ORIGINAL RESEARCH

Six-Year Incidence of Cardiometabolic Risk Factors in a Population-Based Cohort of Chinese Adults Followed From 2009 to 2015

Yiqing Wang, BS; Huijun Wang, PhD; Annie Green Howard, PhD; Linda S. Adair, PhD; Barry M. Popkin, PhD; Chang Su, PhD; Wenwen Du, PhD; Bing Zhang, PhD; Penny Gordon-Larsen PhD

***Background*—**China faces a substantial burden from cardiometabolic diseases, but longitudinal studies on a wide range of cardiometabolic risk factors are limited. We examined the 6-year incidence of 8 cardiometabolic risk factors in a diverse, population-based cohort.

***Methods and Results*—**In the China Health and Nutrition Survey, anthropometry, blood pressure, and fasting blood samples were collected from 9621 adults (47.6% men) aged 18 to 99 years in 2009 who were followed into 2015. Using inverse probability weights to account for loss to follow-up, we estimated the 6-year incidence of 8 cardiometabolic risk factors and compared the incidence of each risk factor across age groups using inverse probability–weighted sex-stratified logistic regression models. Incidence was noted for the following cardiometabolic risk factors during 2009–2015: hypertension (systolic/diastolic blood pressure ≥140/90 mm Hg; men: 29.2%; women: 24.9%), high waist circumference/height ratio (≥0.5; men: 42.4%; women: 43.8%), and high total to HDL (high-density lipoprotein) cholesterol ratio (≥5; men: 17.0%; women: 14.5%). Older men and women (aged ≥65 years) had the highest incidence of hypertension. Incidence of high waist circumference/height ratio and high LDL (low-density lipoprotein) cholesterol (≥130 mg/dL) was highest among older (aged ≥65 years) women, whereas incidence of overweight (body mass index ≥25) and high triglycerides (≥150 mg/dL) was highest among younger (aged 18–35 and 35–50 years) men.

***Conclusions*—**We found increases in cardiometabolic risk among Chinese adults during this recent, short, 6-year period that are higher than previous studies in China. The higher incidence of overweight and elevated dyslipidemia markers in younger versus older men portends an increasing burden of cardiometabolic diseases in China as the younger population ages. **(*J Am Heart Assoc*. 2019;8:e011368. DOI: 10.1161/JAHA.118.011368.)**

Key Words: cardiovascular disease risk factors • Chinese adults • incidence

The burden of cardiometabolic risk in China has expanded rapidly. Mortality from cardiometabolic diseases such as type 2 diabetes mellitus, cardiovascular disease (CVD), and coronary heart disease has increased,[1] and CVD is now the leading cause of death.[2] Moreover, the prevalence of major cardiometabolic risk factors in Chinese adults has risen considerably: combined overweight and obesity increased from 13.4% in 1993 to 26.4% in 2009[3]; abdominal obesity increased from 18.6% in 1993 to 37.4% in 2009[3]; hypertension increased from 14.5% in 1991 to 21.4% in 2009[4]; and type 2 diabetes mellitus increased from 9.7% in 2007 to 11.6% in 2010.[5,6] By 2010, China already had the largest absolute disease burden of diabetes mellitus[5] and hypertension[7] in the world. Approximately 114 million Chinese adults had diabetes mellitus and 265 million had hypertension in 2010. Changes in social and behavior factors, such as population aging, rapid urbanization, and unhealthy lifestyles characterized by physical inactivity and poor diet[2,8] have contributed to the high cardiometabolic risk in Chinese adults.

Although others have reported the prevalence of a wide range of cardiometabolic risk factors in Chinese adults,[4,5,9–11] few longitudinal studies have investigated the incidence of

From the Department of Nutrition, Gillings School of Global Public Health & School of Medicine (Y.W., L.S.A., B.M.P., P.G.-L.), Department of Biostatistics, Gillings School of Global Public Health (A.G.H.), and Carolina Population Center (A.G.H, L.S.A., B.M.P., P.G.-L.), University of North Carolina at Chapel Hill, NC; National Institute for Nutrition and Health, Chinese Center for Disease Control and Prevention, Beijing, China (H.W., C.S., W.D., B.Z.).

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Correspondence to: Penny Gordon-Larsen, PhD, University of North Carolina at Chapel Hill; Carolina Population Center, 123 West Franklin Street, Chapel Hill, NC 27516. E-mail: pglarsen@unc.edu

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Clinical Perspective

What Is New?

- Our study adds incidence data for a wide range of cardiometabolic risk factors in a diverse, population-based cohort in China with a recent time frame compared with previous studies focused on single cardiometabolic risk factors.
- We found an increase in the incidence of cardiometabolic risk factors during the past decade in China.

What Are the Clinical Implications?

- Understanding patterns of cardiometabolic risk in the understudied Asian population is important for Asians across the globe, including those in the United States.
- The distinct patterns of cardiometabolic risk by sex and age group suggest that sex- and age-specific strategies may be needed to address cardiometabolic diseases in Asian populations.
- The higher incidence of overweight and elevated dyslipidemia markers in younger versus older men portends an increasing future burden of cardiometabolic diseases, which is a major concern for the Chinese healthcare system, and understanding the cardiometabolic risk in China during rapid urbanization has huge implications for other low- to middle-income countries experiencing rapid urbanization.

cardiometabolic risk factors, and most were limited to overweight,[12] hypertension,[13,14] and type 2 diabetes mellitus[15–20] and reflected risk in 1 region.[15–17] Fundamental gaps exist in knowledge about the emergence of cardiometabolic risks in the full population and how these risks differ by sex and age, and this lack limits the ability to plan for the reduction of disease and disability as the current population ages. Using the most recent rounds of fasting blood collection in the longitudinal and population-based CHNS (China Health and Nutrition Survey; 2009 and 2015), we estimated the sex- and age-specific 6-year incidence of overweight; high waist circumference (WC)/height ratio (WHR); hypertension; type 2 diabetes mellitus; and elevated high sensitivity CRP (C-reactive protein), LDL-C (low-density lipoprotein cholesterol), triglycerides, and ratio of total cholesterol (TC) to HDL-C high-density lipoprotein cholesterol in 9621 Chinese adults aged 18 to 99 years from 2009 to 2015, with inverse probability weighting (IPW) to account for loss to follow-up.[21]

Methods

The data, analytic methods, and study materials are available to other researchers for purposes of reproducing the results or replicating the procedure. The CHNS data can be accessed at the CHNS website (https://www.cpc.unc.edu/projects/china).

China Health and Nutrition Survey

The CHNS is a longitudinal study of 388 communities within 15 provinces and cities of China. The CHNS began in 1989, with subsequent surveys every 2 to 4 years for a total of 10 rounds of surveys through 2015, with fasting blood collected in 2009 and 2015. Individuals from 3 megacities (autonomous cities with populations of more than 20 million people) and 3 of the 12 provinces were added to the sample after 2009 and thus cannot contribute to incidence estimates from 2009 and 2015. Consequently, only individuals in the 9 primary provinces (Liaoning, Shandong, Heilongjiang, Henan, Jiangsu, Hubei, Hunan, Guizhou, and Guangxi), who were followed from 2009 to 2015, were included in this analysis. The CHNS was designed to examine rapid urbanization and its impacts on health across diverse communities in China.[22] The study used a multistage, random-cluster design to select a stratified probability sample to capture rural/urban contrasts within each province. The CHNS provinces reflect 47% of the Chinese population, with sample selection focused on representation of urban and rural communities across China.[23] The CHNS provinces vary in industrialization, lifestyle, income, and population density as well as geography, economy, resources, health, and behaviors, capturing the diversity of China across rural and urban areas and over time. More detailed survey procedures have been described elsewhere.[22] All participants signed informed consent before participating in the survey. The study met the standards for the ethical treatment of participants and was approved by the institutional review boards of the University of North Carolina at Chapel Hill, the China–Japan Friendship Hospital, the Ministry of Health of China, and the Institute of Nutrition and Health, Chinese Center for Disease Control and Prevention.

Analytic Sample

The 2009 CHNS included 12 133 participants. Participants were eligible for the analytic sample if they were between the ages of 18 and 99 years and had at least 1 of the following measures in 2009: body mass index (BMI), WC and height, systolic blood pressure (SBP) and diastolic blood pressure (DBP), CRP, HbA1c or fasting glucose, fasting TC and HDL-C, fasting LDL-C, or fasting triglycerides. These criteria resulted in an eligible sample of 9699 participants. We excluded women pregnant at the time of the 2009 examination (n=62) and participants missing any of the following covariates in 2009: age, sex, educational attainment, per capita household income, household asset score, and urbanization index (n=16). These criteria resulted in an analytic sample of 9621 participants for the 2009 cross-sectional prevalence sample. Of these 9621 participants, we excluded 3920 who were lost to follow-up between 2009 and 2015 and 2 participants who were pregnant at the 2015 physical

examination for our 2015 cross-sectional prevalence sample (n=5699). Of these 5699 participants, we excluded individuals who had cardiometabolic risk factors above thresholds of risk at baseline (2009) for incidence analysis of cardiometabolic risk factors, resulting in an incidence sample of 5540 participants (ie, participants in the incidence analysis had to be free of baseline cardiometabolic risk to generate incidence statistics). The sample flow is shown in Figure 1.

Outcome Measures

We measured height without shoes to the nearest 0.1 cm using portable stadiometers, weight to the nearest 0.1 kg in light clothing using calibrated beam scales, and WC to the nearest 0.1 cm at midway between the lowest rib and iliac crest using nonelastic tape. According to the World Health Organization (WHO), we defined overweight as BMI (kg/m^2) ≥25.[24] In the sensitivity analysis, we defined overweight as BMI ≥23 based on the Asian cutoff point[24] to examine whether different overweight definitions resulted in different patterns of overweight prevalence and incidence by sex and age groups. We defined high WHR as WHR ≥0.5, the standard cut point for abdominal obesity,[25] shown to predict CVD and diabetes mellitus.

Blood pressure was measured 3 times on the right arm after 10 minutes of seated rest by trained examiners using standard mercury sphygmomanometers. We defined hypertension as the average of 3 measurements of SBP/DBP ≥140/90 mm Hg according to WHO[26] or self-reported use of antihypertension medications. Blood was collected by venipuncture (12 mL) following 8-hour fasting and was immediately tested for serum glucose using the GOD-RAP method (Randox Laboratories). The remaining samples were immediately frozen, stored, and processed in a national central laboratory in Beijing (medical laboratory accreditation certificate ISO 15189:2007) with strict quality control. HbA1c was measured by an automated glycohemoglobin analyzer with a high-performance liquid chromatography system (model HLC-723 G7; Tosoh Corp). We defined type 2 diabetes mellitus as HbA1c ≥6.5% or fasting glucose ≥126 mg/dL according to the American Diabetes Association[27] or self-reported use of diabetes mellitus medication. CRP was measured by the immunoturbidimetric method with Denka Seiken reagents (Hitachi 7600 automated analyzer). We defined high CRP as >3 and ≤10 mg/L, a marker of chronic low-grade inflammation[28] and a stronger risk factor for coronary heart disease events,[29] and excluded individuals with CRP >10 mg/L in the estimations of the prevalence and incidence of high CRP because CRP>10 mg/L indicates acute infection.[28] HDL-C, LDL-C, and triglycerides were estimated using the glycerol–phosphate oxidase method and the polyethylene glycol–modified enzyme assay by determiner reagents (Kyowa Medex) using a Hitachi 7600 automated analyzer. We defined TC/HDL-C ≥5, triglycerides ≥150 mg/dL, and LDL-C ≥130 mg/dL as high TC/HDL-C,[30,31] high triglycerides,[32] and high LDL-C,[32] respectively, which are dyslipidemia markers.

Predictors of Loss to Follow-up for IPW Analysis in the 2015 Cross-sectional and 2009–2015 Incidence Samples

The following covariates from the 2009 survey were used to derive the IPW, predicting loss to follow-up from 2009 to 2015: age, sex, urbanization index, educational attainment, per capita household income, household asset score, and province. We used a validated, community-level, multidimensional, 12-component, urbanization index[33] derived from household and community survey questions at each wave. We defined low, medium, and high urbanization based on tertiles of urbanization index in 2009. We categorized age in 2009 into 4 groups (18 to 35, 35 to 50, 50 to 65, ≥65 years) and dichotomized educational attainment as of 2009 to less than high school and high school or more. We imputed missing baseline education (n=46) based on education reported in other survey years, assuming it rarely changed during adulthood. We generated a household asset score representing the number of items from the following list: color TV, refrigerator, microwave oven, electric cooking pot, air conditioner, electric fan, computer, camera, telephone, cell phone, and video disk player. These items represented household wealth regardless of rural or urban area. For individuals missing household information (number of household members) in 2009, we imputed household size if it was the same in the 2 adjacent survey years (2006 and 2011, n=118) and subsequently excluded those with missing 2009 household size and unequal household sizes between 2006 and 2011 from the analysis due to missing covariates. We estimated income based on detailed reports of all income activities of all household members and imputed missing household income in 2009 (n=132) using single imputation from observed province, urbanicity, household asset score, education attainment, and household size in 2009 using Poisson regression. We defined low, medium, and high income levels using tertiles of per capita household income in 2009, which was calculated by dividing household income by household size.

Statistical Analyses

Prevalence

We conducted all statistical analyses using Stata 14 (StataCorp). We present continuous variables as mean (SD) and categorical variables as proportion (95% CI). We calculated crude 2009 prevalence of cardiometabolic risk factors and used

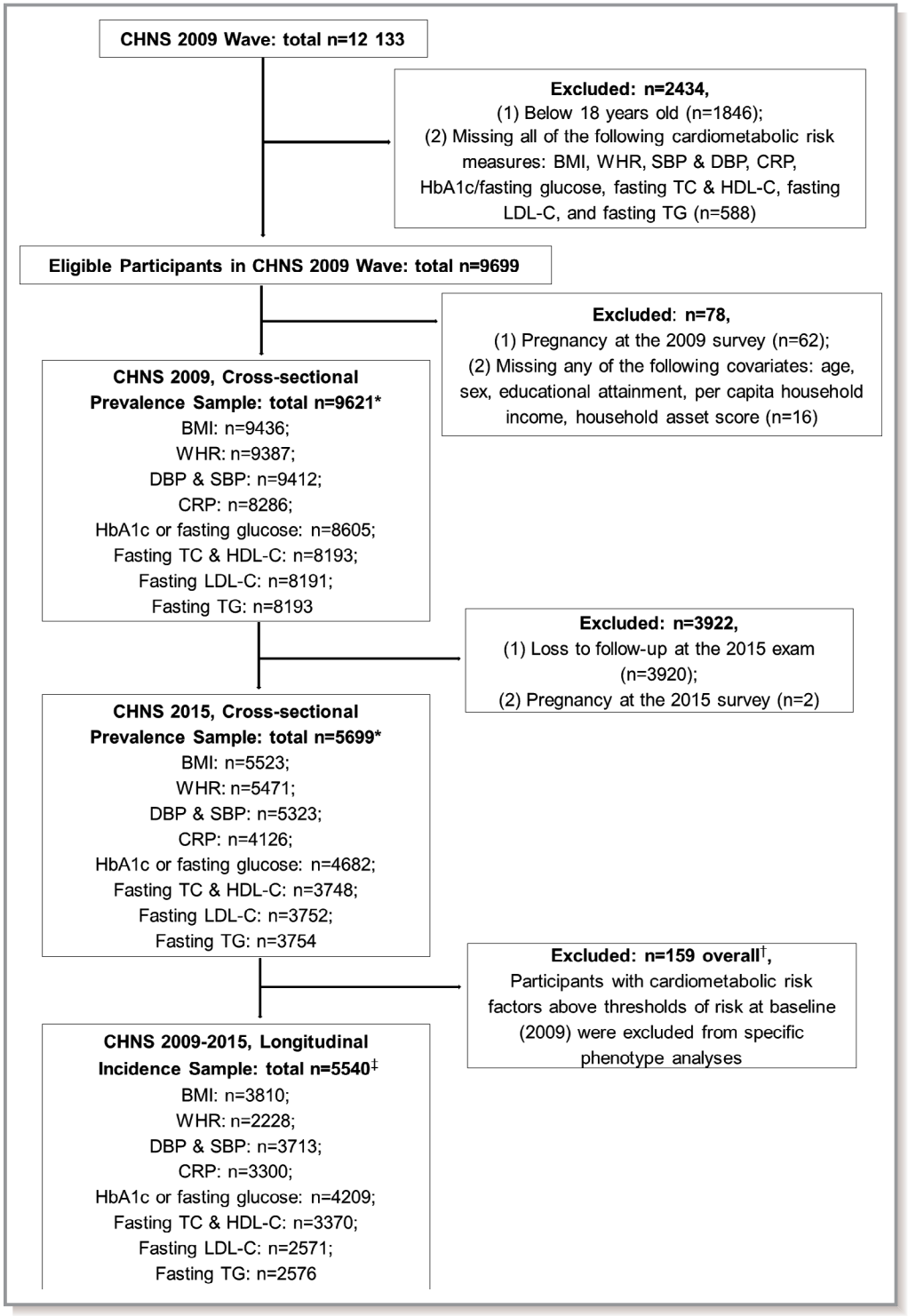

Figure 1. Sample flow diagram. *Total sample listed, note that specific cardiometabolic phenotypes have different sample sizes to allow for missingness across phenotypes. †We excluded 159 participants who were present in 2009 and 2015 but were above cardiometabolic risk thresholds for all available phenotypes at baseline (2009), thus they were excluded from all incidence analyses. ‡Total sample listed, note that specific cardiometabolic phenotypes have different sample sizes due to differences across these phenotypes in numbers of participants above baseline cardiometabolic risk thresholds for each phenotype (eg, 3810 participants had BMI <25 at baseline and thus were eligible for analysis of the incidence of overweight). BMI indicates body mass index; CHNS, Chinese Health and Nutrition Survey; CRP, high sensitivity C-reactive protein; DBP, diastolic blood pressure; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; SBP systolic blood pressure; TC, total cholesterol; TG, triglycerides; WHR, waist circumference/height ratio.

sex-stratified logistic regression to compare the 2009 prevalence of each cardiometabolic risk factor across age groups.

Incidence

In our longitudinal analysis, we used IPW to control for loss to follow-up in the period between 2009 and 2015 to calculate IPW prevalence of cardiometabolic risk factors in 2015, which comprised persistent cardiometabolic risk (ie, risk factors above cardiometabolic risk thresholds in 2009 that remained above threshold in 2015) and incident cardiometabolic risk (ie, risk factors below cardiometabolic risk thresholds in 2009 but increased above cardiometabolic thresholds in 2015), as well as incidence of cardiometabolic risk factors in the period between 2009 and 2015. To derive IPW, we used a probit model to create IPW for each cardiometabolic risk factor to account for loss to follow-up. The probability of having the risk factor data in 2015, given that the risk factor was measured in 2009, was predicted by the following baseline characteristics based on a priori hypotheses: sex, age, age squared, sex×age interaction, sex×age squared interaction, urbanization level, educational attainment, income level, household asset score, and province. We used a probit model to examine the associations of the above baseline characteristics with loss to follow-up from 2009 to 2015 for each cardiometabolic risk factor. We added each cardiometabolic risk factor to this model to confirm that cardiometabolic risk factors in 2009 did not predict the probability of loss to follow-up after adjustment for the baseline characteristics listed. However, the final IPW model did not include these cardiometabolic risk factors, only the covariates specified a priori. We used IPW and sex-stratified logistic regression to test the differences in 2015 prevalence of cardiometabolic risk factors (including proportions of persistent and incident cardiometabolic risk) and 2009–2015 incidence of cardiometabolic risk factors across age groups.

Total number of cardiometabolic risk factors

In a subsample of participants with all cardiometabolic risk factor data in the 2009 and 2015 CHNS surveys (n=3260), we estimated the average total number of cardiometabolic risk factors above risk factor thresholds for each sex and age group to test whether the total number of cardiometabolic risk factors increased from 2009 to 2015, using a paired *t* test.

Results

Crude Prevalence of Cardiometabolic Risk Factors in 2009

The 2009 crude prevalence of overweight, high WHR, hypertension, high CRP, high LDL-C, and high triglycerides was high across the full sample (Table) and varied by age group in both men and women (*P* value across age groups <0.001; Figure 2, Table S1). The highest prevalence of overweight, high TC/HDL-C, and high triglycerides occurred in middle-aged men (aged 35–50 years) and women aged ≥50 years. In the sensitivity analysis, the prevalence of overweight by Asian definition (BMI ≥23)[24] also differed by age group (*P*<0.001).

Loss to Follow-up

In 2015, 3920 (40.7%) adults in the 2009 analysis sample were lost to follow-up (Figure 1). Participants who were male, younger, lived in more urbanized areas, and had completed at least a high school education at baseline were more likely to be lost in 2015 (Table S2). The likelihood of loss to follow-up varied across provinces. Although we found no evidence that baseline household asset score and income level were associated with loss to follow-up, we retained these variables in the IPW model due to a priori assumptions. Moreover, no evidence was found that baseline cardiometabolic risk factors were associated with loss to follow-up after adjustment for other covariates.

IPW Prevalence of Cardiometabolic Risk Factors in 2015

The IPW 2015 prevalence of all cardiometabolic risk factors among individuals in the 2009 analysis sample differed across age groups (*P*<0.05) except for high TC/HDL-C in men (Figure 3, Table S3). The prevalence of high CRP was highest among young men (aged 18–35 years; 13.4% [95% CI, 7.8–22.3%]) and old men (aged ≥65 years; 13.7% [95% CI, 10.9–17.0%]), and the prevalence of high triglycerides was highest in men aged 35–50 years (39.2% [95% CI, 34.1–44.5%]), whereas the prevalence of overweight was lowest in men aged ≥65 years (32.7% [95% CI, 29.3–36.2%]). The proportions with persistent (ie, present in both years) overweight, high WHR, and high LDL-C were higher in older versus younger men and women (*P*<0.01), whereas the proportions of incident overweight and LDL-C in men and incident high WHR in women were higher in younger versus older participants (*P*<0.01).

IPW Incidence of Cardiometabolic Risk Factors From 2009 to 2015

We estimated the IPW-adjusted incidence of each cardiometabolic risk factor from 2009 to 2015 among individuals with cardiometabolic risk below cardiometabolic risk thresholds at baseline (2009). The IPW-adjusted incidence of high WHR, hypertension, type 2 diabetes mellitus, and dyslipidemia markers differed across age groups in women (*P*<0.01; Figure 4, Table S4), with particularly high incidence of high WHR (61.7% [95% CI, 50.8–71.5%]), hypertension (50.4% [43.6–57.2%]), and high LDL-C (35.2% [95% CI, 27.6–43.6%]) in women aged ≥65 years. The incidence of overweight,

Table. Characteristics of Participants in the 2009 CHNS

	Men, n=4584	Women, n=5037	Total, n=9621
Age, y, mean (SD)	50.2 (15.4)	50.9 (15.3)	50.6 (15.3)
Age distribution, % (95% CI)			
18–35 y	17.3 (16.2–18.4)	15.6 (14.6–16.6)	16.4 (15.7–17.1)
35–50 y	31.8 (30.5–33.2)	32.6 (31.3–33.9)	32.2 (31.3–33.2)
50–65 y	33.1 (31.8–34.5)	33.3 (32.0–34.6)	33.2 (32.3–34.2)
≥65 y	17.8 (16.7–18.9)	18.5 (17.5–19.6)	18.2 (17.4–19.0)
BMI, kg/m^2, mean (SD)	23.3 (3.4)	23.3 (3.5)	23.3 (3.5)
OW, % (95% CI)	29.4 (28.0–30.7)	29.3 (28.0–30.5)	29.3 (28.4–30.2)
WHR, mean (SD)	0.51 (0.1)	0.52 (0.1)	0.51 (0.1)
High WHR, % (95% CI)	53.0 (51.6–54.5)	60.5 (59.1–61.8)	56.9 (55.9–57.9)
SBP, mm Hg, mean (SD)	126.0 (17.3)	123.7 (20.0)	124.8 (18.8)
DBP, mm Hg, mean (SD)	82.1 (11.0)	79.2 (11.3)	80.6 (11.3)
Hypertension, % (95% CI)	31.9 (30.6–33.3)	27.6 (26.4–28.9)	29.7 (28.7–30.6)
CRP, mg/L, mean (SD)	1.7 (1.9)	1.7 (2.0)	1.7 (1.9)
High CRP, % (95% CI)	20.8 (19.5–22.1)	21.8 (20.6–23.0)	21.3 (20.5–22.2)
HbA1c, %, mean (SD)	5.6 (0.9)	5.6 (0.9)	5.6 (0.9)
Fasting glucose, mg/dL, mean (SD)	98.3 (28.0)	96.0 (23.2)	97.0 (25.6)
T2DM, % (95% CI)	11.2 (10.2–12.2)	9.7 (8.9–10.6)	10.4 (9.8–11.1)
Fasting TC/HDL-C, mean (SD)	3.7 (1.3)	3.5 (1.1)	3.6 (1.2)
High TC/HDL-C, % (95% CI)	13.4 (12.4–14.5)	8.3 (7.5–9.1)	10.5 (9.8–11.2)
Fasting LDL-C, mg/dL, mean (SD)	113.1 (37.4)	117.7 (38.2)	115.5 (37.9)
High LDL-C, % (95% CI)	28.2 (26.8–29.6)	33.5 (32.1–34.9)	31.0 (30.0–32.0)
Fasting TG, mg/dL, mean (SD)	158.7 (152.4)	137.5 (110.1)	147.4 (132.1)
High TG, % (95% CI)	34.6 (33.1–36.1)	28.9 (27.5–30.2)	31.6 (30.6–32.6)
Urbanization index (maximum 120 points),* mean (SD)	67.3 (19.4)	67.8 (19.4)	67.5 (19.4)
Per capita household income, yuan, mean (SD)	12 904.1 (20 176.5)	11 914.9 (17 037.1)	12 386.2 (18 604.7)
Household asset score (maximum 11 points),† mean (SD)	6.1 (2.4)	6.1 (2.4)	6.1 (2.4)
Educational attainment (high school and above), % (95% CI)	28.7 (27.4–30.1)	20.8 (19.7–21.9)	24.6 (23.7–25.4)

BMI indicates body mass index; CHNS, Chinese Health and Nutrition Survey; CRP, high sensitivity C-reactive protein; DBP, diastolic blood pressure; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density cholesterol; OW, overweight; SBP systolic blood pressure; TC, total cholesterol; TG, triglycerides; T2DM, type 2 diabetes mellitus; WHR, waist circumference/height ratio.

*Urbanization index is a 12-component scale with a maximum of 120 points that includes population density, economic activity, transportation infrastructure, sanitation, etc., to define and distinguish urbanicity.[33]

†Asset score ranges from 0 to 11, with each asset (color TV, refrigerator, microwave oven, electric cooking pot, air conditioner, electric fan, computer, camera, telephone, cell phone, and video disk player) worth 1 point.

hypertension, high LDL-C, and high triglycerides differed across age groups in men (P<0.05), with the highest incidence of overweight in young men (aged 18–35 years; 29.0% [95% CI, 23.3–35.4%]) and the highest incidence of high triglycerides in men aged 18 to 35 years (22.4% [95% CI, 15.3–31.6%]) and 35–50 years (23.9% [95% CI, 19.5–28.8%]). The incidence of overweight defined by Asian cutoff point[24] (BMI ≥23) and by WHO cutoff point (BMI ≥25) had similar patterns by sex and age groups.

Total Number of Cardiometabolic Risk Factors

In a subsample of participants who were seen in 2009 and 2015 and had data for all cardiometabolic risk factors (n=3206; Table S5), the average total number of cardiometabolic risk factors above risk factor thresholds increased from 2.23 (SD: 1.70) in 2009 to 2.62 (SD: 1.76) in 2015 in men (P<0.001) and from 2.27 (SD: 1.74) in 2009 to 2.60 (SD: 1.81) in 2015 in women (P<0.001). The age group–specific average number of cardiometabolic

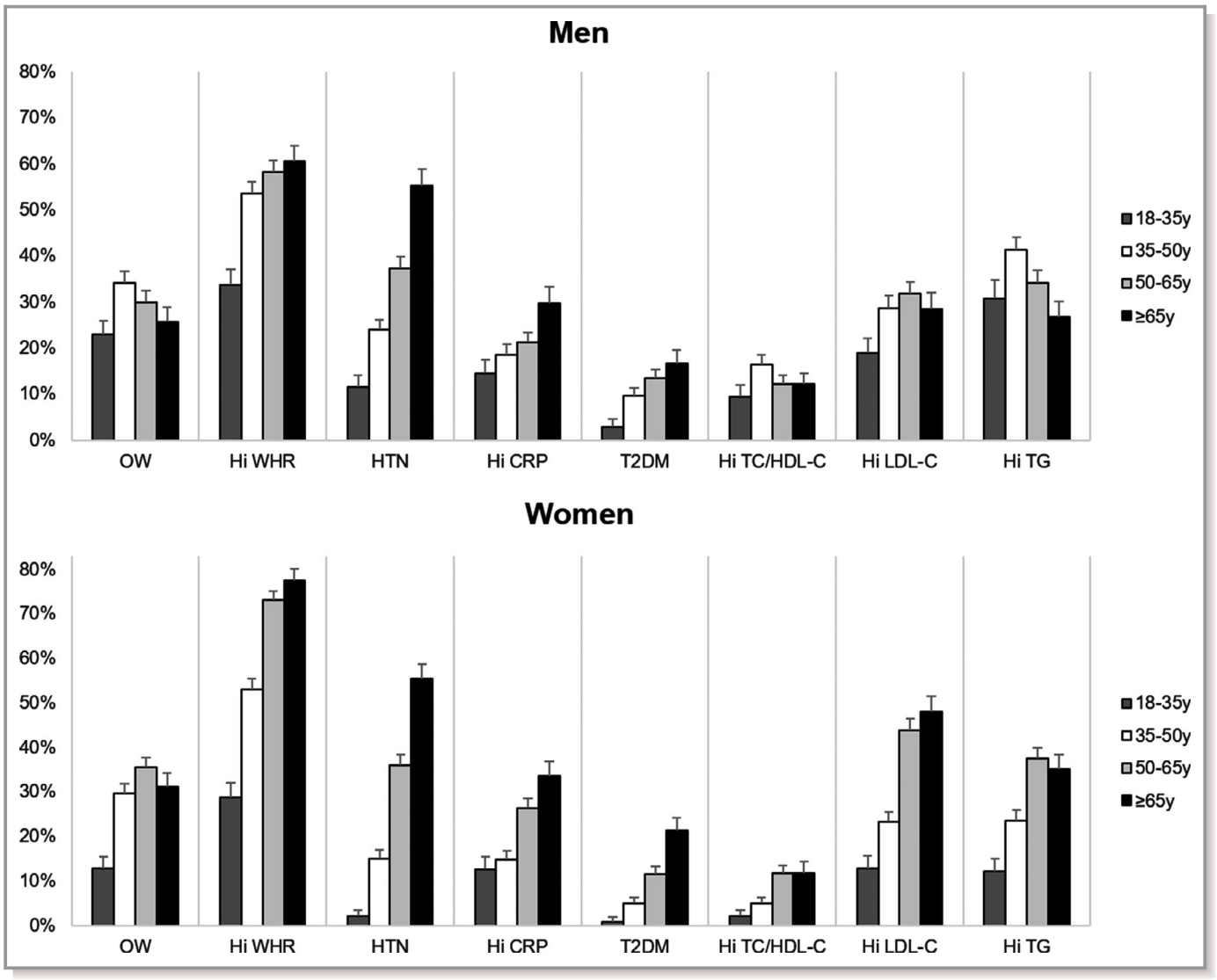

Figure 2. Crude 2009 prevalence of cardiometabolic risk factors (95% CI) by age at 2009 in adult men and women. All *P* values for difference across age groups <0.001. Hi CRP indicates high sensitivity C-reactive protein (3 mg/L to ≤10 mg/L); Hi LDL-C, high fasting low-density lipoprotein cholesterol (≥130 mg/dL); Hi TC/HDL-C, high ratio of fasting total cholesterol to fasting high-density lipoprotein cholesterol (≥5); Hi TG, high fasting triglycerides (≥150 mg/dL); Hi WHR, high waist circumference/height ratio (≥0.5); HTN, hypertension (systolic/diastolic blood pressure ≥140/90 mm Hg or antihypertension medication); OW, overweight (body mass index ≥25); T2DM, type 2 diabetes mellitus (HbA1c ≥6.5%, fasting glucose ≥126 mg/dL, or diabetes mellitus medication).

risk factors above risk factor thresholds also increased from 2009 to 2015 in men aged 18 to 35, 35 to 50, and 50 to 65 years and in women aged 35 to 50 and 50 to 65 years.

Discussion

We observed a higher incidence of cardiometabolic risk development in a recent population-based cohort of Chinese adults from the CHNS compared with previous studies with 5 to 9 years of follow-up.[14,18–20] These data portend an increasing burden of CVD in Chinese adults, and CVD is already the leading cause of death in China.[2] In only 6 years between 2009 and 2015, among women with cardiometabolic risk factors below cardiometabolic risk thresholds in 2009, a significant proportion of women (43.8%) developed high WHR, 24.9% developed hypertension, and 14.5% developed high TC/HDL-C. The incidence of high WHR (42.4%) during the same 6-year period was also high in men who had cardiometabolic risk factors below cardiometabolic risk thresholds in 2009, with 20.4% incident overweight and

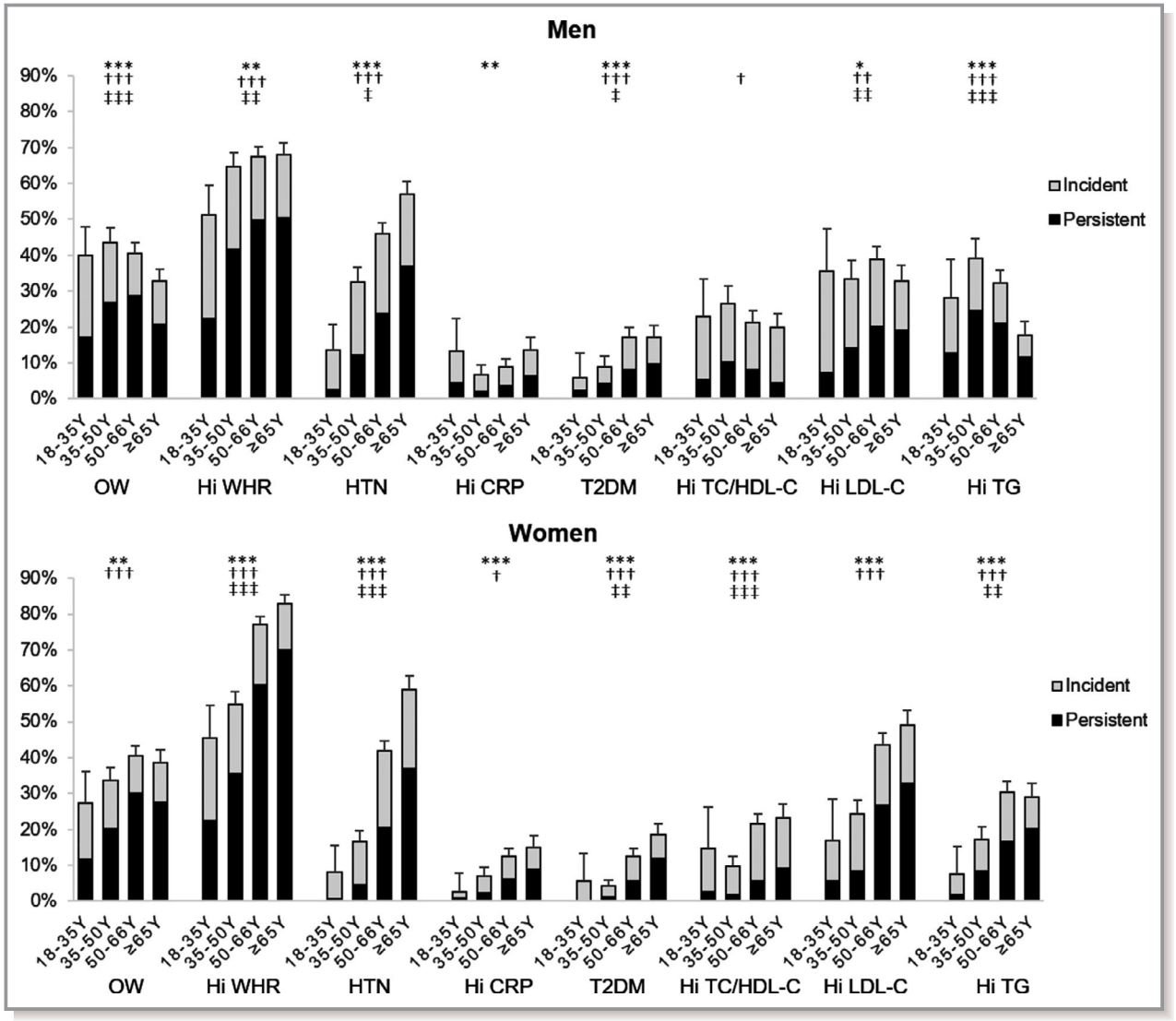

Figure 3. Inverse probability–weighted 2015 prevalence of cardiometabolic risk factors (95% CI) comprised incident and persistent cases by age at 2015 in adult men and women. *P value for difference in prevalence across age groups, $P<0.05$; **$P<0.01$; ***$P<0.001$. *Persistent* was defined as having the cardiometabolic risk factor in 2009 and 2015. †P value for difference in proportions of persistent cases, $P<0.05$; ††$P<0.01$; †††$P<0.001$. *Incident* was defined as having the cardiometabolic risk factor in 2015 but not in 2009. ‡P value for difference in proportions of incident cases, $P<0.05$; ‡‡$P<0.01$; ‡‡‡$P<0.001$. Hi CRP indicates high high sensitivity C-reactive protein (3 mg/L to ≤10 mg/L); Hi LDL-C, high fasting low-density lipoprotein cholesterol (≥130 mg/dL); Hi TC/HDL-C, high ratio of fasting total cholesterol to fasting high-density lipoprotein cholesterol (≥5); Hi TG, high fasting triglycerides (≥150 mg/dL); Hi WHR, high waist circumference/height ratio (≥0.5); HTN, hypertension (systolic/diastolic blood pressure ≥140/90 mm Hg or antihypertension medication); OW, overweight (body mass index ≥25); T2DM, type 2 diabetes mellitus (HbA1c ≥6.5%, fasting glucose ≥126 mg/dL, or diabetes mellitus medication).

17.0% incident high TC/HDL-C. Furthermore, incident cardiometabolic risk factors contributed to large proportions of the 2015 prevalence of cardiometabolic risk factors. The elevated total number of cardiometabolic risk factors in our subsample analysis also demonstrated an increased burden of cardiometabolic risk over time. In Chinese adults, overweight is a strong risk factor for stroke and coronary heart disease independent of age,[34] hypertension is strongly associated with elevated risk of and mortality from CVD,[35] and TC/HDL-C has high discriminatory power and even greater predictive value for coronary heart disease than TC or HDL-C alone.[31,36] The broad risk of high WHR in men and women across all age groups is an additional concern for the cardiometabolic disease burden in China, as WHR is superior to and independent of BMI in predicting CVD.[25,37] Our findings add to the literature showing a temporal increase in WC at given BMI from 1993 to 2009.[38]

Our findings also suggest strong age-related differences in cardiometabolic risk within sex groups. Paralleling the pattern of incident overweight, the incidence of high LDL-C and high

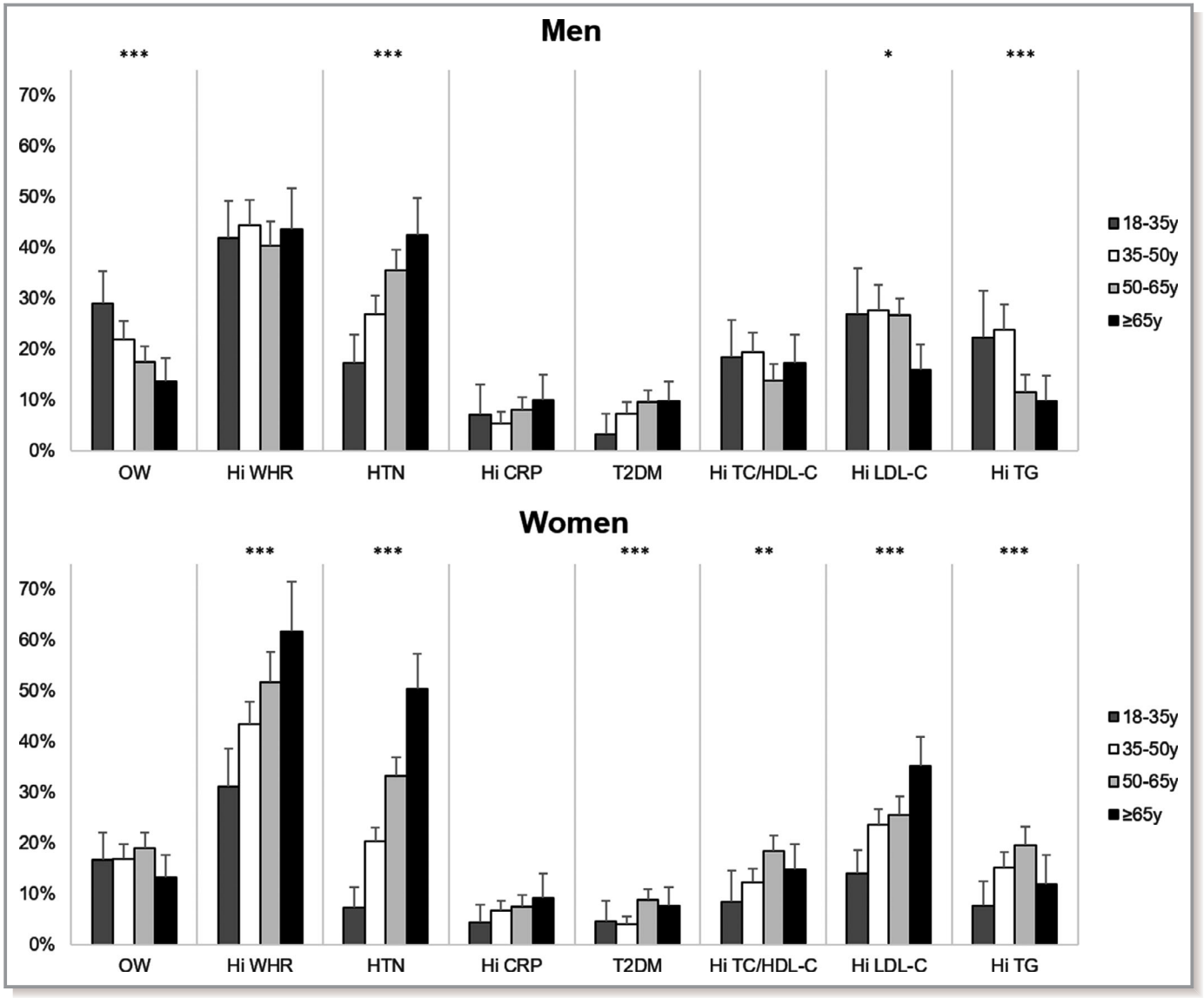

Figure 4. Inverse probability–weighted 6-year incidence of cardiometabolic risk factors (95% CI) from 2009 to 2015 by age at 2009 in adult men and women. *P value for difference across age groups, $P<0.05$; **$P<0.01$; ***$P<0.001$. Hi CRP indicates high sensitivity C-reactive protein (3 mg/L to ≤10 mg/L); Hi LDL-C, high fasting low-density lipoprotein cholesterol (≥130 mg/dL); Hi TC/HDL-C, high ratio of fasting total cholesterol to fasting high-density lipoprotein cholesterol (≥5); Hi TG, high fasting triglycerides (≥150 mg/dL); Hi WHR, high waist circumference/height ratio (≥0.5); HTN, hypertension (systolic/diastolic blood pressure ≥140/90 mm Hg or antihypertension medication); OW, overweight (body mass index ≥25); T2DM, type 2 diabetes mellitus (HbA1c ≥6.5%, fasting glucose ≥126 mg/dL, or diabetes mellitus medication).

triglycerides tended to be higher in younger men (aged 18–50 years) than in older men (aged ≥50 years), portending exacerbated future risk of CVD. Elevated cholesterol levels in young men aged 18 to 39 years in 3 large US cohorts were associated with excess long-term risk of CVD death.[39] In comparison, paralleling the pattern of incident high WHR, incidence of high TC/HDL-C, high LDL-C, and high triglycerides was generally higher in older women (aged ≥50 years) than in younger women (aged 18–50 years). These age differences in incidence of cardiometabolic risk may reflect different associations between cardiometabolic risk factors and obesity measures in men and women. Studies in American Indians[40] and Danish adults[41,42] showed that, compared with BMI, WC had a stronger association with lipid profiles in women, whereas BMI was equally or more strongly associated with lipid markers than WC in men. The different patterns of incident abnormal lipid levels in our sample may also relate to differential association between aging with lipid profiles by sex. A study of Chinese Singaporeans aged 30 to 70 years[43] suggested that lipid levels in men did not differ by age group, whereas TC, LDL-C, and TC/HDL-C were higher in older women (aged >50 years) than in younger women (aged

30–46 years). Moreover, the elevated incidence of high WHR, type 2 diabetes mellitus, and abnormal lipid levels in women aged >50 years in our sample may relate to hormonal changes during perimenopause and menopause. Studies in Chinese women[44–46] found that menopause was associated with increased central body fat, fasting glucose, HbA1c, TC, TC/HDL-C, LDL-C, and triglycerides. In addition, the comparable patterns of incident high WHR and incident type 2 diabetes mellitus by age group in men and women in our study may suggest a positive correlation between WHR and diabetes mellitus, regardless of sex. Two large systematic reviews showed that WHR was a stronger predictor for diabetes mellitus than BMI.[25,37] Furthermore, age-related differences in prevalent cardiometabolic risk by sex groups were observed in cross-sectional population-based studies of Chinese adults from 2007 to 2012.[10,47,48] Similar to our study, the results of these studies suggest that the prevalence of abnormal lipid levels and diabetes mellitus increased with age in women, whereas the prevalence of abnormal lipid levels tended to be highest in middle-aged men (aged 40–60 years), paralleling the prevalence of overweight.[10,47,48] Our study adds incidence data for a much wider range of cardiometabolic risk factors in a diverse, population-based cohort reflecting urban and rural communities across 9 provinces in China.

China has the greatest absolute disease burden of diabetes mellitus[5] and hypertension[7] in the world. We documented 6-year incidence of type 2 diabetes mellitus of 7.9% in men and 6.3% in women, similar to the incidence of type 2 diabetes mellitus in the Hong Kong Cardiovascular Risk Factor Prevalence Study during a median follow-up of 6.4 years from 1995 to 2004 (7.1%; 120 new cases of type 2 diabetes mellitus among 1679 adults)[15] but higher than the incidence of self-reported type 2 diabetes mellitus from the Shanghai Women's Health Study during an average follow-up of 5 years from 1996 to 2004 (2.5%; 1608 new cases of type 2 diabetes mellitus among 64 227 women)[17] and the Shanghai Men's Health Study during an average follow-up of 5.4 years from 2002 to 2011 (2.5%; 1304 new cases of type 2 diabetes mellitus among 51 464 men).[16] These differences may reflect underreporting in self-reported type 2 diabetes mellitus compared with our measured data and may be due to the more homogeneous sample compared with our diverse population-based sample. A few large population-based studies have reported type 2 diabetes mellitus incidence in China over 7 to 9 years. A combined study based on the China Multicenter Collaborative Study of Cardiovascular Epidemiology and the China Cardiovascular Health Study reported an age-standardized type 2 diabetes mellitus incidence rate of 9.5 and 9.2 per 1000 person-years in men and women, respectively, from 1998 to 2008 during an average 8-year follow-up.[18] Among ≈500,000 participants in the China Kadoorie Biobank Study launched in 2004, the incidence of type 2 diabetes mellitus was 2.8 and 3.1 per 1000 person-years during 7 years (last follow-up in 2014) and 9 years (last follow-up in 2016) of follow-up, respectively.[19,20] Our study contributes to this literature over a more recent time frame. In addition, we found higher incidence of type 2 diabetes mellitus than the earlier studies, thus our findings suggest an increase in type 2 diabetes mellitus in China over the past decade. We have shown elsewhere that a substantial proportion of Chinese adults have undiagnosed hypertension and diabetes mellitus.[49] The 6-year incidence of hypertension in our sample (29.2% in men, 24.9% in women) is similar to the 8-year incidence of hypertension from the China National Hypertension Survey of adults aged ≥40 years from 1991 to 2000 (28.9% in men, 26.9% in women),[14] despite the shorter follow-up in the CHNS, suggesting an increase in hypertension risk over the past 2 decades. Indeed, a recent study from the CHNS[13] showed that hypertension incidence increased from 1991–1997 to 2004–2009, especially in young adults (aged 18–39 years). Consistent with our findings, the 1991 China National Hypertension Survey[14] also documented an increase in hypertension incidence with age. Aging is an independent risk factor for arterial stiffening,[50] which was found to be associated with higher incident hypertension in the Framingham Offspring study[51] and to precede the development of hypertension in a diet-induced obese mouse model.[52]

This study has some limitations. First, we documented large loss to follow-up from 2009 to 2015 (40.7%). To address potential selection bias, we used IPW to account for loss to follow-up assuming that loss to follow-up was dependent on the selected baseline predictors.[21] The use of IPW allowed us to generalize our results to 6-year incidence and 2015 prevalence of cardiometabolic risk factors in the full 2009 analysis sample (Table S2). Second, we used conventional cutoff points for cardiometabolic risk factors to allow for comparison across countries, but this approach may not reflect the true risks for Chinese adults, especially for overweight. There is disagreement about the optimal cutoff points for overweight in Chinese populations, with some advocating lower cutoff points[53,54] than the WHO cutoff point (BMI 25),[24] whereas others support the WHO cutoff point.[55–57] For comparison with Asian populations, we also reported the prevalence and incidence of overweight from 2009 to 2015 defined by the Asian cutoff point (BMI 23)[24] (Tables S1, S3, S4). Moreover, we acknowledge that defining cardiometabolic risk factors by cutoff points could result in false-negative and false-positive incident cases due to small variations near the cutoff points. The media has the potential to play an important role in controlling cardiometabolic risk factors. Some national campaigns have addressed lifestyles in China (eg, China Healthy Lifestyle for All campaign),[58] but we do not have data on the effects of such campaigns.

The strengths of our study include the prospective design, which allows incident estimation of elevated cardiometabolic

risk factors, the collection of various biomarkers, and the representation of a wide age range of adults, multiple geographical regions, and diverse rural and urban communities. Our findings from the population-based cohort of the CHNS underscore the substantial cardiometabolic risks among Chinese adults, provide evidence for differential patterns of cardiometabolic risk by sex and age groups, and foreshadow the increasing burden of cardiometabolic diseases in China. The observed higher incidence of cardiometabolic risk among young Chinese adult men and women relative to that found in other countries parallels increasing trends in obesity in China over the past decade. This represents a major concern for the future of Chinese health and the healthcare system and portends lengthy treatment, higher costs, and early disability. Given that rapid urbanization has affected China over the past 3 decades, understanding the cardiometabolic risks in China has huge implications for other low- to middle-income countries that are entering or experiencing the same rapid increase in urbanization.

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Disclosures

None.

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SUPPLEMENTAL MATERIAL

Table S1. Crude 2009 prevalence of cardiometabolic risk factors by age at 2009 in men and women, percent (95% Confidence Interval).

Shown in Figure 2.

	Overweight (BMI ≥25 kg/m²)	Overweight (Asian cut-points, BMI≥23 kg/m²)	High WHtR (≥0.5)	Hypertension (SBP/DBP ≥140/90 mmHg)*	High CRP (3mg/L ≤ CRP ≤10 mg/L)	Type 2 diabetes (HbA1c≥6.5% or fasting glucose≥126 mg/dL)*	High total cholesterol to HDL-C ratio (≥5)	High LDL-C (≥130 mg/dL)	High triglycerides (≥150 mg/dL)
Men									
Total n	4,486	4,486	4,466	4,483	3,878	4,053	3,843	3,841	3,843
18-35y	22.9	39.9	33.7	11.6	14.6	3.0	9.5	18.9	30.9
	(20.1, 26.0)	(36.5, 43.4)	(30.4, 37.2)	(9.5, 14.1)	(12.0, 17.6)	(1.9, 4.6)	(7.4, 12.1)	(15.9, 22.2)	(27.3, 34.7)
35-50y	34.1	58.1	53.6	23.9	18.5	9.7	16.4	28.7	41.4
	(31.7, 36.7)	(55.5, 60.6)	(51.0, 56.2)	(21.8, 26.2)	(16.4, 20.8)	(8.2, 11.4)	(14.4, 18.6)	(26.3, 31.4)	(38.7, 44.2)
50-65y	30.0	52.9	58.3	37.3	21.2	13.4	12.2	31.7	34.2
	(27.8, 32.4)	(50.3, 55.4)	(55.8, 60.8)	(34.9, 39.8)	(19.1, 23.5)	(11.7, 15.3)	(10.5, 14.1)	(29.3, 34.3)	(31.7, 36.8)
≥65y	25.7	45.9	60.6	55.4	29.8	16.7	12.2	28.5	26.8
	(22.8,28.8)	(42.5, 49.4)	(57.2, 63.9)	(51.9, 58.8)	(26.5, 33.4)	(14.2, 19.5)	(9.8, 14.6)	(25.3, 32.0)	(23.7, 30.2)
Total	29.4	51.1	53.0	31.9	20.8	11.2	13.4	28.2	34.6

	(28.0, 30.7)	(49.6, 52.5)	(51.6, 54.5)	(30.6, 33.3)	(19.5, 22.1)	(10.2, 12.2)	(12.4, 14.5)	(26.8, 29.6)	(33.1, 36.1)
P-value†	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Women									
Total n	4,950	4,950	4,921	4,929	4,408	4,552	4,350	4,350	4,350
18-35y	12.9	26.0	28.8	2.2	12.6	0.9	2.1	12.9	12.3
	(10.7, 15.5)	(23.0, 29.2)	(25.7, 32.1)	(1.4, 3.6)	(10.2, 15.4)	(0.4, 2.0)	(1.2, 3.5)	(10.5, 15.8)	(9.9, 15.1)
35-50y	29.6	51.4	53.1	15.1	14.9	5.0	5.0	23.3	23.6
	(27.4, 31.9)	(49.0, 53.8)	(50.6, 55.5)	(13.4, 16.9)	(13.2, 16.8)	(4.0, 6.2)	(4.0, 6.3)	(21.2, 25.6)	(21.4, 25.9)
50-65y	35.5	60.2	73.1	36.0	26.3	11.6	11.8	43.9	37.5
	(33.2, 37.8)	(57.8, 62.6)	(70.9, 75.2)	(33.8, 38.4)	(24.1, 28.6)	(10.1, 13.3)	(10.3, 13.6)	(41.5, 46.5)	(35.1, 40.0)
≥65y	31.2	49.0	77.6	55.5	33.5	21.4	11.8	48.0	35.0
	(28.2, 34.4)	(45.8, 52.3)	(74.7, 80.2)	(52.2, 58.7)	(30.3, 36.9)	(18.8, 24.3)	(9.8, 14.3)	(44.6, 51.5)	(31.8, 38.4)
Total	29.3	49.9	60.5	27.6	21.8	9.7	8.3	33.5	28.9
	(28.0, 30.5)	(48.5, 51.3)	(59.1, 61.8)	(26.4, 28.9)	(20.6, 23.0)	(8.9, 10.6)	(7.5, 9.1)	(32.1, 34.9)	(27.5, 30.2)
P-value†	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

*or medication;

†p-value for difference across age groups.

Table S2. Association of baseline characteristics [parameter estimates (95% confidence interval)] with likelihood of being lost to follow-up from 2009 to 2015 for each of the cardiometabolic risk factors*

	Overweight (BMI≥25 kg/m²)	High WHtR (≥0.5)	Hypertension (SBP/DBP ≥140/90 mmHg)†	High CRP (3mg/L ≤ CRP ≤10 mg/L)	Type 2 diabetes (HbA1c≥6.5 % or fasting glucose≥126 mg/dL)†	High total cholesterol to HDL-C ratio (≥5)	High LDL-C (≥130 mg/dL)	High triglycerides (≥150 mg/dL)
N	9,436	9,387	9,412	8,286	8,605	8,193	8,191	8,193
Cardiometabolic risk factor‡	-0.05 (-1.09, 0.01)	-0.03 (-0.09, 0.02)	-0.00 (-0.06, 0.06)	0.05 (-0.02, 0.12)	0.06 (-0.04, 0.15)	0.09 (-0.01, 0.18)	0.04 (-0.02, 0.10)	0.03 (-0.03, 0.09)
Sex								
Men	Ref.		-	-	-	-	-	-
Women	0.86 (0.37, 1.36)	0.87 (0.38, 1.37)	0.55 (0.05, 1.05)	0.78 (0.22, 1.34)	0.81 (0.27, 1.36)	0.64 (0.06, 1.22)	0.62 (0.04, 1.20)	0.61 (0.04, 1.19)
Age	-0.10 (-0.11, -0.09)	-0,10 (-0.11, -0.09)	-0,11 (-0.13, -0.96)	-0,09 (-0.06, -0.02)	-0,10 (-0.12, -0.09)	-0,09 (-0.11, -0.08)	-0,10 (-0.11, -0.08)	-0,10 (-0.11, -0.08)
Age squared	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	(0.00, 0.00)	(0.00, 0.00)	(0.00, 0.00)	(0.00, 0.00)	(0.00, 0.00)	(0.00, 0.00)	(0.00, 0.00)	(0.00, 0.00)
Age × sex	-0.04	-0.04	-0.03	-0.04	-0.04	-0.03	-0.03	-0.03
	(-0.06, -0.02)	(-0.06, -0.02)	(-0.05, -0.01)	(-0.06, -0.02)	(-0.06, -0.02)	(-0.06, -0.01)	(-0.06, -0.01)	(-0.06, -0.01)
Age squared ×	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
sex	(0.00, 0.00)	(0.00, 0.00)	(0.00, 0.00)	(0.00, 0.00)	(0.00, 0.00)	(0.00, 0.00)	(0.00, 0.00)	(0.00, 0.00)
Urbanization index[§]								
Low	Ref.	-	-	-	-	-	-	-
Middle	0.03	0.03	0.02	0.06	-0.03	-0.06	-0.06	-0.06
	(-0.04, 0.10)	(-0.05, 0.09)	(-0.06, 0.09)	(-0.14, 0.02)	(-0.10, 0.04)	(-0.13, 0.02)	(-0.14, 0.01)	(-0.13, 0.02)
High	0.27	0.26	0.28	0.27	0.26	0.28	0.28	0.28
	(0.19, 0.35)	(0.18, 0.34)	(0.20, 0.36)	(0.19, 0.36)	(0.18, 0.35)	(0.19, 0.36)	(0.19, 0.37)	(0.19, 0.37)
Educational Attainment								
Below high school	Ref.	-	-	-	-	-	-	-
High school and	0.14	0.14	0.14	0.11	0.10	0.11	0.11	0.11
above	(0.07, 0.21)	(0.07, 0.21)	(0.07, 0.21)	(0.04, 0.19)	(0.03, 0.17)	(0.03, 0.18)	(0.03, 0.18)	(0.03, 0.18)
Per capita household income								
Low	Ref.	-	-	-	-	-	-	-
Middle	0.00	0.00	-0.02	-0.03	-0.05	-0.00	-0.00	-0.00

	(-0.06, 0.07)	(-0.06, 0.07)	(-0.08, 0.05)	(-0.10, 0.04)	(-0.12, 0.02)	(-0.07, 0.07)	(-0.07, 0.07)	(-0.07, 0.07)
High	0.04	0.04	0.03	0.01	0.02	0.03	0.03	0.03
	(-0.03, 0.12)	(-0.03, 0.12)	(-0.05, 0.10)	(-0.07, 0.08)	(-0.06, 0.09)	(-0.05, 0.11)	(-0.05, 0.11)	(-0.05, 0.11)
Household asset	-0.01	-0.01	-0.01	-0.01	-0.01	-0.00	-0.00	-0.00
score[ll]	(-0.02, 0.01)	(-0.02, 0.01)	(-0.02, 0.01)	(-0.02, 0.00)	(-0.02, 0.00)	(-0.02, 0.01)	(-0.02, 0.01)	(-0.02, 0.01)
Province								
Liaoning	Ref.	-	-	-	-	-	-	-
	0.23	0.23	0.19	0.24	0.19	0.24	0.24	0.24
Heilongjiang	(0.11, 0.34)	(0.11, 0.35)	(0.07, 0.31)	(0.12, 0.37)	(0.06, 0.32)	(0.11, 0.37)	(0.11, 0.37)	(0.11, 0.37)
	-0.02	-0.01	-0.09	-0.11	-0.07	-0.09	-0.08	-0.09
Jiangsu	(-0.14, 0.09)	(-0.13, 0.10)	(-0.21, 0.17)	(-0.23, 0.01)	(-0.19, 0.04)	(-0.21, 0.04)	(-0.21, 0.04)	(-0.21, 0.03)
	0.09	0.09	0.06	0.04	0.06	0.06	0.05	0.06
Shandong	(-0.02, 0.21)	(-0.02, 0.20)	(-0.05, 0.17)	(-0.08, 0.16)	(-0.06, 0.18)	(-0.07, 0.18)	(-0.07, 0.18)	(-0.07, 0.18)
	0.34	0.33	0.27	0.29	0.27	0.51	0.50	0.50
Henan	(0.23, 0.46)	(0.21, 0.45)	(0.16, 0.39)	(0.17, 0.42)	(0.15, 0.40)	(0.38, 0.64)	(0.37, 0.63)	(0.37, 0.63)
	-0.06	-0.06	-0.02	0.02	0.07	0.25	0.25	0.25
Hubei	(-0.18, 0.05)	(-0.18, 0.06)	(-0.14, 0.09)	(-0.10, 0.15)	(-0.05, 0.20)	(-0.13, 0.38)	(-0.13, 0.38)	(-0.13, 0.37)
Hunan	0.18	0.18	0.10	0.11	0.18	0.30	0.30	0.30

	(0.06, 0.29)	(0.07, 0.29)	(-0.01, 0.22)	(0.01, 0.23)	(0.06, 0.30)	(0.18, 0.42)	(0.18, 0.42)	(0.17, 0.42)
	0.06	0.08	-0.03	0.02	0.03	0.06	0.06	0.06
Guangxi	(-0.05, 0.17)	(-0.03, 0.20)	(-0.14, 0.08)	(-0.10, 0.14)	(-0.09, 0.15)	(-0.06, 0.18)	(-0.06, 0.18)	(-0.06, 0.19)
	0.06	0.06	-0.05	0.10	0.12	0.26	0.26	0.26
Guizhou	(-0.06, 0.17)	(-0.06, 0.18)	(-0.16, 0.07)	(-0.03, 0.23)	(-0.01, 0.25)	(-0.13, 0.40)	(-0.13, 0.39)	(-0.13, 0.39)

*Probit model predicting loss to follow-up from 2009 to 2015 for each of the cardiometabolic risk factors, versus remaining in the study, controlling for sex, age, squared age, sex and age interaction, sex and squared age interaction, urbanization level, educational attainment, income level, household asset score, province, and the given cardiometabolic risk factor in 2009.

†Or medication.

‡Each of the cardiometabolic risk factors in 2009 was included in the model predicting its own lost to follow-up. For example, overweight was in the model predicting the likelihood of missing 2015 overweight data among individuals who had 2009 overweight data.

§Urbanization index, a 12-component scale with a maximum of 120 points that includes population density, economic activity, transportation infrastructure, sanitation, etc., to define and distinguish urbanicity,[1] was categorized by tertiles.

‖Household asset score ranges 0-11, with each asset (color TV, refrigerator, microwave oven, electrical cooking pot, air conditioner, electric fan, computer, camera, telephone, cell phone and VCD/DVD) worth 1 point.

Table S3. Inverse probability weighted 2015 prevalence of cardiometabolic risk factors by age at 2015 among men and women, percent (95% Confidence Interval). Shown in Figure 3.

	Overweight (BMI ≥25 kg/m²)	Overweight (Asian cut-points, BMI≥23 kg/m²)	High WHtR (≥0.5)	Hypertension (SBP/DBP ≥140/90 mmHg)*	High CRP (3mg/L ≤ CRP ≤10 mg/L	Type 2 diabetes (HbA1c≥6.5% or fasting glucose≥126 mg/dL)*	High total cholesterol to HDL-C ratio (≥5)	High LDL-C (≥130 mg/dL)	High triglycerides (≥150 mg/dL)
Men									
Total n	2,552	2,552	2,529	2,439	1,858	2,115	1,686	1,686	1,687
18-35y	39.9	53.8	51.3	13.7	13.4	6.0	23.0	35.6	28.1
	(32.4, 48.0)	(45.8, 61.7)	(43.3, 59.3)	(8.7, 20.8)	(7.8, 22.3)	(2.7, 12.8)	(15.2, 33.4)	(25.4, 47.4)	(19.4, 38.9)
35-50y	43.5	64.2	64.8	32.7	6.7	9.0	26.6	33.4	39.2
	(39.6, 47.6)	(60.3, 68.0)	(60.8, 68.6)	(28.8, 36.8)	(4.7, 9.5)	(6.8, 12.0)	(22.2, 31.5)	(28.6, 38.5)	(34.1, 44.5)
50-65y	40.5	63.2	67.4	45.9	8.8	17.3	21.2	38.9	32.2
	(37.5, 43.5)	(60.2, 66.1)	(64.6, 70.2)	(42.8, 49.0)	(7.0, 11.0)	(14.9, 19.9)	(18.4, 24.5)	(35.3, 42.6)	(28.8, 35.8)
≥65y	32.7	53.3	67.9	57.0	13.7	17.2	19.9	32.8	17.8
	(29.3, 36.2)	(49.6, 56.9)	(64.4, 71.3)	(53.3, 60.6)	(10.9, 17.0)	(14.4, 20.3)	(16.6, 23.8)	(28.8, 37.2)	(14.6, 21.5)
Total	38.9	59.5	65.2	42.4	10.2	14.2	22.2	35.5	29.0

	(36.9, 40.8)	(57.5, 61.5)	(63.2, 67.1)	(40.4, 44.5)	(8.8, 11.8)	(12.8, 15.8)	(20.2, 24.4)	(33.1, 38.0)	(26.7, 31.3)
P-value†	<0.001	<0.001	0.001	<0.001	0.002	<0.001	0.110	0.014	<0.001
Women									
Total n	2,971	2,971	2,942	2,884	2,268	2,567	2,062	2,066	2,067
18-35y	27.3	39.5	45.4	8.1	2.6	5.5	14.7	16.8	7.4
	(20.1, 36.0)	(31.1, 48.5)	(36.5, 54.5)	(4.0, 15.6)	(0.8, 7.7)	(2.2, 13.2)	(7.3, 26.3)	(9.3, 28.4)	(3.5, 15.2)
35-50y	33.6	55.8	54.9	16.6	7.0	4.1	9.6	24.2	17.2
	(30.4, 37.1)	(52.2, 59.3)	(51.3, 58.5)	(14.2, 19.5)	(5.2, 9.4)	(2.8, 6.0)	(7.3, 12.4)	(20.6, 28.1)	(14.1, 20.7)
50-65y	40.5	66.5	77.1	41.8	12.4	12.5	21.6	43.6	30.2
	(37.7, 43.3)	(63.7, 69.1)	(74.7, 79.4)	(39.0, 44.6)	(10.4, 14.6)	(10.7, 14.7)	(18.9, 24.4)	(40.3, 47.0)	(27.2, 33.4)
≥65y	38.5	59.0	82.8	59.1	15.0	18.5	23.1	49.0	28.9
	(35.2, 42.0)	(55.4, 62.5)	(79.9, 85.4)	(55.2, 62.8)	(12.4, 18.2)	(15.8, 21.6)	(19.8, 26.9)	(44.8, 53.3)	(25.2, 32.8)
Total	37.0	59.0	70.3	37.8	11.0	11.7	18.4	38.2	24.7
	(35.1, 38.8)	(57.1, 60.9)	(68.5, 72.1)	(36.0, 39.8)	(9.8, 12.4)	(10.4, 13.0)	(16.7, 20.2)	(36.0, 40.4)	(22.8, 26.6)
P-value†	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

*or medication;

†p-value for difference across age groups.

Table S4. Inverse probability weighted 6-year incidence of cardiometabolic risk factors from 2009 to 2015 by age at 2009 in men and women, percent (95% Confidence Interval). Shown in Figure 4.

	Overweight (BMI ≥25 kg/m²)	Overweight (Asian cut-points, BMI≥23 kg/m²)	High WHtR (≥0.5)	Hypertension (SBP/DBP ≥140/90 mmHg)*	High CRP (3mg/L ≤ CRP ≤10mg/L	Type 2 diabetes (HbA1c≥6.5% or fasting glucose≥126 mg/dL)*	High total cholesterol to HDL-C ratio (≥5)	High LDL-C (≥130 mg/dL)	High triglycerides (≥150 mg/dL)
Men									
Total n	1,777	1,219	1,170	1,628	1,505	1,884	1,482	1,198	1,120
18-35y	29.0	35.4	41.9	17.4	7.2	3.4	18.5	26.9	22.4
	(23.3, 35.4)	(28.2, 43.4)	(34.8, 49.3)	(13.0, 22.9)	(3.8, 13.2)	(1.5, 7.4)	(12.9, 25.8)	(19.3, 36.1)	(15.3, 31.6)
35-50y	21.9	30.7	44.4	27.0	5.4	7.4	19.4	27.8	23.9
	(18.6, 25.6)	(26.1, 35.7)	(39.5, 49.4)	(23.5, 30.7)	(3.7, 7.8)	(5.5, 9.8)	(16.0, 23.4)	(23.5, 32.5)	(19.5, 28.8)
50-65y	17.6	24.4	40.4	35.6	8.1	9.7	14.0	26.7	11.7
	(14.9, 20.7)	(20.7, 28.6)	(35.7, 45.2)	(31.8, 39.6)	(6.1, 10.6)	(7.7, 12.0)	(11.4, 17.1)	(22.8, 31.0)	(9.0, 15.0)
≥65y	13.8	20.3	43.7	42.6	10.0	9.8	17.4	16.1	9.9
	(10.3, 18.3)	(15.3, 20.5)	(36.1, 51.7)	(35.5, 49.9)	(6.5, 15.1)	(6.9, 13.8)	(13.1, 22.9)	(11.6, 21.9)	(6.5, 14.8)

Total	20.4	27.6	42.4	29.2	7.4	7.9	17.0	25.2	16.5
	(18.4, 22.4)	(25.0, 30.4)	(39.5, 45.5)	(27.0, 31.6)	(6.0, 9.0)	(6.7, 9.2)	(15.0, 19.1)	(22.6, 28.0)	(14.3, 18.9)
P-value[†]	<0.001	<0.001	0.141	<0.001	0.175	0.051	0.132	0.016	<0.001
Women									
Total n	2,033	1,386	1,058	2,085	1,795	2,325	1,888	1,373	1,456
18-35y	16.8	25.5	31.2	7.2	4.3	4.6	8.4	14.0	7.7
	(12.5, 22.1)	(19.8, 32.2)	(24.6, 38.6)	(4.5, 11.3)	(2.3, 7.8)	(2.4, 8.7)	(4.7, 14.6)	(9.3, 20.4)	(4.7, 12.4)
35-50y	17.0	35.2	43.4	20.3	6.6	4.0	12.3	23.5	15.1
	(14.4, 19.9)	(31.1, 39.5)	(38.9, 47.9)	(17.8, 23.1)	(5.0, 8.7)	(2.9, 5.5)	(10.0, 15.0)	(20.2, 27.3)	(12.3, 18.3)
50-65y	19.0	29.8	51.8	33.4	7.5	8.9	18.5	25.5	19.6
	(16.3, 22.1)	(25.7, 34.2)	(45.9, 57.6)	(29.9, 36.9)	(5.7, 9.9)	(7.2, 11.0)	(15.8, 21.5)	(21.7, 29.6)	(16.4, 23.3)
≥65y	13.2	22.0	61.7	50.4	9.1	7.6	14.7	35.2	11.9
	(9.7, 17.7)	(16.9, 28.1)	(50.8, 71.5)	(43.6, 57.2)	(5.8, 14.1)	(5.0, 11.3)	(10.7, 19.8)	(27.6, 43.6)	(7.8, 17.6)
Total	16.9	29.1	43.8	24.9	6.9	6.3	14.5	23.7	14.6
	(15.2, 18.7)	(26.6, 31.6)	(40.6, 47.0)	(23.0, 26.9)	(5.8, 8.2)	(5.3, 7.4)	(13.0, 16.1)	(21.4, 26.2)	(12.8, 16.5)
P-value[†]	0.182	0.247	<0.001	<0.001	0.236	<0.001	0.002	<0.001	<0.001

*or medication;

[†]p-value for difference across age groups.

Table S5. The total number of cardiometabolic risk factors above risk factor thresholds [mean (standard deviation)] by sex and age in a subsample of China Health and Nutrition Survey participants seen in 2009 and 2015 with data for all cardiometabolic risk factors (n=3,260).

Age in 2009	N	2009	2015	P-value*
Men				
18-35y	154	1.61 (1.55)	2.32 (1.87)	<0.001
35-50y	471	2.25 (1.77)	2.71 (1.79)	<0.001
50-65y	590	2.29 (1.69)	2.59 (1.78)	0.003
≥65y	224	2.43 (1.61)	2.71 (1.58)	0.07
Total	1,439	2.23 (1.70)	2.62 (1.76)	<0.001
Women				
18-35y	191	1.05 (1.33)	1.27 (1.39)	0.124
35-50y	662	1.73 (1.52)	2.22 (1.67)	<0.001
50-65y	729	2.80 (1.67)	3.06 (1.78)	0.005
≥65y	239	3.13 (1.76)	3.30 (1.73)	0.271
Total	1,821	2.27 (1.74)	2.60 (1.81)	<0.001

*P-value for a paired t-test comparing the total number of cardiometabolic risk factors above thresholds between wave 2009 and 2015 by sex and age groups.

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