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Health Disparities in China

Mapping the Way Forward

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EXECUTIVE SUMMARY

The formal adoption of the "Healthy China 2030" blueprint on October 25, 2016, marked a turning point in the evolution of China's public health policy reforms. The significance of this national strategic plan, with 12 well-defined targets to meet by 2030, lies in its focus on preventative health policies as opposed to reactive policies that the government had taken in all of its previous policy endeavors. Specifically, the core components of the plan include the reduction of premature deaths from non-communicable (chronic) diseases by 30 percent and the improvement in indicators of a healthy lifestyle.[1]

The burden of non-communicable diseases (stroke and ischemic heart disease being the two leading causes of death and disabilities in China) over the past decade makes this strategic plan more pertinent than ever. Moreover, the fact that elevated systolic blood (SB) pressure (>140), high body mass index (BMI >23), and abdominal obesity (waist circumference, or WC >85 cm for men and >80 cm for women) are critical contributors to stroke and heart disease further highlights the importance of developing effective policies to modify behavioral risk factors.

TARGETS FOR BEHAVIORAL RISK FACTORS

How much should behavioral risk factors change to achieve the goal of a 30 percent reduction in premature deaths from chronic diseases by 2030? A recent comprehensive study shows that the desired modification is attainable if the prevalence of elevated systolic blood pressure in the population falls by 25 percent below 2013 levels and the distribution of BMI in 2030 stays the same as in 2013.[2] The authors highlight a few obstacles and potential solutions to meeting the targeted reductions in behavioral risk factors. Despite the concerted efforts by health professionals, hypertension awareness, treatment, and control remain low, and obesity rates continue to rise, posing a significant challenge. The authors note that lifestyle modification may be the best strategy for preventing hypertension. They also note that current segmented policies to modify lifestyles have not been successful.

NON-SINGULAR EFFECTS OF BEHAVIORAL RISK FACTORS

The first part of the analysis in this report and findings in many other studies show that no single factor can explain China's disparities in obesity, hypertension, and other precursors to chronic diseases. Our analysis of individual-level and aggregate data suggests that the largest gap in health is seen across Chinese provinces. However, we did not discover a sole risk factor that accounts for a majority of regional differences. The lack of a single explanatory factor is not surprising, given that many constraints such as culture, genetics, resources, and environment jointly contribute to the individual's behavior. Behavioral factors are influenced by typical constraints as well. For example, dietary choices prevalent in the northern provinces significantly differ from those prevailing in the southeast or southwest, and these differences are partly dictated by the type of agricultural produce available and the pace of life in urban versus rural regions.

THE WAY FORWARD

The success of "Healthy China 2030" is not limited to just identifying what must be changed. Our study highlights how multiple health indicators interact and suggests that any policy targeting lifestyle modification must account for unique cultural, economic, demographic, and environmental peculiarities in each province. In other words, the way forward to reducing premature non-communicable disease mortality requires a tailored approach by region. Furthermore, our findings identify clusters of provinces by their risk level. Focusing on the provinces with the highest risk may be a cost-effective approach to achieve policy targets.

INTRODUCTION

Most citizens of China are living longer and healthier than ever. Average life expectancy at birth in China increased from 44 years in 1950 to 77 in 2020.[3] The annual death rate dropped from 23.4 per 1,000 in 1950 to 7.4 per 1,000 in 2020.[4] In recent decades, China's rapid economic progress, combined with broad policies implemented by the central government, resulted in substantial improvements in public health. The mortality rate for children under the age of five decreased by more than 80 percent, and maternal mortality fell by almost 75 percent over the period 1990-2015. The mortality rate from communicable diseases has shown sizable reductions.[5]

However, rapid industrialization and urbanization with massive internal migration significantly widened the health disparities in China. Moreover, mortality and morbidity associated with non-communicable diseases (stroke and ischemic heart disease, in particular) have been increasing at an alarming rate with disproportionate impact on specific population sub-groups.[5] In 2016, as a response to these public health threats and partly as a response to the United Nation's Sustainable Development Goals, the government of China passed a comprehensive public health reform blueprint called "Healthy China 2030." Although the government has taken necessary steps declaring its measurable and feasible public health goals for 2030, with prevention as its focus, the past policy tools that relied on access to resources and infrastructure for primary care do not instill confidence among practitioners and researchers.

In this study, we show that regional differences account for the greatest variation in health disparities. Furthermore, we identify nine provincial clusters and their corresponding salient features. Our results provide evidence for policymakers to change the framework of how they implement public health policies and point to a targeted approach, addressing provinces with the highest need first with solutions that work.

DATA AND METHODOLOGY

DATA

Our dataset is comprised of individual-level longitudinal data from the China Health and Nutrition Survey (CHNS; 1989, 1991, 1993, 1997, 2000, 2004, 2006, 2011, and 2015) and province-level annual data from the National Bureau of Statistics of China, China Statistical Yearbook 2017, and peer-reviewed publications. The longitudinal data from the CHNS covers 14 provinces (Figure 1). The CHNS provides sample data of multiple birth cohorts over time. We excluded data from the 1989 wave because it did not have data for all age groups and did not employ the same standardized procedure used in subsequent waves. After retaining complete cases and limiting the sample to adults only (respondent's age greater or equal to 18), our sample includes data from 26,853 individuals tracked over time with a total of 84,937 observations. We provide the detailed summary statistics of key variables from the longitudinal data categorized by wave, urban-rural status, and regions in the appendix (descriptive statistics of longitudinal data and regional variation in mean BMI, WC, and BP). The mean age for our sample increased from 42 to 54 in the urban sample and 41 to 53 in the rural sample. The actual prevalence of obesity increased from 7 percent in 1991 to 21 percent in 2015 in the urban sample and from 4 percent to 21 percent in the rural sample. Similarly, the prevalence of hypertension increased from 10 percent (7 percent rural) to 17 percent (22 percent rural) over the same period. The evolution of mean BMI, systolic blood pressure, diastolic blood pressure, and waist circumference for urban and rural subjects shows consistent growth and demonstrates an overall tendency toward convergence of indicators for urban and rural residents.

The individual-level data from the China Health and Nutrition Survey covers only 14 provinces. We supplement our analysis with additional province-level data that cover all 31 provinces. The province-level dataset summary statistics, reported in the appendix (summary statistics for province-level data), show a wide variation in health outcomes as well as socioeconomic indicators across provinces. Below, Table 1 presents the description of variables from the China Health and Nutrition Survey, and Table 2 presents the description of variables from province-level aggregate data compiled from several sources.

Figure 1: Provinces Participating in the CHNS Survey (1991-2015)

Source: Milken Institute (2020)

Table 1: Description of Variables Used in the Analysis (14 provinces in CHNS)

Variables	Description
Demographics	
Sex	Respondent's sex
Age	Respondent's age
Urban	Respondent's urban/rural status
Health Indicators	
Overweight or Obese	Calculated indicator variable for BMI>23 and BMI>28
Hypertension	Calculated indicator variable for systolic blood pressure>130 and diastolic blood pressure>80
Metabolic Risk	Calculated indicator variable for joint occurrence of overweight, hypertension, and waist circumference>85 cm
Behavioral Risks	
Tobacco Use	Indicator variable for former or current smoker status
Alcohol Use	Indicator variable for current alcohol consumption
Socioeconomic Indicators	
Education	Categorical variable for no formal education, high school education, technical training, and university degree
Income	Respondent's per capita real household income (yuans)
Community-Level Indicators	
Province	Categorical indicator capturing participating 14 provinces
Diversity Index	Variation in community education levels and variation in community income levels
Economic Index	Typical daily wage for male workers (reported by community officials) and percentage of the population engaged in nonagricultural work
Health Index	Number and type of health facilities in or nearby (≤12 kilometers) the community and number of pharmacies in the community
Housing Index	Average number of days a week that electricity is available to the community, percentage of the community with indoor tap water, percentage of the community with flush toilets, and percentage of the community that cooks with gas
Social Service Index	Provision of preschool for children under age three years and availability of commercial medical insurance (offered in community), free medical insurance, and/or insurance for women and children

Source: China Health and Nutrition Survey (1991-2015)

Table 2: Description of Variables Used in the Analysis (for all 31 provinces)

Variables	Description
Demographics	
Elderly Dependency Ratio	Proportion of population over the age of 65[6]
Urban Population	Proportion of population urban[7]
Health Indicators	
Abdominal Obesity	Prevalence (WC>85 cm for men and WC>80cm women)[8]
Hypertension	Prevalence of hypertension[9]
Waist Circumference	Mean waist circumference in centimeters[10]
High SB Pressure	High systolic blood pressure exposure value[11]
High BMI	High BMI exposure value[11]
High Low-Density Lipoprotein (LDL) Cholesterol	High LDL exposure value[11]
Behavioral Risks	
Tobacco Use	Tobacco use exposure value[11]
Alcohol Use	Alcohol exposure value[11]
Socioeconomic Indicators	
Education	Illiteracy rate for population aged 15 or older[12]
Income	Nominal disposable income per capita[13]
Community-Level Indicators	
Licensed Doctors	Licensed physicians per capita[13]
Local Expenditure on Health	Local government health-care spending in 100 million yuans[13]
Education Funding	Local government education spending in 10,000 yuans[13]
Number of Hospital Beds	Number of hospital beds per 10,000 population[13]

Source: China Statistical Yearbook (2017); National Bureau of Statistics of China (2017); Zhang et al. (2019); Wang et al. (2018)

METHODOLOGY

In this section, we provide a brief overview of the methodology we applied to the analysis of longitudinal data from the China Health and Nutrition Survey and provincial-level data from government and peer-reviewed publications.

I. MULTILEVEL LINEAR MIXED EFFECTS AGE-PERIOD-COHORT MODEL

To understand how health outcomes changed over time for different population subgroups, we use a commonly utilized statistical technique called Age-Period-Cohort analysis. In a nutshell, the method allows a researcher to separate a health indicator of interest into three components: age effect, period effect, and cohort effect. The age effects component is related to the aging process of individuals and therefore captures biological realities associated with the condition. The period effects component, on the other hand, captures how events that occur at a specific point in time affect all people of all ages. The cohort effects component arises from characteristics that are shared by a group of individuals going through the same event in the same period.

We use the Hierarchical Age-Period-Cohort model advocated by Yang and Land.[14] The underlying idea of this model is that periods and cohort membership represent the socio-historical context, and individuals are embedded in this context. This conceptualization is then translated in the model by specifying age as a fixed effect, and period and cohort as random effects.[15] A clear example regarding the application of such methodology is given by Master, Hummer, and Powers.[16]

II. UNSUPERVISED MACHINE LEARNING: HIERARCHICAL CLUSTERING OF PROVINCES AND PRINCIPAL COMPONENT ANALYSIS

Standard econometric approaches often require a researcher to impose a particular structure on the relationships among variables. To understand the hidden structure of the data, especially when we do not know how features of provinces relate to one another, we use a standard unsupervised machine learning technique called hierarchical clustering. Namely, we use a specific algorithm called Ward D2 for hierarchical clustering.[17] In essence, clustering techniques split provinces according to some shared characteristics, identify unusual cases, and classify remaining provinces into coherent groups. The main challenge in most of the clustering techniques is determining the number of optimal groups before assigning individual members into them. Several data-informed criteria help with this task. In our analysis, we use the Silhouette method developed by Kaufman and Rousseeuw[18] and the Gap statistics developed by Tibshirani, Walther, and Hastie.[19]

In addition to the clustering of provinces according to their features, we use principal component analysis to understand how different features statistically correlate with each cluster. This statistical method takes data with large dimensions and creates a significantly smaller number of summary indices. In this report, we use these indices or principal components to obtain useful information such as which variables exert greater influence on specific clusters and how clusters differ along with some key features.

We carry out all of our statistical analyses using the statistical software R, version 3.6.2. The data and codes for all procedures are available upon request.

RESULTS

I. AGE-PERIOD-COHORT INVESTIGATION OF CHINA HEALTH AND NUTRITION SURVEY DATA

We show the detailed output of the hierarchical random effects Age-Period-Cohort analysis with covariates in the appendix (parameter estimates from logit hierarchical models for Chines adult population). Table 3 below indicates a subset of those results and is limited to only those variables that had a statistically significant association with the likelihood of being obese or hypertensive. The coefficients are in terms of logit units, which can be roughly translated to probabilities by multiplying them by a factor of 0.25 (transforming from logit units to linear probability model units in Ordinary Least Squares [OLS] that have a more intuitive probability interpretation). For example, the coefficient for a university degree in the obesity model for the urban population is -0.44, which we can interpret as follows: The difference in the probability of being obese between someone with a high school education and a university degree is 11 percent.

The main results can be summarized as follows:

- Likelihood of having obesity and hypertension increases with age with slightly higher magnitude for urban residents; the age effect appears to peak at the 50-60 age group.
- Both urban and rural women appear to have a significantly higher chance of being hypertensive compared to men.
- Both probabilities of having obesity and hypertension decrease with more education with a substantially larger impact in urban areas.
- Smoking status appears to have a negative association with obesity and hypertension, whereas alcohol is a positive predictor of having obesity and hypertension.
- There is a large regional gradient to both obesity and hypertension.

Table 3: Salient Parameter Estimates from Logit Hierarchical Models for the Adult Population from the China Health and Nutrition Survey (1991-2015)

	OBESE		HYPERTENSIVE	
	Rural	Urban	Rural	Urban
Age Group 30-40	0.69 *	0.82 *	0.94 *	1.22 *
Age Group 41-50	0.91 *	1.23 *	1.97 *	2.21 *
Age Group 51-60	1.00 *	1.42 *	2.63 *	2.92 *
Age Group 61-70	0.99 *	1.31 *	2.80 *	3.12 *
Age Group 71-100	0.67 *	1.06 *	2.86 *	3.08 *
Sex: Men=1 and Women=0	0.10 ***	-0.07	-0.33 *	-0.31 *
No Formal Education	-0.01	0.18 *	0.17 *	0.19 *
Technical or Vocational Training	-0.12	-0.28 *	-0.18 ***	-0.13
University Degree	-0.22 ***	-0.44 *	-0.21 *	-0.39 *
Former or Current Smoker=1	-0.27 *	-0.21 *	-0.12 **	0.02
Consume Alcohol=1	0.09 ***	0.06	0.12 **	0.14 **
Liaoning	-0.38 *	-0.05	0.02	0.74 *
Heilongjiang	-0.43 *	-0.2	0.06	0.54 *
Shanghai	-1.03 *	-0.28 **	-0.36 ***	0.34 ***
Jiangsu	-0.84 *	-0.31 **	-0.60 *	0.53 *
Shangdong	-0.07	0.22 ***	-0.07	0.55 *
Henan	-0.24 ***	0.37 *	-0.23	0.43 **
Hubei	-1.02 *	-0.32 **	-0.28 ***	0.38 **
Hunan	-1.33 *	-0.74 *	-0.70 *	0.35 **
Guangxi	-1.90 *	-1.13 *	-0.91 *	-0.02
Guizhon	-1.26 *	-0.66 *	-0.94 *	-0.13
Chongqing	-1.14 *	0.02	-0.11	0.07
σ_{wave}	0.263	0.155	0.204	0.142
σ_{cohort}	0.054	0.102	0.102	0.132

* p<0.001; ** p<.01; *** p<0.05.

Source: China Health and Nutrition Survey (1991-2015)

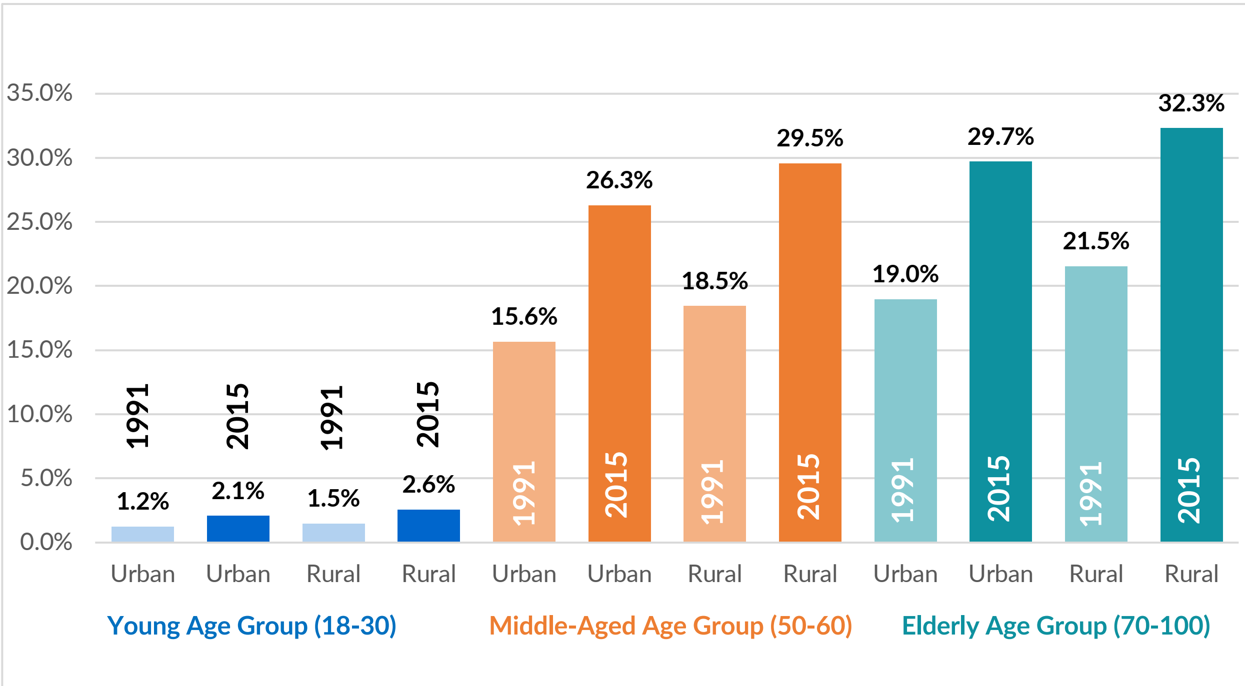
II. WHAT IS DRIVING HEALTH DISPARITIES IN CHINA?

The estimates from Table 3 show how increasing one variable by one unit while keeping the others at their mean level changes the probability of a person having obesity or hypertension. But that still does not provide a clear picture of how individuals with varying characteristics differ in their actual likelihood of having overweight/obesity or hypertension. Furthermore, it does not show which gradient is driving health disparities among Chinese population subgroups. To remedy this deficiency, we use a simulation technique to generate probabilities of a representative person having those conditions. We use the estimated models shown in the appendix (parameter estimates from logit hierarchical models for Chinese adult population) to produce 10,000 random realizations and calculate probabilities of obesity, hypertension, and cardiometabolic risk. We limit the simulation exercise to two provinces, Shangdong and Guanxi, as these provinces had more complete cases over the 1991-2015 period and showed differing health outcomes.

We illustrate the results of our simulation exercise in Figures 2-9 below. What do these results show?

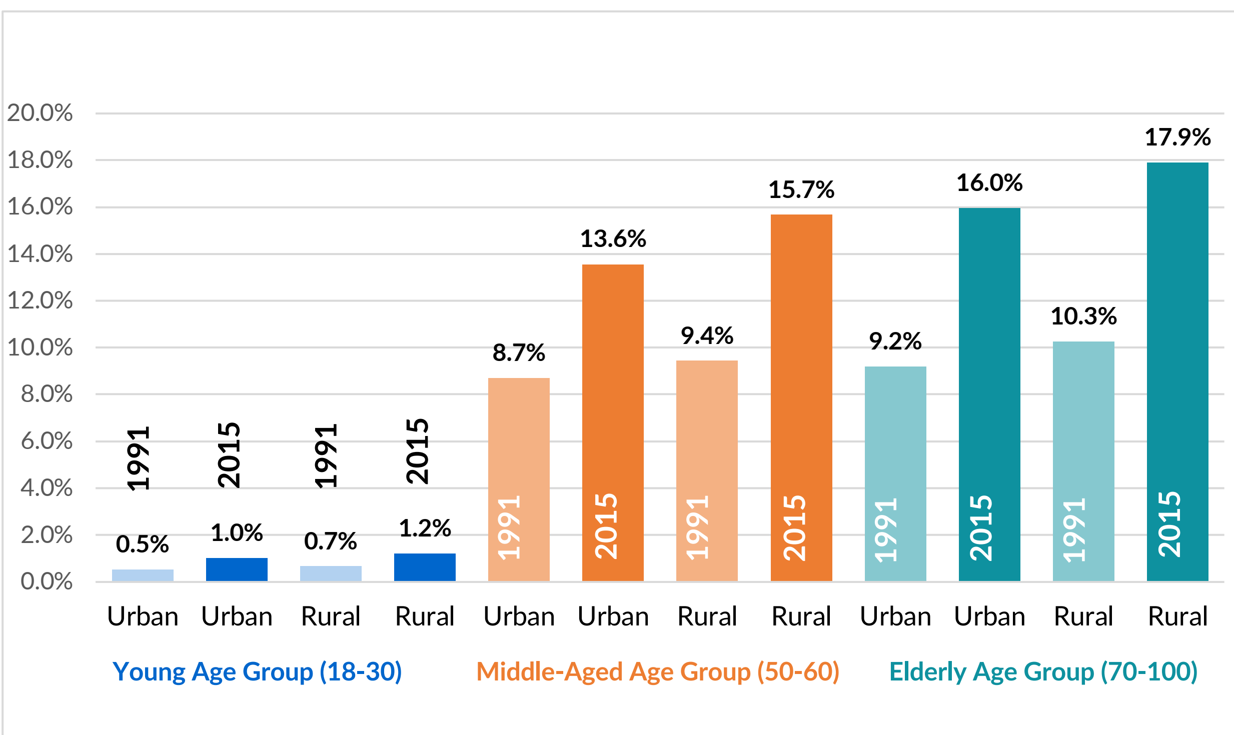
- After adjusting for age, the most significant disparity in health is along the regional dimension. For example, in 2015, the probability of having hypertension for a middle-aged person in the rural area of Shangondong is roughly 30 percent. In contrast, for a person with similar characteristics in Guanxi, the probability is almost half of that.
- Probabilities increased roughly proportionately for all age groups, for both urban and rural residents, and across all three precursors (weight, hypertension, and cardiometabolic risk).
- Probabilities of having hypertension and obesity are slightly higher for rural residents compared to urban residents.

Figure 2: Probability of Being Hypertensive, Shangdong



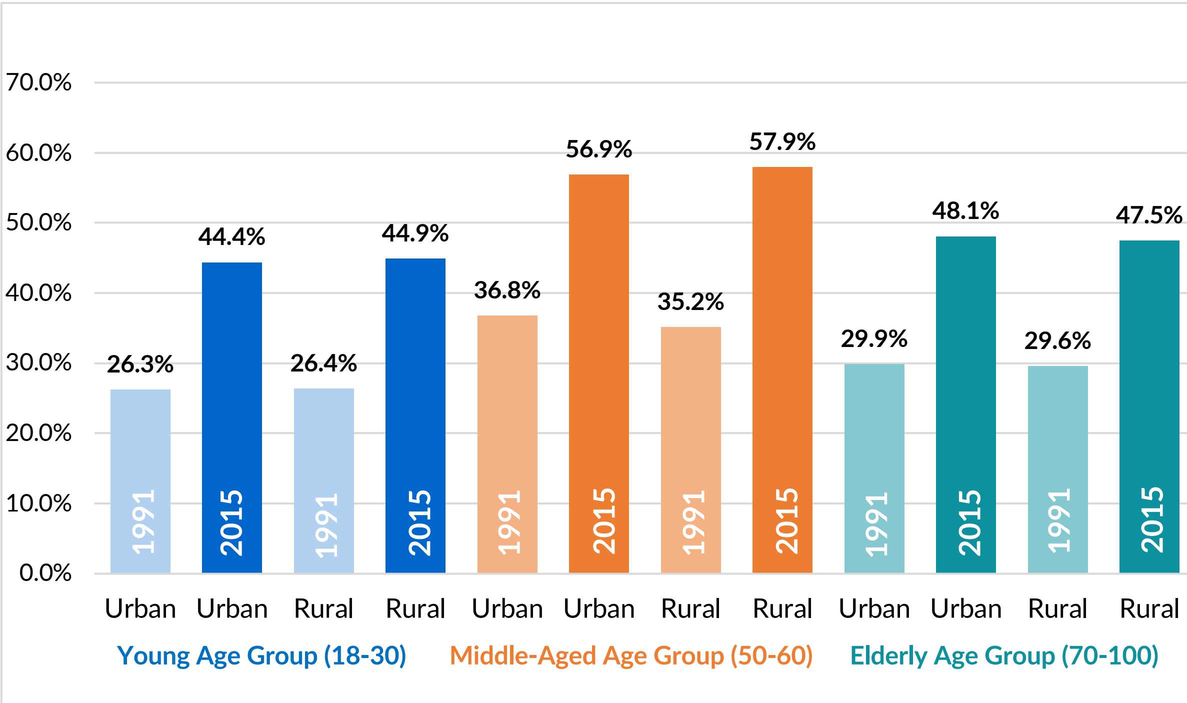
Source: Authors' calculations, Milken Institute (2020)

Figure 3: Probability of Being Hypertensive, Guangxi



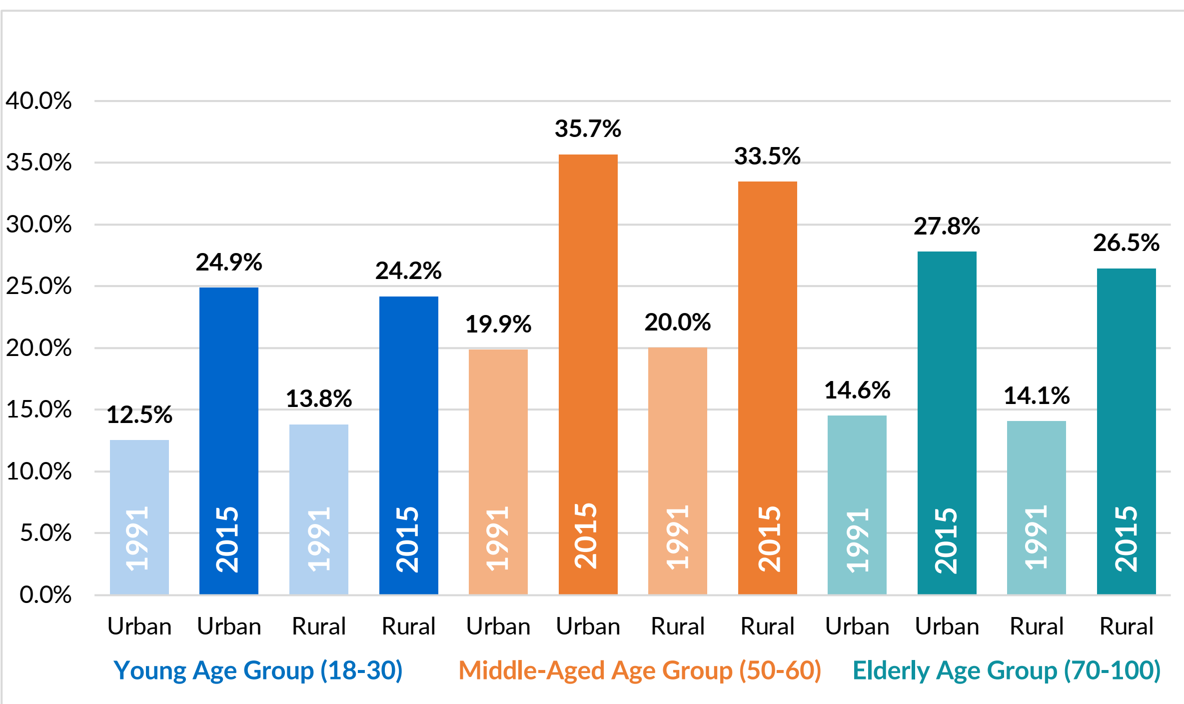
Source: Authors' calculations, Milken Institute (2020)

Figure 4: Probability of Being Overweight, Shangdong



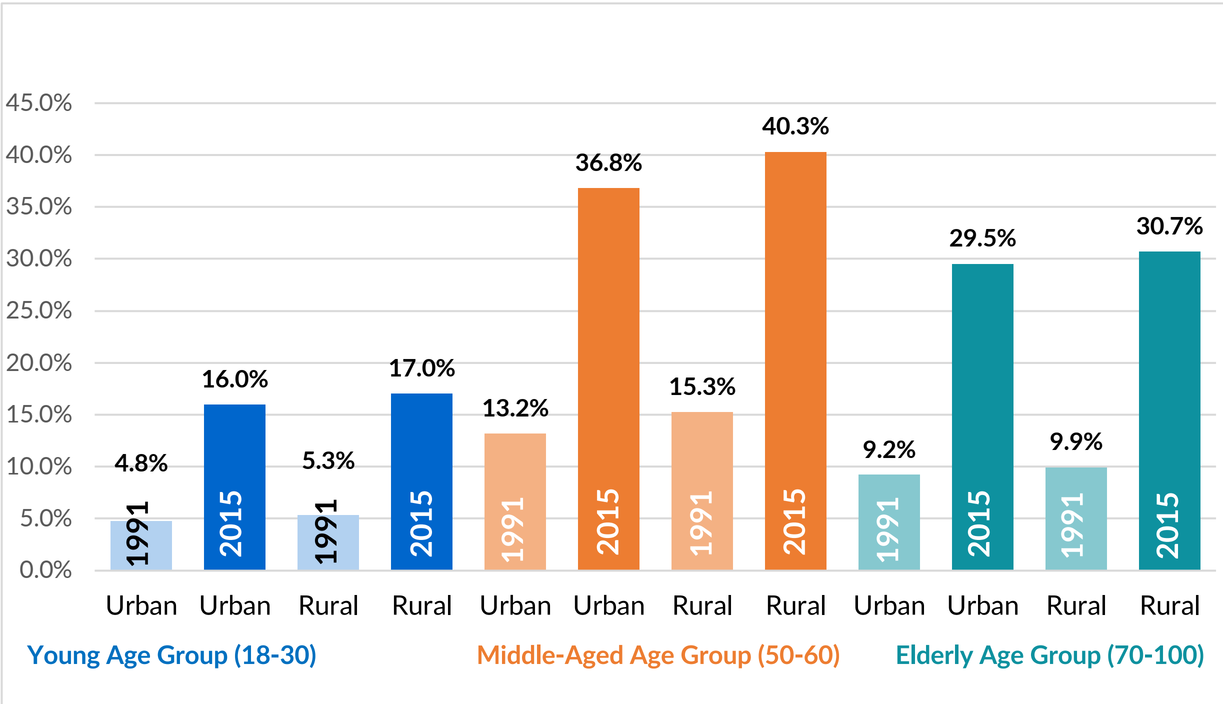
Source: Authors' calculations, Milken Institute (2020)

Figure 5: Probability of Being Overweight, Guangxi



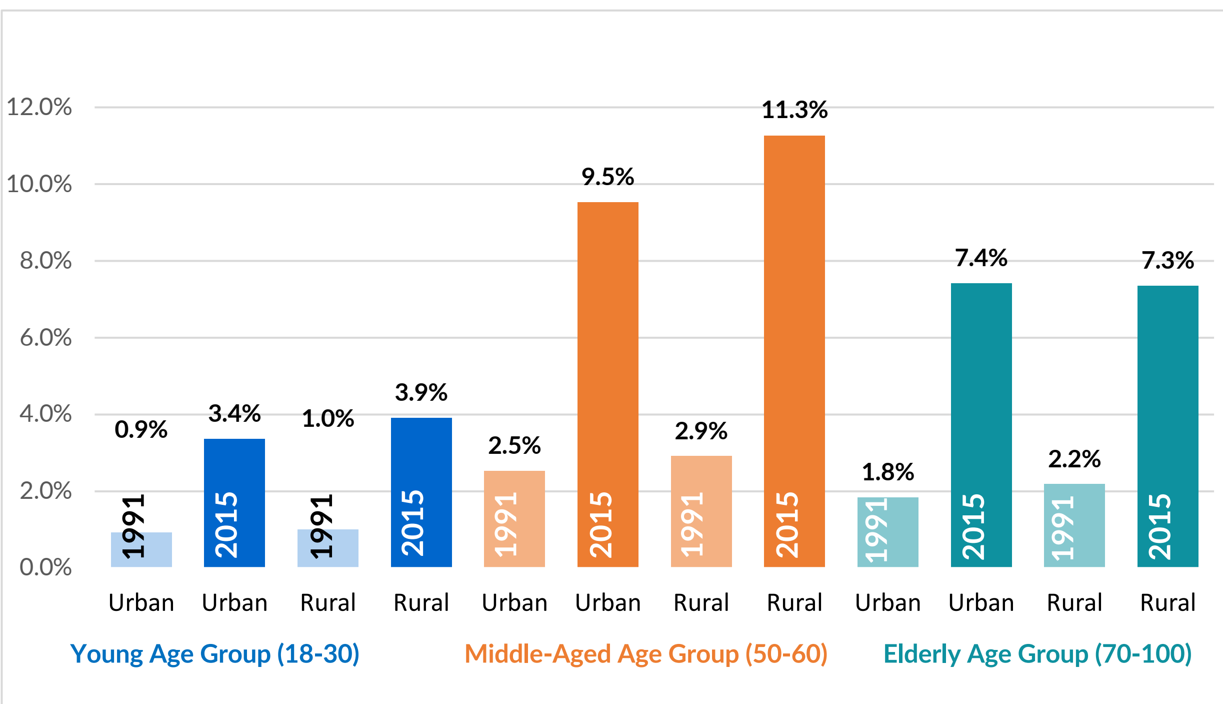
Source: Authors' calculations, Milken Institute (2020)

Figure 6: Probability of Having Obesity, Shangdong



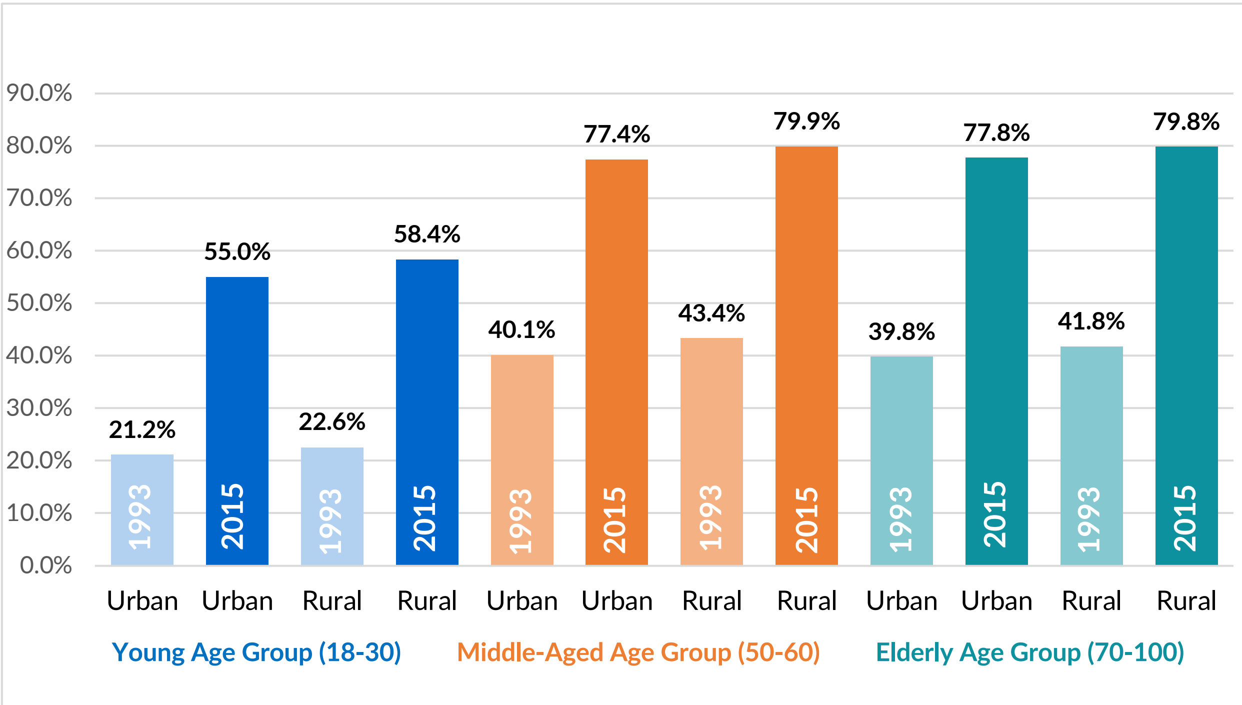
Source: Authors' calculations, Milken Institute (2020)

Figure 7: Probability of Having Obesity, Guangxi



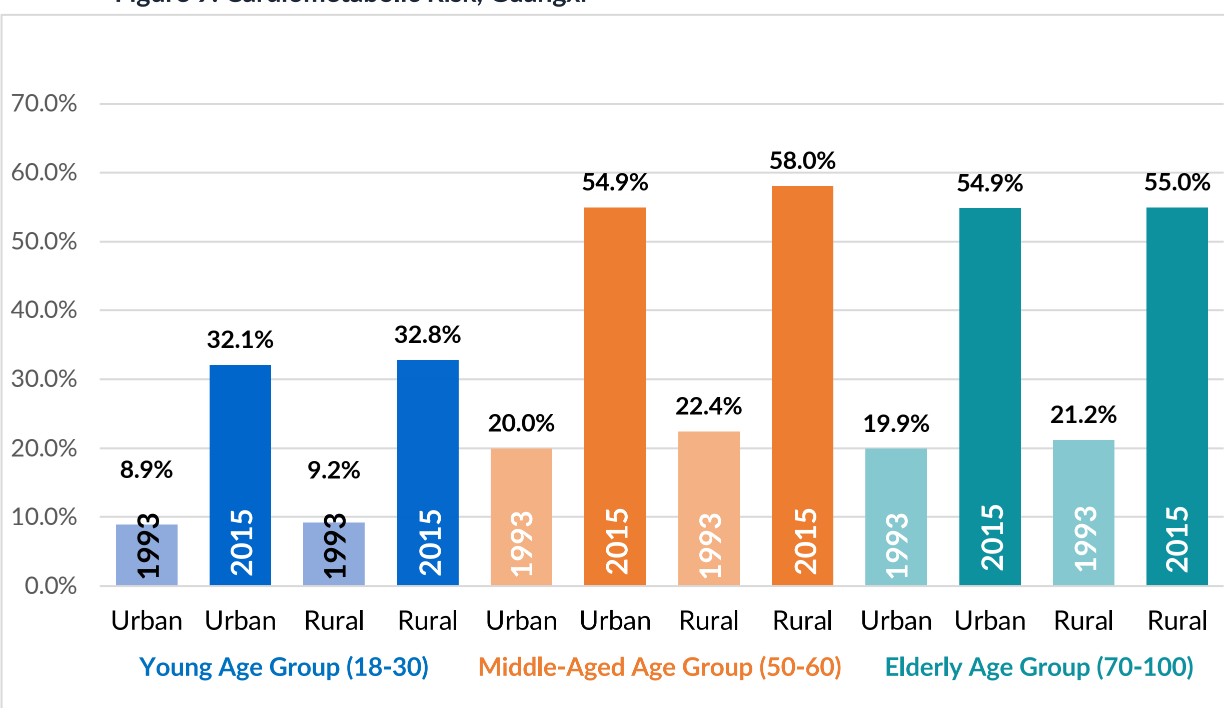
Source: Authors' calculations, Milken Institute (2020)

Figure 8: Cardiometabolic Risk, Shangdong



Source: Authors' calculations, Milken Institute (2020)

Figure 9: Cardiometabolic Risk, Guangxi



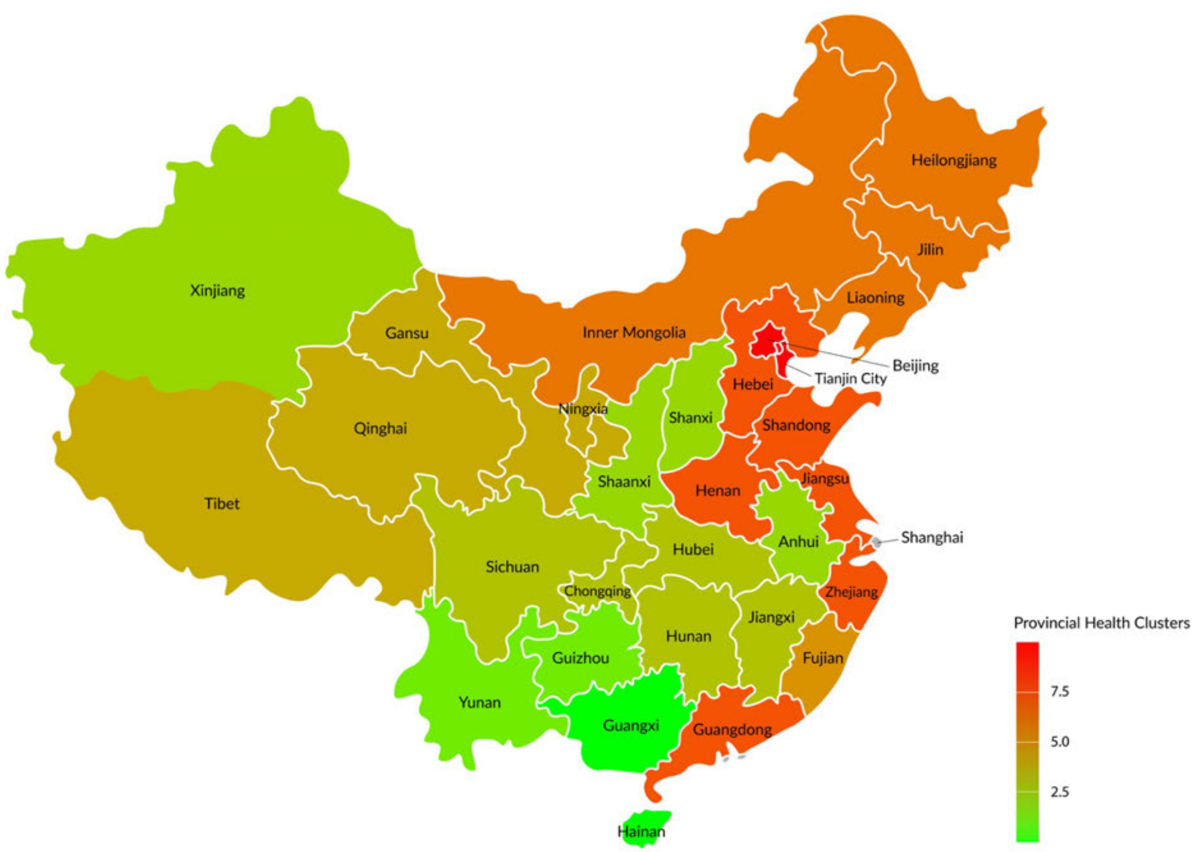
Source: Authors' calculations, Milken Institute (2020)

III. HOW (DIS)SIMILAR ARE PROVINCES IN HEALTH?

The results of our individual-level data analyses clearly suggest that the greatest disparities in obesity, hypertension, and cardiometabolic risks are among regions. To better understand how provinces are similar or different in terms of health outcomes, we carry out a hierarchical clustering of 31 provinces along all health indicators outlined in Table 2. The optimality criteria for cluster sizes indicate that we should have nine groups. After assigning each province to its corresponding cluster, we see that geographic proximity plays an important role (Figure 10). But we also know that proximity is not the only driver. For example, Shanghai and Fujian are along the eastern shores of China. Still, they are in a different cluster than Shangdong, Jiangsu, or Guangdong, which is at the southeast corner of the mainland. In a way, this clustering resembles what one can observe in the mainland states of the United States. The state of Florida is located in the southeast of the country, yet it is different in most attributes from its neighboring southern states such as Georgia and Alabama. If it is not geographic proximity, what makes these provinces similar or dissimilar from one another?

Figure 10. Health Clusters, 2017 Data

The cluster coloring scheme indicates ranges from green (healthy) to red (unhealthy).



Source: Milken Institute (2020)

IV. WHY ARE SOME PROVINCES HEALTHIER THAN OTHERS?

The health clusters that we identified in the previous section point to gradients that are beyond simple geographic proximity. To determine what else might help us characterize these clusters, we use principal component analysis. We combine health indicators along with economic, social, demographic, environmental, and dietary features for each province and find how these features interact with each other as well as with our previously defined nine clusters. We find that clusters do not differ along with any single feature but more in the combination of several features. For example, provinces in the high-risk clusters differ from the low-risk clusters in terms of a specific combination of urbanicity, pollution, diet, income, and behavioral risks, as shown in Figure 11. High-risk provinces tend to have a greater share of the urban population, high disposable income, inadequate intake of fruits and whole grains, and high alcohol consumption.

On the other hand, the healthiest clusters tend to be more rural provinces where the smoking prevalence tends to be high. But what do these features tell us? When taken as a whole, these features suggest that the primary health conditions such as hypertension, which is a crucial precursor to the costliest and deadliest diseases in China, are not driven by poverty or access to health-care facilities or the number of physicians alone as they had been for decades. Furthermore, the critical health disparities that require the state's attention are not along the urban-rural dimension or income. Although urbanicity and income remain important as social determinants of health, these factors are less important for health disparities compared to the regional differences. Our study shows that the drivers of these regional disparities are primarily lifestyle-determined and require a different set of policy tools than health officials had previously employed.

Figure 11. Low-Risk vs. High-Risk Clusters: Key Differentiating Features

LOW-RISK PROVINCES | **HIGH-RISK PROVINCES**

Provinces	**Guangxi, Hainan, Guizhou, Yunnan**	**Beijing, Tianjin, Guangdong, Hebei, Henan, Jiangsu, Shandong, Zhejiang**
Disease Precursors	Low abdominal obesity, smaller waist circumference, low prevalence of hypertension, low BMI, low systolic BP	High abdominal obesity, larger waist circumference, high prevalence of hypertension, high BMI, high systolic BP
Behavioral Risks	Low alcohol intake and high rate of smoking	High alcohol intake and low rate of smoking
Diet	High consumption of fruits and whole grains	Low consumption of fruits and whole grains
Income	Average disposable income	High disposable income
Urbanicity	Low urban population	Large urban population
Environment	Low levels of pollution	High levels of pollution

Source: Milken Institute (2020)

V. POLICY IMPLICATIONS: A RENEWED PERSPECTIVE FOR A NEW PROBLEM

POLICY REFORM

The formal adoption of the "Healthy China 2030" blueprint on October 25, 2016, marks a turning point in the evolution of China's public health policy reform. The significance of this national strategic plan, with well-defined 12 targets to meet by 2030, lies in its particular focus on preventative health policies as opposed to reactive policies that the government had taken in all of its previous policy endeavors. Specifically, the core components of the plan include the reduction of premature deaths from non-communicable (chronic) diseases by 30 percent and the improvement in healthy lifestyle indicators.[20] The overwhelming weight of non-communicable conditions in the total burden of disease in China in the recent decade, with stroke and ischemic heart disease being the two leading causes of deaths and disabilities, make this strategic plan more pertinent than ever. Moreover, the fact that elevated systolic blood pressure (>140), high BMI (>23), and abdominal obesity (waist circumference >85 cm for men and >80 cm for women) are vital contributors to stroke and heart disease further highlights the importance of developing effective policies to modify behavioral risk factors.

TARGETS FOR BEHAVIORAL RISK FACTORS

How much should the behavioral risk factors change to achieve the goal of a 30 percent reduction in premature deaths from chronic diseases by 2030? A recent comprehensive study shows that the desired modification is attainable if and only if the prevalence of elevated systolic blood pressure in the population falls by 25 percent below 2013 levels and the distribution of BMI in 2030 stays the same as in 2013.[21] The authors highlight a few obstacles and potential solutions to meeting the targeted reductions in behavioral risk factors. In particular, the fact that, despite the concerted efforts by health professionals, the awareness, treatment, and control of hypertension remain low, and obesity rates continue to rise, poses a significant challenge. The authors note that lifestyle modification may be an essential strategy for preventing hypertension. They also note that current segmented policies to modify lifestyles have not been successful.

NON-SINGULAR EFFECTS OF BEHAVIORAL RISK FACTORS

The first part of the analysis in this report and findings in many other studies show that no single factor is capable of explaining disparities in China in obesity, hypertension, and other precursors of chronic diseases. Our analysis of individual-level and aggregate data suggest that the most significant gap is seen across Chinese provinces. But we do not find a single risk factor that accounts for a majority of regional differences. That should not be surprising, given that many constraints such as culture, genetics, resources, and environment jointly contribute to the individual's behavior. Similarities in behavior within regions will also have to be influenced by typical constraints unique to the region. For example, dietary choices prevalent in the northern provinces are significantly different from those prevailing in the southeast or southwest, and partly dictated by the type of agricultural produce availability and the pace of life in more urbanized versus mostly rural regions.

THE WAY FORWARD

The success of "Healthy China 2030" is not limited to just identifying what must be changed. Our study highlights the role of complex interactions of multiple factors. It suggests that practical policies to modify lifestyle must necessarily account for unique cultural, economic, demographic, and environmental peculiarities in each province. In other words, the way forward in reducing premature death from non-communicable diseases requires tailored approaches to each region. Furthermore, our findings identify clusters of provinces by their risk level. Targeting provinces with the highest risk may be a more cost-effective approach in achieving the 2030 targets.

CONCLUSION

Despite significant achievements in averting tens of millions of deaths from infectious disease and improving maternal and childhood health, China's government faces an imminent and present threat from non-communicable diseases such as stroke and ischemic heart disease. Although the government has taken essential steps in declaring measurable and feasible public health goals for 2030, with prevention as its focus, the past policy tools that relied on just access to resources do not instill confidence among the practitioners and researchers to get the job done. In this study, we show that the regional differences account for the most significant variation in health disparities. Furthermore, we identify nine provincial clusters and their corresponding salient features. Our results provide evidence for policymakers to change the framework of how they implement public health policies and point to a targeted approach, addressing provinces with the highest need first with solutions that work.

APPENDIX

REVIEW OF LITERATURE EMPLOYING CHINA HEALTH AND NUTRITION SURVEY

METHODS

The review process included identifying potentially relevant research articles, reviewing abstracts, and reviewing and analyzing full articles using Google Scholar and PubMed databases. We included only articles published since 2000 in the searches. Using the key terms “urban rural health disparities inequalities china” and/or “CHNS survey,” Google Scholar search results produced 17,200 potentially relevant articles. A PubMed search using the key terms produced 123 possibly relevant results. Upon review, we identified 13 articles as meeting the inclusion criteria.

RESULTS AND REVIEW OF PAPERS

Li et al. looked at the urban-rural disparities of hypertension among Chinese adults from 1993 to 2011.[22] They used publicly available data from the China Health and Nutrition Survey (CHNS). Seven years of CHNS survey data were used (1993, 1997, 2000, 2004, 2006, 2009, and 2011). To distinguish whether a citizen was urban or rural, they used the hukou system, China’s resident registration system. The main objective of the study was to identify the urban-rural disparities in hypertension prevalence, detection, and medication usage. Their results revealed that rural adults are more likely to be underweight than urban adults and less likely to be overweight or obese. Key findings of the study revealed that urban adults are 24.5 percent more likely to have hypertension compared to rural adults. Compared to urban adults, rural adults who have hypertension are 49.4 percent less likely to be detected and 89.5 percent less likely to use medication.

Further analysis revealed that the probabilities of having hypertension were 27.5 percent for urban adults and 21.7 percent for rural. The rural-urban gap narrowed for hypertension prevalence but expanded over time for hypertension detection. The authors recommend that the state health authorities should make an effort to prevent and make aware hypertension to rural adults as hypertension prevalence among rural adults may extend to urban in the future.

Fang, Chen, and Rizzo looked at the general urban-rural health disparities in China. Using CHNS data from 1997, 2000, 2004, and 2006, they obtained self-reported health statuses of urban and rural residents.[23] Survey results revealed that more rural adults report excellent or good health status compared to urban (65.78 percent versus 60.69 percent). Compared to rural adults, urban adults have a higher rate of having either diabetes, myocardial infarction, or stroke (4.36 percent urban versus 1.94 percent rural). Their multivariate results revealed that an urban adult is 24 percent less likely to be in excellent or good health compared to rural adults. Although in all surveys rural adults always reported being in better health than urban adults, the gap consistently declined from 1997 to 2006. Fang et al. noted that this is likely due to a decline in health for rural adults, not an improvement in health for urban individuals. However, the gap increased slightly for urban residents reporting to have a serious disease from 1997 to 2006 compared to rural adults. Urban adults are also 1.5 times more likely to report having a stroke, diabetes, or a myocardial infarction compared to rural adults. The authors predicted that the probability of being in excellent or good health is 66 percent for rural adults and 61 percent for urban adults.

Attard et al. looked into the association between urbanization-related factors and the prevalence of diabetes in China.[24] To obtain their results, they used CHNS survey data from 2009, which included 7,741 adults. Findings revealed that the prevalence of diabetes varied across low, medium, and high urbanization areas, with the highest prevalence in highly urbanized areas.

Key results revealed that diabetes is more prevalent in more-urbanized areas than in less-urbanized areas. Diabetes was prevalent among 12 percent of men in more urbanized areas compared to 6 percent of men in less urbanized areas. Diabetes was prevalent among 9 percent of women in more urbanized areas compared to 5 percent of women in less urbanized areas. Surprisingly, over half of the individuals in this study with diabetes were not previously diagnosed by a doctor for having diabetes. Results showed that there was approximately a two times higher prevalence of diabetes in urban versus rural areas.

Liu, Fang, and Zhao examined the urban-rural disparities of child health and nutrition status among Chinese children from 1989 to 2006.[15] To obtain their results, they used CHNS survey data from 1989, 1991, 1993, 1997, 2000, 2004, and 2006. Excluding those that had missing data, there were 15,719 total child respondents in their dataset. Findings revealed that, on average, urban children have higher heights and weights for age. Urban children are 40 percent less likely to be stunted or underweight compared to rural children. However, the urban-rural health and nutritional gap has been decreasing as both urban and rural children are eating more high protein and fatty foods. Given this, their results revealed that the weight disparity, although still present, has been decreasing over time.

Hou investigated the urban-rural disparity of overweight, hypertension, undiagnosed hypertension, and untreated hypertension among adults in China.[26] Hou used CHNS data from 2000, resulting in 7,864 adults in the final sample. Survey data revealed that the average BMI for rural adults was 22.9, and the average BMI for urban adults was 23.5. Hou's findings revealed that there is no significant difference in the prevalence of obesity among urban and rural adults. However, there is a significant difference in overweight adults between urban and rural individuals: 22.8 percent of adults in rural China are overweight compared to 29.9 percent in urban China, and 13.3 percent of rural adults have hypertension compared to 15.9 percent of urban adults. Among those adults who have hypertension, 64 percent are undiagnosed in rural areas, and 50 percent are undiagnosed in urban areas. Furthermore, 78.4 percent are untreated in rural areas, and 66.3 percent are untreated in urban areas. Their results showed that urban adults have a higher probability of being overweight and having hypertension than rural adults. When they controlled for lifestyle variables, they found that the differences between urban and rural adults in terms of predicting hypertension and having obesity was not significant, suggesting that lifestyle differences are a major factor in determining hypertension and being overweight among individuals.

Zhang examined the trends in urban-rural inequalities in cardiovascular risk biomarkers among Chinese adolescents from 1991 to 2011.[27] CHNS data were used from 1991, 1993, 1997, 2000, 2004, 2006, 2009, and 2011. Zhang's results showed that urbanization has a positive effect on BMI and waist circumference for boys but not for girls. He found, however, that there is a positive interaction effect between the urbanization and years on waist circumference for girls. Results also revealed that boys in the most urbanized areas have higher systolic blood pressure than boys from the least urbanized areas. Zhang concludes that urbanization has led to further inequalities in cardiovascular risks among adolescents, especially for boys from less urbanized areas and girls from more urbanized areas.

Miao and Wu looked into the urbanization, socioeconomic status, and health disparities among Chinese adults.[28] The authors used CHNS data from 1991, 1993, 1997, 2000, 2004, 2006, 2009, and 2011. Their results showed that urbanization is associated with poorer health: For an additional 10 point increase in the urbanization index, the odds of developing a chronic disease multiplies by 1.128. This result concludes that living in a more urbanized area has a detrimental impact on health compared to living in a rural area in China.

Wang et al. looked into the rural-urban differences in the prevalence of chronic diseases in Northeast China.[29] They used the Jilin Provincial Chronic Disease Survey from 2012 to obtain their results. With this survey, the authors estimated the prevalence of chronic diseases between rural and urban adults in the Jilin Province. Results showed that cigarette smoking rates and the prevalence of overweight/obesity was slightly higher in urban than rural areas. After controlling for age and gender, their results revealed that rural residents had a higher prevalence of several chronic diseases, including hypertension, chronic ischemic heart disease, and chronic lower respiratory disease. The authors concluded this difference could be because rural adults, on average, have less education and may lack information and knowledge about health and chronic diseases. Rural adults also tend to have limited availability of health services, which could lead to chronic diseases being left untreated.

Song et al. examined the long-term trends of urban-rural disparity in obesity prevalence among Chinese children from 1985 to 2010.[30] They used data from the Chinese National Survey on Students' Constitution and Health from 1985, 1995, 2000, 2005, and 2010 to estimate the odds ratio for obesity prevalence in urban-rural areas. Their findings revealed that the prevalence of obesity was significantly higher in urban children than rural children. They noted, however, that the prevalence of obesity was increasing at a more rapid pace in rural than in urban areas. Thus, the urban-rural disparity gap was decreasing.

Cai, Coyte, and Zhao studied the general health inequalities among urban and rural adults in China from 1991 to 2006.[31] The authors used CHNS data from 1991, 1993, 1997, 2000, 2004, and 2006. Findings revealed that from 1989 to 2006, the average health status declined for both urban and rural populations. The average health scores for the rural populations were greater than the urban populations. Health inequalities consistently rose in rural areas, which may be due to the lack of comprehensive health services in rural areas and the fact that, for a long period of time, only private health insurance was available for rural individuals, which is too expensive for many residing in those areas.

Van de Poel et al. examined how the distribution of overweight and hypertension varies across Chinese provinces at different stages of urbanization from 1991 to 2004.[32] Using CHNS data from 1991, 1993, 1997, 2000, and 2004, they construct an urbanicity index, which provides a rank-based measure of inequality in disease risk factors by degree of urbanicity. Compared to the static urban-rural classification used in the CHNS, this urbanicity index allows for tracking of the changes in the communities' environment/level of urbanization over time. Their findings revealed that comparing 2004 to 1991, prevalence rates of overweight and hypertension are concentrated in more urban areas; however, the rates for both have become less concentrated in more urbanized areas over time. This suggests that the inequalities of overweight and hypertension across all areas has narrowed.

The constructed urbanicity index reveals that the level of hypertension that is directly attributable to the urbanicity-related inequalities increases from 20 percent in 1991 to 62 percent in 2004. This suggests that environmental factors are becoming increasingly important in determining one's health as community-level characteristics are increasing overweight and hypertension rates. Their findings also revealed that one-half of the urbanicity-related inequality in overweight is due to community-level characteristics as well. The authors suggest that one factor contributing to the decline of inequalities of overweight and hypertension rates among rural and urban populations is that more rural communities are catching up to urban communities regarding infrastructure, the economy, and community services and that their environmental conditions are becoming more urbanized.

Van de Poel et al. attempted to identify the net effect of urbanization on an individual's health in China from 1991 to 2004 using differences in differences method.[33] The authors used CHNS data from 1991, 1993, 1997, 2000, and 2004. Their findings revealed that, in general, urbanization increases the probability of reporting fair or poor health by approximately 4.2 percentage points. Accounting for fixed effects, they found that urbanization increases the probability of reporting fair or poor health by 5.5 percentage points, making the urbanization effect comparable to the effects of unhealthy living conditions. The authors concluded that, in general, urbanization translates to an increase of almost one-fifth in the baseline probability of reporting fair or poor health. Their results also showed that moving from the bottom half of the urbanization index to the top quartile increases the probability of reporting a decline in health by 8-10 percentage points, which translates to an increase of about one-third relative to baseline probability. This finding suggests that larger degrees of urbanization have stronger and more significant effects on reporting poor health.

Luo et al. studied the difference of height and BMI among urban and rural adolescents in the Hunan province of China and whether those differences have changed over time.[34] The authors used health records from the local hospital that conducted routine physicals for all middle school students each year. Their results revealed that both male and female students from urban areas aged 15-18 years had significantly higher BMIs and heights than those in rural areas during the 1990s and 2000s. They found that the BMI of adolescents aged 15-18 years was significantly greater in the 2000s compared to the 1990s for all cohorts except for rural females. The same effect was observed for adolescents aged 12-14 years for urban groups, male and female.

Table 4: Descriptive Statistics of Longtitudinal Data

URBAN		AGE	HOUSEHOLD INCOME	BODY MASS INDEX	WAIST CIRCUMFERENCE	WEIGHT-to-HEIGHT RATIO	SYSTOLIC BP	DIASTOLIC BP
1991	Mean	42	4,310	22.02	-	-	117	75
	Std.Dev.	16	2,592	3.01	-	-	20	12
1993	Mean	43	5,305	22.21	77.55	0.48	117	76
	Std.Dev.	16	3,938	2.97	9.80	0.06	19	12
1997	Mean	44	5,656	22.76	78.62	0.49	120	78
	Std.Dev.	16	4,321	3.25	10.03	0.06	19	11
2000	Mean	46	8,223	23.14	80.43	0.50	120	78
	Std.Dev.	16	7,683	3.28	10.37	0.06	18	11
2004	Mean	49	11,447	23.38	81.88	0.51	123	79
	Std.Dev.	16	10,374	3.46	10.36	0.06	19	11
2006	Mean	50	12,680	23.38	82.14	0.51	122	79
	Std.Dev.	16	12,323	3.38	10.20	0.06	18	11
2009	Mean	51	16,996	23.45	82.85	0.51	124	80
	Std.Dev.	16	15,943	3.52	10.37	0.06	18	11
2011	Mean	51	21,143	23.84	83.92	0.52	124	79
	Std.Dev.	16	18,731	3.50	11.07	0.07	17	10
2015	Mean	54	29,839	24.23	84.59	0.52	128	80
	Std.Dev.	15	43,264	3.50	13.75	0.08	19	11
RURAL		**AGE**	**HOUSEHOLD INCOME**	**BODY MASS INDEX**	**WAIST CIRCUMFERENCE**	**WEIGHT-to-HEIGHT RATIO**	**SYSTOLIC BP**	**DIASTOLIC BP**
1991	Mean	40	2,789	21.51	-	-	114	74
	Std.Dev.	15	2,127	2.76	-	-	18	11
1993	Mean	41	3,087	21.66	74.97	0.47	115	75
	Std.Dev.	15	2,579	2.76	8.50	0.06	17	11
1997	Mean	43	4,097	22.06	77.00	0.48	119	77
	Std.Dev.	15	3,193	3.00	9.17	0.06	18	11
2000	Mean	44	5,104	22.62	79.03	0.49	119	77
	Std.Dev.	15	5,013	3.20	9.59	0.06	18	11
2004	Mean	47	6,494	22.89	80.38	0.50	122	79
	Std.Dev.	15	6,299	3.32	9.74	0.06	19	12
2006	Mean	49	7,884	23.05	80.94	0.51	122	79
	Std.Dev.	15	12,152	3.32	9.92	0.06	18	11
2009	Mean	50	12,028	23.26	82.55	0.51	125	81
	Std.Dev.	15	16,177	3.42	10.33	0.06	19	12
2011	Mean	51	14,234	23.68	83.82	0.52	125	80
	Std.Dev.	15	16,649	3.55	11.08	0.07	19	11
2015	Mean	53	20,601	24.20	84.07	0.52	130	83
	Std.Dev.	15	30,468	3.68	12.16	0.08	20	12

Descriptive Statistics of Longtitudinal Data (continued)

URBAN	WOMEN	OVERWEIGHT	OBESE	METABOLIC SYNDROME RISK	HIGH BP	SMOKING	ALCOHOL	UNIVERSITY DEGREE
1991	54%	28%	7%	-	10%	34%	41%	5%
1993	52%	31%	7%	39%	10%	33%	41%	4%
1997	52%	35%	11%	45%	12%	31%	39%	5%
2000	52%	38%	13%	50%	11%	30%	38%	10%
2004	52%	40%	15%	57%	13%	32%	36%	9%
2006	53%	40%	15%	58%	11%	32%	33%	11%
2009	53%	40%	15%	61%	15%	31%	36%	11%
2011	53%	43%	17%	64%	12%	29%	37%	21%
2015	55%	46%	21%	71%	17%	24%	27%	22%
RURAL	**WOMEN**	**OVERWEIGHT**	**OBESE**	**METABOLIC SYNDROME RISK**	**HIGH BP**	**SMOKING**	**ALCOHOL**	**UNIVERSITY DEGREE**
1991	52%	22%	4%	-	7%	35%	36%	1%
1993	53%	23%	5%	30%	7%	34%	33%	0%
1997	51%	26%	7%	37%	9%	33%	34%	1%
2000	52%	33%	10%	48%	10%	32%	33%	2%
2004	52%	35%	11%	54%	12%	32%	31%	2%
2006	53%	37%	12%	56%	12%	31%	31%	3%
2009	52%	38%	14%	62%	16%	32%	32%	3%
2011	53%	40%	17%	67%	15%	31%	32%	7%
2015	54%	43%	21%	70%	22%	28%	28%	8%

Source: China Health and Nutrition Survey (1991-2015)

Table 5: Regional Variation in Mean BMI, WC, and BP

	Body Mass Index (BMI)		Waist Circumference (WC)		Systolic Blood Pressure (SBP)		Diastolic Blood Pressure (DBP)	
PROVINCE	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
Beijing	25.1	3.6	86.5	12.6	126.3	16.3	80.5	10.4
Liaoning	25.1	3.7	87.3	10.7	133.8	20.9	85.5	12.1
Heilongjiang	24.7	3.7	86.8	14.1	130.5	20.1	82.4	11.6
Shanghai	24.3	3.3	84.7	12.1	130.4	18.1	81.1	10.4
Jiangsu	24.2	3.5	85.3	11.8	131.7	17.2	82.8	10.0
Shangdong	25.4	3.5	85.8	16.6	136.5	18.2	84.6	10.7
Henan	24.6	3.7	84.2	16.5	133.0	21.6	83.1	12.5
Hubei	23.7	3.6	84.6	11.6	125.3	18.7	81.4	11.7
Hunan	23.7	3.3	82.8	11.4	125.7	19.5	79.7	10.9
Guangxi	22.7	3.4	79.3	11.4	129.6	20.2	79.9	10.9
Guizhon	23.5	3.7	82.1	10.6	122.1	17.0	78.9	10.4
Chongqing	24.1	3.6	83.4	11.7	128.9	19.0	81.6	12.7

Source: China Health and Nutrition Survey (2015)

Table 6: Summary Statistics for Province-Level Data

Province	Licensed Doctors	Urban Population	Disposable Income	Local Expenditure on Health	Education Funding	Number of Hospital Beds
Anhui	12.08	0.53	21,863.30	597.74	13,751,567.00	30.57
Beijing	9.44	0.87	57,229.83	427.87	12,512,746.00	12.06
Chongqing	6.85	0.64	24,152.99	353.79	9,483,526.00	20.64
Fujian	8.40	0.65	30,047.75	420.44	11,390,975.00	18.24
Gansu	5.61	0.46	16,011.00	289.24	7,087,547.00	14.66
Guangdong	25.80	0.70	33,003.29	1,307.56	38,610,331.00	49.21
Guangxi	10.11	0.49	19,904.76	512.31	11,891,781.00	24.11
Guizhou	7.55	0.46	16,703.65	436.21	12,488,005.00	23.30
Hainan	2.08	0.58	22,553.24	127.37	3,390,271.00	4.20
Hebei	19.19	0.55	21,484.13	605.10	15,938,479.00	39.50
Heilongjiang	8.85	0.59	21,205.79	297.17	7,545,432.00	24.17
Henan	22.03	0.50	20,170.03	836.66	21,546,749.00	55.90
Hubei	14.73	0.59	20,170.03	614.69	13,821,834.00	37.62
Hunan	17.30	0.55	23,102.71	585.98	15,165,690.00	45.23
Inner Mongolia	7.03	0.62	26,212.23	323.48	7,601,337.00	15.03
Jiangsu	21.71	0.69	35,024.09	789.52	25,960,645.00	46.92
Jiangxi	8.36	0.55	22,031.45	492.59	11,717,849.00	23.40
Jilin	7.06	0.57	21,368.32	279.22	6,586,685.00	15.37
Liaoning	11.57	0.67	27,835.44	336.63	9,651,893.00	29.86
Ningxia	1.82	0.58	20,561.66	97.98	2,288,400.00	3.98
Qinghai	1.55	0.53	19,001.02	125.21	2,343,469.00	3.83
Shaanxi	9.32	0.57	20,635.21	418.27	10,545,862.00	24.13
Shandong	26.46	0.61	26,929.94	829.27	23,946,021.00	58.48
Shanghai	6.79	0.88	58,987.96	412.18	12,104,556.00	13.46
Shanxi	9.43	0.57	20,420.01	321.34	8,533,662.00	19.75
Sichuan	19.49	0.51	20,579.82	831.46	19,274,514.00	56.35
Tianjin	4.11	0.83	37,022.33	182.10	5,850,624.00	6.84
Tibet	0.76	0.31	15,457.30	93.80	2,387,658.00	1.61
Xinjiang	6.23	0.49	19,975.10	266.71	8,462,090.00	16.76
Yunnan	9.39	0.47	18,348.34	546.99	13,292,088.00	27.48
Zhejiang	17.87	0.68	42,045.69	584.17	21,327,866.00	31.35

Source: National Bureau of Statistics of China (2017)

Summary Statistics for Province-Level Data (continued)

Province	Number of Outpatients	Abdominal Obesity	Waist Circumference	Hypertension	Pollution	Smoking
Anhui	2.67	43.90	81.00	20.50	53.85	7.33
Beijing	2.22	63.50	85.70	35.90	86.01	5.59
Chongqing	1.50	36.30	79.40	20.60	53.42	6.93
Fujian	2.20	42.60	80.50	23.90	43.06	7.28
Gansu	1.26	41.40	80.10	20.70	36.09	7.80
Guangdong	8.17	49.30	82.10	27.30	51.19	6.64
Guangxi	2.54	32.60	78.90	18.20	41.55	6.42
Guizhou	1.46	37.10	79.10	23.60	32.32	8.41
Hainan	0.49	26.70	76.80	20.30	25.91	7.00
Hebei	3.98	55.20	83.80	23.30	73.59	6.50
Heilongjiang	1.10	58.40	84.70	26.40	48.04	6.80
Henan	5.55	54.60	84.00	24.10	65.37	6.51
Hubei	3.43	39.10	79.90	18.10	59.79	6.56
Hunan	2.51	37.10	79.70	15.60	50.61	7.05
Inner Mongolia	0.98	55.50	83.40	19.70	41.19	6.81
Jiangsu	5.68	53.50	83.10	25.30	68.41	6.55
Jiangxi	2.06	32.80	78.60	17.30	40.09	7.05
Jilin	0.96	51.70	83.00	26.20	53.73	6.30
Liaoning	1.86	49.70	82.90	28.40	61.78	6.34
Ningxia	0.39	50.90	82.60	22.10	47.92	7.59
Qinghai	0.23	41.00	80.80	17.20	41.86	8.10
Shaanxi	1.87	51.50	83.40	22.00	53.25	7.04
Shandong	6.14	62.20	85.40	22.00	68.61	6.57
Shanghai	2.62	41.90	81.00	29.10	71.43	5.77
Shanxi	1.24	48.00	82.00	26.00	55.69	6.65
Sichuan	4.66	40.50	80.40	23.60	48.36	7.23
Tianjin	1.16	70.10	87.70	34.50	85.42	6.29
Tibet	0.15	48.90	82.20	25.00	16.78	7.67
Xinjiang	1.07	63.70	85.90	18.20	57.51	5.77
Yunnan	2.49	40.30	80.60	28.40	29.09	8.26
Zhejiang	5.83	41.50	80.40	23.20	59.47	7.30

Summary Statistics for Province-Level Data (continued)

Province	Alcohol Use	High SBP	High BMI	Diet Low in Fruits	Diet Low in Whole Grains	Diet High in Sodium	High LDL Cholesterol
Anhui	10.43	6.45	9.32	40.72	42.29	48.84	9.81
Beijing	14.66	6.79	15.58	27.89	38.00	27.04	10.89
Chongqing	10.09	6.66	8.30	37.81	41.30	46.90	10.75
Fujian	11.89	5.54	8.49	32.74	39.69	48.52	11.72
Gansu	9.41	6.66	6.74	42.60	43.00	33.99	9.04
Guangdong	12.21	5.97	8.37	31.59	39.25	43.28	11.10
Guangxi	10.16	5.00	6.53	40.29	42.10	19.29	11.30
Guizhou	9.45	6.90	6.51	43.83	43.47	44.72	10.91
Hainan	10.47	4.76	6.96	39.27	41.74	37.32	11.96
Hebei	10.87	7.66	11.14	36.90	41.04	47.39	10.63
Heilongjiang	11.74	7.49	9.48	38.77	41.62	36.81	10.72
Henan	10.56	6.81	10.83	38.61	41.59	47.95	9.66
Hubei	12.37	6.50	7.65	38.52	41.55	42.89	9.97
Hunan	10.45	6.18	7.81	39.38	41.82	46.67	10.36
Inner Mongolia	11.55	7.83	10.58	36.05	40.73	50.49	11.06
Jiangsu	13.58	6.73	11.41	31.35	39.26	47.48	9.88
Jiangxi	9.87	5.65	6.74	40.90	42.35	47.36	9.71
Jilin	11.91	7.25	10.55	37.73	41.28	42.60	11.43
Liaoning	12.46	8.92	11.14	34.93	40.38	43.58	10.31
Ningxia	10.08	6.54	7.01	39.88	41.96	41.54	9.02
Qinghai	9.40	6.53	6.41	40.58	42.22	48.60	9.02
Shaanxi	11.06	6.56	7.86	39.46	41.86	47.94	9.43
Shandong	11.93	6.85	11.62	33.04	39.78	50.21	10.87
Shanghai	13.64	6.08	13.10	28.62	38.26	45.14	12.44
Shanxi	10.37	7.74	10.73	39.22	41.76	46.99	8.93
Sichuan	10.71	6.36	7.88	39.79	41.96	45.78	10.87
Tianjin	13.02	6.82	14.78	27.28	38.77	25.51	11.14
Tibet	9.52	8.41	4.99	42.30	42.83	50.54	9.38
Xinjiang	9.32	6.08	10.54	38.74	41.56	52.07	9.85
Yunnan	9.74	5.44	6.07	41.39	42.49	46.18	11.13
Zhejiang	13.56	6.40	9.85	32.24	38.72	43.71	10.58

Table 7: Parameter Estimates (95% confidence intervals) from Logit Hierarchical Models for Chinese Adult Population

	OBESE		OVERWEIGHT		HYPERTENSIVE		CARDIOMETABOLIC RISK	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Intercept	-2.20 *	-2.63 *	-1.07 *	-0.86 *	-3.56 *	-4.58 *	-0.21	-0.60 *
	-0.16	-0.18	-0.12	-0.12	-0.18	-0.22	-0.22	-0.18
Age Group 30-40	0.69 *	0.82 *	0.38 *	0.61 *	0.94 *	1.22 *	0.45 *	0.62 *
	-0.08	-0.11	-0.05	-0.06	-0.12	-0.17	-0.05	-0.08
Age Group 41-50	0.91 *	1.23 *	0.59 *	0.83 *	1.97 *	2.21 *	0.76 *	1.11 *
	-0.09	-0.14	-0.06	-0.08	-0.12	-0.17	-0.07	-0.11
Age Group 51-60	1.00 *	1.42 *	0.46 *	0.76 *	2.63 *	2.92 *	0.89 *	1.31 *
	-0.09	-0.17	-0.07	-0.09	-0.13	-0.18	-0.09	-0.15
Age Group 61-70	0.99 *	1.31 *	0.31 *	0.77 *	2.80 *	3.12 *	0.89 *	1.43 *
	-0.1	-0.19	-0.09	-0.11	-0.15	-0.19	-0.12	-0.19
Age Group 71-100	0.67 *	1.06 *	0.12	0.43 *	2.86 *	3.08 *	0.81 *	1.31 *
	-0.11	-0.21	-0.1	-0.12	-0.16	-0.2	-0.14	-0.21
Household Income Per Capita	0.02	0.01	0.02	0	0.02	**-0.06** ***	0.02	-0.01
	-0.01	-0.02	-0.01	-0.01	-0.01	-0.03	-0.01	-0.02
Sex: Men=1 and Women=0	**0.10** ***	-0.07	-0.05	-0.06	-0.33 *	-0.31 *	0.36 *	**0.08** ***
	-0.04	-0.05	-0.03	-0.03	-0.04	-0.05	-0.03	-0.04
No Formal Education	-0.01	0.18 *	**-0.06** ***	-0.05	0.17 *	0.19 *	0.12 *	0.22 *
	-0.04	-0.06	-0.03	-0.04	-0.04	-0.05	-0.03	-0.05
Technical or Vocational Training	-0.12	-0.28 *	0	0.02	**-0.18** ***	-0.13	**-0.14** ***	**-0.12** ***
	-0.07	-0.07	-0.05	-0.05	-0.08	-0.07	-0.06	-0.05
University Degree	**-0.22** ***	-0.44 *	-0.19 **	-0.03	**-0.21** ***	-0.39 *	-0.23 *	-0.37 *
	-0.08	-0.06	-0.06	-0.05	-0.1	-0.07	-0.07	-0.05
Former or Current Smoker=1	-0.27 *	-0.21 *	-0.22 *	-0.18 *	-0.12 **	0.02	-0.24 *	-0.18 *
	-0.04	-0.05	-0.03	-0.04	-0.04	-0.05	-0.03	-0.04
Consume Alcohol=1	**0.09** ***	0.06	0.03	0.11 *	0.12 **	0.14 **	0.10 *	0.15 *
	-0.04	-0.05	-0.03	-0.03	-0.04	-0.05	-0.03	-0.04
Diversity Index	0.06 **	-0.01	0.05 *	0.03	**-0.05** ***	0.05	0.05 **	0.10 *
	-0.02	-0.02	-0.01	-0.02	-0.02	-0.03	-0.02	-0.02
Economic Index	**0.05** ***	0.10 **	0.07 *	0.07 *	0.03	0.08 **	0.05 **	0.03
	-0.02	-0.03	-0.02	-0.02	-0.02	-0.03	-0.02	-0.02
Health Index	0.04 **	0.01	**0.03** ***	-0.02	0.08 *	-0.03	-0.01	-0.05 **
	-0.02	-0.02	-0.01	-0.01	-0.02	-0.02	-0.01	-0.02
Housing Index	0.29 *	0.16 *	0.16 *	0.08 *	0.12 *	-0.05	0.17 *	0.11 *
	-0.03	-0.03	-0.02	-0.02	-0.03	-0.03	-0.02	-0.02

Parameter Estimates (95% confidence intervals) from Logit Hierarchical Models for Chinese Adult Population (continued)

	OBESE		OVERWEIGHT		HYPERTENSIVE		CARDIOMETABOLIC RISK	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Diversity Index	0.06 **	-0.01	0.05 *	0.03	**-0.05** *	0.05	0.05 **	0.10 *
	-0.02	-0.02	-0.01	-0.02	-0.02	-0.03	-0.02	-0.02
Economic Index	**0.05** ***	0.10 **	0.07 *	0.07 *	0.03	0.08 **	0.05 **	0.03
	-0.02	-0.03	-0.02	-0.02	-0.02	-0.03	-0.02	-0.02
Health Index	0.04 **	0.01	**0.03** ***	-0.02	0.08 *	-0.03	-0.01	-0.05 **
	-0.02	-0.02	-0.01	-0.01	-0.02	-0.02	-0.01	-0.02
Housing Index	0.29 *	0.16 *	0.16 *	0.08 *	0.12 *	-0.05	0.17 *	0.11 *
	-0.03	-0.03	-0.02	-0.02	-0.03	-0.03	-0.02	-0.02
Social Services Index	-0.02	0.04	0.02	0.03	-0.01	-0.04	0.02	0.07 *
	-0.02	-0.02	-0.01	-0.02	-0.02	-0.03	-0.01	-0.02
Liaoning	-0.38 *	-0.05	**0.21** ***	-0.05	0.02	0.74 *	**-0.27** ***	0.18
	-0.1	-0.1	-0.09	-0.08	-0.11	-0.13	-0.11	-0.09
Heilongjiang	-0.43 *	-0.2	0.35 *	-0.07	0.06	0.54 *	-0.22	-0.12
	-0.1	-0.11	-0.09	-0.09	-0.12	-0.14	-0.11	-0.1
Shanghai	-1.03 *	-0.28 **	0.13	-0.09	**-0.36** ***	**0.34** ***	-0.75 *	-0.11
	-0.13	-0.11	-0.12	-0.09	-0.14	-0.14	-0.14	-0.1
Jiangsu	-0.84 *	-0.31 **	0.18	-0.15	-0.60 *	0.53 *	-0.43 *	-0.08
	-0.1	-0.1	-0.09	-0.08	-0.12	-0.13	-0.11	-0.09
Shangdong	-0.07	**0.22** ***	0.50 *	0.25 **	-0.07	0.55 *	0.29 **	-0.1
	-0.1	-0.11	-0.09	-0.09	-0.11	-0.13	-0.11	-0.1
Henan	**-0.24** ***	0.37 *	0.50 *	-0.02	-0.23	0.43 **	0.08	0.30 **
	-0.11	-0.1	-0.09	-0.08	-0.12	-0.14	-0.12	-0.1
Hubei	-1.02 *	-0.32 **	-0.02	-0.26 **	**-0.28** ***	0.38 **	**-0.25** ***	-0.02
	-0.11	-0.11	-0.09	-0.08	-0.12	-0.13	-0.11	-0.1
Hunan	-1.33 *	-0.74 *	-0.12	-0.30 *	-0.70 *	0.35 **	-0.53 *	-0.17
	-0.11	-0.11	-0.09	-0.08	-0.12	-0.13	-0.11	-0.09
Guangxi	-1.90 *	-1.13 *	-0.40 *	-0.62 *	-0.91 *	-0.02	-0.98 *	-0.32 *
	-0.11	-0.12	-0.09	-0.09	-0.12	-0.14	-0.11	-0.1
Guizhon	-1.26 *	-0.66 *	-0.31 **	-0.44 *	-0.94 *	-0.13	-0.61 *	-0.16
	-0.11	-0.12	-0.09	-0.09	-0.12	-0.14	-0.11	-0.09
Chongqing	-1.14 *	0.02	0.13	**-0.23** ***	-0.11	0.07	-0.49 *	0.02
	-0.15	-0.12	-0.12	-0.1	-0.14	-0.16	-0.14	-0.11
σ_{wave}	0.263	0.155	0.132	0.072	0.204	0.142	0.413	0.231
σ_{cohort}	0.054	0.102	0.103	0.105	0.102	0.132	0.250	0.132

* $p < 0.001$; ** $p < 0.01$; *** $p < 0.05$.

Source: CHNS (1991-2015)

Provincial Maps

The following maps illustrate regional differences in income, urban population, air pollution, tobacco and alcohol consumption, abdominal obesity, waist circumference, systolic blood pressure, and hypertension prevalence. The color scheme ranges from yellow (smaller values) to red (higher values). All maps were generated by the authors using the province-level data outlined in Table 2.

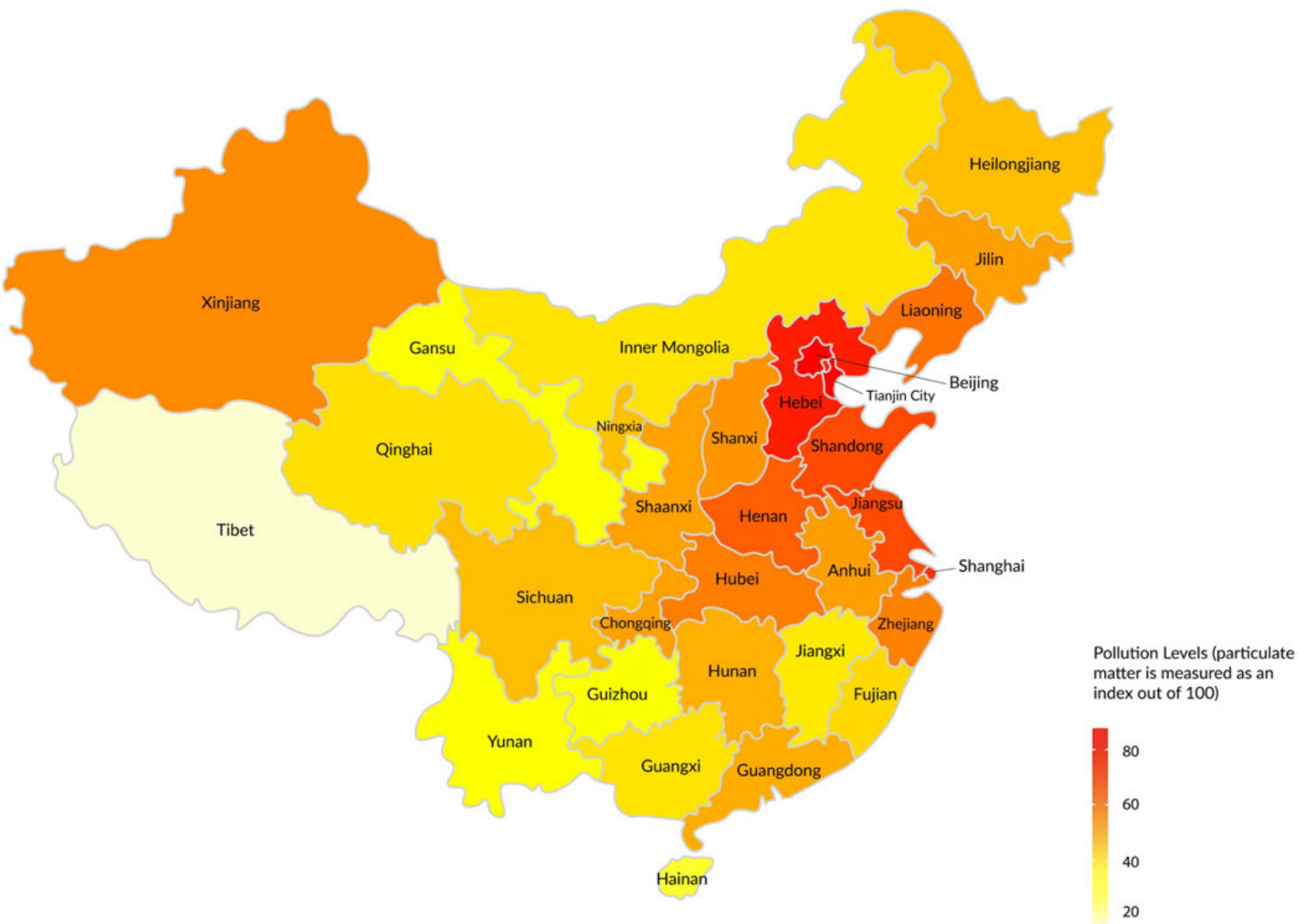
Figure 12: Disposable Income by Province

Source: Milken Institute (2020)

Figure 13: Urban Population by Province

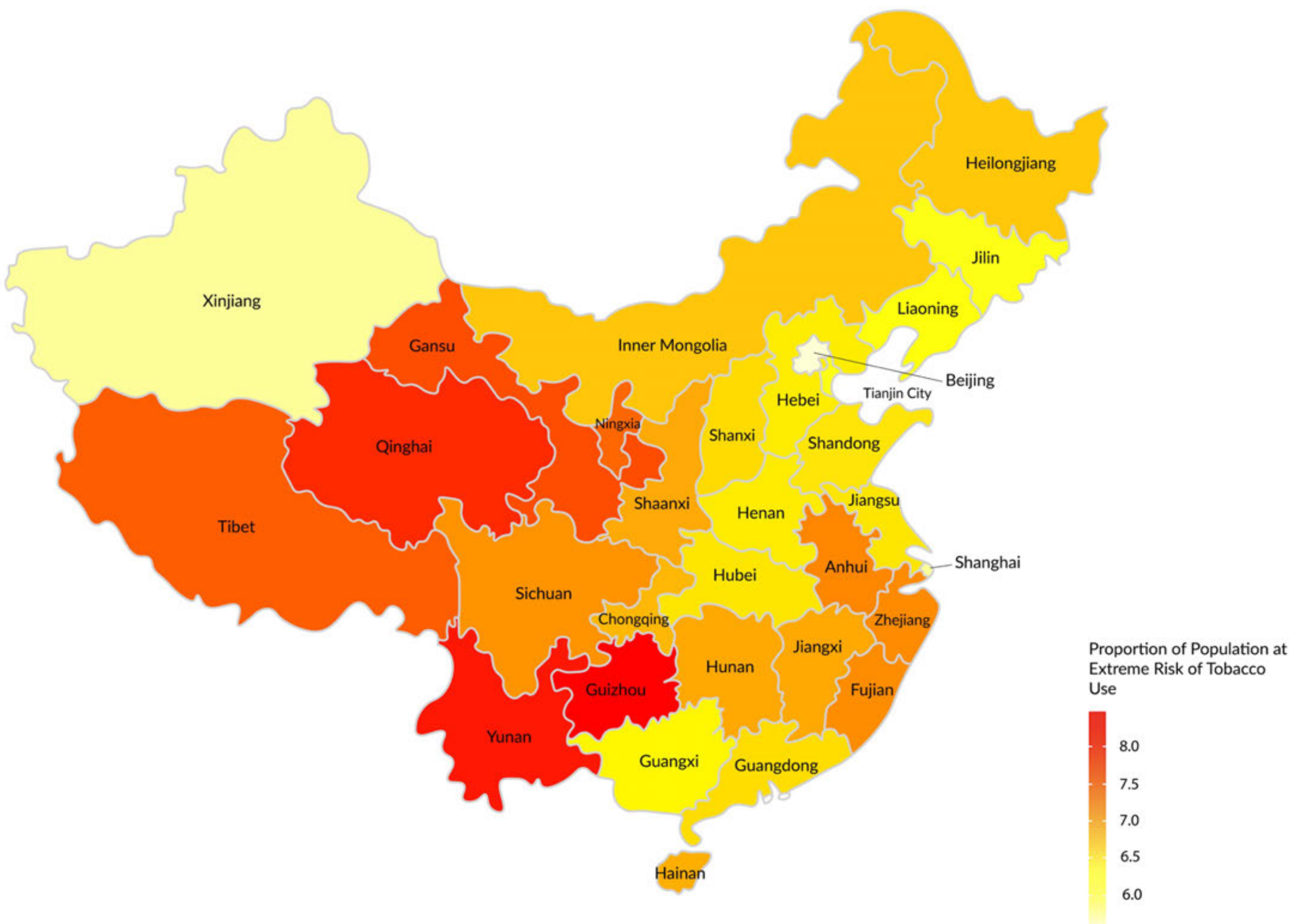
Source: Milken Institute (2020)

Figure 14: Air Pollution Levels by Province



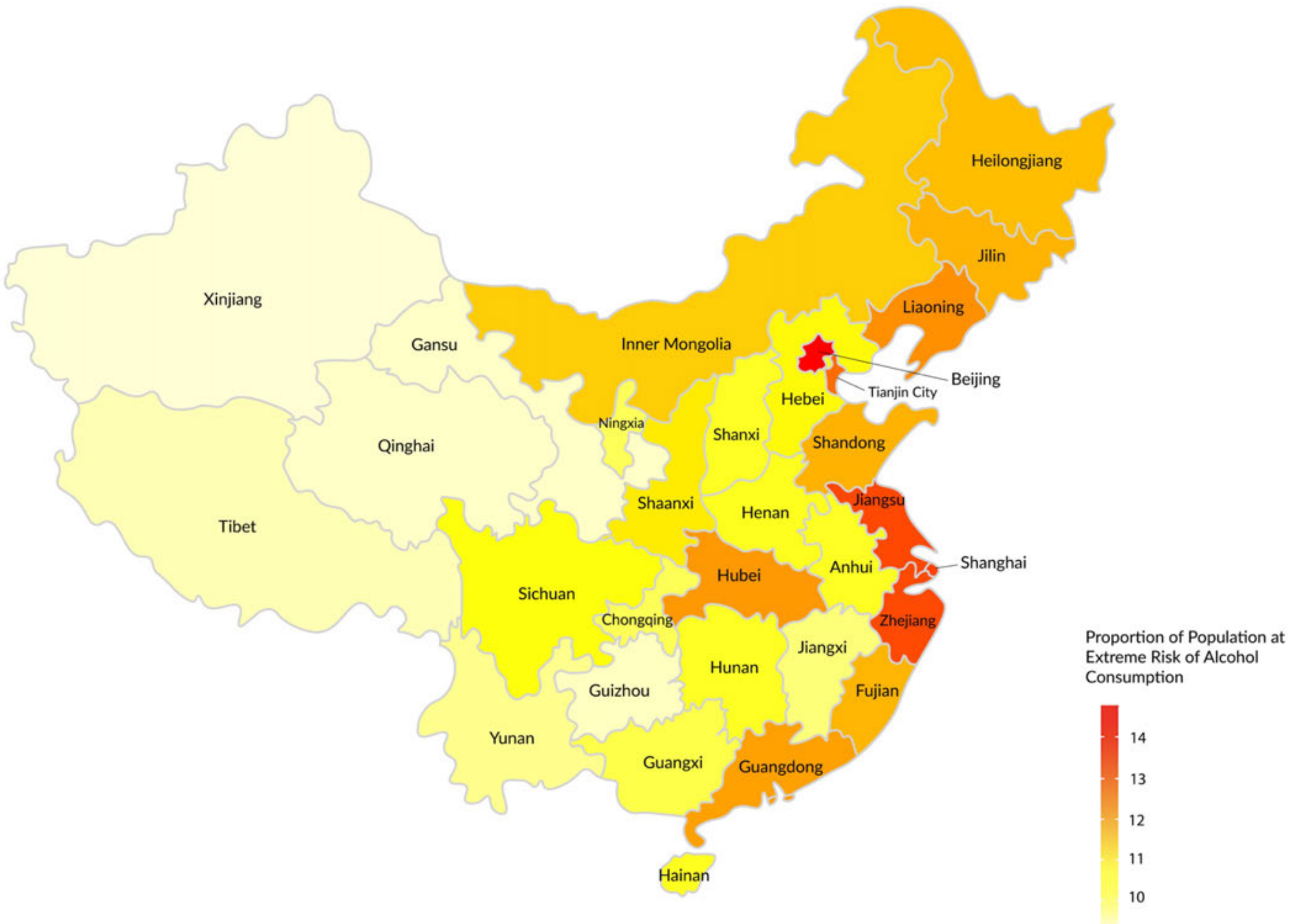
Source: Milken Institute (2020)

Figure 15: Tobacco Use by Province



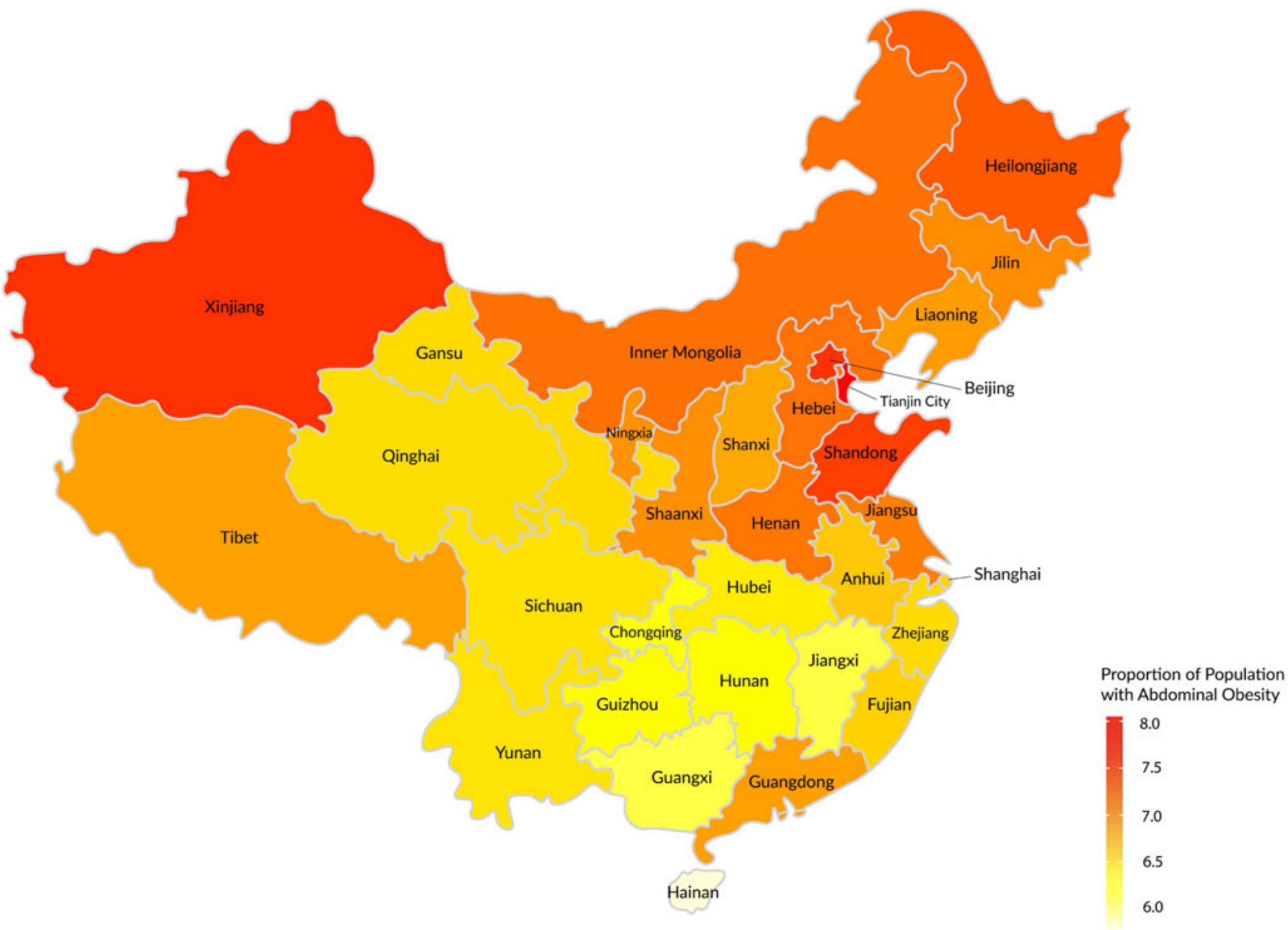
Source: Milken Institute (2020)

Figure 16: Alcohol Consumption by Province



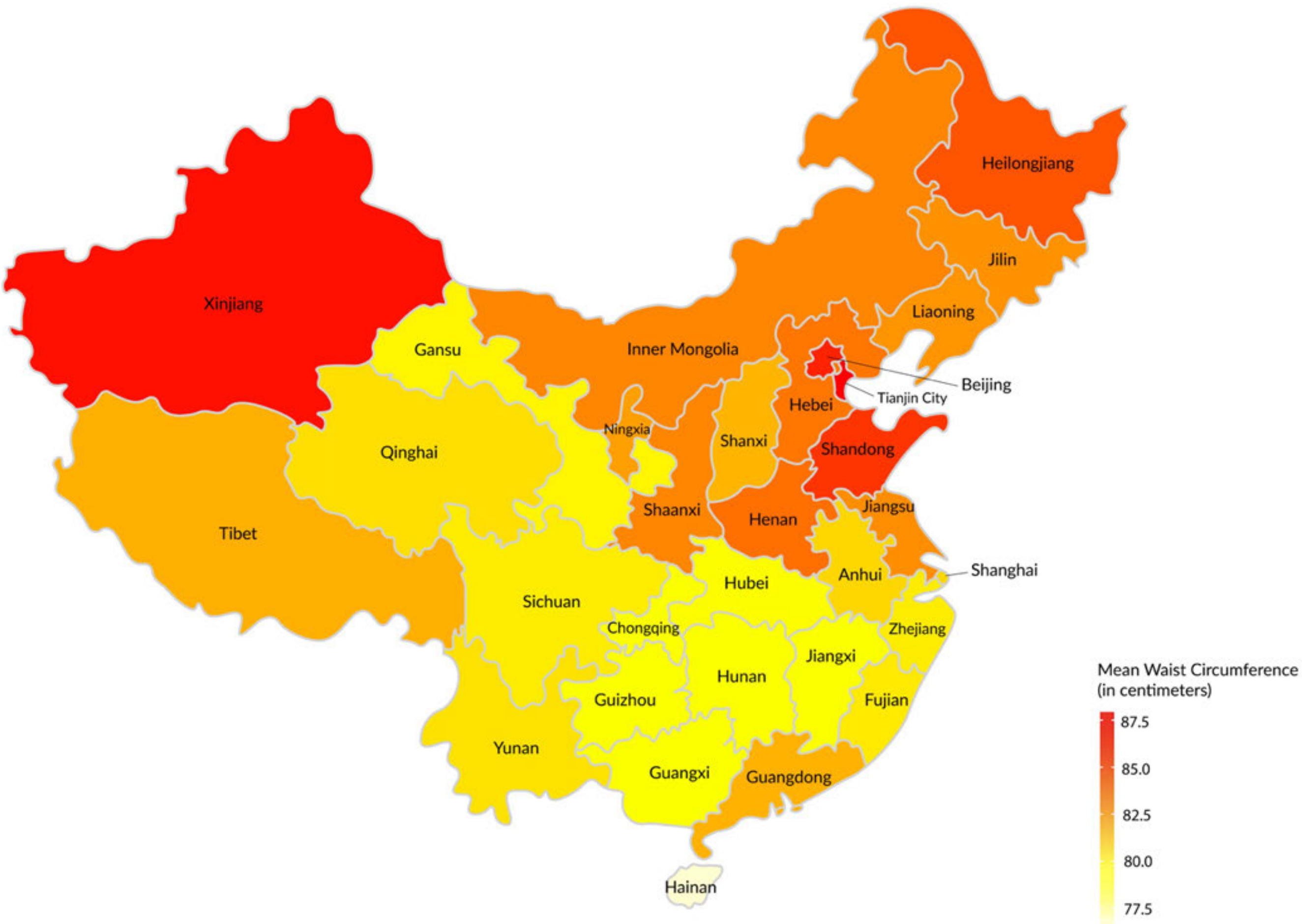
Source: Milken Institute (2020)

Figure 17: Abdominal Obesity by Province



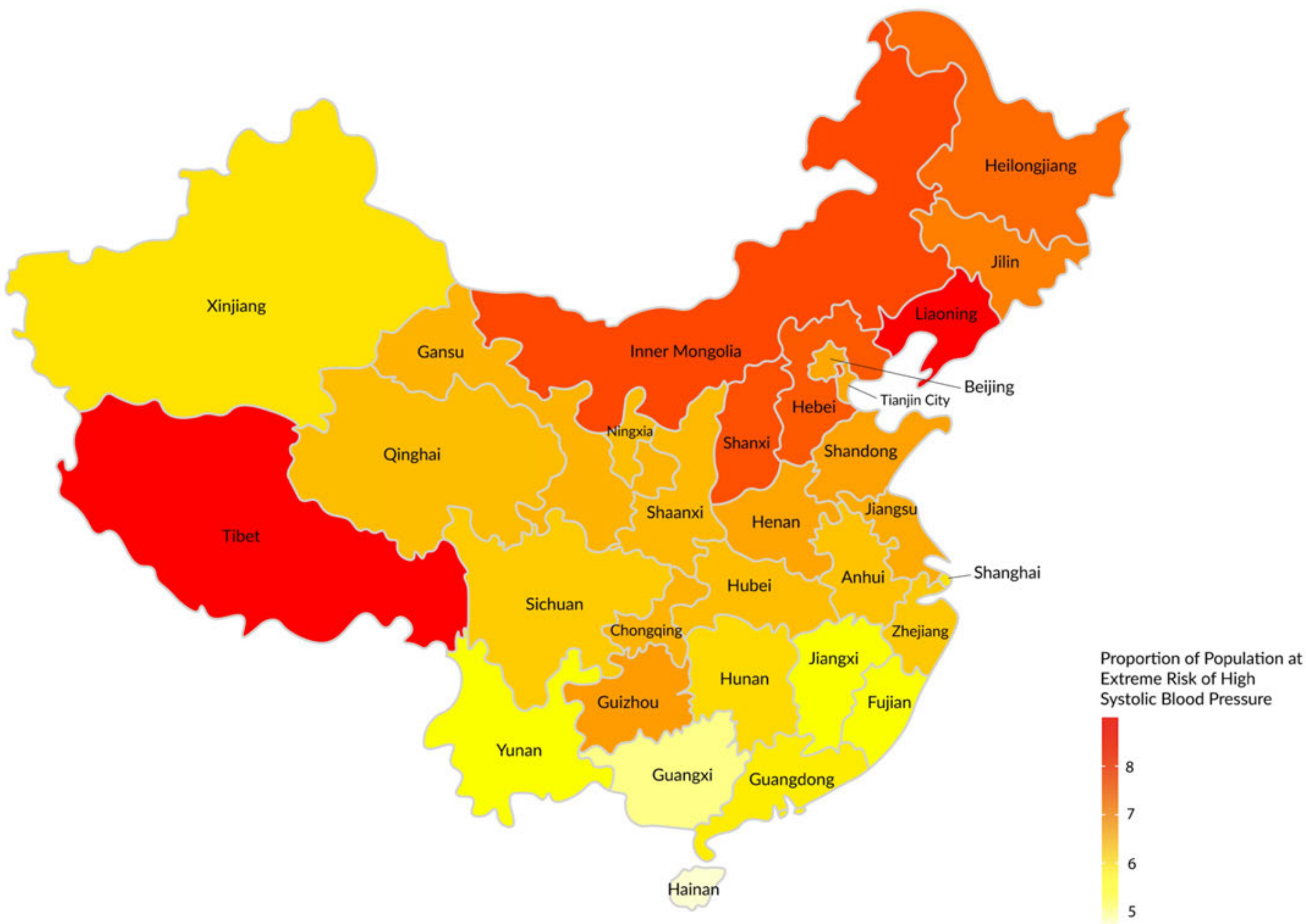
Source: Milken Institute (2020)

Figure 18: Waist Circumference by Province



Source: Milken Institute (2020)

Figure 19: High Systolic Blood Pressure by Province



Source: Milken Institute (2020)

Figure 20: Hypertension by Province

Source: Milken Institute (2020)

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