group. The incidence of adverse cardiovascular events and mortality in patients receiving PCI was lower than that in those receiving conservative treatment (Table 3-9-4) [2] .

[1] Atkins ER, X Du, Y Wu, et al. Use of cardiovascular prevention treatments after acute coronary syndrome in China and associated factors. Int J Cardiol, 2017,241:444-449.

[2] Yang Q, Y Wang, J Liu, et al. Invasive Management Strategies and Antithrombotic Treatments in Patients With Non-ST-Segment-Elevation Acute Coronary Syndrome in China: Findings From the Improving CCC Project (Care for Cardiovascular Disease in China). Circulation Cardiovascular Interventions, 2017, Jun;10(6). pii: e004750. doi: 10.1161/CIRCINTERVENTIONS.116.004750.

Table 3-9-4 Reperfusion therapy and adverse cardiovascular events among patients with NSTE-ACS by risk stratification

Variable	Overall (n=9 953)	Moderate-risk (n=1 822)	High-risk (n=6 273)	Very-high-risk (n=1 656)
Coronary angiography (%)	63.1	56.3	63.7	41.7
PCI (%)	58.2	56.3	63.7	41.7
Vascular access (%)				
Transradial access	85.8	88.5	87.1	75.4
Transfemoral access	4.4	3.0	4.2	7.7
Transbrachial access	0.2	0.0	0.3	0.0
Others	10.6	8.5	8.5	17.0
Stent (%)				
Yes	75.6	76.5	76.9	66.8
No	9.5	9.2	9.2	12.0
Unknown	14.9	14.3	13.9	21.2
Stent types (%)				
DES	93.2	93.8	93.3	91.3
BMS	1.1	1.4	0.9	2.4
Unknown types	5.7	4.8	5.9	6.3
Timing of PCI (%)				
<2h	9.0	2.9	10.4	11.1
2-24h	14.8	10.2	15.9	16.9
24-72h	31.3	41.8	29.6	23.4
>72h	44.8	45.1	44.1	48.7
PCI performed within recommended time by guidelines (%)	-	54.9	26.3	11.1
In-hospital adverse cardiovascular events (%)				
PCI group	7.5	0.7	4.3	37.1
Conservative group	18.4	1.5	9.7	55.0
In-hospital mortality (%)				
PCI group	0.5	0.1	0.4	2.0
Conservative group	3.3	0.1	2.1	2.0

BMS, bare metal stent; DES, drug-eluting stents; NSTE-ACS, non-ST-segment-elevation acute coronary syndrome; PCI, percutaneous coronary intervention

3.9.1.3 China Patient-centered Evaluative Assessment of Cardiac Events Study (China PEACE)

• Trend of Medication Use in Patients with AMI

The China PEACE retrospective AMI study found that the use of aspirin, clopidogrel, statins and other drugs in patients with AMI was significantly improved, but the use of β blockers and ACEI/ARB was still insufficient (Table 3-9-5).

Table 3-9-5 Trend of medication use in patients with AMI

Medication	Sample	Measure						
		Trend of utilization			Geographic variation in utilization（2011）			
		2001	2006	2011	Eastern Urban	Central/ Western Urban	Eastern Rural	Central Rural
Aspirin (within 24h of admission)[1]	14 041 patients with AMI eligible for aspirin	78.8%	86.4%	90.0%	89.8%	92.7%	87%	89.5%
Clopidogrel (within 24h of admission)[2]	11 944 patients with AMI eligible for clopidogrel	--	45.7%	79.8%	86.8%	87.7%	69.1%	48.7%
Statin (during hospitalization)[3]	14 958 patients with AMI eligible for statins	29.4%	74.8%	90.7%	92.3%	90.3%	86.8%	78.1%

［1］Gao Y, FA Masoudi, S Hu, et al. Trends in early aspirin use among patients with acute myocardial infarction in China, 2001-2011: the China PEACE-Retrospective AMI study. J Am Heart Assoc, 2014,3(5): e001250.
［2］Zhang L, NR Desai, J Li, et al. National Quality Assessment of Early Clopidogrel Therapy in Chinese Patients With Acute Myocardial Infarction (AMI) in 2006 and 2011: Insights From the China Patient-Centered Evaluative Assessment of Cardiac Events (PEACE)-Retrospective AMI Study. J Am Heart Assoc, 2015, Jul 10;4(7). pii: e001906. doi: 10.1161/JAHA.115.001906.
［3］Zhang L, J Li, X Li, et al. National Assessment of Statin Therapy in Patients Hospitalized with Acute Myocardial Infarction: Insight from China PEACE-Retrospective AMI Study, 2001, 2006, 2011. PLoS One, 2016,11(4): e0150806.

Table 3-9-5 Trend of medication use in patients with AMI (Continued)

Medication	Sample	Measure						
		Trend of utilization			Geographic variation in utilization（2011）			
		2001	2006	2011	Eastern Urban	Central/ Western Urban	Eastern Rural	Central Rural
ACEI/ARB (during hospitalization)[1]	13 896 patients with AMI eligible for ACEI/ARB，separating into Class I recommendation group (Chinese Class I) and Class IIa recommendation group (Chinese Class IIa) , also grouping patients according to ACC/AHA guidelines to Class I recommendation group and Class IIa recommendation group	Chinese Class I 62.0%，Chinese Class IIa 38.6%，ACC/AHA Chinese Class I 66.0%，ACC/AHA Chinese Class IIa 40.0%；	Chinese Class I 71.4%，Chinese Class IIa 38.9%，ACC/AHA Chinese Class I 73.8%，ACC/AHA Chinese Class IIa 50.4%；	Chinese Class I 67.6%，Chinese Class IIa 47.9%，ACC/AHA Chinese Class I 70.4%，ACC/AHA Chinese Class IIa 45.8%；	65%	68.4%	67.9%	66.2%
β blocker (within 24h of admission)[2]	6 426 patients with AMI and without contraindications for β blocker，grouping into eligible patients and high-risk patients (with at least 1 risk factor for cardiac shock	Overall 49.6%，eligible patients 54.3%，high-risk patients 42.6%；	Overall 63.9%，eligible patients 67.8%，high-risk patients 59.5%；	Overall 57.7%，eligible patients 61.8%，high-risk patients 52.9%；				

• Medical Care Quality Assessment on STEMI

The China PEACE study found that the in-hospital mortality of STEMI patients did not significantly change between 2001 and 2011, mainly due to little improvement of clinic visit time and the rate of reperfusion therapy. The study has shown that only half of the patients with STEMI were admitted within the time window of reperfusion therapy, and only half of these eligible patients received reperfusion therapy. The rate of PCI increased in the past 10 years, while the rate of fibrinolytic therapy decreased, and the rate of total reperfusion therapy did not increase. In addition, the rate of diagnostic tests and evidence-based medications

［1］Liu J, FA Masoudi, JA Spertus, et al. Patterns of use of angiotensin-converting enzyme inhibitors/angiotensin receptor blockers among patients with acute myocardial infarction in China from 2001 to 2011: China PEACE-Retrospective AMI Study. J Am Heart Assoc, 2015, Feb 23;4(2). pii: e001343. doi: 10.1161/JAHA.114.001343.

［2］Zhang H, FA Masoudi J Li, et al. National assessment of early beta-blocker therapy in patients with acute myocardial infarction in China, 2001-2011: The China Patient-centered Evaluative Assessment of Cardiac Events (PEACE)-Retrospective AMI Study. Am Heart J, 2015,170(3):506-515.

for STEMI increased significantly with the exception of β blockers and ACEI/ARB (Table 3-9-6) [1] .

Table 3-9-6 Treatments, procedures, mortality and complications among patients with STEMI

	2001 (n=1 995)	2006 (n=3 626)	2011 (n=6 643)	P for trend
Reperfusion therapies* (%)				
No reperfusion	45.3	45.5	44.8	0.69
Primary PCI	10.6	17.4	28.1	<0.0001
Fibrinolytic therapy	44.1	37.1	27.0	<0.0001
Acute drugs (%)				
Aspirin within 24 h *	79.7	86.8	91.2	<0.0001
Clopidogrel within 24 h*	1.5	47.4	82.1	<0.0001
β blocker within 24 h *	51.3	63.7	57.3	0.58
Statins*/#	30.2	75.9	92.5	<0.0001
ACEI/ARB*/#	61.7	70.7	66.4	0.26
Procedures# (%)				
Coronary angiography	12.7	25.8	41.9	<0.0001
Non-primary PCI	3.4	12.3	20.3	<0.0001
Coronary artery bypass graft	1.1	0.9	0.6	0.019
Intra-aortic balloon pump	0.5	1.0	2.5	<0.0001
Tests# (%)				
Troponin	22.3	46.9	68.6	<0.0001
Cardiac enzymes	87.3	93.1	97.2	<0.0001
Creatinine	63.8	84.7	94.9	<0.0001
Echocardiogram	30.1	47.6	67.7	<0.0001
In-hospital outcomes (%)				
Death	8.7	9.6	7.1	0.07
Death or treatment withdrawal	10.5	12.5	10.2	0.85
Complications	18.0	21.1	18.5	0.88

*Only among eligible patients for the treatment (ie, patients with no documented contraindications).
#During hospital admission

[1] 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. Lancet, 2015,385(9966):441-451.

• Medical Care Quality Assessment on PCI

The China PEACE retrospective PCI study included patients who underwent coronary angiography and PCI in 55 urban hospitals in China, 48.6% of which received PCI. From 2001 to 2011, the use of glycoprotein IIb/IIIa inhibitors, clopidogrel and statins, as well as the radial approach and drug-eluting stents (DES), especially domestic DES had increased significantly in the patients who received PCI. The postoperative in-hospital mortality rate decreased with no statistical difference. The incidence of bleeding decreased significantly (Table 3-9-7) [1] .

Table 3-9-7 Procedure characteristics, medication use and adverse outcomes in patients undergoing PCI

Characteristics	2001 %（95%CI）	2006 %（95%CI）	2011 %（95%CI）	P for trend
	n=419	n=1 476	n=3 961	
Vascular access				
Femoral	85.8 (82.5-89.2)	60.3 (57.8-62.8)	19.4 (18.2-20.6)	<0.001
Radial	3.5 (1.7-5.3)	37.4 (35.0-39.9)	79.0 (77.7-80.3)	<0.001
Brachial	0.6 (0.0-1.3)	0.4 (0.1-0.8)	0.6 (0.3-0.8)	0.75
Unrecorded	10.1 (7.2-13.0)	1.8 (1.1-2.5)	1.0 (0.7-1.4)	<0.001
Hemostasis technique*				
Manual compression	84.0 (80.1-87.8)	84.0 (81.7-86.3)	73.1 (70.2-76.1)	<0.001
Sealant	0.3 (0.0-0.8)	2.9 (1.9-4.0)	1.4 (0.6-2.2)	0.65
Suture	0.9 (0.0-2.0)	2.5 (1.5-3.4)	4.2 (2.9-5.6)	0.001
Other	0.0 (0.0-0.0)	0.1 (0.0-0.3)	0.3 (0.0-0.7)	0.19
Unrecorded	14.8 (11.1-18.6)	10.5 (8.6-12.4)	21.0 (18.2-23.7)	<0.001
Stent				
DES	18.0 (14.2-21.7)	87.2 (85.9-88.6)	97.3 (96.9-97.7)	<0.001
Domestic DES	1.6 (0.0-4.4)	52.5 (50.3-54.7)	74.8 (73.7-75.8)	<0.001
BMS	54.7 (49.8-59.5)	9.6 (8.4-10.8)	0.8 (0.6-1.1)	<0.001
Unrecorded	27.3 (22.9-31.6)	3.1 (2.4-3.9)	1.8 (1.4-2.1)	<0.001

[1] Zheng X, JP Curtis, S Hu, et al. Coronary Catheterization and Percutaneous Coronary Intervention in China: 10-Year Results From the China PEACE-Retrospective CathPCI Study. JAMA Intern Med, 2016,176(4): 512-521.

Table 3-9-7 Procedure characteristics, medication use and adverse outcomes in patients undergoing PCI (Continued)

Characteristics	2001 % (95%CI) n=419	2006 % (95%CI) n=1 476	2011 % (95%CI) n=3 961	P for trend
LMWH	64.7 (60.0-69.3)	80.8 (78.7-82.9)	74.6 (73.2-76.0)	0.49
UFH	73.7 (69.4-78.0)	50.6 (48.0-53.2)	60.8 (59.2-62.4)	0.98
Bivalirudin	-	-	-	
Fondaparinux	-	-	5.2 (4.5-5.9)	<0.001
GPIIb / IIIa	-	6.5 (5.2-7.8)	26.1 (24.7-27.5)	<0.001
Aspirin	91.2 (88.5-94.0)	94.0 (92.7-95.2)	97.6 (97.1-98.1)	<0.001
Clopidogrel	11.1 (8.0-14.1)	96.4 (95.4-97.4)	98.7 (98.3-99.1)	<0.001
Ticlopidine	81.2 (77.4-85.0)	1.1 (0.5-1.6)	0.1 (0.0-0.2)	<0.001
Statins	60.1 (55.4-64.9)	85.3 (83.5-87.2)	94.6 (93.9-95.4)	<0.001
In-hospital adverse outcomes				
Death	0.8	0.9	0.5	0.08
Death or treat withdrawal	1.0	1.0	0.6	0.13
Composite complications	1.9	2.8	2.2	0.65
Any bleeding[#]	12.4	10.7	7.7	<0.001
Major bleeding[##]	1.1	1.0	0.9	0.46
Bleeding on puncture	4.8	4.8	1.3	<0.001
Blood transfusion	1.2	1.2	0.9	0.33

[a] Among the patients with femoral access.

[#] Any bleeding: any documented bleeding event or the decrease of hemoglobin ≥3 g/dL during hospitalization.

[##] Major bleeding: intracranial bleeding, absolute hemoglobin decrease of at least 50 g/L, bleeding resulting in hypovolemic shock, or fatal bleeding (bleeding that resulted directly in death within 7 days)

3.9.1.4 China Acute Myocardial Infarction Study (CAMI)

• Reperfusion Therapy and In-hospital Medication Use Among Patients with STEMI

The CAMI study evaluated the reperfusion and use of secondary preventive drugs for STEMI patients in provincial, municipal and county hospitals. It showed that the proportion of fibrinolytic therapy in county hospitals was higher than that in municipal or provincial hospitals. Reperfusion rate was significantly higher in provincial hospitals than in municipal or county-level hospitals (Table 3-9-8) [1] .

Table 3-9-8 Reperfusion therapy and in-hospital medication use among patients with STEMI

Treatment	Overall (n=18 744)	Provincial hospitals (n=6 537)	Municipal hospitals (n=9 625)	County hospitals (n=2 582)	P value
Reperfusion within 7 days of onset	9 885 (52.7%)	4 041 (61.8%)	4 728 (49.1%)	1 116 (43.2%)	<0.001
Primary PCI	8 038 (42.9%)	3 840 (58.7%)	3 753 (39.0%)	445 (17.2%)	<0.001
Fibrinolytic therapy	1 847 (9.9%)	201 (3.1%)	975 (10.1%)	671 (26.0%)	<0.001
Admission within 12h of onset	12 502	4423	6332	1747	
Reperfusion therapy	8 856 (70.8%)	3 537 (80.0%)	4 274 (67.5%)	1 045 (59.8%)	<0.001
Primary PCI	7 089 (56.7%)	3 357 (75.9%)	3 329 (52.6%)	403 (23.1%)	<0.001
Fibrinolytic therapy	1 746 (14.1%)	180 (4.1%)	945 (14.9%)	642 (36.7%)	<0.001
Admission beyond 12 h of onset	6 242	2 114	3 313	835	
Reperfusion therapy	1 029 (16.5%)	504 (23.8%)	454 (13.8%)	71 (8.5%)	<0.001
Primary PCI	949 (15.2%)	483 (22.8%)	424 (12.9%)	42 (5.0%)	<0.001
Fibrinolytic therapy	80 (1.3%)	21 (1.0%)	30 (0.9%)	29 (3.5%)	<0.001
Medication					
Statins	16 575 (88.4%)	5 903 (90.3%)	8 712 (90.5%)	2 260 (87.5%)	0.003
Aspirin	17 963 (88.4%)	6 209 (95.0%)	9 278 (96.4%)	2 476 (95.9%)	0.002
P2Y12 inhibitor	17 922 (95.6%)	6 230 (95.3%)	9 291 (96.5%)	2 401 (93.0%)	<0.011
β blocker	12 657 (67.5%)	4 530 (69.3%)	6 484 (67.4%)	1 643 (63.6%)	<0.001
ACEI/ARB	10 541 (56.2%)	3 650 (55.8%)	5 354 (55.6%)	1 537 (59.5%)	0.014

• Medical Care Quality Assessment on NSTEMI

The CAMI study found significant differences in the rate of coronary angiography, CABG and PCI in patients with NSTEMI at different levels of hospitals. The patients in county hospitals had higher risk of heart failure. There was no significant difference in hospital mortality for NSTEMI among different levels of

[1] Yang JG, Xu HY, Gao XJ, et al. In-hospital reperfusion and secondary preventive drug therapy for ST-segment elevation myocardial infarction patients in provincial, city and county hospitals of China. Chinese Circulation Journal, 2017,32(1):12-16.

hospitals (Table 3-9-9) [1] .

Table 3-9-9 Rate of coronary angiography, CABG, PCI and adverse outcomes in patients with NSTEMI at different levels of hospitals

Variable	Provincial hospitals	Municipal hospitals	County hospital
Coronary angiography			
<24h（%）	16.8	7.3	2.5
>24h（%）	36.4	30.6	9.7
None（%）	46.9	62.2	87.8
CABG（%）	2.9	0.5	0.7
PCI（%）	55.8	39.4	12.5
In-hospital outcomes			
Death（%）	3.2	4.1	5.9
Heart failure（%）	12.2	19.9	26.4

3.9.1.5 Bridging the Gap on CAD Secondary Prevention Project (BRIG)

The BRIG research selected 33 tertiary hospitals and 32 secondary hospitals in 31 provinces, municipalities and autonomous regions across China. 50 hospitalized patients were enrolled from each hospital. Among 3 323 patients recruited, 1 304 (39.2%) had ST-segment elevation ACS. Standard questionnaires were used to collect clinical treatment and secondary prevention information. The results showed that 50.3% (656/1 304) of patients with ST-segment elevation ACS received reperfusion therapy. The rate of reperfusion therapy was higher in tertiary hospitals than in secondary hospitals [57.9% (380/668) vs 42.3% (267/636), P=0.000], while the rate of fibrinolytic therapy was higher in secondary hospitals [37.4% (237/636)] than in tertiary hospitals [14.5% (97/668)]. Aspirin, ACEI and β blockers were commonly used in different hospitals. The proportion of medicine use in low molecular weight heparin (80.5%), platelet membrane glycoprotein IIIa/IIb receptor antagonists (7.6%), and clopidogrel (73.8%) and statins (82.8%) was higher in tertiary hospitals than in secondary hospitals (72.3%, 0.3%, 25.8% and 69.3%, respectively, P<0.01). The incidence of major cardiovascular events during hospitalization was higher in secondary hospitals than in tertiary hospitals, and higher in the non-reperfusion group than in the reperfusion treatment group (Table 3-9-10). The average time from symptom onset to treatment was 230 min in secondary hospitals and 282 min in tertiary hospitals; the average duration of door-to-needle was 60 min in secondary

[1] Zhao Q, H Xu and Y Yang. Variations in Non-ST-Elevation Myocardial Infarction Care Across Three Levels Of Hospitals In China: Analysis From The China Acute Myocardial Infarction Registry. Journal of the American College of Cardiology, 2018,71(11): A39.10.1016/s0735-1097(18)30580-1.

hospitals and 45 min in tertiary hospitals; the average duration of door-to-balloon was 134 min in secondary hospitals and 105 min in tertiary hospitals. The study suggested that there was a big gap between guidelines and current management of ST-segment elevation ACS in China. Efforts should be made to promote the implementation of guidelines in clinical practice of CVD [1] .

Table 3-9-10 In-hospital cardiovascular event incidence among ACS patients with ST-segment elevation (%)

Event	Secondary hospital (n=636)	Tertiary hospitals (n=667)	Overall (n=1 303)	P value
Heart failure (New onset/ exacerbation)	25.8	14.2	19.9	0.000
Re-infarction	12.3	10.1	11.2	0.108
Malignant ventricular arrhythmia	11.7	8.4	10.0	0.030
Stroke	2.8	2.1	2.5	0.256
Severe bleeding	2.4	0.9	1.6	0.032
Death	6.9	4.3	5.6	0.028
Death/re-infarction	19.2	14.4	16.8	0.018

3.9.2 Medical Care Quality Assessment on CABG

The China Cardiovascular Surgery Registry Study (CCSR) is the largest CABG registry study in China. The investigators assessed the trends of in-hospital mortality and major complication rates among patients who received CABG in 102 urban teaching hospitals from 2004 to 2013 (excluding 2006 and 2009) in China. From 2004 to 2013, the in-hospital mortality, major complication rate, and postoperative length of stay improved significantly: in-hospital mortality dropped from 2.8% to 1.6%. (difference=1.3%, 95%CI: 0.70-1.85); major complication rate decreased from 7.8% to 3.8% (difference=4.0%; 95%CI: 3.05-4.90); postoperative median length of stay reduced from 12 days to 10 days (Table 3-9-11) .[2]

[1] Liu Q, Zhao D, Liu J, et al. Current clinical practice patterns and outcome for acute coronary syndromes in China: results of BRIG project. Chinese Journal of Cardiology, 2009,37(3):213-217.

[2] X Yuan, H Zhang, Z Zheng, et al. Trends in mortality and major complications for patients undergoing coronary artery bypass grafting among urban teaching hospitals in China: 2004 to 2013. Eur Heart J Qual Care Clin Outcomes, 2017,3(4):312-318.

Table 3-9-11 Length of stay and rate of adverse outcomes for patients receiving CABG

Indicators	Overall (n=40 652)	2004-2005 (n=8 082)	2007-2008 (n=8 739)	2010-2011 (n=10 046)	2012-2013 (n=13 785)	P value
LOS, day (IQR*)						
Preoperative LOS	9.0 (8.0)	9.0 (9.0)	10.0 (9.0)	8.0 (8.0)	9.0 (8.0)	0.0601
Postoperative LOS	10.0 (7.0)	12.0 (8.0)	11.0 (7.0)	9.0 (6.0)	9.0 (6.0)	<0.001
Total LOS	20.0 (13.0)	22.0 (14.0)	22.0 (14.0)	19.0 (11.0)	19.0 (12.0)	<0.001
In-hospital adverse outcomes (%)						
Death	1.77	2.66	2.15	1.15	1.44	<0.001
Myocardial infarction	0.4	0.5	0.4	0.4	0.4	0.2168
Reoperation due to bleeding	2.25	3.56	2.9	2.27	1.06	<0.001
Stroke	0.44	0.46	0.39	0.56	0.38	0.6402
Reintubation	0.35	0.37	0.65	0.54	<0.01	<0.001
Renal failure	1.87	2.26	3.28	1.21	1.21	<0.001
At least one of above	5.47	7.32	7.32	4.95	3.58	<0.001

*IQR, Inter-quartile Range

3.9.3 Medical Care Quality Assessment on Stroke

A multicenter, cluster-randomized clinical trial was conducted among 40 hospitals in China to examine the effectiveness of a multifaceted quality improvement intervention on hospital personnel adherence to evidence-based performance measures and outcomes in patients with acute ischemic stroke (AIS). Patients with AIS within 7 days after symptom onset were included in the study. Twenty hospitals received a multifaceted quality improvement intervention (intervention group, 2 400 patients), including clinical pathway, care protocols, quality coordinator oversight, and performance measure monitoring and feedback. 20 hospitals participated in the stroke registry with usual care (control group, 2 400 patients). Among 4 800 patients with AIS enrolled from 40 hospitals and randomly assigned, 3 980 patients (82.9%) completed the 12-month follow-up of the trial.[1]

The multifaceted quality improvement intervention compared with usual care resulted in a statistically significant but small improvement in hospital personnel adherence to evidence-based performance measures in patients with AIS. Patients in intervention group were more likely to receive performance measures than those in the control group (88.2% vs 84.8%, respectively). New clinical vascular events were significantly reduced in the intervention group compared with the control group at 12 months (9.1% vs 11.8%,

[1] Wang Y, Li Z, Zhao X, et al. Effect of a Multifaceted Quality Improvement Intervention on Hospital Personnel Adherence to Performance Measures in Patients With Acute Ischemic Stroke in China: A Randomized Clinical Trial. JAMA, 2018,320(3):245-254.

respectively), with a difference of 22.9%. Stroke disability was also lower in the intervention group than the control group at 12 months (12.7% vs 14.7%) with a difference of 11.7%. There was no significant difference in total mortality rates at 1-year. However, except for DVT prophylaxis and antidiabetic medication at discharge, the differences at the level of each individual performance measure between the 2 groups did not reach significance (Table 3-9-12).

The study confirmed that multifaceted quality improvement intervention and quality feedback can increase the quality of care and decrease the short-term and long-term rates of new vascular events and disability among patients with ischemic stroke.

Table 3-9-12 Adherence to evidence-based performance measures and adverse events among eligible patients with acute ischemic stroke receiving a multifaceted quality improvement intervention (intervention) vs routine care (control) in China

	Intervention group No. of events/Total patients（%）	Control group No. of events/Total patients（%）	Absolute difference（95%CI）,%	P value	OR/HR（95%CI）	P value
Composite measure, mean（SD）	88.2（15.1）	84.8（18.2）	3.5（0.7-6.4）	0.02	1.39(1.12-1.72)	0.003
All-or-none measure	1 290/2 400（53.8）	1 147/2 400（47.8）	6.7（-0.4-13.8）	0.06	1.19(0.85-1.67)	0.31
Performance measures at the beginning of hospitalization						
Intravenous rtPA within 3 h of symptom onset*	46/212(21.7)	23/204(11.3)	7.3(-5.3-19.9)	0.26	3.18(0.94-10.78)	0.06
Early antithrombotics	2 307/2 353(98.0)	2 253/2 330(96.7)	1.5(-0.3-3.2)	0.10	1.93(0.94-3.95)	0.07
Dysphagia screening	2 255/2 328(96.9)	2 040/2 139(95.4)	1.6(-2.1-5.3)	0.41	2.49(0.84-7.40)	0.10
DVT prophylaxis	178/645(27.6)	66/592(11.1)	15.6(3.3-27.9)	0.01	2.42(1.02-5.72)	0.04
Performance measures at discharge						
Antithrombotics[#]	2 272/2 324(97.8)	2 141/2 305(92.9)	4.2(-0.6-8.9)	0.09	2.29(0.86-6.11)	0.10
Anticoagulation for atrial fibrilliation	63/155(40.6)	39/137(28.5)	12.9(-5.8-31.6)	0.18	1.80(0.68-4.75)	0.23
Lipid-lowering for LDL-C>100mg/dl	1 415/1 481(95.5)	1 439/1 547(93.0)	2.4(-1.6-6.4)	0.25	1.35(0.67-2.73)	0.40
Antihypertensive medication	1 510/1 838(82.2)	1 372/1 771(77.5)	6.1(-0.6-12.7)	0.07	1.44(0.94-2.20)	0.10
Antidiabetic medication	653/728(89.7)	557/663(84.0)	5.0(0.8-9.3)	0.02	1.57(1.08-2.28)	0.02
New vascular events						
3 month	93/2 400 (3.9)	127/2 400 (5.3)	−2.0 (−3.5-−0.6)	0.007	0.65（0.49-0.68）	0.002
6 month	150/2 400 (6.3)	186/2 400 (7.8)	−2.2 (−4.0-−0.4)	0.02	0.72（0.57-0.90）	0.004
12 month	218/2 400 (9.1)	282/2 400 (11.8)	−3.1 (−5.3-−1.0)	0.005	0.72（0.60-0.87）	<0.001

Table 3-9-12 Adherence to evidence-based performance measures and adverse events among eligible patients with acute ischemic stroke receiving a multifaceted quality improvement intervention (intervention) vs routine care (control) in China (Continued)

	Intervention group No. of events/Total patients（%）	Control group No. of events/Total patients（%）	Absolute difference（95%CI）,%	P value	OR/HR（95%CI）	P value
Morbidity（mRS[##]3-5）						
3 month	418/2 180 (19.2)	443/2 105 (21.0)	−3.7 (−6.7-−0.8)	0.01	0.76（0.63-0.91）	0.002
6 month	326/2 058 (15.8)	360/2 009 (17.9)	−3.9 (−6.6-−1.1)	0.006	0.74（0.61-0.89）	0.002
12 month	236/1 852 (12.7)	264/1 798 (14.7)	−3.1 (−5.8-−0.5)	0.02	0.74（0.59-0.93）	0.01
In-hospital death	11/2 400 (0.5)	23/2 400 (1.0)	−0.7 (−1.1 - 0.2)	0.009	0.96（0.90-1.02）	0.14
3 month	66/2 400 (2.8)	76/2 400 (3.2)	−1.0 (−2.1 - 0.1)	0.08	0.81（0.57-1.15）	0.23
6 month	103/2 400 (4.3)	101/2 400 (4.2)	−0.5 (−1.7 - 0.6)	0.38	0.97（0.73-1.29	0.81
12 month	139/2 400 (5.8)	160/2 400 (6.7)	−1.5 (−3.0-−0.0)	0.05	0.86（0.68-1.09）	0.21

*rtPA, recombinant tissue plasminogen activator (alteplase); DVT, Deep Vein Thrombosis

[#] Antithrombotics includes aspirin, clopidogrel, ozagrel, dipyridamole, ticlopidine, cilostazol, low-molecular-weight heparin, unfractionated heparin and warfarin.

[##]mRS, modified Rankin Scale

3.9.4 Medical Care Quality Assessment on Atrial Fibrillation

The Chinese Atrial Fibrillation Registry (CAFR) was a prospective, multicenter, hospital-based registry study involving 20 tertiary and 12 non-tertiary hospitals in Beijing. A total of 11 496 patients with AF were enrolled from 2011 to 2014. The CAFR investigators analyzed the current status and time trends of oral anticoagulation (OAC) use among AF patients with different risk stratification of stroke. They found that the use of aspirin was high in patients with non-valvular AF, and high proportions of patients with $CHADS_2$ score ≥2 or CHA_2DS_2-VASc score ≥2 were using antiplatelet therapy as the only measure for thromboprophylaxis (Table 3-9-13). The rate of OAC use in patients with high-risk AF increased during the study period (Figure 3-9-1) [1] .

［1］Chang, SS, JZ Dong, CS Ma, et al. Current Status and Time Trends of Oral Anticoagulation Use Among Chinese Patients With Nonvalvular Atrial Fibrillation: The Chinese Atrial Fibrillation Registry Study. Stroke, 2016,47(7):1803-1810.

Table 3-9-13 Antithrombotic rate in patients with non-valvular atrial fibrillation by $CHADS_2$ score or CHA_2DS_2-VASc score

	Warfarin（%）	NOAC[*]（%）	Antiplatelet drugs（%）	OAC[**]+ Antiplatelet drugs（%）
$CHADS_2$ score				
0	25.0	0.4	44.6	1.2
1	32.1	0.5	51.6	1.8
≥2	36.9	0.6	51.8	3.4
CHA_2DS_2-VASc score				
0	20.9	0.5	41.4	0.7
1	27.9	0.6	48.9	1.1
≥2	36.0	0.5	51.9	3.0

[*]NOAC, non-vitamin K oral anticoagulant;**OAC, oral anticoagulation

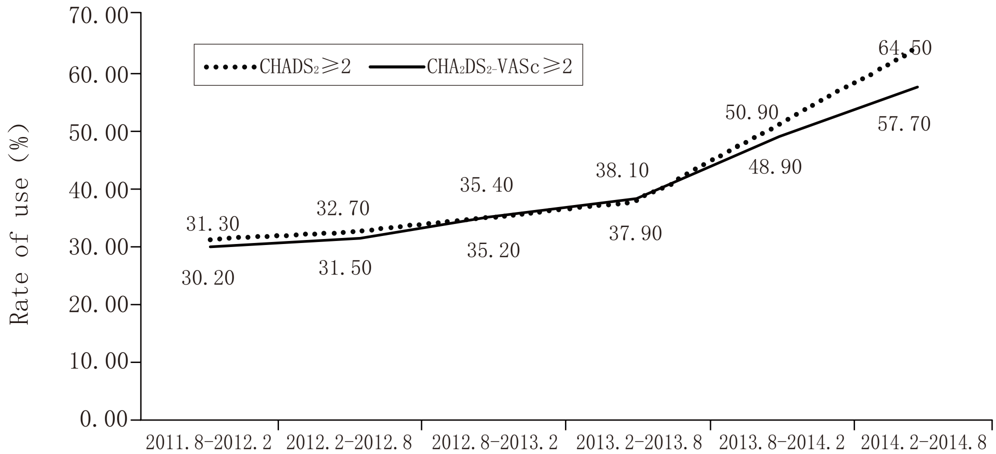

Figure 3-9-1 Time trends in rate of oral anticoagulant use

Part 4
Community-based Prevention and Control of CVD

The exploration and practice of community-based management of CVD in China have been preceded for 40 years. With a progressive expansion from part to whole and a comprehensive intervention strategy for the prevention and control of hypertension, the community-based management of CVD in China is moving forward in the process of exploration and has achieved notable success.

4.1 National Basic Public Health Service Program: National Primary Health Care Hypertension Management

4.1.1 Background

Primary Health Care (PHC) institutions (community health service centers, community health service stations, township health centers, village clinics) are the main battlefields for hypertension and are the main implementing agencies of national basic public health service programs. Their capability of management will directly affect the trend of CVD in China in the future.

In order to further standardize the implementation of national basic public health service programs, improve the hypertension management capability of PHC institutions and enhance the sense of benefit, the Department of Primary Care of National Health Commission authorized the National Cardiovascular Disease Center (NCCD) to establish the office of "National Basic Public Health Service Program: National PHC Hypertension Management" (herein after referred to as "the office") on March 30, 2017. The main responsibilities of the office include: organizing and developing the guidelines for hypertension management of PHC institutions, monitoring and evaluating the quality of hypertension management in PHC institutions, carrying out health education and other related work for the public, and gradually achieving the homogenization of hypertension management between PHC institutions and tertiary hospitals.

4.1.2 Objectives

Generally, PHC institutions in China have poor homogeneity (enormous differences of hypertension management capabilities and effects exist among regions and health service staff), low acceptance of heath knowledge among the public, and lack of enthusiasm due to no association between hypertension management performance and personnel income. In order to rapidly change the current situation before 2020, the office will have initiatives on training, education, management, monitoring, quality control and other aspects to improve the accessibility and quality, enthusiasm and efficiency, and ultimately improve the management effect of hypertension management in PHC institutions. To achieve these ends, the following work objectives are specifically formulated: gradually fulfilling the homogenization of management between PHC and hospitals; gradually increasing the first-contact rate of hypertension diagnosis in PHC; and gradually increasing the control rate of hypertension in PHC.

4.1.3 Work Policy: Five-Unity

4.1.3.1 Unified Implementation Guideline for PHC

The National PHC Hypertension Management Expert Committee officially released the "Guidelines for the Management of Hypertension in the Community (2017)" on November 10, 2017, within a half year after its establishment in April 2017. [1] The guideline is based on the current status of PHC, and focuses on the principle of being enforceable, traceable, measurable and affordable. Compared with previous academic guidelines, this guideline embodies the will of the government, and would be widely promoted and implemented in PHC institutions across China.

4.1.3.2 Unified Training and Licensure

Considering the current situation of uneven levels in training ability, and the mixture of qualified and unqualified training institutions for PHC hypertension management, the office adopts a combination of online (PICA Training Program) and offline training programs (EAGLE Training Program and GOOSE Training Program) for staff from PHC institutions to study the Guidelines.

- Online: PICA Training Platform

Tracking and assessment modules are included in the platform to guarantee the training effect, and the feedbacks from PHC doctors were also collected in order to continuously improve the training quality.

At present, 1 196 000 community doctors from 272 000 PHC institutions have registered the online training program, covering 2 945 districts and counties of 31 provinces, municipalities, and autonomous regions, and 868 000 of them have obtained training certificates. Before the study, the rate of correct answers was 65%, while it increased to 87% after the training, which demonstrated the notable outcome of the program.

- Offline: EAGLE Training Program, GOOSE Training Program

EAGLE Training Program for backbones (targeted audience, high entry level)

[1] National Basic Public Health Service Program, National Primary Health Care Hypertension Management Office, Hypertension Management Expert Committee. Guidelines for the Management of Hypertension in the Community (2017). Chinese Circulation Journal, 2017,32(11):1041-1048.

Training objective: train the senior member of PHC hypertension management.

Training format: closed training for one week, 50 doctors per session.

Currently, 8 sessions have been held, covering more than 410 PHC backbone doctors.

GOOSE Training Program for doctors (general PHC staff, low entry level)

Training objective: PHC doctors including village doctors

Training format: open training for one day at different regions, 100-150 doctors per session.

Currently, 18 sessions have been held, covering more than 2 450 PHC doctors.

4.1.3.3 Unified Quality Monitoring

The office has set up an evaluation system for PHC hypertension management quality, including "PHC hypertension management electronic record system" and "PHC hypertension management system", which have been officially used in the pilot area (Yunnan Province).

The online real-time data browsing has been put into practice from the state to the PHC medical institutions- seven levels of accesses. Different from the previous on-site monitoring, the office implements real-time remote monitoring and quality controlling based on the electronic data platform, which effectively regulates the behavior of PHC doctors, promotes orderly development of PHC hypertension management, and avoids the phenomenon of forgery, false, and missing data.

The office also established evaluation indicators based on the electronic database platform (training pass rate, mandatory drug equipped rate, management task completion rate, standardized management rate, rational prescription rate, blood pressure control rate, cardiovascular event rate, etc.). The evaluation of PHC hypertension management was based on the related indicators.

Major achievements: The data analysis report on quality control of PHC hypertension management has been officially released, which will be regularly sent to the pilot area (Yunnan Province) to monitor the status of hypertension management in PHC institutions in the format of seasonal reports. To continuously improve the hypertension management of PHC, the report comprehensively analyzes the indicators and management quality of PHC institutions, and provides suggestions for improvement on outstanding issues.

4.1.3.4 Unified Performance Assessment

Based on the electronic quality assessment data from the remote platform and on-site assessment, each pilot province has formulated specific performance evaluation plans, which link the assessment results with the performance evaluation of PHC hypertension management, in order to effectively inspire the enthusiasm of PHC doctors.

4.1.3.5 Unified Public Health Education

Regarding the low level of education at grass-roots and the poor effect of hypertension health education, the office plans to unify the health education of hypertension. Experts are invited to ensure the scientific quality of the education content. In terms of the education format, the office encourages using internet, smart phone apps, paper materials, audio, video, and other media according to the education level of the local public. Feedback would be collected, and the data would be used to evaluate the effectiveness of health education, and these measures were promoted at the national level. People would be instructed to raise their awareness and recognition of PHC institutions and the hierarchical medical system, influencing their minds and habits of selecting medical treatment, with giving priority to PHC institutions.

Major achievements: The number of patients registered under management through the online platform has reached 3.28 million, and online health knowledge has been pushed to 2.14 million patients. The book "Protect the heart wholeheartedly: Prevention and Treatment of Cardiovascular Diseases" has been printed out. The WeChat public account posts the knowledge of hypertension every week, and the influence of new media outlet has gradually increased. Educational activities such as free clinics and public lectures on healthcare are organized regularly.

Under the leadership of the National Health Commission and NCCD, the office will introduce a series of training and assessment measures, information management and evaluation systems for PHC hypertension management, and establish quality requirements of hypertension management based on the technical support. Solid objective evidences would be provided to the government to formulate practical policies. A set of feasible protocols and tools will be established gradually during practice for prevention and control of hypertension, and expect to play an important role in prevention of other cardiovascular related diseases and risk factors, as well as other chronic diseases in PHC institutions.

4.2 Fuxin Program in Liaoning Province

A low-cost comprehensive intervention study of hypertension included 6 460 cases from 11 natural villages. They were randomly divided into 3 groups: health education group, standard treatment group and comprehensive treatment group. The first group was provided with health education. The second group was additionally administrated with hydrochlorothiazide and nitrendipine plus captopril, which was a cheap but effective treatment for hypertension, as the 'stepwise protocol'. For the third group, in addition to the interventions in second group, patients with blood pressure ≥160/100 mmHg were also given lipid-lowering treatment (Xuezhikang 0.6 g, twice a day) plus intensive lifestyle modification. The selected patients were followed up for 15 months to explore the effect of the comprehensive intervention on CVD events among hypertension patients. The primary endpoints were defined as all-cause death, cardiovascular death, ischemic stroke, hemorrhagic stroke, myocardial infarction and hospitalized heart failure.

A total of 5 292 subjects were enrolled in the first and second groups, and 308 of them were lost at the end of the follow-up (rate of loss was 10.9%). 4 984 patients with 42.8% males (2 134) and 57.2% females (2 850) were included in the final analysis, including 2 530 in the basic treatment group and 2 454 in the health education group. Results showed a decline of mean blood pressure by 16.07/9.42 mmHg at the end of the 15 months' follow-up among the treatment group. At the same time, the rate of hypertension control increased significantly from 1.1% at baseline to 33.1% (29.7% for males and 35.7% for females). Subgroup analysis showed the negative association between the rate of hypertension control and age, with the highest (37.6%) in the 35-44 age group. The health education group also achieved good results, where the blood pressure decreased by 6.70/3.52 mmHg and the control rate of hypertension increased to 15.1%.

The incidence of cardiovascular and cerebrovascular diseases was significantly reduced among patients who took the free anti-hypertension drugs. Compared with the health education group, the risk of total cardiovascular and cerebrovascular diseases, and the risk of stroke decreased by 55.9% and 55.2%, respectively. The risk of hemorrhagic stroke was reduced by 80.6% ($p=0.004$), and the risk of ischemic stroke was reduced by 40.6% but there was no statistically significant difference in comparison with those in health education group.

Part 5
Medical Treatment and Expenditure on CVD

The number of patients with CVD or diabetes discharged from hospitals in China has been increasing since 1980, and this trend has been accelerating, especially after 2000. Correspondingly, the total expenditure on CVD hospitalization also increased rapidly. Since 2004, the average annual growth rate in CVD costs has been much higher than that of China's GDP. The increase was mainly attributed to the increased number of hospitalized cases and the high proportion of inappropriate prescriptions.

5.1 Number and Trend for Patients Discharged with CVD

In 2016, 20.0219 million patients with CVD discharged from hospitals in China, which accounted for 12.57% of the total number of discharges within the same period. Among all discharged patients, those with cardiovascular diseases accounted for 6.30% (10.0263 million), and those with cerebrovascular disease accounted for 6.27% (9.9956 million) (Figure 5-1-1).

Among the discharged patients with CVD, the leading diseases were IHD (in total: 7.3824 million, AMI: 732.4 thousand) and cerebral infarction (6.4030 million), which accounted for 36.87% and 31.98%, respectively. Other causes included hypertension (2.4070 million, including 244.9 thousand patients with hypertensive heart and renal disease), intracranial hemorrhage (1.4291 million), and rheumatic heart disease (236.9 thousand). Additionally, 3.472 3 million patients were discharged for diabetes in 2016. From 1980 to 2016, the trend of the number of discharged patients with major cardiovascular and cerebrovascular diseases and diabetes in China is shown in Figure 5-1-2. For the first time in 36 years, the number of discharged hypertensive patients had decreased.

From 1980 to 2016, the average annual growth rate of discharged patients with CVD in China was 9.85%, which was higher than that of all discharged patients (6.33%) in the same period (Figure 5-1-3). The annual average growth rates of various CVD in descending order were: cerebral infarction (12.16%), IHD (11.42%), AMI (10.73%), intracranial hemorrhage (9.48%), hypertension (7.45%), and hypertensive heart and kidney disease (5.77%). The number of discharged patients with rheumatic heart disease (1.20%) did not change significantly. The annual average growth rate of discharged patients with diabetes was 13.59% between 1980 and 2016 (Figure 5-1-4).

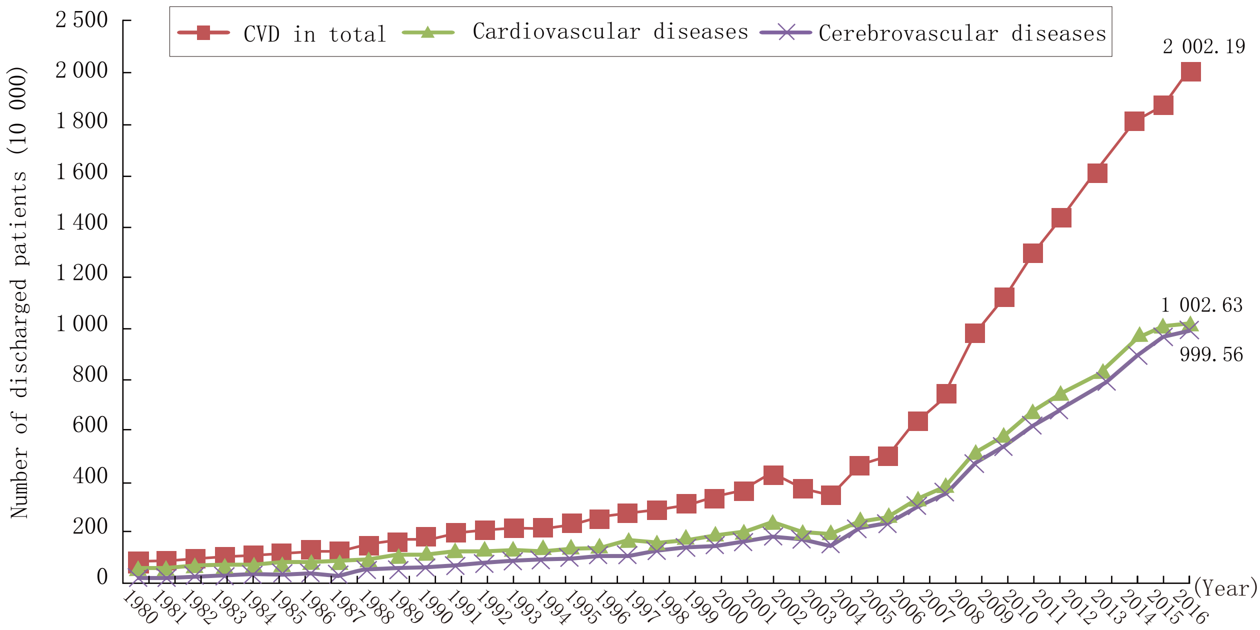

Figure 5-1-1 Trends in the number of discharged patients with cardiovascular diseases in China, 1980-2016

Note: CVD includes IHD (angina pectoris, AMI and other IHD), chronic rheumatic heart disease, hypertension (including hypertensive heart and kidney diseases) and cerebrovascular diseases (intracranial hemorrhage and cerebral infarction). Before 2002, IHD was listed as coronary heart disease in the Annual Report of Health Statistics

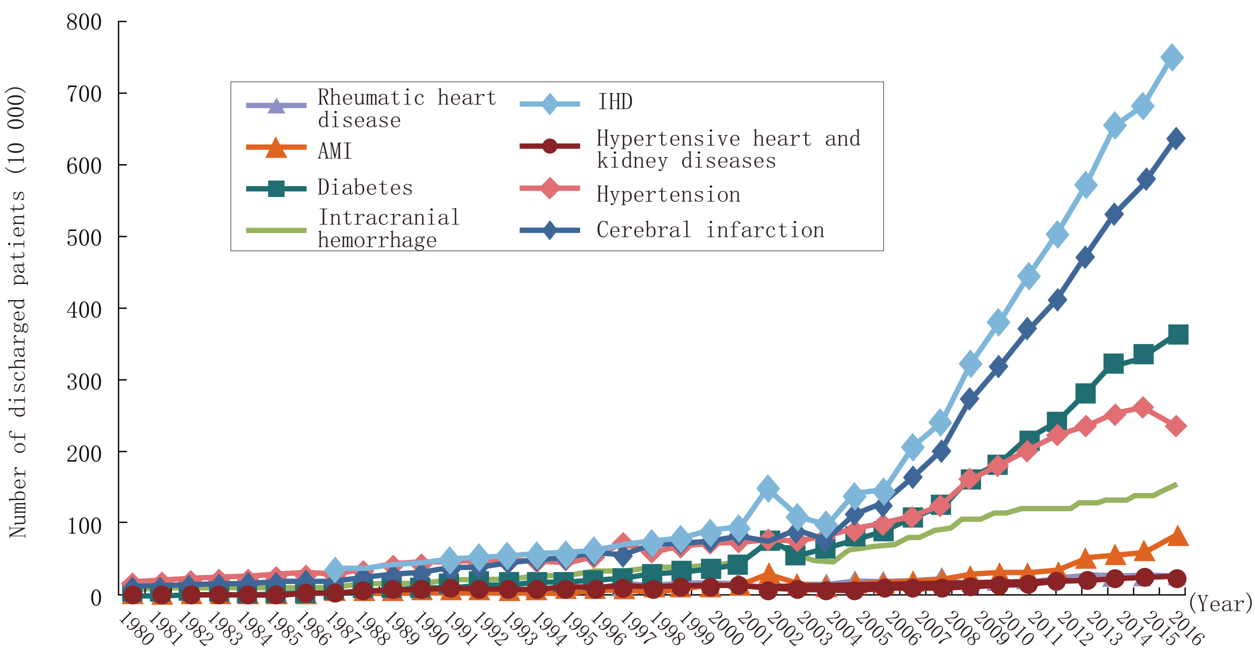

Figure 5-1-2 Trends in the number of discharged patients from major cardiovascular diseases and diabetes in China, 1980-2016

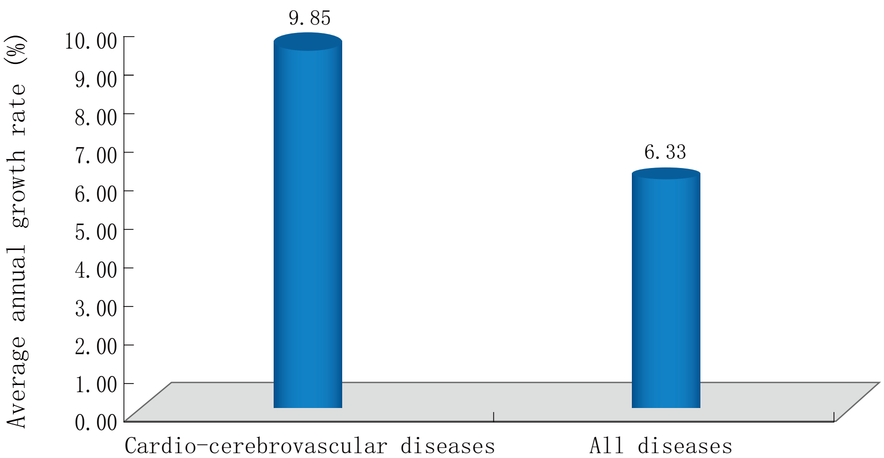

Figure 5-1-3 Average annual growth rate of discharged patients with cardiovascular and cerebrovascular diseases in China from 1980 to 2016

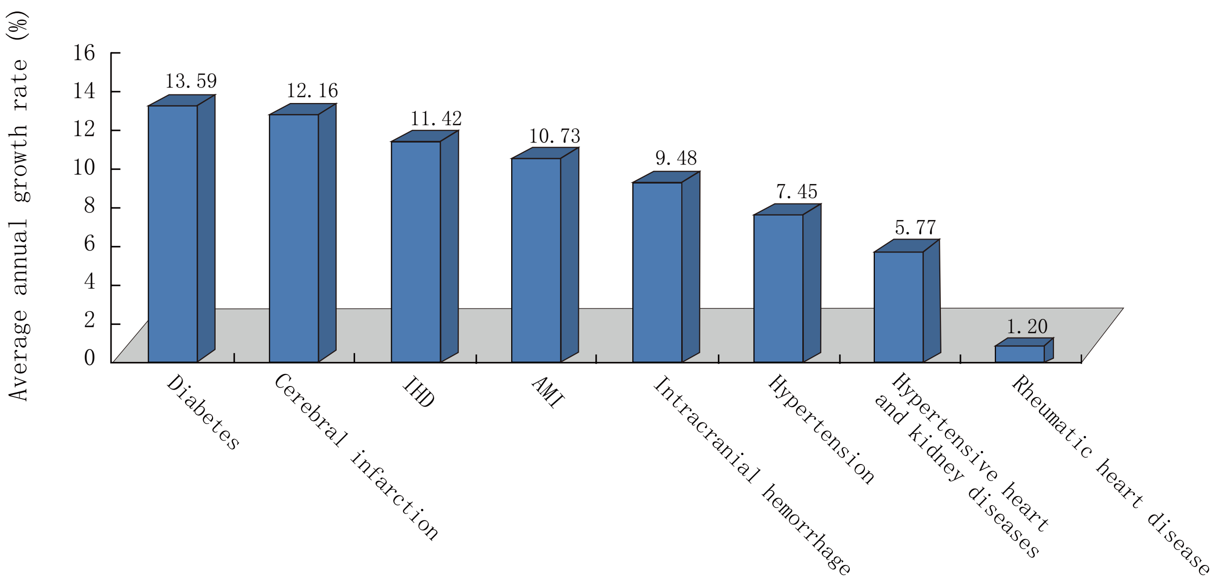

Figure 5-1-4 Annual average growth rate of discharged patients from major CVD and diabetes in China from 1980 to 2016

5.2 Hospitalization Costs for CVD

In 2016, the hospitalization cost was 19.085 billion for AMI, 25.419 billion for intracranial hemorrhage, and 60.105 billion for cerebral infarction (Figure 5-2-1). After adjustment of annual price inflation, the average annual growth rates since 2004 were 29.15%, 16.88%, and 22.24%, respectively.

The average individual expenses were 26 056.9, 17 787.0, and 9 387.0 RMB for AMI, intracranial hemorrhage and cerebral infarction, respectively (Figure 5-2-2). After adjustment for annual price inflation, the average annual growth rates since 2004 were 7.12%, 5.90%, and 2.30%, respectively (Figure 5-2-3).

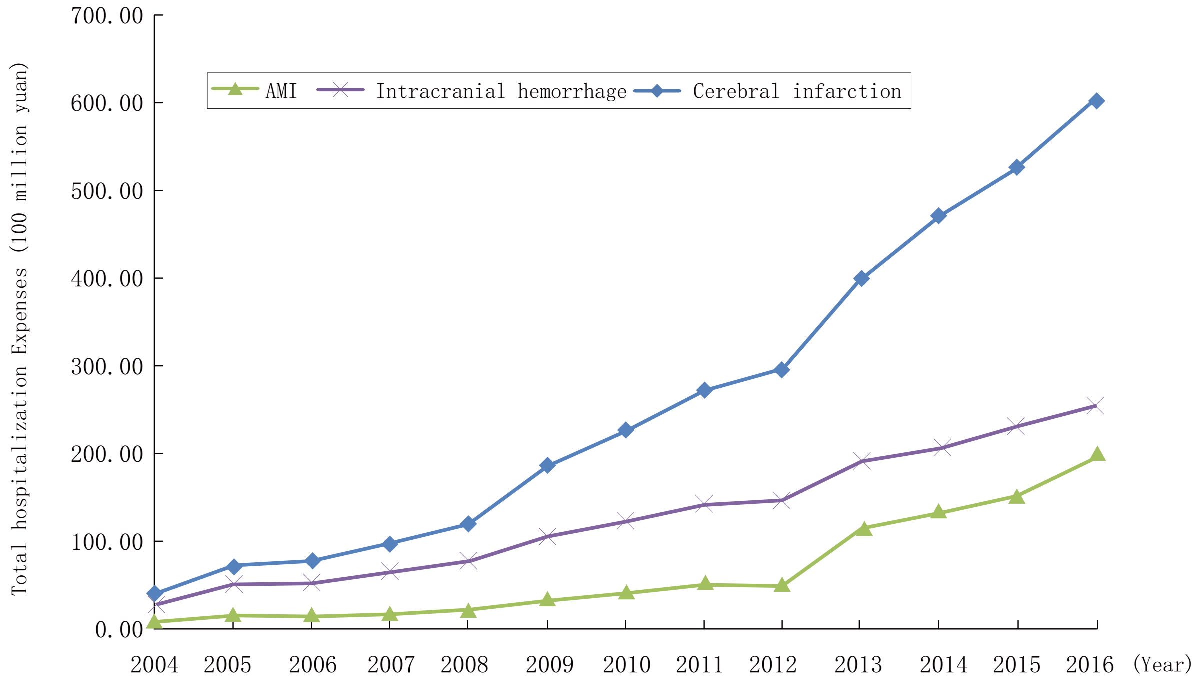

Figure 5-2-1 Trend of total hospitalization expenses for CVD, 2004-2016

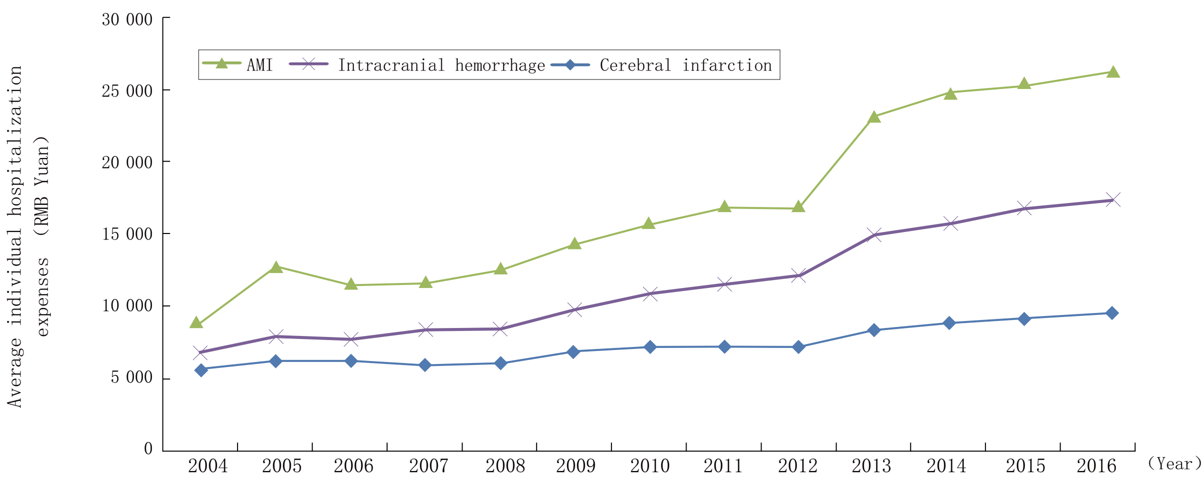

Figure 5-2-2 Trend of average individual hospitalization expenses for CVD, 2004-2016

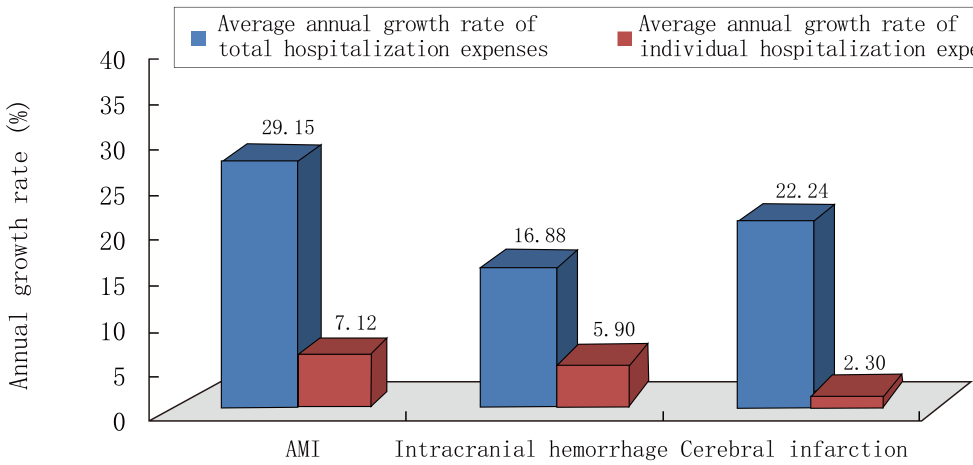

Figure 5-2-3 Average annual growth rate of total and individual hospitalization expenses for CVD from 2004 to 2016

Note: Total hospitalization expenses = average individual hospitalization expenses*number of hospitalized persons

5.3 Pharmaceutical Market for CVD

In 2016 and 2017, the total pharmacy expenses in hospitals with 100 beds or more amounted to 722.05 and 745.731 billion RMB in China, and 80.013 and 83.442 billion was respectively used for CVD treatment. The five most frequently purchased medicines were unchanged in 2016 and 2017: medications improving cardiovascular circulation, nutritional supplements for the myocardium and medications for coronary circulation improvement, lipid lowering drugs, CCB (monotherapy), and ARB (monotherapy) (Table 5-3-1).

Table 5-3-1 The 15 most commonly used medications for cardiovascular and cerebrovascular diseases in China, 2016-2017 (RMB 100 000 000)

Category of medicine	2016	2017
Total	800.13	834.42
Medications improving the cardiovascular circulation *	205.48	212.81
Nutritional supplements for myocardium and medications for coronary circulation improvement	168.66	151.48
Lipid lowering drugs	122.26	138.22
CCB(monotherapy)	74.68	79.41
ARB (monotherapy)	52.06	54.73
β-blocker (monotherapy)	24.56	28.20
ARB (combo-therapy)	24.29	27.00
Medication for varicose veins	21.98	22.78

Table 5-3-1 The 15 most commonly used medications for cardiovascular and cerebrovascular diseases in China, 2016-2017 (RMB 100 000 000) (Continued)

Category of medicine	2016	2017
Nitrite and nitrate	17.39	16.85
ACEI (monotherapy)	14.51	15.11
Antianginal medications (excluding CCB and nitrates)	11.53	12.67
Cardiac stimulants, except cardiac stimulants	6.93	11.65
Diuretics	9.30	10.45
positive inotropic drugs	7.04	8.41
Others medicine for CVD	39.47	44.66

Note: * cardiovascular circulation improving drugs include fleabane, Fick Chavez, Xingding, ginaton, Ginkgo Biloba Extract, Shuxuening, Duxil, flunarizine, Mailuoning and Di Inovel, etc.
Sources of data: The above mentioned data is extrapolated by IMS Health Market Research Consulting (Shanghai) Corporation Beijing Branch from the results of a survey of 2 000 nationwide hospitals with at least 100 beds. It includes the western medicalized Chinese patent medicine, such as the compound Danshen dripping pills, Ginkgo agent and Erigeron breviscapus, etc.

5.4 Cost-effective Evaluation on Intensive Intervention for Hypertension

Intensive hypertension control can help patients achieve lower blood pressure and reduce the incidence of CVD events. However, it also incurs additional costs to patients and society and may result in a substantial unwanted side effects. By developing the Markov based stimulation model of hypertension, the researchers estimated the cost and expected effect of intensive and standard hypertension control strategies for Chinese hypertensive patients aged 35-84 years old, and explored the possible social benefits of prevention and control of hypertension by using health economics evaluation method. [1]

• Intervention Strategy

Intensive blood pressure control group: target of blood pressure was 133/76 mmHg (based on a recent meta-analysis).

Standard blood pressure control group: target of blood pressure was 140/90 mmHg (based on the current guidelines).

• Model Structure

The Markov model includes hypertension, acute CVD events (revascularization, angina, AMI, stroke),

[1] Xie X, He T, Kang J, et al. Cost-effectiveness analysis of intensive hypertension control in China. Preventive Medicine, 2018,111:110-114.

drug-induced side effects (hypotension, syncope, electrolyte abnormalities, and acute kidney injury or failure), death due to acute CVD events or drug-induced side effects, all-cause death, etc. The study projected the consequences and cost-effectiveness of intensive hypertension control compared to standard hypertension control over 10 and 20 years, respectively.

• Key Parameters

The key parameters were selected based on recent published relevant studies, including relative risk, adverse events due to the use of hypertension medicine, medication adherence, incidence of cardiovascular and cerebrovascular events, population gender- and age-specific mortality, annual direct medical costs and disability weight of hypertension and its complications, etc.

• Results of the Study

The simulated 20 000 hypertensive individuals had the same characteristics as the entire hypertensive population in China. After substituting the parameters into the model, the researchers calculated the cumulative incidence of coronary heart disease, stroke, adverse events, and death due to CVD for the overall population under the two different hypertension control strategies. Compared with standard hypertension control, intensive hypertension control would avert about 2.2 million coronary heart disease events and 4.4 million stroke events for all hypertensive patients in China in 10 years. Considering the full population of Chinese adults 35 to 84 years of age with hypertension, intensive hypertension control would lead to an increase of 136.9 billion RMB in treatment costs and 17.4 million additional quality-adjusted life year (QALY) in the next 10 years compared to standard hypertension control. The incremental cost-effectiveness ratio (ICER) for intensive hypertension control is estimated at 7 876 RMB per QALY compared to standard hypertension control. The 20-year ICER for intensive hypertension control is estimated at 5 811 CNY per QALY compared to standard hypertension control. The lower ICER implies that intensive hypertension control could be more cost-effective in the long term. Therefore, it suggested that policymakers should consider expanding intensive hypertension control among hypertensive population.

5.5 Note for the Content and Data Cited in This Part

Hospital expenditures for CVD in 2016: Considering the principles of data representativeness and scientific significance, the data of hospitalization expenditures and trends on CVD (AMI, intracerebral hemorrhage and cerebral infarction) was retrieved from the medical records of 30 types of diseases in the nationally sampled hospitals according to the China Health Statistics Yearbook.

Number of discharges: The Statistics Information Center of the National Health Commission adjusted the criteria for statistical analysis for the relevant diseases in 1987 and 2002, resulting in a fluctuation of numbers of discharges, which affected the data consistency to some extent, and the 2003 data for CVD hospitalization expenditure were therefore excluded in this part.

Ischemic heart disease: Given that different diagnosis standards were employed in different local hospitals, some systematic error existed in the estimation of the relevant discharge rates; however, the trend of discharge numbers for ischemic heart disease was not affected.

Pricing effect elimination: In order to accurately reflect the growth rate of medical costs, the impact of pricing factors should be eliminated; namely, changes in medicine price index should be considered in all calculations. The healthcare consumer price index (published in the China Health Statistics Yearbook) was used in this chapter for analysis on the comparison among various medical expenses.

Appendix

Guidelines for CVD Released in China in the Past Five Years

★ Prevention

1. China Cardiovascular Disease Prevention Guidelines (2017)
China Cardiovascular Disease Prevention Guidelines (2017) Writing Committee Members & Editorial Board of Chinese Cardiovascular Diseases.
Chinese Journal of Cardiovascular Diseases, 2018,46(1):10-25.

2. Chinese Dietary Guidelines (2016)
China Disease Prevention and Control Bureau, National Health and Family Planning Commission of the People's Republic of China.
Beijing: People's Medical Publishing House, 2016.

3. China Clinical Smoking Cessation Guidelines (2015)
National Health and Family Planning Commission of the People's Republic of China.
Chinese Journal of Health Management, 2016,10(2):88-95.

★ Hypertension

1. Guidelines for the Management of Hypertension in the Community (2017)
National Basic Public Health Service Project, Primary Health Management Office, Hypertension Management Expert Committee.
Chinese Circulation Journal, 2017,32(11):1041-1048.

2. Chinese Guidelines for the Management of Hypertension (2014 Update)
Revision Committee of Chinese Guidelines for the Management of Hypertension.
Chinese Journal of Health Management, 2015,9(1):10-30.

3. China Education Guidelines for Hypertension Patients (2014)
China Hypertension League.
Clinical Focus, 2015,30(7):725-744.

4. Guidelines for the Diagnosis and Treatment of Hypertensive Disorders in Pregnancy (2015)
Disease Group for Hypertension in Pregnancy, Subcommission of Obstetrics and Gynecology, Chinese Medical Association, China.
Chinese Journal of Obstetrics and Gynecology, 2015,50 (10):721-728.

★ Dyslipidemia

Guidelines for the Prevention and Treatment of Dyslipidemia in Chinese Adults - 2016 Update
Joint Committee for the Revision of Guidelines for Prevention and Treatment of Dyslipidemia in Chinese Adult.
Chinese Circulation Journal, 2016,31(10):937-950.

★ Diabetes

Guidelines for the Prevention and Treatment of Type 2 Diabetes in China (2017)
Diabetes Branch of Chinese Medical Association.
Chinese Journal of Diabetes, 2018,10(1):4-67.

★ Cerebrovascular Disease

1. Guidelines for the Diagnosis and Treatment of Acute Ischemic Stroke in China (2018)
Neurology Branch of Chinese Medical Association, Cerebrovascular Diseases Group of Neurology Branch of Chinese Medical Association.
Chinese Journal of Neurology, 2018,51 (9):666-682.

2. Guidelines for the Diagnosis and Treatment of Subarachnoid Hemorrhage in China (2015)
Neurology Branch of Chinese Medical Association, Cerebrovascular Diseases Group of Neurology Branch of Chinese Medical Association.
Chinese Journal of Neurology, 2016,49(3):182-191.

3. China Cerebrovascular Disease Primary Prevention Guidelines (2015)
Neurology Branch of Chinese Medical Association, Cerebrovascular Disease Group of Neurology Branch of Chinese Medical Association.
Chinese Journal of Neurology, 2015,48(8):629-643.

★ Cardiovascular Diseases

1. Guidelines of Diagnosis and Treatment of Chronic Heart Failure
Cardiovascular Branch of Chinese Medical Association, Editorial Board of Chinese Journal of Cardiovascular Diseases.
Chinese Journal of Cardiovascular Diseases, 2014,42(2):98-122.

2. Guidelines for the Diagnosis and Treatment of non-ST-segment Elevation Acute Coronary Syndrome (2016)
Cardiovascular Branch of Chinese Medical Association, Editorial Board of Chinese Journal of Cardiovascular Diseases.
Chinese Journal of Cardiovascular Diseases, 2017,45(5):359-376.

3. Acute ST-segment Elevation Myocardial Infarction Diagnosis and Treatment Guidelines (2015)
Cardiovascular Branch of Chinese Medical Association, Editorial Board of Chinese Journal of Cardiovascular Diseases.
Chinese Journal of Cardiovascular Diseases, 2015,43(5):380-393.

4. Guidelines for the Diagnosis and Treatment of Dilated Cardiomyopathy in China (2018)
Cardiovascular Branch of Chinese Medical Association, China Myocarditis Cardiomyopathy Cooperative Group.
Journal of Clinical Cardiology, 2018,34(5):421-434.

5. Chinese Percutaneous Coronary Intervention Therapy Guidelines (2016)
Cardiovascular Branch of Chinese Medical Association, Intervention Cardiology Group, Cardiovascular Physician Branch of Chinese Medical Association, Committee of Thrombosis Prevention, Editorial Board of Chinese Journal of Cardiovascular Diseases.
Chinese Journal of Cardiovascular Diseases, 2016,44(05):382-400.

6. Atrial Fibrillation: Current Understanding and Treatment Recommendations (2018)
Cardiac Electrophysiology and Pacing Branch of Chinese Medical Association, Chinese Physician Association Heart Rhythm Committee.
Chinese Journal of Cardiac Pacing and Electrophysiology, 2018,32(4):315-365.

7. Guidelines for the Diagnosis and Treatment of Adult Hypertrophic Cardiomyopathy in China
Cardiovascular Branch of Chinese Medical Association, Chinese Adult Hypertrophic Cardiomyopathy Diagnosis and Treatment Guidelines Writing Group.
Chinese Journal of Cardiovascular Diseases, 2017,45(12):1015-1032.

8. Guidelines for Clinical Diagnosis and Treatment of Abnormal Glucose Metabolism and Atherosclerotic Cardiovascular Diseases
Cardiovascular Branch of Chinese Medical Association.
Chinese Journal of Cardiovascular Diseases, 2015,43(6):488-506.

★ Peripheral Vascular Disease

1. Guidelines for Diagnosis and Treatment of Carotid Stenosis
Department of Vascular Surgery, Surgical Branch of Chinese Medical Association.
Chinese Journal of Vascular Surgery, 2017,02 (02):78-84.

2. Guidelines for Diagnosis and Treatment of Lower Limb Occlusive Arteriosclerosis Disease
Department of Vascular Surgery, Surgical Branch of Chinese Medical Association.
Chinese Medical Journal, 2015,95 (24):1883-1896.

★ Pulmonary Vascular Disease and Thromboembolic Disease

1. Guidelines for Diagnosis and Treatment of Pulmonary Thromboembolism
Respiratory Diseases Branch of Chinese Medical Association.
Chinese Medical Journal, 2018,98(14):1060-1087.

2. Guidelines for the Diagnosis and Treatment of Deep Vein Thrombosis (The 3rd edition)
Surgery Branch of Chinese Medical Association.
Chinese Journal of General Surgery, 2017,32(9):807-812.

3. Chinese Intracranial Venous System Thrombosis Diagnosis and Treatment Guidelines (2015)
Neurology Branch of Chinese Medical Association.
Chinese Journal of Neurology, 2015,48(10):819-829.

★ Recommendations

Recommendations for the Suitability Criteria for Coronary Revascularization in China (Trial implementation)
National Center for Cardiovascular Diseases, Working Group on Recommendations for the Suitability of Coronary Revascularization in China.
Chinese Circulation Journal, 2016,31(4):313-317.