Postprint: Interpretation of Key Points from the China Cardiovascular Health and Disease Report 2023

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Abstract

The prevalence of cardiovascular disease (CVD) in China continues to rise. It is estimated that there are currently 330 million CVD patients, including 13 million with stroke, 11.39 million with coronary heart disease (CHD), 8.9 million with heart failure (HF), 5 million with pulmonary heart disease, 4.87 million with atrial fibrillation, 2.5 million with rheumatic heart disease, 2 million with congenital heart disease, 45.3 million with peripheral arterial disease (PAD), and 245 million with hypertension. In 2021, the total number of discharges of patients with cardiovascular and cerebrovascular diseases in China was 27.6498 million, accounting for 15.36% of the total number of discharges during the same period (including all inpatient disease categories), of which CVD accounted for 14.8723 million (8.26%), and cerebrovascular disease accounted for 12.7775 million (7.10%). The economic burden of CVD on residents and society continues to increase, and the inflection point for CVD prevention and treatment has not yet arrived.

Full Text

Preamble

Interpretation of Report on Cardiovascular Health and Diseases in China 2023

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Abstract The prevalence of cardiovascular disease (CVD) in China continues to rise. It is estimated that 330 million people have CVD, including 13 million cases of stroke, 11.39 million cases of coronary heart disease (CHD), 8.9 million cases of heart failure (HF), 5 million cases of pulmonary heart disease, 4.87 million cases of atrial fibrillation, 2.5 million cases of rheumatic heart disease, 2 million cases of congenital heart disease, 45.3 million cases of peripheral arterial disease (PAD), and 245 million cases of hypertension. In 2021, the total number of discharges for cardiovascular and cerebrovascular diseases in China was 27.6498 million, accounting for 15.36% of all discharges (including all inpatient conditions) during the same period. This included 14.8723 million CVD cases (8.26%) and 12.7775 million cerebrovascular disease cases (7.10%). The economic burden of CVD on residents and society continues to increase, and the inflection point for CVD prevention and treatment has not yet been reached.

[**Keywords**] cardiovascular diseases; epidemiology; burden of disease; risk factors; prevalence; mortality; rehabilitation; basic research; medical device development; costs

With socioeconomic development and changes in national lifestyle patterns, particularly accelerated population aging and urbanization, unhealthy lifestyles have become increasingly prominent. The impact of CVD risk factors on residents' health is growing more significant, and CVD incidence continues to rise. The economic burden on residents and society is increasing daily, making CVD a major public health problem that urgently requires strengthened government-led prevention and treatment efforts. Since 2005, the National Center for Cardiovascular Diseases has organized national experts to compile the *Report on Cardiovascular Health and Diseases in China* annually. The *Report on Cardiovascular Health and Diseases in China 2023* includes data from projects undertaken by the National Center for Cardiovascular Diseases for the first time. These firsthand data greatly enrich the report's content and more timely and comprehensively reflect the state of CVD prevention and treatment in China. This article interprets the key contents of the newly published *Report on Cardiovascular Health and Diseases in China 2023* [1] to provide a scientific basis for CVD prevention and treatment and related policy development.

1. Prevalence of CVD and Risk Factors

1.1.1 CVD: The prevalence of CVD in China continues to rise. It is estimated that 330 million people have CVD, including 13 million cases of stroke, 11.39 million cases of coronary heart disease (CHD), 8.9 million cases of heart failure (HF), 5 million cases of pulmonary heart disease, 4.87 million cases of atrial fibrillation, 2.5 million cases of rheumatic heart disease, 2 million cases of congenital heart disease, 45.3 million cases of peripheral arterial disease (PAD), and 245 million cases of hypertension.

According to Global Burden of Disease Study (GBD) data [2], the age-standardized incidence of CVD (including rheumatic heart disease, ischemic heart disease (IHD), stroke, hypertensive heart disease, non-rheumatic valvular heart disease, cardiomyopathy and myocarditis, atrial fibrillation, atrial flutter, aortic aneurysm, PAD, endocarditis, and other cardiovascular and circulatory diseases) among Chinese aged 1–79 years increased from 646.2/100,000 person-years to 652.2/100,000 person-years between 1990 and 2019. The age-standardized incidence of CHD increased from 177.1/100,000 person-years in 1990 to 203.7/100,000 person-years in 2010, then decreased to 197.4/100,000 person-years in 2019.

According to GBD data [3-4], disability-adjusted life years (DALYs) due to CVD increased by 33.7% between 1990 and 2016, with a 51.8% increase in men—much higher than the 12.1% increase in women. The diseases with the fastest-growing burden were atrial fibrillation and atrial flutter (147.0%), IHD (122.0%), PAD (108.9%), ischemic stroke (80.4%), and aortic aneurysm (49.1%).

Although the absolute burden of CVD continues to grow, age-standardized DALYs decreased by 33.3% between 1990 and 2016, with a faster decline in women (-43.7%) than in men (-24.7%). Age-standardized DALYs for other CVD types also decreased to varying degrees, with the largest reductions seen in rheumatic heart disease (-77.6%), other CVDs (-68.7%), hypertensive heart disease (-54.8%), and hemorrhagic stroke (-52.6%).

According to the *China Health Statistics Yearbook 2022* [5], CVD ranked first among causes of death for both urban and rural residents. In 2021, CVD accounted for 48.98% of deaths in rural areas and 47.35% in urban areas (Figure 1 [Figure 1: see original paper], Figure 2 [Figure 2: see original paper]).

Rural CVD mortality has exceeded and remained higher than urban rates since 2009 (Figure 3 [Figure 3: see original paper]). In 2021, rural CVD mortality was 364.16/100,000, including 188.58/100,000 from heart disease and 175.58/100,000 from cerebrovascular disease. Urban CVD mortality was 305.39/100,000, including 165.37/100,000 from heart disease and 140.02/100,000 from cerebrovascular disease.

The *China Health Statistics Yearbook 2022* [5] shows that in 2021, urban CHD mortality was 135.08/100,000, while rural mortality was 148.19/100,000. Male

CHD mortality was higher than female mortality in both urban and rural areas (Figure 4 [Figure 4: see original paper]). CHD mortality has continued its upward trend since 2012 (Figure 5 [Figure 5: see original paper]), with a more pronounced increase in rural areas that surpassed urban levels by 2016.

From July 2021 to June 2022, the "China Cardiovascular and Cerebrovascular Events Surveillance" project analyzed data from 103 surveillance sites in 20 provinces, autonomous regions, and municipalities. The project found that among Chinese residents aged $ $18 years, the crude incidence of CVD (including acute myocardial infarction (AMI), percutaneous transluminal coronary angioplasty/stent implantation and/or coronary artery bypass grafting (CABG), angina, stroke, and sudden cardiac death) was 600.9/100,000 (age-standardized rate: 411.8/100,000), with higher rates in men (crude rate: 689.5/100,000; standardized rate: 501.9/100,000) than in women (crude rate: 510.7/100,000; standardized rate: 324.9/100,000). The incidence of AMI was 79.7/100,000 (age-standardized rate: 55.8/100,000), higher in men (99.0/100,000) than in women (60.1/100,000).

The "China Cardiovascular Disease and Risk Factor Surveillance" project conducted surveys at 262 surveillance sites in 31 provinces, autonomous regions, and municipalities between 2020 and 2022. Preliminary results showed that among Chinese residents aged $ $18 years, the prevalence of CHD (including AMI, stent implantation, CABG, and hospitalization for unstable angina) was 758/100,000, higher in men (940/100,000) than in women (570/100,000), and higher in urban areas (892/100,000) than in rural areas (639/100,000). CHD prevalence increased rapidly with age. AMI mortality showed an overall upward trend from 2002 to 2021. Starting in 2005, AMI mortality increased rapidly, with rural AMI mortality exceeding urban levels in 2007, 2009, 2010, and 2011, and consistently surpassing urban levels since 2013 (Figure 6 [Figure 6: see original paper]).

1.1.2 Cerebrovascular Disease: GBD 2019 results [6] showed that in 2019, China had 28.76 million stroke patients, a 147.5% increase from 1990. Between 1990 and 2019, the greatest increase in prevalence was for ischemic stroke (195.2%), followed by subarachnoid hemorrhage (54.8%) and intracerebral hemorrhage (43.0%). In 2019, the age-standardized stroke prevalence was 1,468.9/100,000, including 1,255.9/100,000 for ischemic stroke, 214.6/100,000 for intracerebral hemorrhage, and 81.4/100,000 for subarachnoid hemorrhage. Compared with 1990, age-standardized stroke prevalence increased by 13.2%, with ischemic stroke increasing by 33.5% while intracerebral hemorrhage and subarachnoid hemorrhage decreased by 31.9% and 21.9%, respectively.

From July 2021 to June 2022, the "China Cardiovascular and Cerebrovascular Events Surveillance" project analyzed data from 103 surveillance sites in 20 provinces, autonomous regions, and municipalities. Preliminary results found

that among Chinese residents aged $ $18 years, the stroke incidence was 496.7/100,000 (age-standardized rate: 338.6/100,000), with higher rates in men than in women (Figure 7 [Figure 7: see original paper]).

According to the *China Health Statistics Yearbook 2022* [5], in 2021, the crude mortality rate from cerebrovascular disease was 140.02/100,000 among urban residents, accounting for 21.71% of all urban deaths and ranking third among causes of death. Among rural residents, it was 175.58/100,000, accounting for 23.62% of all rural deaths and ranking second. Cerebrovascular disease mortality was higher in men than in women and higher in rural than in urban areas (Figure 8 [Figure 8: see original paper]).

From 2003 to 2021, cerebrovascular disease mortality showed an overall increasing trend. Compared with 2003, the crude mortality rate in urban residents increased 1.37-fold by 2021, while in rural residents it increased 1.58-fold. Rural mortality rates exceeded urban rates in all years (Figure 9 [Figure 9: see original paper]).

GBD 2019 results showed that in 2019, 2.189 million deaths in China were attributable to stroke. Between 1990 and 2019, total stroke deaths increased by 59.0%, with deaths from ischemic stroke and intracerebral hemorrhage increasing by 171.1% and 37.4%, respectively, while deaths from subarachnoid hemorrhage decreased by 58.7%. In 2019, China's age-standardized stroke mortality rate was 127.2/100,000, including 62.2/100,000 from ischemic stroke, 60.1/100,000 from intracerebral hemorrhage, and 5.0/100,000 from subarachnoid hemorrhage. Compared with 1990, age-standardized stroke mortality decreased by 39.8%, with no significant change for ischemic stroke (-3.3%), but decreases of 48.1% and 84.1% for intracerebral hemorrhage and subarachnoid hemorrhage, respectively [6-7].

1.2 Tobacco Use

Tobacco control is a major public health issue. Since the WHO Framework Convention on Tobacco Control took effect in 2005, global tobacco control has made significant progress, with smoking rates among people aged $ $15 years decreasing from 22.8% in 2007 to 17.0% in 2019 [8]. In 2018, the smoking rate among Chinese aged $ $15 years was 26.6% [9], with over 300 million smokers.

A study that followed 512,000 adults aged 30–79 years from 10 regions in China for a median of 11 years (2004–2008) found that smoking was significantly associated with the risk of 15 circulatory system diseases, with hazard ratios [HR (95% CI)] including aortic aneurysm and aortic dissection [2.46 (1.71–3.54)], arterial embolism and thrombosis [1.99 (1.40–2.83)], other pulmonary heart disease [1.78 (1.65–1.92)], pulmonary embolism (PE) [1.54 (1.03–2.30)], other aneurysms [1.54 (1.02–2.31)], AMI [1.49 (1.39–1.59)], cardiac arrest [1.43 (1.20–1.70)], atherosclerosis [1.32 (1.16–1.49)], HF [1.30 (1.21–1.40)], cardiac complications and ill-defined heart disease [1.20 (1.08–1.33)], chronic IHD [1.18 (1.15–1.22)], cerebral infarction [1.12 (1.09–1.15)], angina [1.09 (1.01–1.19)], and

varicose veins [0.81 (0.72–0.92)] [10].

1.3 Diet and Nutrition

Data from the 2015–2017 Chinese Nutrition and Health Surveillance (CNHS) show that Chinese residents have adequate total dietary energy supply. Long-term trends indicate that total energy intake is declining, with a significant decrease in the proportion of energy from carbohydrates, while the proportion from fat continues to rise. Since 2002, urban residents have exceeded the recommended upper limit of 30% for fat energy contribution, and rural residents exceeded this limit for the first time during 2015–2017, reaching 33.2% [11-12].

CNHS data from 2015–2017 on 72,231 adults aged $ $18 years show severe micronutrient deficiencies among Chinese adults, with inadequate intake rates ranging from 2.58% to 97.63%. Calcium had the highest inadequacy rate, followed by vitamin B2 (Figure 10 [Figure 10: see original paper]). Sodium intake was excessively high, averaging 5,139.61 mg/day, with only one-quarter of Chinese adults consuming less than the WHO recommendation [13].

The dietary structure of Chinese residents remains suboptimal. Data from the China Chronic Disease and Risk Factor Surveillance (CCDRFS) and Chinese Nutrition and Health Surveys show that between 2002 and 2018, intake of whole grains, vegetables, fruits, red meat, soybeans, and nuts increased among Chinese residents aged $ $20 years, while sugar-sweetened beverage intake grew rapidly. Red meat and sugar-sweetened beverage intake exceeded Chinese dietary guidelines, while other foods remained below recommendations. Daily intake of whole grains (21.2 g/day) and fruits (114.1 g/day) was only about half the recommended amounts (whole grains: 50–100 g/day; fruits: 200–350 g/day) [14].

1.4 Physical Activity

A cross-sectional survey of 298 districts and counties in 31 provinces, autonomous regions, and municipalities through the China Chronic Disease and Nutrition Monitoring system found that in 2015, only 12.5% of Chinese adults aged $ $18 years regularly participated in physical activity, with higher rates in urban (18.1%) than rural (8.5%) areas. Leisure-time sedentary behavior increased significantly from 2.7 h/day in 2010 to 3.2 h/day in 2018 [15-16].

Between 1985 and 2014, the excellent rate of student physical fitness 达标 showed an overall declining trend [17]. From 2004 to 2015, sedentary behavior increased by 1.8 h/7 days, and physical inactivity rates increased by 5.5% [18]. In 2016, 85.2% of primary and secondary school students had $ $2 physical education classes per week, and 31.5% had $ $5 extracurricular sports training sessions per week. However, 23.7% watched TV, 27.7% used mobile phones, and 17.5% used computers for $ $2 hours on weekends [19]. In 2017, activity 达标 rates among primary and middle school students were higher than in 2016 [20]. In

2019, 39.3% of students engaged in muscle-strengthening exercises $ $3 times per week [21].

A WHO 2016 report [22] indicated that meeting physical activity targets could reduce premature mortality risk by 18.3% among Chinese aged 40–74 years, equivalent to preventing 1.0165 million premature deaths annually. The China Kadoorie Biobank (CKB) study [23] found that compared with physical activity $ $9.1MET \cdot h \cdot d^{-1}$, activity $ $33.8MET \cdot h \cdot d^{-1}$ reduced CVD death risk by 41%. Each 4 $\mathrm{MET \cdot h \cdot d^{-1}}$ increase in physical activity reduced CVD death risk by 12%.

1.5 Overweight and Obesity

Data from seven national student physique and health surveys conducted between 1985 and 2019 [24] showed that in 2019, the prevalence of overweight and obesity among Chinese children and adolescents aged 7–18 years was 23.4% (overweight: 13.9%; obesity: 9.6%), higher in urban (25.4%) than rural (21.5%) areas and higher in boys (28.4%) than girls (18.4%). The prevalence increased 18.1-fold from 1.2% in 1985 to 23.4% in 2019, with obesity prevalence increasing 75.6-fold. The prevalence increased 22.3-fold, 11.7-fold, 54.2-fold, and 10.1-fold among urban boys, urban girls, rural boys, and rural girls, respectively, with rural boys showing the fastest growth.

The "China Cardiovascular Disease and Risk Factor Surveillance" project surveyed 298,438 people at 262 surveillance sites in 31 provinces, autonomous regions, and municipalities between 2020 and 2022. Preliminary results showed that among residents aged $ $18 years, the prevalence of overweight, obesity, and central obesity was 34.6%, 17.8%, and 34.9%, respectively. Obesity prevalence was higher in men (20.5%) than women (15.0%) and higher in rural (18.7%) than urban (16.7%) areas. Both overweight and obesity rates increased initially then decreased with age (Figure 11 [Figure 11: see original paper]).

The Kailuan cohort study [25] followed 68,603 adults (mean age 55.46 years) without CVD or cancer for a median of 7.0 years, during which 3,325 developed CVD. Compared with the stable low-normal weight group, those with stable high-normal weight, stable overweight, stable low obesity, and stable high obesity had higher CVD risk, suggesting that long-term overweight and obesity are associated with increased lifetime CVD risk.

Overweight and obesity increase CVD burden. GBD data [26] estimated that in 2019, high body mass index contributed to 549,500 CVD deaths in China, with an age-standardized CVD mortality rate of 38.64/100,000 attributable to high body mass index, accounting for 11.98% of all CVD deaths.

1.6 Hypertension

National hypertension prevalence surveys conducted between 1958 and 2022 show an overall upward trend. The "China Cardiovascular Disease and Risk

Factor Surveillance" project surveyed 298,438 people at 262 surveillance sites in 31 provinces, autonomous regions, and municipalities between 2020 and 2022. Preliminary results showed that among residents aged $ $18 years, hypertension prevalence was 31.6%, higher in men (36.8%) than women (26.3%) and higher in rural (33.7%) than urban (29.1%) areas. Hypertension prevalence increased rapidly with age (Figure 12 [Figure 12: see original paper]).

The 2019 National Student Physique and Health Survey (n=190,000, aged 7–17 years, Han ethnicity) [27] found that hypertension prevalence among children and adolescents was 13.0%, higher in girls (13.2%) than boys (12.7%) and higher in rural (14.1%) than urban (11.9%) areas, with an overall increasing trend with age ($P<0.001$).

The China Health and Nutrition Survey (CHNS) [28] prospective cohort study of 12,952 Chinese adults aged $ $18 years found that the age-standardized hypertension incidence increased from 40.8/1,000 person-years in 1993–1997 to 48.6/1,000 person-years in 2011–2015.

CCDRFS data [29] from six national surveys between 2004 and 2018 showed that awareness, treatment, and control rates of hypertension among Chinese adults aged 18–69 years all increased over time (Figure 13 [Figure 13: see original paper]). The "China Cardiovascular Disease and Risk Factor Surveillance" project survey of 298,438 people at 262 surveillance sites between 2020 and 2022 found that among residents aged $ $18 years, hypertension awareness, treatment, and control rates were 43.3%, 38.7%, and 12.9%, respectively, continuing the upward trend.

CHNS results showed that the age-standardized prevalence of high-normal blood pressure among Chinese adults aged $ $18 years increased from 30.1% in 1991 to 43.1% in 2015 [30]. The China Hypertension Survey (CHS) found that in 2012–2015, the crude prevalence of high-normal blood pressure among Chinese residents aged $ $18 years was 39.1% (weighted rate: 41.3%), estimating 435 million people with high-normal blood pressure nationwide [31].

The DECIDE-salt study based on Chinese elderly [32] showed that salt substitution effectively lowered blood pressure and significantly reduced cardiovascular event risk. A study of mortality, incidence, and risk factors in China and its provinces from 1990 to 2017 [33] found that high systolic blood pressure was one of the four leading risk factors for deaths and DALYs. In 2017, high systolic blood pressure caused 2.54 million deaths, 95.7% of which were from CVD. A study of cardiovascular disease burden attributable to high systolic blood pressure in China and its provinces from 2005 to 2018 [34] found that CVD deaths caused by elevated systolic blood pressure continued to rise, from 1.98 million in 2005 to 2.67 million in 2018.

1.7 Dyslipidemia

The 2015 Chinese Adults Nutrition and Chronic Diseases Surveillance (CANCDS) project [35] surveyed 179,728 residents aged $ $18 years and found that total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), non-high-density lipoprotein cholesterol (HDL-C), and triglyceride (TG) levels all increased compared with 2002 (Figure 14 [Figure 14: see original paper]).

The prevalence of dyslipidemia among Chinese adults aged $ $18 years increased dramatically from 18.6% in 2002 to 40.4% in 2012. The "China Cardiovascular Disease and Risk Factor Surveillance" project surveyed 275,961 people at 262 surveillance sites in 31 provinces, autonomous regions, and municipalities between 2020 and 2022. Preliminary results showed that dyslipidemia prevalence among residents aged $ $18 years was 38.1%, higher in men (46.1%) than women (29.6%) and higher in urban (38.9%) than rural (37.4%) areas. Dyslipidemia prevalence initially increased then decreased with age (Figure 15 [Figure 15: see original paper]).

Results from the 4th CCDRFS project (2013–2014) [36], CANCDS (2015) [35], China National Stroke Screening and Prevention Project (CNSSPP) (2014) [37], and China Patient-centered Evaluative Assessment of Cardiac Events Million Persons Project (China-PEACE MPP, now China-HEART project) (2014–2019) [38] all showed that the main types of dyslipidemia among Chinese adults were low HDL cholesterol and high triglycerides (Figure 16 [Figure 16: see original paper]).

The "China Cardiovascular Disease and Risk Factor Surveillance" project surveyed 275,961 people at 262 surveillance sites between 2020 and 2022. Preliminary analysis showed that awareness, treatment, and control rates of dyslipidemia among Chinese residents aged $ $18 years were 11.7%, 10.1%, and 4.8%, respectively—higher than the 2010 China Chronic Disease Surveillance Project rates (awareness: 10.93%; treatment: 6.84%; control: 3.53%) [39].

Analysis of nearly 3 million people from China-PEACE data examined the relationship between LDL-C levels and all-cause and CVD mortality risk. Results showed U-shaped curves between LDL-C levels and both all-cause and CVD death. Compared with LDL-C of 100–129.9 mg/dL, those with LDL-C <70 mg/dL and >190 mg/dL had 16% and 31% higher all-cause death risk, respectively. J-shaped curves were observed between LDL-C and CVD death, IHD death, and ischemic stroke death, while an L-shaped curve was seen for hemorrhagic stroke death. Compared with LDL-C 100–129.9 mg/dL, LDL-C <70 mg/dL increased CVD death and hemorrhagic stroke death risk by 10% and 37%, respectively, while LDL-C >190 mg/dL increased CVD death and IHD death risk by 51% and 108%, respectively.

1.8 Diabetes

A cross-sectional survey of 75,880 adults aged $ $18 years in 31 provinces, autonomous regions, and municipalities between 2015 and 2017 [40] found that using WHO diagnostic criteria, the prevalence of diabetes among Chinese adults was 11.2% (95% CI=10.5%–11.9%). If glycated hemoglobin (HbA1c) was also used as a diagnostic criterion, diabetes prevalence was 12.8% (95% CI=12.0%–13.6%), including previously diagnosed diabetes (6.0%; 95% CI=5.4%–6.7%), newly diagnosed diabetes (6.8%; 95% CI=6.1%–7.4%), and prediabetes (35.2%; 95% CI=33.5%–37.0%). It is estimated that 129.8 million Chinese adults currently have diabetes (70.4 million men, 59.4 million women). The 2017 survey found diabetes awareness, treatment, and control rates of 43.3%, 49.0%, and 49.4%, respectively.

The China-PAR study [41] included 12,145 Chinese adults aged 35–74 years without diabetes at baseline. Based on fasting glucose at baseline (1998–2001) and follow-up 8 years later, participants were categorized into six groups: normal fasting glucose (NFG; 50–99 mg/dL), impaired fasting glucose (IFG; 100–125 mg/dL), and diabetes. Using Cox proportional hazards models, the study found that during a median follow-up of 5.5 years with 373 CVD events, participants with persistent IFG, progression from NFG to diabetes, or progression from IFG to diabetes had higher CVD risk than those with persistent NFG, with multivariable-adjusted HRs (95% CI) of 1.792 (1.141–2.816), 1.723 (1.122–2.645), and 1.946 (1.120–3.381), respectively. When stratified by baseline glucose status, compared with reversal from IFG to NFG, persistent IFG and progression from IFG to diabetes still increased CVD risk, with multivariable-adjusted HRs (95% CI) of 1.594 (1.003–2.532) and 1.913 (1.080–3.389). Thus, individuals with long-term IFG who progress to diabetes have higher CVD risk.

1.9 Chronic Kidney Disease

The 6th CCDRFS [42] conducted between August 2018 and June 2019 included 176,874 adults aged $ $18 years from 31 provinces, autonomous regions, and municipalities. The prevalence of albuminuria and impaired kidney function was 6.7% and 2.2%, respectively, with total chronic kidney disease (CKD) prevalence at 8.2%—lower than the 10.8% reported in 2009–2010 [43].

The China Kidney Disease Network (CK-NET) annual report showed that among inpatients in tertiary hospitals in 2016, diabetic nephropathy, hypertensive nephropathy, and obstructive nephropathy accounted for 26.7%, 21.4%, and 16.0% of cases, respectively—all higher than chronic glomerulonephritis (14.4%) [44].

The China-PEACE project surveyed 269,026 adults aged $ $35 years in 31 provinces, autonomous regions, and municipalities between 2015 and 2019. The prevalence of morning urinary albumin-creatinine ratio (UACR $ $30 mg/g) was 8.75%, including 7.38% with 30 mg/g $\leq$ UACR <300 mg/g and 1.37% with UACR $ $300 mg/g. The study found that across the full UACR range, risks

of all-cause death, cardiovascular death, and CVD-specific death increased with UACR levels. Compared with UACR <5 mg/g, even traditionally "normal" UACR levels (<30 mg/g) significantly increased these death risks.

1.10 Sleep Disorders

A 2019 survey of 107,650 residents aged $ $15 years in 31 provinces, autonomous regions, and municipalities found an age-standardized prevalence of sleep difficulties of 21.25%, with 90.27% experiencing difficulty falling asleep and 75.70% experiencing sleep interruption or early awakening [45].

A 2020 meta-analysis of 13,920 hypertensive patients found a sleep difficulty prevalence of 52.5% (95% CI=46.1%–58.9%), significantly higher than the 32.5% (95% CI=19.0%–49.7%) prevalence in healthy controls, with an OR of 2.66 (95% CI=1.80–3.93) [46].

A 2021 nationwide study of 47,841 people aged $ $45 years across 7 regions in China, with 47,588 completing self-administered questionnaires, compared emotional status between CVD patients and those without CVD. The prevalence of depression and anxiety was significantly higher in CVD patients. Among HF patients, depression and anxiety prevalence was 12.0% and 9.1%, respectively; among stroke patients, it was 10.9% and 7.9%. Among people with three or more CVDs, depression and anxiety prevalence was 9.7% and 7.3% in women and 6.3% and 3.5% in men, respectively [47].

1.11 Environmental Factors

GBD studies show that the top two environmental factors affecting Chinese population health are air pollution and non-optimal temperature. Non-optimal temperature ranked 8th among risk factors for disease burden in both 2013 and 2019, causing 400,000 excess CVD deaths in 2019. Air pollution ranked 3rd in 2013 and 4th in 2019, with 1.842 million excess deaths in 2019, including 1.14 million CVD deaths related to PM2.5 exposure.

A time-series study of high summer temperatures and mortality at 353 locations in China from 2006 to 2017 found that high temperature events were associated with a 12.95% (95% CI=12.82%–13.09%) increase in excess CVD mortality [48]. A study of heatwaves and CVD mortality risk in 272 Chinese cities found that heatwaves increased total CVD and CHD mortality risk by 14% (RR=1.14, 95% CI=1.09–1.18) and 13% (RR=1.13, 95% CI=1.07–1.19), respectively [49].

A study of low temperature exposure and CVD mortality in 272 Chinese cities from 2013 to 2015 found that compared with the threshold temperature (the temperature at which population mortality was lowest) of 22.8°C, low temperature cold exposure increased CVD death risk (RR=1.92, 95% CI=1.75–2.10) [50]. A case-control study in 15 Chinese cities found that 15.8% (95% CI=13.1%–17.9%) of CVD deaths (305,902 cases) were attributable to low temperature [51].

2. CVD Treatment and Outcomes

2.1 Hypertension

Hospital Quality Monitoring System (HQMS) data show that in 2022, 5,000 hospitals admitted hypertensive inpatients (with hypertension as primary or other diagnosis and age $ $18 years), accounting for 88.5% of hospitals admitting CVD inpatients. These included 1,921 tertiary hospitals and 3,079 secondary hospitals, which admitted 35.243 million hypertensive inpatients, accounting for 68.4% of all CVD inpatients.

The top three comorbidities among hypertensive inpatients were cerebrovascular disease, CHD, and diabetes, accounting for 32.7%, 30.5%, and 28.4%, respectively. Secondary hypertension accounted for 2.1% of hypertensive inpatients, with the top three causes being renal parenchymal hypertension, obstructive sleep apnea (OSA), and renovascular hypertension, accounting for 48.2%, 28.5%, and 10.9%, respectively.

In 2022, the inpatient mortality rate for patients with hypertension as the primary discharge diagnosis was 0.2%, and the non-recovery discharge rate was 3.8%.

A prospective study of 13,383 CVD-free patients aged 60–80 years with baseline systolic blood pressure of 110–150 mmHg (1 mmHg=0.133 kPa) found that after a median follow-up of 13.01 years with 1,727 CVD cases and 3,742 deaths, targeting systolic blood pressure to 110–130 mmHg reduced CVD (HR=0.81, 95% CI=0.76–0.87) and all-cause mortality (HR=0.89, 95% CI=0.85–0.93) risk compared with targeting 130–150 mmHg [52]. An open cluster-randomized controlled study of 33,995 people suggested that intensive blood pressure control strategies are safe and effective in the general population. Compared with usual care, community-based intensive blood pressure control reduced hypertensive patients' cardiovascular events by 33%, myocardial infarction by 23%, stroke by 34%, HF by 42%, cardiovascular death by 30%, and all-cause death by 15% [53].

2.2 CHD

HQMS data show that in 2022, 4,961 hospitals admitted CHD inpatients (with CHD as primary diagnosis and age $ $18 years), accounting for 87.8% of hospitals admitting CVD inpatients, including 1,886 tertiary and 3,075 secondary hospitals. These hospitals admitted 6.127 million CHD inpatients, including 4.195 million in tertiary and 1.932 million in secondary hospitals.

Among CHD inpatients, 60.9% had comorbid hypertension, 26.3% had diabetes, and 19.1% had atrial fibrillation or atrial flutter. The top three discharge diagnoses were unstable angina (38.1%), unclassified CHD (28.0%), and stable angina (15.3%).

In 2022, 1.034 million AMI inpatients were admitted, including 47.4% with ST-

elevation myocardial infarction (STEMI), 41.1% with non-ST-elevation myocardial infarction (NSTEMI), and 11.5% unclassified AMI. Among AMI inpatients, 7.8% had cardiogenic shock, 2.3% had cardiac arrest, and 2.2% had ventricular tachycardia. The inpatient mortality rate for AMI patients was 4.3%, and the non-recovery discharge rate was 13.4%.

In 2022, 1.421 million patients underwent percutaneous coronary intervention (PCI), accounting for 23.2% of CHD inpatients. Another 1.539 million patients underwent coronary angiography alone, accounting for 25.1% of CHD inpatients. The inpatient mortality rate for PCI patients was 0.7%, and the non-recovery discharge rate was 2.7%.

In 2022, 571 hospitals performed at least one CABG, with a total of 49,000 cases, including 45,000 isolated CABGs. The inpatient mortality rate was 1.4%, and the non-recovery discharge rate was 2.9%. The ratio of PCI to CABG volume was 28.8:1.

A multicenter, randomized, non-inferiority prospective study of 4,551 patients compared the efficacy and safety of indobufen plus clopidogrel versus aspirin plus clopidogrel after percutaneous coronary intervention. The primary endpoint was a composite of 1-year major adverse cardiovascular events and Bleeding Academic Research Consortium (BARC) type 2, 3, or 5 bleeding. Results showed that indobufen-based dual antiplatelet therapy reduced 1-year net clinical outcome risk compared with aspirin, with similar ischemic events but significantly fewer bleeding events [55].

2.3 Arrhythmia

HQMS data show that in 2022, 5,481 hospitals provided arrhythmia diagnosis and treatment services, accounting for 96.8% of hospitals providing CVD services, including 3,348 tertiary hospitals (61.1%) and 2,133 secondary hospitals (38.9%). There were 8.32 million arrhythmia inpatients (with arrhythmia as primary or other diagnosis). The top three conditions were atrial fibrillation/atrial flutter (33.4%), atrial premature contractions (14.2%), and ventricular premature contractions (13.9%).

A total of 233,000 ablation procedures were performed for various arrhythmias, accounting for 2.8% of total arrhythmia hospitalizations. Catheter ablation accounted for 96.6% of procedures, with increasing volumes. Over 13,000 left atrial appendage closures were performed (56.0% as "ablation + closure" one-stop procedures), and over 120,000 pacemakers were implanted.

The LBBP-RESYNC study (Left Bundle Branch vs Biventricular Pacing for Cardiac Resynchronization Therapy) was the world's first investigator-initiated prospective randomized controlled trial comparing left bundle branch pacing with conventional biventricular pacing for HF patients, confirming that left bundle branch pacing offers significant advantages in improving patient outcomes compared with conventional biventricular pacing. For patients with

non-ischemic cardiomyopathy and left bundle branch block, left bundle branch pacing and biventricular pacing are effective complementary cardiac resynchronization strategies [56].

2.4 Valvular Heart Disease

HQMS data show that in 2022, 5,129 hospitals admitted valvular heart disease inpatients, accounting for 90.8% of hospitals admitting CVD inpatients, including 2,069 tertiary and 3,060 secondary hospitals. These hospitals admitted 1.882 million valvular heart disease patients (with valvular disease in discharge diagnosis), with mitral valve disease being most common (980,000 cases, 45.4%), followed by tricuspid (28.5%), aortic (24.3%), and pulmonary valve disease (1.8%). The top three comorbidities were HF (46.8%), hypertension (43.0%), and CHD (33.0%).

In 2022, 24,000 patients underwent isolated mitral valve surgery, including 31.6% valve repairs and 68.4% valve replacements, with a 42.0% bioprosthetic valve usage rate. The inpatient mortality rate was 1.2%, and the non-recovery discharge rate was 2.9%.

In 2022, 1,773 patients underwent mitral valve intervention, with mitral valve clip procedures accounting for 49.7%. The inpatient mortality rate was 0.8%, and the non-recovery discharge rate was 1.5%.

ValveClamp has the most evidence and longest follow-up for treating primary mitral regurgitation and has received National Medical Products Administration approval. A prospective, multicenter, single-arm trial included 102 high-surgical-risk mitral regurgitation patients. The primary endpoint was all-cause death, reoperation, and mitral regurgitation $ $3+. Results showed 97% immediate procedural success, mean catheter time of 19 minutes (as short as 5 minutes), with 88% of patients achieving satisfactory clipping with only one clip. The 1-year overall effectiveness rate was 87.3% (96.1% in the later 52-patient cohort), with 97.8% maintaining mitral regurgitation $ $2+, significantly improved left ventricular ejection fraction, and NYHA functional class [57].

In 2022, 8,068 patients underwent transcatheter aortic valve replacement (TAVR). A total of 36,000 tricuspid valve surgeries were performed, with a non-recovery discharge rate of 5.0%; 133 transcatheter tricuspid procedures were performed, with an inpatient mortality rate of 0.8% and non-recovery discharge rate of 1.5%. A total of 903 pulmonary valve surgeries were performed, with a non-recovery discharge rate of 5.3%; 560 transcatheter pulmonary valve procedures were performed, with an inpatient mortality rate of 1.1% and non-recovery discharge rate of 3.4%.

2.5 Heart Failure

HQMS data show that in 2022, 5,402 hospitals admitted HF inpatients (with HF as primary or other diagnosis and age $ $18 years), accounting for 95.6 \pm \$12.7$)

years, with women accounting for 44.6%.

The top three comorbidities among HF inpatients were CHD (68.9%), hypertension (58.6%), and stroke (34.2%). During hospitalization, 2.5% of HF patients received mechanical ventilation, 0.3% received hemofiltration, and 0.2% received intra-aortic balloon pump (IABP) treatment. The inpatient mortality rate was 2.6%, non-recovery discharge rate was 10.2%, and 30-day readmission rate was 10.0%.

The China Cardiovascular Association (CCA) HF Registry Study included 41,708 hospitalized HF patients with preserved ejection fraction between January 2017 and June 2021. Ischemia (26.6%), infection (14.4%), and arrhythmia (10.5%) were the three most common precipitating factors for HF hospitalization. 67.4% of patients had three or more comorbidities. Hypertension (65.2%), CHD (60.3%), and atrial fibrillation (41.2%) were the three most common comorbidities among Chinese HF patients with preserved ejection fraction [58].

2.6 Congenital Heart Disease

HQMS data show that in 2022, 4,947 hospitals admitted inpatients with congenital heart disease (CHD) in the diagnosis, accounting for 87.6% of hospitals providing CVD services, including 2,059 tertiary hospitals (94.9%) and 2,888 secondary hospitals (83.0%). These hospitals treated 1.508 million inpatient episodes with CHD, with atrial septal defect/patent foramen ovale accounting for 57.0%, patent ductus arteriosus 14.1%, ventricular septal defect 5.8%, aortic coarctation 1.3%, endocardial cushion defect 0.4%, and tetralogy of Fallot 0.3%.

In 2022, 38.95% of CHD inpatients were neonates and infants (hospital age <1 year), 7.57% were children (1–17 years), and 53.48% were adults ($ $18 years). A total of 131,000 CHD patients (8.7% of those with CHD diagnosis) received surgical or interventional treatment, including 116,000 simple CHD cases (88.6%) and 15,000 complex CHD cases (11.4%).

In 2022, 49,000 CHD patients underwent surgical treatment (37.1% of those receiving surgical or interventional treatment), with children aged 1–17 years accounting for the largest proportion (42.8%), followed by adults (35.2%). Complex CHD accounted for 30.8% of surgical cases. The inpatient mortality rate for CHD surgery was 1.0%, and the non-recovery discharge rate was 2.1%.

In 2022, 83,000 CHD patients underwent interventional treatment, with children (<18 years) accounting for 30.8%. Among children undergoing interventional treatment, atrial septal defect or patent foramen ovale closure was most common (55.1%), followed by patent ductus arteriosus closure (21.4%), ventricular septal defect closure (20.7%), and pulmonary valve balloon dilation (2.8%). The inpatient mortality rate for CHD interventional treatment was 0.01%, and the non-recovery discharge rate was 0.46%.

2.7 Aortic and Peripheral Vascular Disease

2.7.1 Aortic Disease HQMS data show that in 2022, 3,722 hospitals provided aortic disease diagnosis and treatment services, accounting for 65.9% of hospitals providing CVD services. In 2022, 128,000 aortic disease inpatients were admitted (with aortic disease as primary diagnosis and age $ $18 years), accounting for 0.2% of CVD inpatients. Aortic dissection accounted for the highest proportion (48.2%), followed by aortic aneurysm (23.1%).

In 2022, approximately 28,000 inpatients had aortic dissection as the primary diagnosis, and 13,000 had unspecified dissection types. The mean age was (58.2$±$13.8) years, with women accounting for 24.7%. The most common comorbidity was hypertension (76.5%), followed by liver disease (16.3%). In 2022, 30.0% of aortic dissection inpatients underwent endovascular surgery, 19.2% underwent open surgery, and 50.8% did not undergo surgery. The inpatient mortality rate was 4.8%, and the non-recovery discharge rate was 16.6%. For type A dissection, the inpatient mortality rate was 9.2% and non-recovery discharge rate was 24.0%; for type B dissection, these were 1.7% and 10.8%, respectively.

HQMS data show that in 2022, 2,244 hospitals provided aortic aneurysm diagnosis and treatment services, accounting for 39.8% of hospitals providing CVD services. In 2022, 31,000 inpatients had aortic aneurysm as the primary diagnosis, with a mean age of (67.5$±$12.2) years and women accounting for 20.6%. Hypertension was the most common comorbidity (59.6%), followed by stroke (19.5%). In 2022, 42.5% of aortic aneurysm inpatients underwent endovascular surgery, 13.5% underwent open surgery, and 44.0% did not undergo surgery. The inpatient mortality rate was 0.8%, and the non-recovery discharge rate was 7.5%.

A multicenter registry study of 1,058 patients with acute type A aortic dissection between 2018 and 2021 showed that the time from onset to presentation was 10.65 hours, and from presentation to surgery was 13 hours. Full arch replacement was performed in 88.7% of cases, and frozen elephant trunk stent surgery in 75.6%. The postoperative inpatient mortality rate was 7.6% [59].

2.7.2 Peripheral Vascular Disease HQMS data show that in 2022, 3,262 hospitals provided diagnosis and treatment services for carotid atherosclerotic stenosis/occlusive disease, accounting for 57.8% of hospitals providing CVD services. These hospitals admitted 171,000 inpatients, with a mean age of (58.2$±$13.8) years and women accounting for 24.7%. Surgical treatment was performed in 47,000 cases (27.66%), carotid intervention in 38,000 cases (22.2%), and carotid open surgery in 9,647 cases (5.6%). The postoperative inpatient mortality rate was 0.7%, and the non-recovery discharge rate was 2.2%.

HQMS data show that in 2022, 4,098 hospitals provided diagnosis and treatment services for lower extremity varicose veins, accounting for 72.6% of hospitals providing CVD services. These hospitals admitted 174,000 inpatients, with a mean age of (58.8$±$11.2) years and women accounting for 43.4%. Surgical treatment

was performed in 150,000 patients (86.4%), including 131,000 conventional stripping procedures (75.1%), 17,000 radiofrequency ablations (10.0%), and 38,000 laser procedures (21.7%).

2.8 Pulmonary Hypertension and Venous Thromboembolism

2.8.1 Pulmonary Hypertension HQMS data show that in 2022, 4,875 hospitals admitted pulmonary hypertension inpatients, accounting for 86.3% of hospitals admitting CVD inpatients. These hospitals admitted 1.131 million adult pulmonary hypertension inpatients (with pulmonary hypertension in discharge diagnosis and age $ 18*years*), *accountingfor*1.9±$19.1) years, with women accounting for 48.2%. The inpatient mortality rate was 1.6%, and the non-recovery discharge rate was 9.9%.

The distribution of pulmonary hypertension types (group 1: pulmonary arterial hypertension; group 2: pulmonary hypertension due to left heart disease; group 3: pulmonary hypertension due to lung disease and/or hypoxia; group 4: pulmonary hypertension due to pulmonary artery obstruction; group 5: pulmonary hypertension with unclear and/or multifactorial mechanisms) was 7.6%, 33.0%, 23.1%, 2.0%, and 4.8%, respectively, with 29.5% unclassifiable. Right heart catheterization was performed in 1.0% of the total pulmonary hypertension population, with rates of 6.6%, 0.5%, 0.3%, 7.2%, and 0.2% in groups 1–5, respectively.

An observational cohort study explored the efficacy and safety of percutaneous transluminal pulmonary angioplasty (PTPA) for Takayasu arteritis-pulmonary hypertension (TA-PH). Between January 2016 and December 2019, 50 TA-PH patients who underwent PTPA and 21 who declined PTPA were included. During a mean follow-up of (37$±$14) months, 3 patients (6.0%) in the PTPA group died and 1 had complications, while 6 patients (28.6%) in the non-PTPA group died. Cox regression analysis showed that PTPA was associated with significantly reduced all-cause mortality in TA-PH patients (RR=0.18, 95% CI=0.05–0.73, P=0.017) [60].

2.8.2 Venous Thromboembolism HQMS data show that in 2022, 4,516 hospitals admitted pulmonary embolism (PE) inpatients, accounting for 80.0% of hospitals admitting CVD inpatients. These hospitals admitted 260,000 adult PE inpatients (with PE in discharge diagnosis and age $ $18 years), accounting for 0.4% of CVD inpatients. A total of 5,092 hospitals (90.2%) admitted 1.321 million adult deep venous thrombosis (DVT) inpatients, accounting for 2.2% of CVD inpatients.

The inpatient mortality rate was 6.0% for PE patients and 2.0% for DVT patients; non-recovery discharge rates were 15.9% and 9.7%, respectively. Among PE patients, 56.1% had a history of surgery, 35.3% had comorbid DVT, and 25.0% had comorbid malignancy. Among DVT inpatients, 64.1% had a history of surgery, 6.9% had comorbid PE, and 26.8% had comorbid malignancy. Dur-

ing hospitalization, 2.8% of PE patients received catheter-directed thrombolysis, while 1.7% of DVT patients received catheter-directed thrombolysis and 7.0% had venous filters placed.

2.9 Cardiomyopathy

HQMS data show that in 2022, 4,928 hospitals admitted cardiomyopathy inpatients (with cardiomyopathy in primary or other diagnosis), accounting for 86.3% of hospitals admitting CVD inpatients. These hospitals admitted 562,000 cardiomyopathy inpatients, with cardiomyopathy as the primary diagnosis in 26.6%. Dilated cardiomyopathy (DCM) accounted for the highest proportion (69.9%), followed by hypertrophic cardiomyopathy (HCM, 18.6%). Women accounted for 34.4% of cardiomyopathy inpatients.

Among DCM inpatients with secondary causes (103,000 cases), anemic heart disease was most common (45.1%), followed by uremic cardiomyopathy (21.5%). Among 6,261 inpatients with secondary HCM, Fabry disease was most common (37.7%), followed by cardiac amyloidosis (22.1%). Over 80% of inpatients had comorbid HF, 25.7% had atrial fibrillation or atrial flutter, 7.5% had ventricular tachycardia, and 9.5% had pulmonary hypertension.

The inpatient mortality rate for cardiomyopathy patients was 1.3%, and the non-recovery discharge rate was 8.0%. Myocardial biopsy was performed in 835 cases at 107 hospitals, accounting for 0.56% of inpatient episodes with cardiomyopathy as the primary diagnosis. Hospitals performing endomyocardial biopsy accounted for 2.2% of all hospitals treating cardiomyopathy. ICD therapy was performed in 0.5% of cardiomyopathy patients, and cardiac resynchronization therapy (CRT/CRT-D) in 0.6%.

Chinese scholars pioneered transapical beating-heart septal myectomy (TABSM). The first-in-human study included 47 patients with drug-refractory symptomatic obstructive HCM, with surgical success achieved in 42 cases at 3 months postoperatively [61].

2.10 Cardiac Rehabilitation

HQMS data show that in 2022, HF patients received rehabilitation services 1.094 million times, followed by post-PCI patients (339,000 times), post-valvular surgery patients (45,000 times), and post-CABG patients (34,000 times.

HQMS data show that in 2022, the average length of stay for CABG patients who received rehabilitation was 11.2 days, compared with 17.8 days for those who did not. For valvular surgery patients, the average length of stay was 11.3 days with rehabilitation versus 17.4 days without.

2.11 Obstructive Sleep Apnea

HQMS data show that in 2022, 4,051 hospitals provided OSA diagnosis and treatment services, accounting for 71.7% of hospitals providing CVD services.

Among them, 1,017 hospitals (25.1%) could perform overnight sleep breathing monitoring, and 1,695 (41.8%) could provide non-invasive positive pressure ventilation therapy. In 2022, 276,000 CVD inpatients (with OSA in discharge diagnosis and age $ 18*years*)*wereadmitted*, *accountingfor*0.5±$15.1) years, with women accounting for 27.5%.

The top four comorbidities among OSA inpatients were hypertension (77.9%), CHD (34.8%), HF (21.3%), and arrhythmia (21.1%). Among 276,000 CVD inpatients with OSA, 18,000 (6.5%) received non-invasive positive pressure ventilation during hospitalization. The non-recovery discharge rate was 3.5%, and the mortality rate was 0.39%.

HQMS data show that in 2022, fewer than 30% of hospitals providing CVD services in China performed overnight sleep breathing monitoring, and only about 0.5% of CVD inpatients were diagnosed with OSA.

A cohort study of 2,031 adult patients with hypertension and OSA found that during a median follow-up of 6.8 years, 317 (15.61%) experienced cardiovascular events, including 198 (9.75%) with CHD and 119 (5.86%) with stroke. The study found that each standard deviation increase in the metabolic score for insulin resistance (METS-IR) was associated with a 30% increase in new overall cardiovascular events, 32% increase in new CHD, and 27% increase in new stroke [62].

2.12 Chronic Kidney Disease

HQMS data show that in 2022, among hospitals admitting cardiac patients, 5,375 (95.2%) could diagnose CKD, 4,687 (83.0%) could diagnose acute kidney injury (AKI), 3,260 (57.7%) could perform hemodialysis, 1,551 (27.5%) could perform peritoneal dialysis, and 2,663 (47.2%) could perform continuous renal replacement therapy.

In 2022, 6.211 million CVD inpatients had comorbid CKD, 341,000 had AKI, 815,000 received hemodialysis, 176,000 received peritoneal dialysis, and 160,000 received continuous renal replacement therapy. CKD prevalence was 21.0% in HF patients, 17.6% in atrial fibrillation patients, 17.0% in valvular heart disease patients, and 15.6% in AMI patients. Among CKD patients, 69.3% were diagnosed with chronic renal insufficiency or chronic renal failure, and comorbidities included hypertension (78.8%), diabetes (32.6%), and renal artery stenosis (0.5%).

In 2022, CVD inpatients with comorbid CKD had higher inpatient mortality rates (2.5% vs 0.9%), non-recovery discharge rates (10.6% vs 6.3%), AKI incidence (1.1% vs 0.6%), and longer hospital stays (8 vs 7 days) than those without CKD.

A nationwide multicenter prospective cohort study (2011–2016) included 12,523 untreated CKD patients and followed them for 43,970 person-years. It found

that CKD patients with blood pressure $ $130/90 mmHg had significantly increased risk of cardiovascular events (including myocardial infarction, stroke, HF hospitalization, or cardiovascular death) and renal events (including estimated glomerular filtration rate decline $ $20%, end-stage renal disease, and renal death), with risk increasing with blood pressure level. Compared with systolic blood pressure of 90–119 mmHg, those with 130–139 mmHg had cardiovascular and renal event HRs (95% CI) of 1.60 (1.06–2.43) and 1.35 (1.05–1.74), respectively. Compared with diastolic blood pressure of 50–69 mmHg, those with 90–99 mmHg had cardiovascular and renal event risks of 1.51 (1.10–2.06) and 1.40 (1.11–1.76), respectively [63].

2.13 Stroke

HQMS data show that in 2022, 5,501 hospitals admitted stroke inpatients (with cerebral infarction, intracerebral hemorrhage, or subarachnoid hemorrhage in discharge diagnosis), including 2,133 tertiary and 3,368 secondary hospitals. In 2022, 12.762 million stroke inpatients were admitted, with cerebral infarction accounting for 92.7%. Stroke was the primary diagnosis in 49.7% of all stroke patients. The mean age of stroke inpatients was (68.5$±$12.0) years, with an inpatient mortality rate of 1.3% and non-recovery discharge rate of 8.6%.

Hypertension, CHD, and diabetes were the most common comorbidities in stroke inpatients, accounting for 66.6%, 29.1%, and 25.6%, respectively.

A randomized controlled trial conducted at 44 Chinese hospitals included 810 patients with acute large-vessel occlusive ischemic stroke who had complete revascularization and sustained systolic blood pressure $ $140 mmHg for at least 10 minutes within 3 hours. Patients were randomized to intensive blood pressure control (target <120 mmHg) or standard control (140–180 mmHg). The study found that compared with standard control, intensive control increased the risk of poor 90-day outcomes (OR=1.37, 95% CI=1.07–1.76), early neurological deterioration (OR=1.53, 95% CI=1.18–1.97), and higher 90-day disability rates (OR=2.07, 95% CI=1.47–2.93), with no difference in symptomatic hemorrhagic transformation. The results confirmed that reducing systolic blood pressure below 120 mmHg after acute revascularization is not reasonable [64].

A prospective, open-label, randomized controlled trial at 46 Chinese medical centers included 456 patients with anterior circulation large-vessel acute occlusion and Alberta Stroke Program Early CT Score of 3–5 or infarct core volume of 70–100 ml. Patients were randomized 1:1 to endovascular treatment (EVT) plus medical therapy (231 cases) or medical therapy alone (225 cases). About 28% in each group received intravenous thrombolysis. At day 90, EVT resulted in better modified Rankin Scale score distribution than medical therapy alone (OR=1.37, 95% CI=1.11–1.69, P=0.004). Symptomatic intracranial hemorrhage occurred in 14 patients (6.1%) in the EVT group and 6 (2.7%) in the medical group, with intracranial hemorrhage in 113 (49.1%) and 39 (17.3%), respectively. The study suggested that EVT within 24 hours improves out-

comes in acute ischemic stroke with large infarct, but with more intracranial hemorrhage [65].

3. CVD Research

3.1 Basic Research

High-level CVD basic research in mainland China began after 2005, with influential papers published in *Circulation*, *Circulation Research*, *Signal Transduction and Targeted Therapy*, *Cell Discovery*, and *Nature Communications*. Data from these journals and *European Heart Journal* and *Cardiovascular Research* show rapid development of high-level cardiovascular basic research in China in recent years.

Between 2022 and 2023, 97 basic research papers with corresponding and first authors from mainland China explored cardiac and vascular anatomy, development, function/pathogenesis, covering myocardial infarction, HF, ischemia-reperfusion injury, cardiomyopathy, cardiac remodeling, aortic dissection, atherosclerosis, and vascular remodeling. Hot topics included cardiac protection and regeneration and gene therapy.

3.2 Clinical Research

CVD research in China has shown vigorous development in recent years, with increasing quantity and quality. China currently ranks second globally in CVD publications, after the United States, with a higher growth rate since 2018. The most active subspecialties are CHD, hypertension, arrhythmia, and HF, with CHD and hypertension publication numbers already exceeding those from the United States.

In 2022, 14 clinical research articles were published in the six highest-impact general medical journals and four cardiovascular specialty journals. Randomized controlled clinical trials were the most common type, followed by large prospective cohort studies, reflecting a shift in focus from understanding disease patterns to scientifically evaluating intervention effects. These studies assessed treatment protocols based on clinical practice or preventive measures based on China's national conditions.

Between August 5, 2022, and July 31, 2023, the National Medical Products Administration approved 68 medical devices for innovative device evaluation, including 42 cardiovascular products (61.5%), demonstrating cardiovascular innovation's dominance in China's medical device innovation field. Of these, 67 were domestically developed original products (98.5%). During the same period, 196 cardiovascular Class III medical device registrations were approved, including 156 domestic products, with 4 having previously entered the national innovative device evaluation channel. Among the 156 domestic products, 125 were interventional, 4 imaging, 6 hemodynamic measurement systems, 4 open

surgical products, 3 active surgical products, 6 AI software, and 8 diagnostic products.

4. Cardiovascular Health Economics

4.1 Economic Burden

In 2022, the total number of discharges for cardiovascular and cerebrovascular diseases was 27.6498 million, accounting for 15.36% of all discharges, including 14.8723 million CVD cases (8.26%) and 12.7775 million cerebrovascular disease cases (7.10%) (Figure 17 [Figure 17: see original paper]). The main conditions were ischemic heart disease (9.449 million, including 4.1678 million angina and 1.148 million AMI) and cerebral infarction (8.6243 million), accounting for 34.17% and 31.19%, respectively (Figure 18 [Figure 18: see original paper]).

In 2022, among CHD inpatients with CHD as the primary diagnosis, unstable angina accounted for the highest proportion of total hospitalization costs (38.6%, ¥35.93 billion), followed by unclassified CHD (18.8%, ¥17.54 billion), STEMI (15.2%, ¥14.19 billion), NSTEMI (11.5%, ¥10.67 billion), stable angina (10.8%, ¥10.08 billion), AMI (3.1%, ¥2.89 billion), and acute coronary syndrome (2.0%, ¥1.88 billion) (Figure 19 [Figure 19: see original paper]).

In 2022, the average per-hospitalization cost for CVD patients with CVD as the primary diagnosis was ¥17,312.8. Valvular heart disease had the highest average cost (¥64,375.7), followed by arrhythmia (¥28,421.4), CHD (¥15,212.3), HF (¥10,156.7), and hypertension (¥7,135.1). For CHD and valvular heart disease, material costs accounted for a higher proportion of total costs than other expenses, while diagnostic fees accounted for a higher proportion in HF, arrhythmia, and hypertension. Additionally, surgical treatment and material fees were higher than non-surgical fees in CHD, arrhythmia, and valvular heart disease, but this trend was not observed in hypertension and HF (Figure 20 [Figure 20: see original paper]).

4.2 Health Economics Evaluations

A health economics evaluation based on the CORE Diabetes Model showed that compared with biphasic insulin aspart 30 (BIAsp30), insulin degludec/insulin aspart (IDegAsp) treatment for Chinese patients with type 2 diabetes increased quality-adjusted life years (QALYs) by 0.280 over 30 years, with total costs increasing by ¥3,888. The incremental cost-effectiveness ratio (ICER) was ¥13,886/QALY. IDegAsp was associated with increased treatment costs but saved complication costs. At a willingness-to-pay threshold of ¥80,976/QALY, IDegAsp was a cost-effective treatment option compared with BIAsp30 for Chinese patients with type 2 diabetes with inadequate basal insulin control [66].

Endovascular therapy within 24 hours has been proven to improve outcomes in acute ischemic stroke with large infarct. A health economics evaluation showed that compared with medical management alone, endovascular therapy for acute

ischemic stroke with large infarct became cost-effective from year 4 and over a lifetime. Over the long term, endovascular therapy produced 1.33 QALY lifetime benefit at an additional cost of ¥73,900 (US$11,400), with an ICER of ¥55,500 (US$8,530). At a willingness-to-pay threshold of ¥243,000/QALY (3 times China's per capita GDP in 2021), probabilistic sensitivity analysis showed endovascular therapy was cost-effective in 99.5% of simulation runs. Thus, endovascular therapy for acute ischemic stroke with large infarct is cost-effective in China [67].

A health economics evaluation based on the COMPASS trial showed that in Chinese patients with stable CVD, low-dose rivaroxaban plus aspirin had an incremental cost of US$7,937.30 per QALY gained compared with aspirin alone, while rivaroxaban alone had an incremental cost of US$15,045.78 per QALY gained. At a willingness-to-pay threshold of US$11,000, low-dose rivaroxaban plus aspirin may be cost-effective for secondary prevention in stable CVD patients [68].

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