



Swiss Re
Centre for Global Dialogue

Risk Dialogue Series

Health Risk Factors China



In collaboration with



HARVARD
SCHOOL OF PUBLIC HEALTH

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Preface

Dear reader

We are very pleased to welcome you to this edition of the Risk Dialogue Series on Health Risk Factors in China.

Non-communicable chronic diseases (NCDs) have become increasingly prevalent in high growth and emerging markets. It is essential to better understand these trends, both from a public health perspective and in order to build sustainable life and health insurance pools.

This publication is part of the joint research collaboration by Swiss Re and the Harvard School of Public Health (HSPH). It describes the research undertaken by 45 colleagues from both institutions. It is an important component of what we call the Systematic Explanatory Analyses of Risk factors affecting Cardiovascular Health (SEARCH) project. The aim of our collaboration is to clarify the relationship between risk factors and health outcomes in the rapidly evolving countries of Brazil, China, India and Mexico. Their health profile is changing swiftly and significantly with economic growth. NCDs are rising rapidly, creating a major challenge for public and private providers and funders of health care.

Among emerging markets, China's health profile has changed quickly, so that the incidence of NCDs now resembles that of a developed market. Much of this change reflects an ageing population, a high prevalence of smoking, and rapid urbanisation, particularly in mega cities with poor air quality. Establishing an effective system of public and private healthcare provision, together with social security coverage in the event of illness or death, is a major undertaking for the country's authorities. We believe that private insurance is a valuable partner in providing effective healthcare; and we hope that these SEARCH articles go some way in demonstrating why.

With best regards

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Closing the financial gap for cardiovascular disease in China

Xiaojie Wang, David Lu, Hueyfang Chen

Cardiovascular Disease (CVD) is the leading cause of mortality and morbidity in China. The medical cost of CVD has been trending upwards at varying rates by geographic location over the past six years, and is projected to increase further in the future. Currently, over 90% of the population in China is covered by the social healthcare system that went through a recent reform in 2009. However, insurance coverage on CVD remains a major challenge and is putting the Chinese population at risk. It is expected to cause even more significant economic burden in the future.

Introduction

Cardiovascular disease (CVD) is the leading cause of mortality and morbidity in China.

Cardiovascular disease (CVD) has been the leading cause of mortality and morbidity in China in recent years. In 2010, 1.7 million people in China died from stroke and another 0.9 million died from ischemic heart disease¹. According to a 2012 report on cardiovascular diseases in China, around 41% of total deaths could be attributed to CVD every year. In China, it is estimated that there is one CVD death every 10 seconds².

CVD risk factors such as hypertension, tobacco smoking, alcohol use and an unhealthy westernised diet have been trending upwards over the last 20 to 30 years.

According to our findings during the Systematic Explanatory Analyses of Risk factors affecting Cardiovascular Health (SEARCH) project, CVD risk factors such as hypertension, tobacco smoking, alcohol use and an unhealthy westernised diet have been trending upwards over the last 20 to 30 years, when a rapid health transition occurred in China³. In Moran's model⁴, it was estimated that the projected number of annual cardiovascular events will increase by more than half from 2010 to 2030, even if we only account for ageing and population growth factors. In short, China is facing a fast growing financial burden due to CVD in the coming decades.

In this paper, the authors estimate the financial protection gap for CVD in China by analysing the medical expenses of CVD and financial protections provided by existing insurance.

China announced nationwide healthcare reform in 2009 in order to achieve universal access to healthcare services and reduce the economic burden of medical expenses for its citizens. Recently, more and more attention has been focused on evaluating the current social health insurance system in China. In this paper, we are going to estimate the financial protection gap for CVD in China by analysing the medical expenses of CVD and financial protections provided by existing insurance, mainly based on the data from the China Health Statistical Yearbooks (2008–2013) and topic-related research publications^{7–12,18}. The financial protection gap is defined as the excess amount of medical expense over the amount reimbursed by both social and commercial insurances. With this, we hope to trigger thoughts on how to better fill these financial gaps, as well as the role that private insurance providers can play to help combat this challenge.

Current health insurance coverage

The social health insurance system in China consists of three schemes.

The social health insurance system in China consists of three schemes: the new rural cooperative medical care system (NRCMS) for rural residents, the urban employee basic medical insurance (UEBMI) for urban residents employed by state-owned/private enterprises and urban resident basic medical insurance (URBMI) for the other urban residents (eg the urban unemployed, self-employed, elderly and students)^{5–8}. The coverage varies across the three schemes and regions, and it is seen as the government's attempt to narrow the financial gap by providing reimbursement for not just CVD-related costs, but also for general healthcare spending. On top of providing insurance to its citizens, the government also has established various programmes to control medical and drug costs in hospitals. China has set the goal to achieve universal health care coverage for all its citizens by 2020⁷.

The inequality in China’s health care system is due to the uneven development across regions.

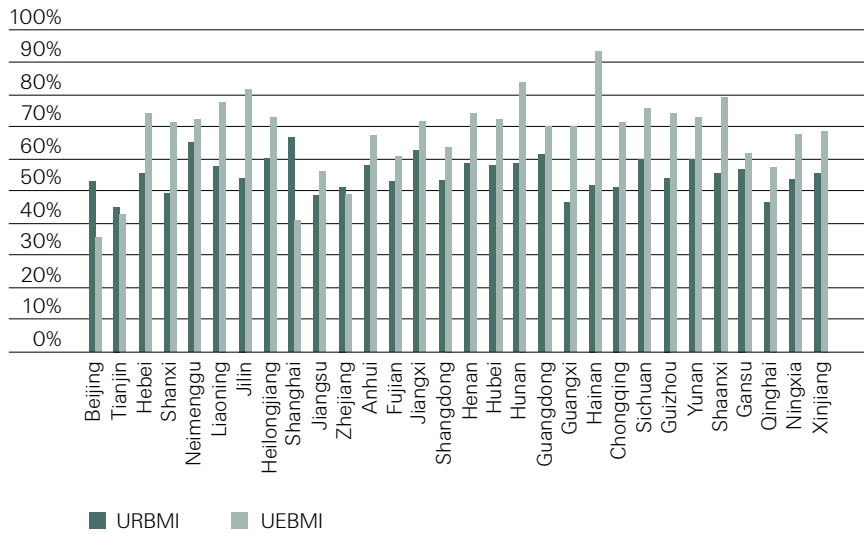
Reimbursement rates vary by health insurance scheme. It is assumed that patients with CVDs are reimbursed at rates that are below average due to the higher costs associated with CVDs.

Regional differences

The inequality in China’s health care system still exists due to the uneven development across regions. In general, UEBMI’s benefits are better than the other two schemes due to its stronger financial base derived from contributions by both employers and employees. In contrast, URBMI and NRCMS are more heavily dependent on government subsidies and hence, wealthier regions tend to have better coverage⁸. Since we lack specific CVD-financial protection data, the publications for general diseases were used for discussion in this section. We believe that the coverage for general diseases should provide a good overview of what might be the financial protections available for CVDs under China’s healthcare system. At any rate, we believe using the general diseases coverage is optimistic as CVDs medical costs are higher than average medical costs, and there are new and innovative treatments for CVDs that are likely not covered by the current system.

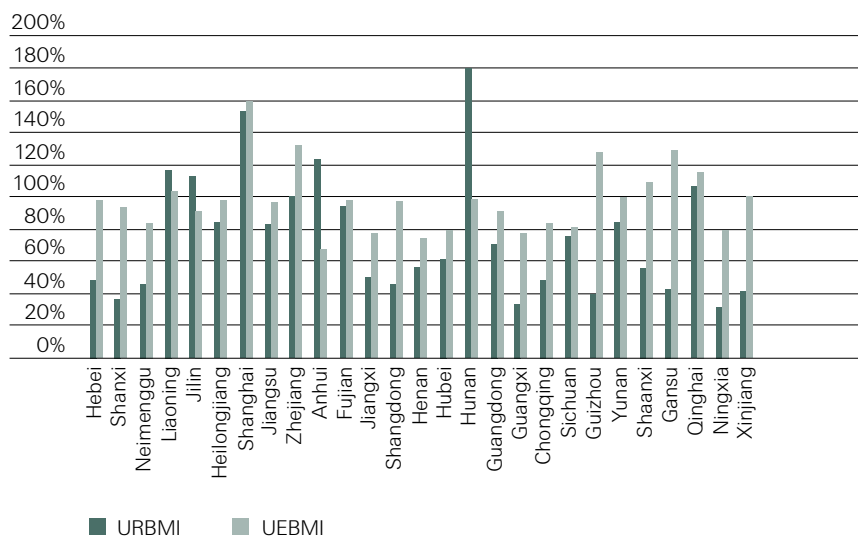
Huang⁸ summarised the inpatient and outpatient coverage under UEBMI and URBMI for each province in China based on a report from the Ministry of Human Resources and Social Insurance in 2010 (Figures 1,2). Employees in Beijing, Tianjin and Shanghai must cover 60–70% of the medical expenses out of pocket; this reflects the big gap between social insurance cover and the higher medical expenses in these big cities. The research⁵ suggests that the reimbursement rates under NRCMS are lower than URBMI. According to this study, the provincial average of inpatient reimbursement rates is around 70% for UEBMI and 55% for URBMI. The provincial average of outpatient reimbursement amount is around 100 RMB for UEBMI, one-third higher than for URBMI. It is reasonable to assume that reimbursement rates for patients with CVDs are lower than average due to more advanced and complicated treatments with costs that could reach the cap much faster. In addition, outpatient costs for CVDs would have less coverage compared to the average due to the expensive long-term medicine cost associated with CVDs.

Figure 1: Inpatient reimbursement rates of UEBMI and URBMI by province in 2010 as a percent of total expenses



Source: Huang (2010)⁸

Figure 2:
Outpatient reimbursement amount of
UEBMI and URBMI by province in 2010
(RMB per patient)

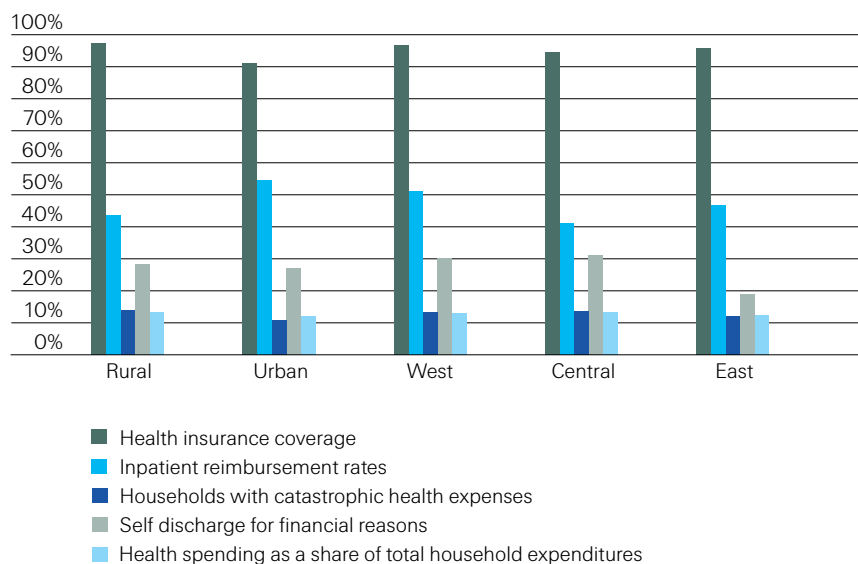


Source: Huang (2010)⁶

Compared to urban areas, rural areas cover a wider population but reimbursement rates are lower.

Meng et al⁷ conducted research on health service accessibility and financial protection for general diseases based on the 2011 National Health Service Survey (Figure 3). To study the regional differences, data were split into urban or rural areas and three geographic regions: east, central, and west (Figure 4). By 2011, health insurance coverage, including both social and commercial insurances, was provided to over 90% of the population nationwide. Compared to urban areas, rural areas cover a wider population but reimbursement rates are lower. The inpatient reimbursement rates range from 40%–55%; the difference is mainly due to different health schemes.

Figure 3:
Regional financial protection comparison



Source: Meng (2012)⁷

Figure 4:
Provinces, municipalities and autonomous regions by Eastern, Central and Western regions



Source: Swiss Re

Catastrophic health expense, defined as spending 40% or more of total annual income on healthcare, is a challenge for both urban and rural residents.

Catastrophic health expense was defined as spending 40% or more of total annual income on healthcare. Meng et al also indicated that little improvement was observed on the percentage of households having catastrophic health expenses during the period 2003–2011. Although reimbursement caps have increased almost twice as much on average since 2007, catastrophic health expenses still remain a concern. Inpatient self-discharge rates due to financial stress were on average 28.8% nationwide, and even in the richest region, the rate was still close to 20%. Some experts believe the percent of households experiencing catastrophic health expenses is expected to be much higher than the numbers in this paper, especially in rural areas. It is also interesting to note that the percentage of households with catastrophic health expenses does not vary much between urban and rural areas, which indicates that urban residents are subjected to similar catastrophic health expense risks as rural residents.

Although the findings from this study apply to general disease, we could reasonably infer that CVD trends are similar if not worse.

To reduce high out-of-pocket spending on medicines, China reformed the essential medicines system back in 2009.

Medicine coverage

Due to significant expenditure on medicine, China reformed the essential medicines system in 2009 to reduce high out-of-pocket spending on medicine^{9–11}. The latest essential drug list (EDL) was released in 2013, which includes 317 western medicines and 203 traditional Chinese medicines. The drugs on EDL have higher reimbursement rates than non-essential drugs and are categorised into two groups – List A and List B. List A comprises lower-priced and the most frequently used drugs (mostly generic) and are fully reimbursed. Drugs on List B are often higher priced and include patented and innovative drugs; the selection of drugs on List B can be adjusted by provinces and municipalities to suit their local economic situation and healthcare needs. The reimbursement level for List B drugs also varies across province governments. It was found that wealthier provinces added more drugs to their provincial EDLs⁵. The NRCMS covers significantly less drugs than the urban healthcare schemes⁵.

Medical expense of cardiovascular diseases

CVD medical expenses, including the various cost components, trends, and variances by regions, age and gender, were analysed.

In this section, we narrow our focus to concentrate on medical costs and components associated with CVD, and the financial protection gap that is still yet to be closed. Due to data availability, the focus is on coronary heart disease (heart attack and heart failure) and cerebrovascular disease (stroke). In 2011, the total inpatient expenses in China were about RMB 50 billion for acute myocardial infarction, RMB 140 billion for cerebral haemorrhage and RMB 270 billion for cerebral infarction². This translates to about USD 75 billion in aggregate. In this section, we studied the CVD medical expense, including the various cost components, trends, and variances by regions, age and gender.

The economic burden of CVD includes both short-term and long-term direct costs as well as indirect costs.

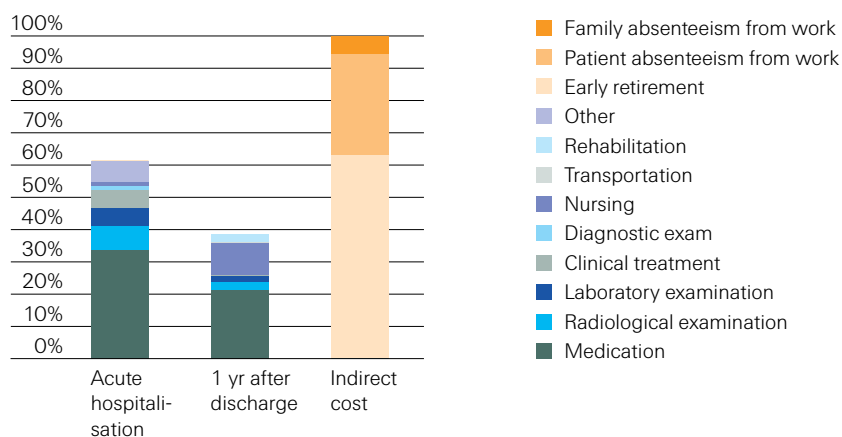
Components of CVD medical expenses

The economic burden of CVD includes both short-term and long-term direct costs as well as indirect costs. All inpatient costs, including drugs during that period, could be grouped into the short-term direct costs category, which contribute to the majority of the total CVD medical expenses. The long-term direct costs consist of medication after hospital discharge, follow-up outpatient service, nursing at home etc. Indirect costs are associated with the impairment of work and life activities, such as loss of income due to short term sick leave from work, or permanent leave such as early retirement.

Researchers found that about 60% of the cost incurred after a stroke was during the acute hospitalisation phase, and 40% was during the first year after discharge. Medicine was the biggest driver of costs.

Hu¹² analysed the direct cost components of atrial fibrillation (AF) related stroke in China (Figure 5). The average total direct cost of AF-related stroke was about USD 5000 per patient-year. About 60% of the cost was incurred during the acute hospitalisation phase, and 40% during the first year after discharge. This shows that the financial burden on medical costs continues to be significant, not just when the patients were first diagnosed with the disease and were hospitalised, but it remains for many months even after the patients are discharged from the hospital. Among all costs listed by Hu, more than half of total direct costs in both the short-term and the long-term can be attributed to drug costs. The indirect cost was more than half of the direct cost, and 63% of the total indirect cost was associated with early retirement. This indicates that besides medicine costs, loss of income is another big component of total costs associated with CVD. Sun et al¹³ also did statistical analysis on inpatient CVD medical cost. They found that about 40% of inpatient costs come from medicines, which was consistent with Hu's research.

Figure 5: Direct and indirect costs components of AF-related stroke



Source: Hu (2013)¹²

Closing the financial gap for cardiovascular disease in China

AF-related stroke patients are expected to pay more than 50% of their associated medical costs.

Geographic variances of CVD medical costs are mostly caused by the disparities in economic development and different social insurance coverage.

Limited accessibility to quality healthcare services in rural areas may be forcing patients to seek care beyond the local hospitals and results in additional costs.

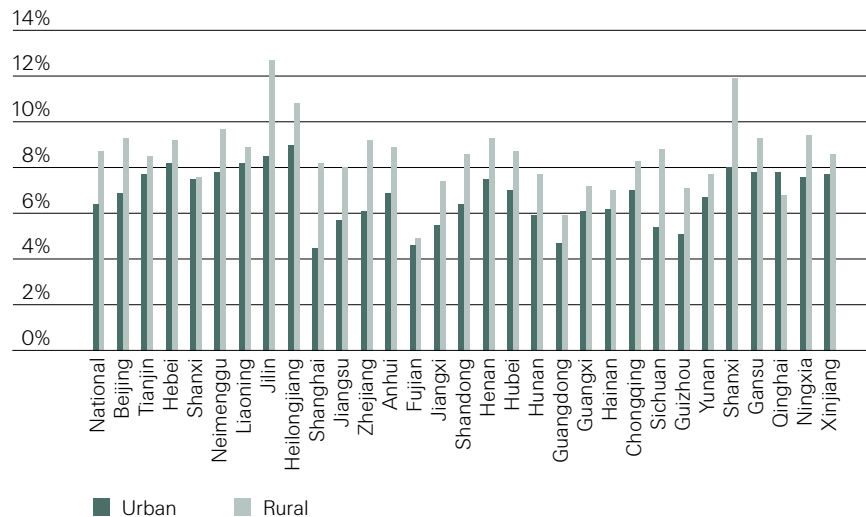
As discussed above, current public insurance schemes reimburse around 50% of inpatient costs, excluding drugs, which represent about 20% of the total direct costs of AF-related stroke. The coverage for medicine cost varies significantly between regions and schemes. With less coverage for the more recent, innovative, and imported Western drugs, the average reimbursement rate for CVD drug cost could be lower than 50%. Therefore, AF-related stroke patients are expected to pay more than 50% of their associated medical costs. In addition to that, there is currently no coverage for any of the indirect costs incurred due to sickness, which could be as high as 50% of total direct costs.

Geographic variances

Geographic variances of CVD medical costs are mostly caused by the disparities in economic development and different social insurance coverage. In this part of study, we analysed the ratio of health expenditure to the annual expenditure by region. Since there is no specific CVD-expenditure data in the China Health Statistical Yearbook, we used the data for overall medical expenses.

Figure 6 shows that the ratio of annual health expenditure to total expenditure per capita ranges from 4%–9% for urban areas and 5%–13% for rural areas. In general, people in rural areas spend relatively more on healthcare than people from urban areas. The less-developed provinces, such as Jilin and Shanxi, usually have above-average health expenditure percentages, especially in the rural areas. They also tend to exhibit higher disparity between urban and rural healthcare spending. This suggests that limited accessibility to quality healthcare services in rural areas forces patients to seek care beyond the local hospitals and results in additional costs (eg transportation, room and board etc). These costs need to be carefully accounted for when developing a viable solution for rural residents to close the financial gap on CVD medical expenses or even general medical expenses. Of all provinces, only Qinghai shows a reverse trend of higher health expenditure ratio in the urban versus rural area. One explanation could be that politics sometimes determines the level of social healthcare benefits. Provinces like Qinghai, with small populations and concentrated ethnic minorities, receive more subsidies from the central government to ensure they have better financial protection¹⁴.

Figure 6: Regional health expenditure comparison



Source: China Health Statistical Yearbook (2013)

Regional health expenditures were compared in several cities/provinces across China.

For the comparison, we focus on the biggest cities in China, where there is generally good healthcare access and plenty of opportunities for private insurance carriers. We chose four cities/provinces, one from each region (Table 1) to compare the variances between the North (Beijing), South (Guangdong), East (Shanghai) and West (Chongqing) of China. Chongqing, being the smallest city among the four, has the highest health expenditure/annual expenditure per capita in its urban area, even though its absolute amount of health expenditure is at the lower end.

Table 1:
Regional health expenditure versus average annual expenditure

Regions	Urban	Rural
National	6.4%	8.7%
Beijing	6.9%	9.3%
Shanghai	4.5%	8.2%
Guangdong	4.7%	5.9%
Chongqing	7.0%	8.3%

Source: China Health Statistical Yearbook (2013)

Even among the big cities, healthcare expenditure as a percentage of average annual expenditure differs.

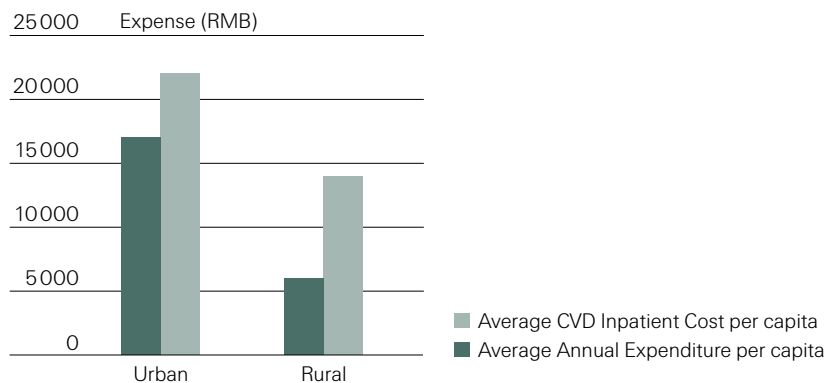
This suggests that even among the big cities, healthcare expenditure as a percentage of average annual expenditure differs and hence, there could be bigger financial gaps observed in such cities. Such areas could be a good market for private health insurance to step in and offer additional protection. Comparing the north and the south, people from Beijing spent more on healthcare compared to people from Guangdong. The figure for Guangdong could be attributable to the better insurance coverage in those areas¹⁵. This is consistent with the findings shown in Figure 1 – ie the inpatient reimbursement rates from social healthcare schemes for urban residents are higher in Guangzhou than Beijing. Although Chongqing has a similar inpatient reimbursement level for urban areas as Guangzhou, its residents spend much more on health care than Guangzhou residents. It is not clear why this is the case.

In urban areas, it is projected that the average CVD inpatient costs are around 130% of annual expenditure per capita, while in rural areas, the ratio increases to 230%.

Rural versus urban comparison

In Figure 7, we compared CVD inpatient medical costs and annual expenditure per capital for both urban and rural areas. According to the definition in the China Health Statistical Yearbook 2013, the urban areas include municipality districts and prefectural-level districts, while the rural areas include county-level cities, counties, towns and villages. CVD inpatient medical costs were significantly higher than annual expenditure per capital in both urban and rural areas. In urban areas, it is projected that the average CVD inpatient costs are around 130% of annual expenditure per capita, while in rural areas, the ratio increases to 230%. This creates a significant financial burden to people with CVD, even if we apply a 50% reimbursement rate under the current public health scheme. Although people in rural areas spend less in terms of annual expenditures and inpatient medical costs, they are more vulnerable after being hit by CVD due to the higher ratio of inpatient medical cost to annual expenditure.

Figure 7:
2012 Average CVD inpatient medical cost versus annual expenditure per capita



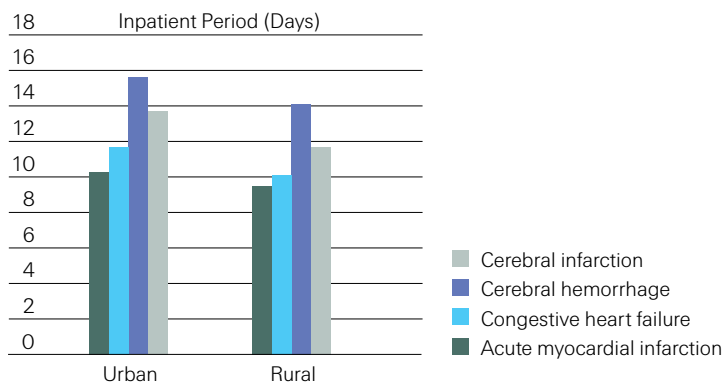
Source: China Health Statistical Yearbook (2013)

Closing the financial gap for cardiovascular disease in China

Hospital stays are longer among urban residents compared to rural residents.

Studies also find that hospital stays are longer among urban residents compared to rural residents (Figure 8), which suggests that rural residents could be receiving inadequate healthcare due to financial hardships. If this is the case, personal private insurance might not be the right solution as rural residents would not be able to afford it. However, government could pair up with large re/insurance companies to design additional affordable healthcare solutions for rural residents, while encouraging urban residents to purchase additional personal private insurance from local insurance providers in order to close the protection gap. This could save a significantly reduce government healthcare expenditures, while providing adequate medical financial protection to all citizens.

Figure 8:
2012 CVD-specific inpatient days between urban and rural areas



Source: China Health Statistical Yearbook (2013)

Annual inpatient medical cost data for five major cardiovascular diseases from the China Health Statistical Yearbook were analysed.

CVD medical cost trends

Six years of annual inpatient medical cost data for five major cardiovascular diseases from the China Health Statistical Yearbook were analysed. The total inpatient medical cost for those CVDs, except coronary artery bypass grafting (CABG), includes the expenses for examination, treatment, medicine and hospital stays. CABG includes the additional surgery expense. The annual expenses for each disease in both urban and rural areas are shown in Table 2.

Table 2:
2012 CVD-specific inpatient medical cost between urban and rural areas (in RMB)

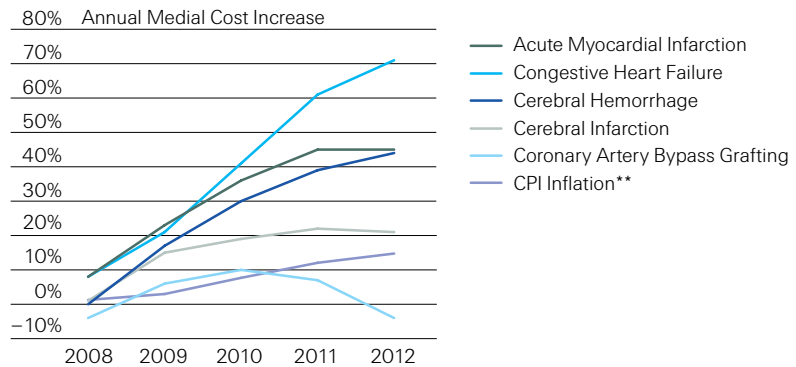
Diseases	Urban	Rural	Urban/Rural Ratio
Acute myocardial infarction	20 000–30 000	7 000–12 000	1.7–4.1
Congestive heart failure	10 000–16 000	5 000–6 000	1.6–3.2
Coronary Artery Bypass Grafting	35 000–50 000	35 000–40 000	0.9–1.4
Cerebral hemorrhage	16 000–20 000	10 000–13 000	1.3–2.1
Cerebral infarction	10 000–15 000	5 000–7 000	1.4–2.8

Source: China Health Statistical Yearbook (2013)

The average annual cost increases for acute myocardial infarction, congestive heart failure, and cerebral haemorrhage were around 8% to 11%, which were higher than the annual inflation rate.

The average annual cost increases for acute myocardial infarction, congestive heart failure, and cerebral haemorrhage were around 8% to 11%, which were higher than the annual inflation rate¹⁶ of 4%. Despite the average inflation rate of 4%, the inpatient medical cost for CABG remained stable over the past six years. One explanation for this is that such surgery becomes a more mature procedure and its cost is controlled by the government, which leads to higher efficiency and lower costs, while the costs for other CVDs continue to increase due to the introduction of new treatments. After the 2009 healthcare reforms, the increase of CVD inpatient cost slowed which could be attributed to the cost-effective control by governments (Figure 9).

Figure 9:
Six year trend of annual CVD inpatient medical cost per capita in China



Note: Data for 2007 was used as the base in the accumulative increase rates

Source: China Health Statistical Yearbook (2013)

The inpatient cost for CVDs represented a significant portion of annual average disposable income.

Table 3 indicates that the inpatient cost for CVDs represented a significant portion of annual average disposable income, which further confirms the heavy financial burden incurred at the onset of CVD events. National healthcare reform helped to control cost increases. The medical costs for the listed CVDs are expected to gradually become more and more affordable as the ratio of those medical costs to disposable income decrease.

Table 3:
Six year trend of annual CVD inpatient medical cost per capita in China

Year	Acute Myocardial Infarction	Congestive Heart Failure	Cerebral Hemorrhage	Cerebral Infarction	Coronary Artery Bypass Grafting	CPI Inflation**
2007	11 602	4 179	8 481	5 990	36 429	6.58%
2008	12 566	4 512	8 489	6 047	34 819	1.26%
2009	14 271	5 067	9 958	6 874	38 574	1.70%
2010	15 774	5 896	11 020	7 143	40 071	4.57%
2011	16 793	6 732	11 802	7 325	38 802	4.06%
2012	16 802	7 148	12 207	7 241	34 836	2.41%
Average Annual Increase Rate	8%	11%	8%	4%	-1%	4%

<http://www.inflation.eu/inflation-rates/china/historic-inflation/cpi-inflation-china.aspx>. The CPI inflation rates in China from 2007–2012¹² were used to calculate the compound average inflation rate during this period, which was 4.11%.

Source: China Health Statistical Yearbook (2013)

For CVDs, the medical costs beyond the social insurance coverage represent the gap to be filled by medical reimbursement insurance.

According to the Swiss Re Asia Medical Survey 2014²⁰, the top two barriers to purchasing personal medical reimbursement insurance in China are lack of knowledge and affordability.

Table 4:
CVD expenditures and income effects among different income strata

Financial protection gap of cardiovascular diseases

Generally speaking, the medical expenses for CVDs include both short-term and long-term direct costs as well as indirect costs. The largest portion of short-term direct cost comes from inpatient costs, about half of which are paid out-of-pocket. Considering the high cost of CVDs, those medical costs beyond the social insurance coverage represent the gap to be filled by medical reimbursement insurance. The longitudinal study from CHARLS Research Team¹⁷ indicated that only 7% of the wealth of the older population (aged 45 and over) is held in liquid assets such as cash, while the majority of their wealth is in the form of property (73%). When facing large out-of-pocket expenses for CVDs, patients might be forced to sell their properties.

Huffman et al¹⁸ included participants aged 25–70 from Beijing and Henan Zhoukou City and collected data in 2008–2009 to assess the economic impact of CVD. They split the survey participants into three groups by income level using the national population income distribution: low (poorest 40%), middle (middle 40%) and high (top 20%). The low income group had the highest out-of-pocket proportion of annual household expenditure and the highest percentage of income loss, although in absolute terms, their income losses were the smallest. The financial gap was the biggest for the low income group, followed by the middle income group; the gap was the smallest for the high income group. The high saving rate in urban areas, an estimated 30% of disposable income¹⁹, indicates that middle and high income groups can use their savings to reduce the financial distress caused by CVD. According to the Swiss Re Asia Medical Survey 2014²⁰, the top two barriers to purchasing personal medical reimbursement insurance in China are lack of knowledge and affordability. Due to cost and limited knowledge about insurance, low income groups are less likely to purchase medical insurance compared to middle and high income groups. The latter are growing due to increasing urbanisation and are more willing to pay for the best healthcare treatment as well as the additional protection offered by commercial insurance.

	Low	Middle	High
Expenditures			
Inpatient expenditures/Total CVD expenditures, %	77.2	77.5	82.1
15-month out-of-pocket CVD expenditures as a proportion of annual total household expenditures, %	40.1	30.5	15.0
Income Effects			
Any decrease in individual income, %	45.5	24.4	13.1
Any decrease in household income, %	40.9	25.6	14.3
Decrease in individual monthly income since hospitalisation, INT\$*	73.3	122.2	244.4
Median decrease in household monthly income since hospitalisation,INT\$	85.6	122.2	342.2

*INT\$ is international dollars

Source: Huffman (2011)¹⁸

There is an increasing need to provide insurance for patients in China that covers cross-regional and overseas medical costs.

Another finding from the Swiss Re Asia Medical Survey 2014²⁰ is that the top two criteria for patients in China when selecting a hospital are quality of treatment and the reputation of the hospital. Compared with patients in other Asian countries, such as India and Thailand, Chinese patients put the most weight on reputation and have a higher propensity to purchase commercial reimbursement products. The hospitals with the highest reputation in China are mostly in metropolises like Beijing and Shanghai. Currently, cross-provincial reimbursement systems are lacking which enable patients from other provinces to seek better treatment in these cities.

Moreover, some advanced medical treatments for CVDs are only available or have higher successful rates in developed countries. However, the medical costs for these advanced overseas treatments are extremely high. If commercial insurance could provide the coverage for these expensive overseas therapies as well as the living expenses during medical tours, it would ease the financial burden for the insured if they choose overseas treatments. Therefore, there is an increasing need to provide insurance for patients in China that covers cross-regional and overseas medical costs.

Commercial insurance could meet the needs of Chinese patients by providing coverage for non-essential drugs, especially patented and innovative drugs, and imported medical devices.

Current social medicine policies provide low/zero reimbursement rates for imported drugs and medical devices. One study²¹ indicated that only up to 25% of patients who need to use high priced treatments for diseases can afford those treatments. When it comes to CVDs, the percentage is expected to be no more than 25%. Therefore, commercial insurance could meet the needs of Chinese patients by providing coverage for non-essential drugs, especially patented and innovative drugs, and imported medical devices.

Care-seeking behaviours are strongly associated with insurance accessibility and affordability.

Patients' care-seeking behaviours are strongly associated with insurance accessibility and affordability. A study of hospitalisation expenses for patients undergoing cardiac interventional surgery in Guangzhou found that inpatient expenses for those with medical insurance were significantly higher than those without insurance²². Fang et al²³ also found that the higher coverage of commercial insurance was associated with higher medical costs. One explanation could be that middle and high income groups are more likely to buy health insurance and are more willing to pay for the best treatments and medicines. Of course, this doesn't exclude the possibility of overtreatment and excessive charge. Therefore, insurance providers should be careful in designing their products to prevent excessive use of the coverage, which could result in higher costs and waste.

Besides drug costs, the long-term costs include the significant cost of care after severe CVDs events.

Besides drug costs, the long-term costs include the significant cost of care after severe CVDs events, such as stroke. Social insurance schemes are more concentrated on the coverage of inpatient costs and less on the costs for care after a patient is discharged from hospital. More than one-third of stroke survivors have some degree of disability and need assistance for daily living²⁴. Because of the 4-2-1 family structure, more and more disabled elderly patients, after CVDs events, are seeking care services from caregivers instead of family members. The monthly cost of full-time caregivers could be around RMB 2000–5000 (USD 300–800) for big cities like Beijing and Shanghai. However, in 2014, the average retirement income in Beijing is only about RMB 3000 (USD 500)²⁵. As the demand and costs of caregiving service increases, patients and their families will face heavier financial burdens.

Disability income insurance and long term care (LTC) insurance could provide protection for patients and financial stability.

The indirect cost comes from the loss of income for both patients and their family members. Huffman et al¹⁸ found that there is a significant decrease in individual income after CVD hospitalisation for both individuals and households. Disability income insurance and long term care (LTC) insurance could provide protection for patients and financial stability.

Summary

The medical costs of cardiovascular diseases consist of both acute hospital expenses and long-term healthcare expenditures.

The medical costs of cardiovascular diseases consist of both acute hospital expenses and long-term healthcare expenditures. Among those, the cost associated with medicine is the major cost driver. The non-medical costs associated with CVD events, such as loss of income, also contribute to the financial distress of patients. The CVD inpatient medical cost represents a larger percentage of total annual expenditure for rural residents compared to urban residents. Health spending as a portion of total annual expenditure varies by geographic location due to the disparities in social insurance coverage, economic development and quality of healthcare.

Financial protection for CVD patients is insufficient in China.

Studies indicated that financial protection for CVD patients is insufficient in China. The lack of protection affects low income groups the most. Nearly half of the inpatient costs were paid out-of-pocket by low income groups. About one-fourth of patients self-discharged due to financial stress as a result of high medical costs and the lack of insurance protection. The reimbursement cap on inpatient costs may have contributed to the relatively high out-of-pocket expenditures for CVD. While the reform of the essential medicines system has reduced high out-of-pocket medicine spending, a gap still exists. Reimbursement rates vary across regions due to differentiated healthcare needs. Since the in-/out-patient medical costs are expected to continue increasing in the future, there is a growing need to fill the gap between medical cost and the financial protection available currently, particularly for households with chronic diseases like CVD.

CVD insurance policies could supplement the national insurance coverage.

CVD insurance policies could supplement the national insurance coverage to cover the out-of-pocket medical expenses such as deductible, co-payment and any amount exceeding the reimbursement caps. In addition, CVD insurance products in China could expand to include long-term care and non-medical costs such as physical therapy, nursing care, transportation & lodging and lost wages. As China is making progress to open its insurance markets to commercial insurers, more and more life and health insurance products are expected to be sold to individuals as additional protection to supplement the national social insurance system.

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Time trends of cardiovascular disease risk factors in China

Frank Hu, Yanping Li

Fueled by rapid urbanisation and changes in dietary and lifestyle choices, cardiovascular and other chronic diseases have emerged as a critical public health issue in China. The prevalence of hypertension in 2010 reached 33.5% (ie an estimated 330 million hypertensive patients), while the awareness and control rates are extremely low. Type 2 diabetes is an increasing epidemic in China with more than 100 million people affected. Although the Chinese population has a lower BMI than the global average, abdominal obesity has become especially common in Chinese adults. Despite tobacco control efforts, the prevalence of smoking in China remains at a high level and domestic production of cigarettes continue to rise. With unprecedented growth in urbanisation, work and transportation-related physical activity levels have declined sharply, accelerating the epidemics of obesity and chronic diseases, which not only affect health and quality of life, but also have economical and social consequences.

Cardiovascular disease is the leading cause of death in China.

Cardiovascular disease is the leading cause of death in China, accounting for 37.8% of all deaths in 2010¹. Unhealthy diets, high blood pressure, smoking, high fasting glucose, physical inactivity and low physical activity, alcohol use, high body mass index (BMI) and high cholesterol contribute to the majority of the cardiovascular deaths in China¹. Most of these risk factors are preventable and could be modified by improving diet and exercise. Exploring the time trends of these risk factors can provide scientific information and evidence for developing strategies to reduce cardiovascular morbidity and mortality.

Dietary risk factors

Dietary patterns in China have shifted in recent decades to resemble those of the West.

China has experienced a dramatic shift from its traditional dietary pattern to a Western dietary pattern in recent decades. According to the annual report of the National Bureau of Statistics of China², the annual consumption of whole grains (unprocessed grains) of rural household per capita decreased from 266 kg in 1993 to 171 kg in 2011; a similar trend was found in the urban population. Meanwhile, the annual consumption of meat, eggs, fish and dairy products increased from 18.7 kg to 36.8 kg in rural areas and from 46 kg to 74 kg in urban areas from 1993 to 2011. Compared to other countries, such as Germany, Finland, South Korea, and India, dietary changes have been the most drastic in China, which is rapidly adopting a Western, animal-based diet¹².

High blood pressure

The second leading contributor to cardiovascular disease mortality in China is high blood pressure.

High blood pressure is the second leading contributor to cardiovascular disease mortality in China¹. As shown in Figure 1, the prevalence of hypertension has been increasing steadily and substantially in the past several decades. The prevalence of hypertension was 5.11% in 1959, based on the first national survey of hypertension, but the definition was not clearly recorded³. The prevalence increased to 7.73% in 1979 among people aged 15 years or above. From 1991, after the new definition of hypertension was applied, the prevalence of hypertension reached 13.6% among people aged 15 years or above⁵. In 2002, the prevalence of hypertension was 17.7% and 18.8% among the population aged over 15 and over 18 years, respectively^{9, 13}.

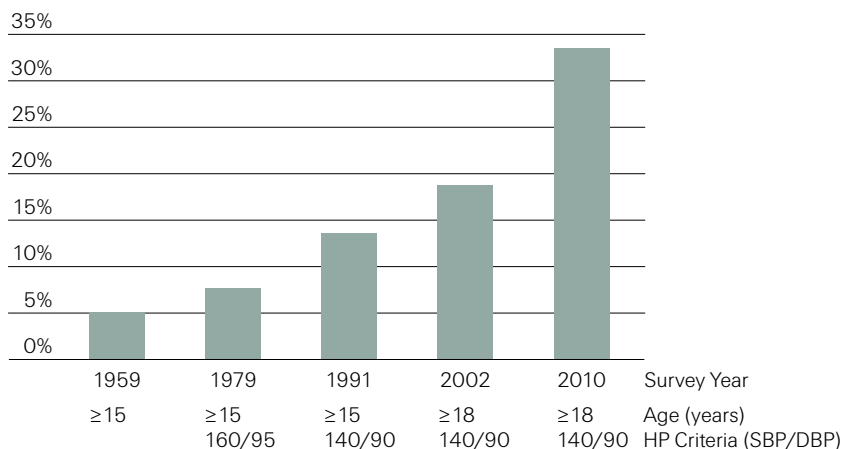
By 2010, prevalence of hypertension in China was similar to that in the US.

Hypertension increased to 33.5% or an estimated 330 million in 2010¹¹. The prevalence of hypertension in Chinese adults was comparable to that in the US¹⁴. Based on the same definition, the overall prevalence of hypertension among US adults aged over 18 years in 2003–2010 was 30.4%^{11, 14}. However, the awareness rate was much lower in the Chinese population (24%)¹³ compared to that in the US adult population (61%)¹⁴. The treatment rate among those affected individuals who were aware of their condition was similar in China (78%) and in the US (74%).

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However, the control rate was much lower in China. Among those with hypertension, an estimated of 46% US citizens had their hypertension controlled¹⁴, compared with only 25% of people with hypertension in China¹³.

Figure 1:
Time trend of prevalence of hypertension in 1959³, 1979³, 1991⁵, 2002⁹ and 2010¹¹



Source: Liu L (2011)³, Tao S et al (1995)⁵, Wang L (2005)⁹ Li YC et al (2012)¹¹

Tobacco smoking

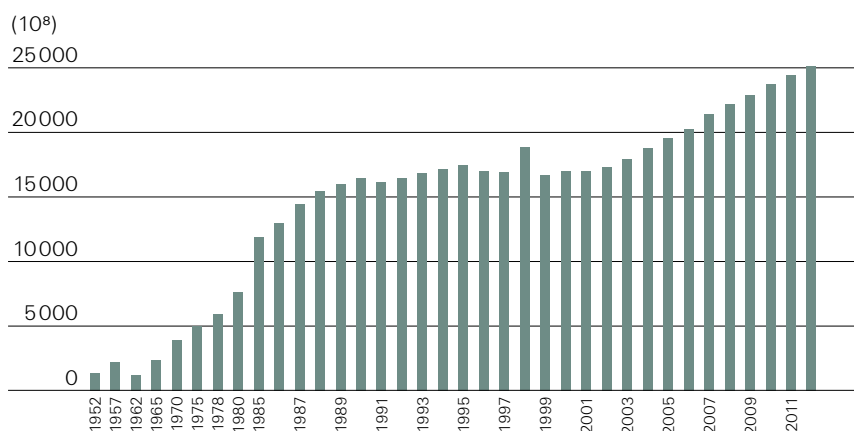
In 2010, just over 300 million people in China were smokers, making China the largest consumer of tobacco in the world.

Despite tobacco control efforts, the prevalence of smoking in China remains at a high level. In 2010, 28.1% of adults (52.9% of men and 2.4% of women) or an estimated 301 million people were smokers in China, making China the largest consumer of tobacco products in the world¹⁵. At the same time, second hand smoke is highly common in China¹⁵⁻¹⁷. In 2010, an estimated 740 million non-smokers were exposed to second hand smoke in China, based on the estimation of the 2010 China Global Adults Smoking Survey (GATS) carried out by the Chinese Center for Disease Control and Prevention¹⁶.

China produces one-third of the world's tobacco, making it the single largest tobacco manufacturer.

China is also the world's largest tobacco manufacturer. The country produces about 2.66 million tonnes of tobacco leaves each year, accounting for one-third of the world's tobacco production¹⁸. In 1952, China produced around 133 million cigarettes per year, which increased steadily to 1649 million cigarettes in 1990 and remained flat for around 10 years, and then increased steadily again to 2516 million cigarettes in 2012 (Figure 2). The fraction of deaths attributable to tobacco use increased from 12.8% in 1990 to 16.4% in 2010 in China¹.

Figure 2:
Time trend of domestic production of cigarettes in China



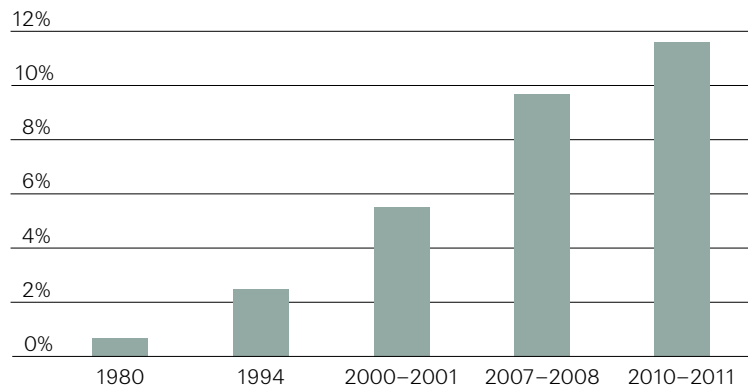
Source: National Bureau of Statistics of China

Type 2 diabetes is a growing epidemic in China. Over 90 million people were diabetic in 2008.

High fasting glucose and diabetes

Type 2 diabetes is a growing epidemic in China, characterised by a rapid rate of increase over a short period of time as well as onset at a relatively young age and low body mass index¹⁹. Type 2 diabetes in China was rare in the 1980s⁴, with an estimated prevalence of 0.67%. In subsequent national surveys conducted in 1994⁶, 2000–2001⁷ and 2007–2008⁸, the prevalence of diabetes was 2.5%, 5.5% and 9.7%, respectively (Figure 3). The estimated number of adult diabetic patients was 92.4 million in 2008⁸, making China the country with the largest number of diabetics in the world.

Figure 3:
Prevalence of type 2 diabetes in China estimated at 1980⁴, 1994⁶, 2000–2001⁷, 2007–2008⁸ and 2010–2011¹⁰



Source: National Diabetes Resource Group⁴, Pan XR et al (1997)⁶, Gu D (2003)⁷, Yang W et al (2010)⁸, Xu Y et al (2013)¹⁰

In 2011, the overall prevalence of diabetes in China was 11.6% among Chinese adults 18 years or older.

In 2010–2011, the China Non-Communicable Disease Surveillance Group applied the 2010 American Diabetes Association diagnostic criteria by further including haemoglobin A1c \geq 6.5%, in addition to elevated fasting glucose, to a large national survey. This resulted in an estimation of overall prevalence of diabetes of 11.6% among Chinese adults 18 years or older¹⁰. This prevalence is similar to that in US adults (11.3%)²⁰ and much higher than the average prevalence worldwide (8.3%)²¹. Similar to hypertension, the awareness, treatment and control rates of diabetes are very low in China. In 2010, the proportion of diabetics who were aware of their condition was 30.1%; only 25.8% of diabetics received treatment for the disease, and only 39.7% of those treated had adequate glycaemic control¹⁰.

Due to urbanisation, major shifts in types of employment and new technologies, physical activity is on the decline in China.

Physical inactivity and low physical activity

Rapid urbanisation, major shifts in types of employment and the growing use of new technologies have caused a steep decline in physical activity in China. The primary means of transportation have changed from walking and bicycling to driving. Meanwhile, China has seen a dramatic increase in sedentary lifestyles such as TV watching and computer use.

The use of bicycles, once the most common form of transportation in China, has decreased since the 1990s.

The bicycle was the most commonly used form of transportation in China in the 1970s and the rates of bicycle use continued to increase in the following two to three decades. By 1983, 37% of people commuted by bicycle compared to 19.5% by mass transit. In 1988, 57.1% of people commuted by bicycle compared to 37% by mass transit²². In the 1990s, the ownership of bicycles in Chinese households reached the peak. On average, each rural family owned 1.5 bicycles and each family in urban areas had two bicycles in the middle of the 1990s. After that, the ownership of bicycles in Chinese household dropped substantially. In 2011, bicycle ownership was only 77 bicycles per 100 households in rural areas. While bicycle ownership decreased, car ownership in urban areas and motorcycle ownership in rural areas have experienced a sharp increase. In 2011, around 61% of rural households owned a motorcycle and 19% of urban households owned a car.

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Ownership of televisions, mobile phones and computers has risen sharply since the 1980s, and led to more sedentary lifestyles.

At the same time, TV ownership has increased from 38 sets per 1000 persons in 1985 to 135 sets per 100 households in urban areas in 2011 (and 112 sets per 100 households in rural areas). Mobile phone ownership increased more rapidly than TV ownership in both rural and urban areas. In 2011, almost every family had more than one mobile phone. Another indicator of sedentary activity is increasing computer ownership. In 2011, computer ownership was 82 computers per 100 households in urban areas and 18 computers per 100 households in rural areas.

Alcohol use

High alcohol consumption is associated with higher risks for stroke incidence and mortality.

Alcohol-related disorders were among the ten most common causes of years lived with disability (YLDs) and cardiovascular mortality in China in 2010¹. Although light to moderate alcohol consumption is associated with a reduced risk of cardiovascular morbidity and mortality, consumption of larger amounts of alcohol is associated with higher risks for stroke incidence and mortality²³.

Consumption of alcohol in China has risen dramatically since 1970. Since 1993, consumption in urban areas has decreased.

Based on the WHO data, per capita alcohol consumption for Chinese aged 15 years and older was 1.03 litres in 1970, and rose to 5.17 litres in 1996. It remained relatively stable afterwards, at 5.91 litres in 2005²⁴. According to the China Bureau of Statistics, the average annual liquor consumption was 6.5kg in rural areas and 9.7 kg in urban areas in 1993. In the following two decades, alcohol consumption has been increasing in rural areas but decreasing in urban areas, leading to much higher consumption levels among rural than urban residents. In 2011, the average annual liquor consumption was 10.2 kg in rural areas and 6.8 kg in urban areas. There is a large gender difference in alcohol consumption patterns. Around 40% men regularly drink at least once per week, while less than 5% women drink alcohol regularly; this pattern did not change significantly between 1991 and 2009.

Data on heavy drinking and alcohol-related disorders are limited in China.

Data on heavy drinking and alcohol-related disorders are limited in China. According to the 2002 China National Nutrition and Health survey, the prevalence of heavy drinking (men >25 g/day, women >15 g/day) in Chinese adults was around 4.7% (8.4% for male and 0.8% for female)²⁵. The prevalence of heavy drinking among alcohol consumers was 39.6% in urban areas and 54.7% in rural areas. The 45–59 years old age group had the highest prevalence of heavy drinking²⁵. In 2004–2008, the prevalence of heavy drinking among regular alcohol consumers was 37% when heavy drinking was defined as >60 g/day of alcohol for men on a weekly basis²⁶.

High cholesterol and dyslipidemia

China's adoption of a more Western animal-based diet has led to higher cholesterol levels.

China's rapid transition to the Western animal-based diet has led to a rapid increase in serum cholesterol levels²⁷. In 1982–1984, the prevalence of borderline high or high total cholesterol⁹ (5.28 mmol/L) was 17.6% in men and 19.2% in women, but had increased to 24% in men and 27.1% in women by 1992–1994. The prevalence further increased to 33.1% in men and 33.8% in women in 1998²⁸, and then remained relatively stable at 31.3% in men and 31.7% in women in 2007–2008²⁹. The awareness, treatment, and control of borderline high or high total cholesterol were 11.0%, 5.1%, and 2.8%, respectively, in 2007–2008²⁹.

Besides high cholesterol, high triglyceride and low high-density lipoprotein (HDL) were also common in the Chinese population.

Besides high cholesterol, high triglyceride and low high-density lipoprotein (HDL) were also common in the Chinese population. Low HDL (≤ 0.91 mmol/L) was reported in 7.4% adults (9.3% of men and 5.4% of women) in the 2002 China National Nutrition and Health Survey⁹. In the 2007–2008 China National Diabetes and Metabolic Disorders Study, low HDL (defined as HDL < 1.04 mmol/L) was observed in 22.3% of Chinese adults (27.1% of men and 17.5% of women)²⁹. Hypertriglyceridemia (defined as plasma triglyceride ≥ 1.7 mmol/L) was observed in 11.9% of adults in 2002 (14.5% of men and 9.9% of women)⁹.

High body mass index (BMI) and obesity

Compared to the global average, the Chinese population has a relatively low BMI; nevertheless, Chinese people tend to develop diabetes and chronic diseases at lower BMI levels.

The Chinese population has a relatively low BMI. The BMI of men and women in China was 0.9 kg/m² and 1.2 kg/m² lower than the global average in 2008³⁰. Despite a steady increase in BMI in the past decades, China remains among the bottom 30% of countries with the lowest male and female mean BMI among the 199 countries and territories that joined the WHO Global Burden of Disease (GBD) project³⁰. However, compared to Caucasian populations, Chinese people tend to develop diabetes and other chronic diseases at a relatively low BMI levels³¹. This is why the cut-off points of overweight and obesity have been defined at lower BMI levels for Chinese adults (24 kg/m² for overweight and 28 kg/m² for obesity)³².

The prevalence of being overweight or obese increased from 13.6% in 1989 to nearly 40% in 2009.

Applying the Chinese BMI criteria, the prevalence of overweight and obesity was 13.6% in males in 1989 based on the data from the China Nutrition and Health Survey (Figure 4). Prevalence rapidly increased from 1989 to 2009, reaching 39.6% in 2009. Among women, the prevalence of overweight and obesity was 17.6% in 1989; it rapidly increased to 40.5% in 2004 and kept flat afterwards (Figure 4).

Figure 4:
Time trend of overweight and obesity



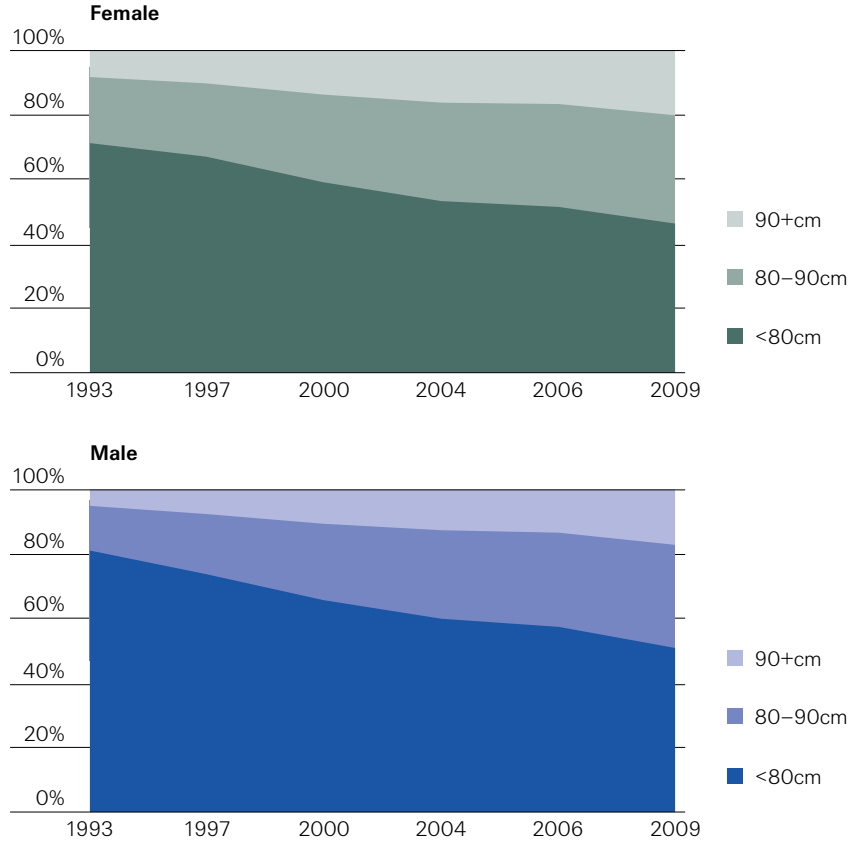
Source: author

Time trends of cardiovascular disease risk factors in China

Waist circumference among men and women has been increasing steadily over time.

Waist circumference (WC), a maker of central or abdominal obesity, has been increasing steeply in the Chinese population. The prevalence of abdominal obesity (WC³85 cm for men and ³80 cm for women) increased from 17.7% to 48.4% among men and from 28.8% to 53.5% among women (Figure 5).

Figure 5: Proportion of waist circumference distribution



Source: author

Obesity in children has witnessed a dramatic increase.

An alarming trend of a dramatic increase in obesity has been observed in children. According to the age-sex-specific BMI percentile criteria for Chinese children and adolescents, the prevalence of overweight and obesity in children and adolescents aged 7–18 years was 1.24%, 4.98%, 8.83%, 11.7% and 14.6%, respectively, in 1985, 1995, 2000, 2005 and 2010³³. In 1985, the prevalence of overweight and obesity was 1.34% (boys) and 1.55% (girls) in urban areas; in rural areas, it was 0.47% (boys) and 1.6% (girls). In 2010³³, the corresponding prevalence of overweight and obesity in urban areas was 23.2% for boys, and 12.7% for girls; in rural areas, the figures were 13.8% for boys and 8.6% for girls.

Summary

Chinese dietary patterns have shifted in recent decades to resemble those of the West, and hypertension is on the rise.

China has experienced a dramatic shift from its tradition dietary pattern to a Western dietary pattern in recent decades. The prevalence of hypertension in 2010 was 33.5% (an estimated 330 million hypertensive patients), and the awareness and control rates are extremely low. Despite tobacco control efforts, the prevalence of smoking in China remains at a high level and domestic production of cigarette continues to rise.

Type 2 diabetes and high cholesterol are increasingly more prevalent in China.

Type 2 diabetes is an increasing epidemic in China with more than 100 million people affected. Rapid transition to a more Western animal-based diet in China has led to a large increase in serum cholesterol levels. Although the Chinese population has a lower BMI than the global average level, the prevalence of overweight and obesity is increasing rapidly in both adults and children, and abdominal obesity is especially common in Chinese adults.

The change in diet and lifestyle has been identified as the reason for the rise in chronic diseases in China.

Compelling evidence indicates that the current chronic disease epidemic is largely driven by changes in diet and lifestyle in China. Over the past several decades, traditional patterns of eating have been replaced with a diet high in animal products, processed carbohydrates, and sugar-sweetened beverages.

Preventive strategies have been shown to reduce disease burden.

At the same time, overall physical activity levels have decreased considerably due to rapid urbanisation and industrialisation. China's limited chronic care infrastructure makes it ill-equipped to deal with a sudden rise in chronic diseases. Population-based intervention studies demonstrate the efficacy of preventive strategies to reduce disease burden. However, translating these findings into practice requires changes in health systems and public policies³⁴. To achieve the goals of improving health for all people, chronic disease prevention needs to be a national public policy imperative. Its great potential to cut medical costs and reduce widespread health and social inequalities in China cannot be realised without the full involvement of all stakeholders, including communities, government, NGOs, urban planners and the media – as well as the healthcare, education, food and service sectors. Prevention is certainly beyond the scope of any one ministry or government agency.

Prevention will also lower medical costs, improve quality of life and reduce health and social inequality.

Clearly, prevention of chronic diseases should be elevated to a top priority for national public policy because it can cut medical costs, improve quality of life, and reduce widespread health and social inequalities in China.

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真陽兩利水陸普



Type 2 diabetes in China: prevalence and risk factors

Hongyu Wu, Qi Sun

China is currently the world's largest economy and the most populous country, with one-fifth of the global population. Along with dramatic economic growth, rapid urbanisation and lifestyle westernisation in the past decades, China has experienced a sharp increase in the prevalence of diabetes. Based on nationwide survey data, the estimated prevalence of diabetes among Chinese adults has increased from 0.67% in 1980 to 11.7% in 2010. It is estimated that 113.9 million Chinese adults are suffering from diabetes. As described in this review, several factors may be contributing to this diabetes epidemic in China, including improved life expectancy, rapid urbanisation, increased overall and abdominal obesity, decreased physical activity levels, high prevalence of cigarette smoking, and the increased adoption of a westernised diet. Some lifestyle intervention programmes seeking to address these risk factors through behavioural education with the goals of improving diet and/or increasing exercise have been conducted in China, and these programmes have provided the best evidence of the effectiveness of lifestyle programmes for diabetes prevention.

The prevalence of diabetes in China has soared from 0.67% in 1980 to 11.6% in 2010.

Prevalence of type 2 diabetes

The first nationwide diabetes epidemiological survey in China was conducted by the Chinese Diabetes Society in 1980. The survey of 14 provinces throughout China indicated a low diabetes prevalence of 0.67%¹. The subsequent 1994 China National Diabetes Survey examination of 224 251 men and women aged 25–64 years yielded estimates of 2.5% for the prevalence of diabetes, almost four times higher than the 1980 estimate². In 2002, the International Collaborative Study of Cardiovascular Disease in Asia (InterASIA) revealed that 5.5% of Chinese adults aged 35 to 74 had diabetes³. Based on a 2008 national survey, the prevalence of diabetes among Chinese adults had climbed to 9.7% (with an estimated 92.4 million Chinese adults affected), establishing China as the country with the largest number of diabetes patients in the world⁴. By 2010, using the updated American Diabetes Association diagnostic criteria, which further includes HbA1c $\geq 6.5\%$ as one of diagnosis criteria, in addition to elevated fasting glucose and the oral glucose tolerance test, the prevalence of diabetes among Chinese adults aged ≥ 18 years had reached 11.6%, with 113.9 million Chinese adults (60.5 million men and 53.4 million women) suffering from diabetes⁵.

Table 1:
Characteristics of nationwide diabetes epidemiological survey in China

Year of survey	Authors	Age (years)	Sample size	Diagnostic criteria*	Diagnostic method	Diabetes Prevalence (%)
1980	National Diabetes Cooperative Study Group	All age groups	300 000	WHO 1999	FPG/OGTT	0.67
1994	National Diabetes Cooperative Study Group	25–64	213 515	WHO 1985	FPG/OGTT	2.28
2002	National Nutrition and Health Survey	≥ 20	47 729	ADA 1997	FPG	2.7
2002	International Collaborative Study of Cardiovascular Disease in Asia (InterASIA)	35–74	15 540	ADA1997	FPG	5.5
2008	National Diabetes and Metabolic Disorders Study Group	≥ 20	46 239	WHO 1999	FPG/OGTT	9.7
2010	The 2010 China Non-Communicable Disease Surveillance Group	≥ 18	98 658	ADA 2010	FPG/OGTT/ HbA1c	11.6

WHO, World Health Organization; ADA, American Diabetes Association; FPG, fasting plasma glucose (≥ 126 mg/dL); FPG > 130 mg/dl or 2 h OGTT >200 mg/dl; OGTT, 2-hour glucose tolerance test (≥ 200 mg/dL); HbA1c, hemoglobin A1C ($\geq 6.5\%$).

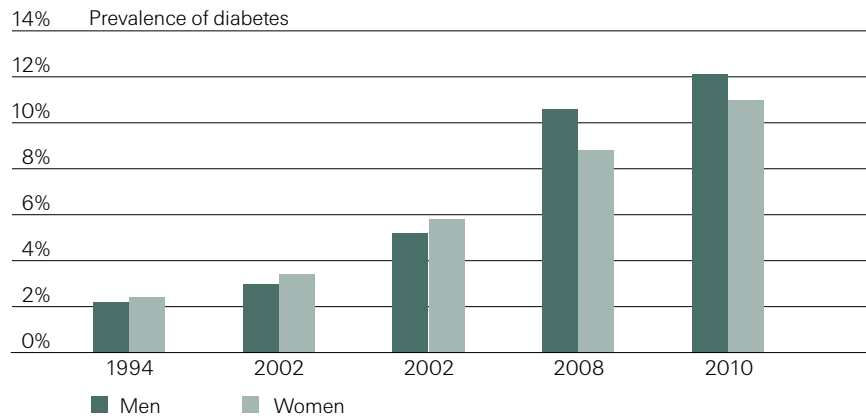
Sources: National Diabetes Cooperative Study Group, National Nutrition and Health Survey, International Collaborative Study of Cardiovascular Disease in Asia, National Diabetes and Metabolic Disorders Study Group, The 2010 China Non-Communicable Disease Surveillance Group

Type 2 diabetes in China: prevalence and risk factors

Since 2008, surveys of Chinese adults indicate that the prevalence of diabetes is slightly higher among men.

Figure 1:
Time trend in prevalence of diabetes among Chinese men and women

Figure 1 illustrates the secular trend in the prevalence of diabetes from 1994 to 2010 among Chinese adults by gender. Similar to the overall trend for the prevalence of diabetes, the prevalence of diabetes among men and women dramatically increased from 1994 to 2010. There was no significant difference observed in the crude prevalence of diabetes between men and women, although in two recent nationally representative samples of Chinese adults, the age-standardised prevalence of diabetes was significantly higher among men than among women^{4, 5}.



Sources: National Diabetes Cooperative Study Group, National Nutrition and Health Survey, International Collaborative Study of Cardiovascular Disease in Asia, National Diabetes and Metabolic Disorders Study Group, The 2010 China Non-Communicable Disease Surveillance Group

Ageing

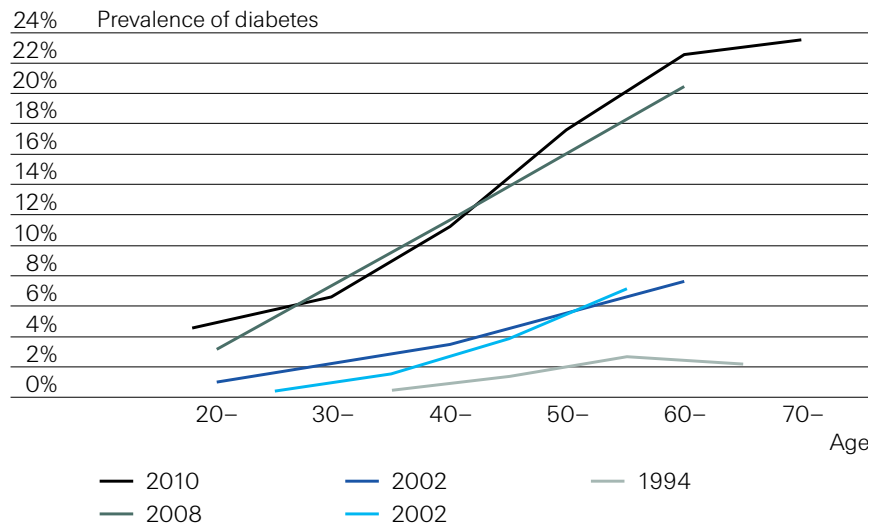
The population in China is ageing, which is contributing to the diabetes epidemic.

In China, population ageing is an important factor contributing to the diabetes epidemic⁶. Due to the reduced fertility rate and an increasing life expectancy, the proportion of the elderly population in China (aged 65 years or older) had increased from 6.96% in 2000⁷ to 8.87% by 2010⁸. The proportion is projected to grow to 13.7% in 2025, and to 25% by 2050⁹.

The prevalence of diabetes among those aged 70 years or older was 23.5% in 2010.

Figure 2 illustrates the prevalence of diabetes has increased by age in each survey. In a 1994 nationwide survey, the National Diabetes Cooperative Study Group found that prevalence of diabetes in the age groups of 25–34, 35–44, 45–54 and 55–64 was 0.3%, 1.41%, 3.71% and 7.11%, respectively². Results from other national-based surveys confirmed a similar positive relationship between age and prevalence of diabetes^{3–5}. In the most recent 2010 survey of 98 658 Chinese adults, the prevalence of diabetes was 4.5%, 6.6%, 11.3%, 17.6%, 22.5%, and 23.5% among persons who were 18–29, 30–39, 40–49, 50–59, 60–69, and ≥70 years of age, respectively⁵.

Figure 2:
Prevalence of diabetes in different age groups in Chinese adult populations. Note: each line represent the age-specific prevalence observed in each survey



Sources: National Diabetes Cooperative Study Group, National Nutrition and Health Survey, International Collaborative Study of Cardiovascular Disease in Asia, National Diabetes and Metabolic Disorders Study Group, The 2010 China Non-Communicable Disease Surveillance Group

Type 2 diabetes in China: prevalence and risk factors

Between 1980 and 2009, China's urban population rose from 191 million to 622 million.

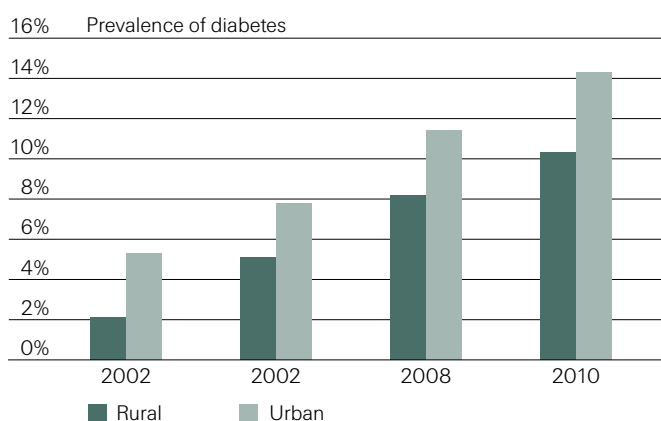
According to national surveys, the prevalence of diabetes in urban areas was higher than in rural regions.

Figure 3: Prevalence of diabetes among Chinese adults living in rural and urban areas

Urbanisation

Since China's economic reforms in the early 1980s¹⁰, China has encountered the largest human migration in history, leading to a rise in urban population from 191 million in 1980 to 622 million in 2009 as a result of the rural-to-urban migration¹¹. The rate of urbanisation in China has continued to accelerate in recent years. According to data from the National Bureau of Statistics of China, China's urban population had already reached 51% in 2011¹⁰. Rapid urbanisation is related to the shift to an unhealthy diet and reduction in physical activity¹², both of which fuel the growing diabetes epidemic in China.

A survey conducted in 31 Chinese provinces estimated that the age-standardised prevalence of diabetes was 1.5 times higher among the urban population versus the rural population (7.8% vs 5.1%, respectively)³. The 2002 National Nutrition and Health Survey documented that the prevalence of diabetes among the urban population was 5.3%, while it was 2.1% among the rural population¹³. As presented in Figure 3, all national surveys reported higher diabetes prevalence in urban regions than rural areas.



Sources: National Nutrition and Health Survey, International Collaborative Study of Cardiovascular Disease in Asia, National Diabetes and Metabolic Disorders Study Group, The 2010 China Non-Communicable Disease Surveillance Group

Regional and provincial surveys also show higher rates of diabetes among those living in urban areas.

Some regional and provincial epidemiological surveys also observed a higher prevalence of diabetes in urban versus rural areas. For example, in 2002, a survey of the prevalence of diabetes conducted in urban and rural populations of Qingdao (a major city in eastern Shandong Province) indicated a higher prevalence of diabetes in urban versus rural areas (6.9% vs 5.6%, respectively)¹⁴. In Shanghai, where lifestyles have changed remarkably in recent years, the prevalence of diabetes in urban and rural areas were reported to be 11.2% and 5.3%, respectively¹⁵. By summarising previous studies which linked urbanisation with risk of diabetes in China, it has been suggested that the Chinese population living in urban areas have a 21% higher risk of developing diabetes compared with those living in rural locations¹⁶.

Obesity

Overweight and obesity are the driving forces of the diabetes epidemic in China.

In China, increased overweight and obesity prevalence are believed to be the major driving force of the diabetes epidemic. China used to be known for its slender people. Now China is facing a growing obesity epidemic, which has become a major threat to population health in modern China. Using the World Health Organization BMI cut-offs (overweight: body mass index (BMI) ≥ 25 kg/m²; obesity: BMI ≥ 30 kg/m²), the combined prevalence of overweight and obesity in Chinese adults increased from 14.6% in 1992 to 21.8% in 2002¹⁷. Using the ethnicity-specific obesity definition for the Chinese population (overweight: BMI ≥ 24 kg/m²; obesity: BMI ≥ 28 kg/m²), the prevalence of obesity rose from 20.0% to 29.9% in the same period, which is equivalent to a 38.6% increase¹⁸. As estimated from the 2002 China National Nutrition and Health Survey (NNAHS), there were 184 million overweight people, and a further 31 million obese people in China, out of a total population of 1.3 billion¹⁹. The prevalence of obesity continues its upward trend in China. By the end of 2009, the obesity rate of Chinese adults had reached 39.6%²⁰.

Compared with their normal weight counterparts, overweight and obese adults were at a significantly higher risk for developing diabetes.

Obesity is well-known to be one of the strongest risk factors of type 2 diabetes^{21–23}. A recent national survey among 31 provinces reported that the prevalence of diabetes was 4.5%, 7.6%, 12.8%, and 18.5% among people with a BMI of <18.5, 18.5 to 24.9, 25.0 to 29.9, and ≥ 30.0 kg/m², respectively⁴. Other large-scale national surveys also documented a much higher prevalence of diabetes among the overweight and obese population compared to those with a normal weight^{5, 13}. In cross-sectional studies, it has been suggested that the prevalence of diabetes was 43% higher for overweight individuals and 117% higher for obese individuals when compared to their normal weight counterparts⁴. Similarly, in the InterASIA study, a cross-sectional study of cardiovascular disease risk factors based on a national representative sample of 19 012 Chinese adults from the general population aged 35–74, obesity was also observed to be a major risk factor for having diabetes. Compared with normal weight participants, the risk of diabetes was higher in overweight men (22% higher) and obese men (149% higher) as well as for overweight women (74% higher) and obese women (170% higher)²⁴. In a recent prospective analysis on 10 704 participants aged 18–59 years from the Qingdao Port Health Study (QPHS), after 11 years, overweight and obese men – compared with the normal weight population – had a 69% and 124% increased risk of developing diabetes. Overweight and obese women had a 81% and 158% higher risk, respectively, of developing diabetes²⁵.

Studies have shown that the accumulation of visceral fat rather than subcutaneous fat increases the risk of insulin resistance and type 2 diabetes.

Body fat distribution is even more important in the aetiology of the development of diabetes. Recent findings indicate that accumulation of visceral fat rather than subcutaneous fat increases the risk of insulin resistance and type 2 diabetes in humans²⁶. Imaging technology, such as computed tomography scan, has suggested that Chinese tend to have greater amounts of visceral fat than Europeans with similar body fat content²⁷. A tendency toward greater abdominal obesity among the Chinese population has led to a higher propensity for insulin resistance and diabetes compared with Western populations^{28, 29}. Waist circumference is a commonly used indicator of abdominal obesity. It has been observed that prevalence of diabetes was 7.9% in populations with a normal waist circumference, while it was 19.1% among the central obesity population (ie waist circumference ≥ 80 cm for women and ≥ 90 cm for men)⁵. In addition, women with central obesity (waist circumference ≥ 80 cm) had a 85% higher risk of having diabetes, while their male counterparts (waist circumference ≥ 85 cm) had almost double the risk of having diabetes, compared with people with a normal waist circumference²⁴.

Type 2 diabetes in China: prevalence and risk factors

Physical inactivity

Physical activity in China is declining due to increased urbanisation and the universal use of automobiles.

Increased urbanisation and universal use of automobiles instead of public transportation were associated with declining physical activity in China. According to data from Chinese National Health and Nutrition Surveys, average weekly physical activity levels among adults in China decreased by 32% from 1991 to 2006³⁰, which was mainly because of the decline in occupational activities as a result of urbanisation. In a prospective study conducted in 8 provinces of China, 14% of households acquired a motorised vehicle between 1989 and 1997³¹, and an average of 1 in 10 Beijing permanent residents owned a car¹⁸. Compared with those whose vehicle ownership remained constant, men who acquired a new vehicle experienced a 1.8kg greater weight gain between 1989 and 1997, and the risk of becoming obese doubled³¹.

Physically activity is beneficial for promoting glucose metabolism, controlling body fat, and improving insulin sensitivity, thereby lowering the risk of diabetes.

Being physically active is beneficial for promoting glucose metabolism, controlling body fat, and improving insulin sensitivity³², and is well-documented as a way to lower the risk of diabetes^{32, 33}. Similarly, in Chinese women from the Shanghai Women's Health Study, physical activity, either from leisure time exercise or daily activity, was associated with lower risk of type 2 diabetes³⁴. Another prospective study, the Shanghai Men's Health Study, confirmed that total physical activity was inversely associated with risk type 2 diabetes in a dose-response manner: men regularly participating in exercise or sports had a 14% lower risk of developing type 2 diabetes³⁵.

Cigarette smoking

China is the largest producer and consumer of cigarettes in the world.

China is the largest producer and consumer of cigarettes in the world. One of every three cigarettes manufactured in the world is consumed in China³⁶. In 2010, there were an estimated 301 million current smokers in China, and most of them were men as only 2.4% adult women smoke in China³⁷. These active smokers consume an average of 14.2 cigarettes per day (14.3 for men and 10.6 for women)³⁸.

Cigarette smoking is an independent risk factor for type 2 diabetes.

A large body of epidemiological evidence has firmly documented that cigarette smoking is an independent risk factor for type 2 diabetes. As suggested by a meta-analysis of prospective studies, active smokers had a 44% higher risk of developing diabetes compared with nonsmokers³⁹. Evidence linking cigarette smoking with type 2 diabetes risk in non-western countries is sparse. In the Shanghai Men's Health Study, after an average of 5.4 years of follow-up, it has been reported that cigarette smoking was significantly associated with an increased risk of developing type 2 diabetes. Compared with non-smokers, smokers who smoked more than one pack of cigarettes per day had a 24% increased risk of developing type 2 diabetes, and those who smoked more than 40 packs per year had a 28% increased risk of developing type 2 diabetes³⁵. Smoking is known to induce insulin resistance and inadequate compensatory insulin secretion responses. Compared with non-smokers, smokers tend to have more abdominal fat⁴⁰ and are thus more likely to have central obesity⁴¹.

Unhealthy diet

Changes to dietary patterns in China have led to an increasing prevalence of type 2 diabetes.

Along with increasing globalisation and marked economic development, China has undergone a major transition in diet and lifestyle, which has led to a rapid increase in the prevalence of type 2 diabetes. This nutritional transition involves increased consumption of animal foods and energy-dense foods, more frequent intake of fast foods, and decreased fibre intake²⁸. Based on national nutritional survey data in China, the proportion of energy intake from animal foods increased from 9.3% in 1992 to 13.7% in 2002, while the energy from fats increased from 22% in 1992 to 29.8% in 2002¹⁸. Meanwhile, Chinese traditional diets, which include polished rice and refined wheat, have high glycaemic index and glycaemic load values⁴². In the Shanghai Women's Health Study, a prospective cohort study of middle-aged Chinese women, a high intake of foods with a high glycaemic index or glycaemic load, especially white rice, is associated with a twofold increased risk of type 2 diabetes⁴³, and the association was largely pronounced among overweight and obese individuals. More studies are needed to investigate how diet transition in China may affect the risk of developing diabetes.

Lifestyle interventions for diabetes prevention

Intensive diet and exercise interventions are effective in preventing pre-diabetes from progressing to diabetes.

Several clinical trials have shown that diabetes is largely preventable. China was the first country that demonstrated more than two decades ago in the Daqing Study that intensive diet and exercise interventions are effective in preventing pre-diabetes from progressing to diabetes. In an intervention group, physicians at clinics provided one-on-one education on diet improvement (ie following a low-fat diet rich in vegetables and with reductions in alcohol and simple sugar intake), and increasing physical activity, or both. After 6 years of intensive intervention, diet, exercise, and diet-plus-exercise interventions resulted in 31%, 46%, and 42% reductions in the risk of developing diabetes, respectively, compared with the control group⁴⁴. Moreover, the benefits from active diet and lifestyle intervention are long lasting. After 20 years of follow-up, compared with the control group, combined lifestyle intervention (diet only, exercise only, or diet plus exercise) led to a 51% lower incidence of type 2 diabetes during the 6 year intervention and a 43% lower risk of incident type 2 diabetes over the 20 year period⁴⁴. Participants who received an intensive lifestyle intervention had an average of 3.6 more diabetes-free years compared with those in the control group. In addition, among those who developed diabetes, fewer participants in intervention groups required insulin, and circulation HbA1c levels were lower than those of the control group, although these differences were not significant⁴⁴.

Metabolic syndrome is a well-established risk factor for type 2 diabetes.

Metabolic syndrome is a constellation of metabolic abnormalities including central obesity, dyslipidaemia, elevated blood pressure, and hyperglycaemia. Metabolic syndrome is a well-established risk factor for type 2 diabetes. A good management of metabolic syndrome was believed to be beneficial for preventing type 2 diabetes. In a three-arm, random, controlled trial, a low-intensity group-based lifestyle education programme was found to be associated with lower prevalence of metabolic syndrome, and supplementation of flaxseed and walnut (both high in omega fatty acids content) provided further benefits to improve central obesity⁴⁵. Overall, a more healthy diet might help to prevent high risk populations from progressing to diabetes.

Type 2 diabetes in China: prevalence and risk factors

If diabetes is not controlled, it is expected to cause significant economic burden for individuals and health care systems in China.

Summary

The diabetes epidemic has become a major public health crisis in China. The large number of diabetes patients and the numerous diabetes-related complications will cause significant economic burden for individuals, families, and health care systems in China. Population ageing, rapid urbanisation, an obese population, physical inactivity, cigarette smoking, and unhealthy diets have been identified as causes for the diabetes epidemic in China. With lifestyle interventions which focus on a healthy diet and lifestyle, diabetes may be prevented, controlled and put into remission.

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Urbanisation in China and India: Impact on cardiovascular risk factors

Nancy Long Sieber

China and India, the world's largest nations, are undergoing unprecedented change as their economies expand and more of their populations move into cities. While these developments can potentially promote increased wealth, a more varied diet and better access to health care, they also bring risk. The lifestyle changes that occur as people become urbanised, including increasing consumption of high calorie processed foods, exposure to higher levels of ambient air pollution, and fewer opportunities for physical activity, can translate into a greater risk of obesity, diabetes, and cardiovascular disease. This paper will examine how urbanisation occurs in these two countries, and how this process affects the risk of cardiovascular health now and in the future.

Introduction

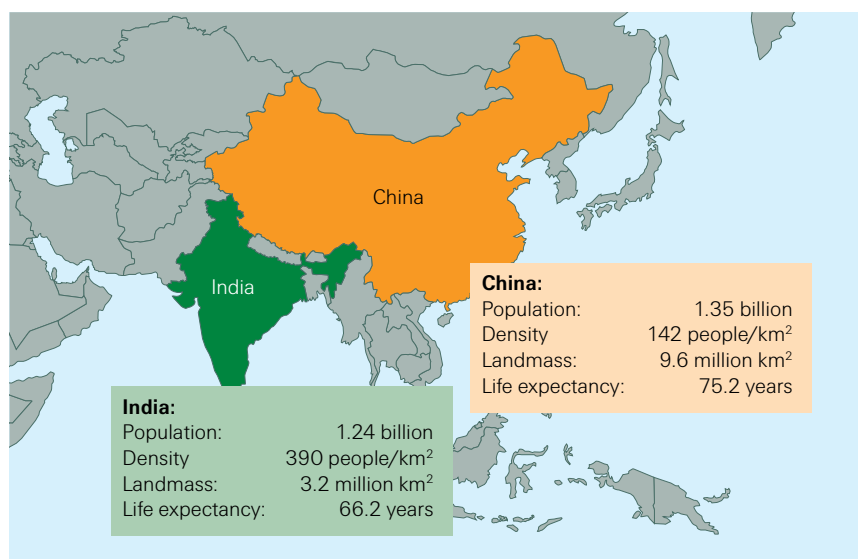
As China and India grow, and become industrialised, their populations are moving from rural areas into cities.

As the world's two largest nations grow and become industrialised, their populations are moving from rural areas into cities. Cities offer economic opportunities and better access to education, two factors that improve both the health and wealth of citizens. However, urbanisation also brings perils. Fast and processed foods are more available in cities. Work is less likely to involve physical activity, and the streets are less friendly to pedestrians and cyclists. The urban environment is also more likely to be polluted, with air pollution being a particular concern. A challenge for India and China is to manage the process of urbanisation to maximise the economic benefits, while minimising the cardiovascular and other health risks that come with it.

China is urbanising more rapidly than India, even though their populations are similar in size.

China is urbanising more rapidly than India, with 52% of its people living in cities, compared with 32% of Indians, according to 2012 World Bank statistics¹. It is notable that India lags in urbanisation, despite being home to a population similar in size to China's, but with a landmass that is just one-third as large. The relative lack of arable land in China is one factor promoting urbanisation in China, but cultural and political factors are also key.

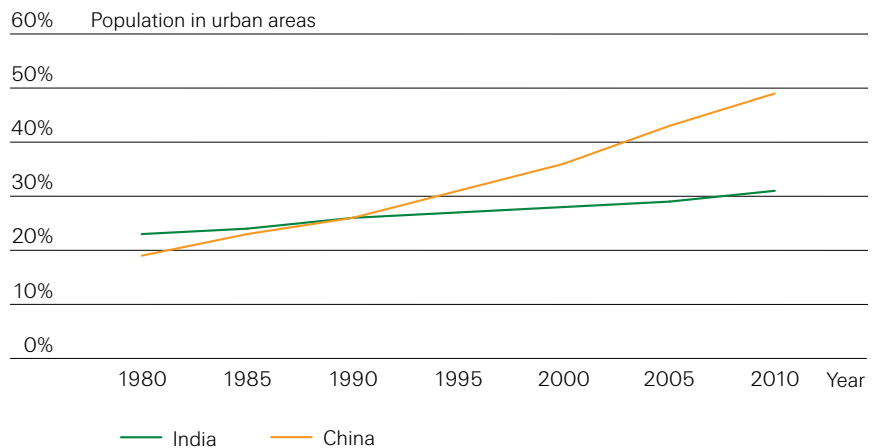
Figure 1: Population, density, landmass and life expectancy in China and India



Sources: China: National Bureau of Statistics; India: United Nations World Population Prospects

Urbanisation in China and India: Impact on cardiovascular risk factors

Figure 2:
Urbanisation in India and China, 1980–2010



Source: The World Bank – World Development Indicators 2012

India and China are approaching the challenge of urbanisation in different ways.

India and China face similar challenges of growing populations that are drawn to the economic opportunities provided by the cities. However, each country approaches these challenges in different ways, leading to different impacts on the health of urban dwellers.

Urbanisation in China

China exerts control over where people live by assigning a home district to each citizen. Those who move lose government benefits and status.

With its centralised government, China is able to exert control over where its people live. This is achieved by the use of the household registration system known as hukou. These rules, which were established in 1958, assign a home district to each citizen. The hukou system determines who is eligible for full citizenship in any particular place, including access to education, welfare, food subsidies and healthcare. These rules were initially used to maintain stability and control during the rapid industrialisation of China's "Great Leap Forward"². It also ensures cheap labour, as the many migrants who do move to cities lose their expensive government benefits and are willing to work in low-paying jobs. The hukou rules often cause families to split up, with one or both parents working in the city, while the children remain at home under the care of grandparents. Alternatively, families may reside on the edges of the cities or crowded into small apartments. Due to the differences in the income and status of a legitimate city dweller versus an unauthorised migrant, the hukou system has been compared with apartheid or a caste system³. Migrants, often known as the "floating population" make up as much as 20% of the population of many cities. The migrant population is often left out of official census numbers. When these data are used to calculate GDP, China's cities appear to be far more prosperous than they actually are⁴.

China is actively encouraging urbanisation and plans to have 60% of its population living in cities by 2020.

China's future development plans encourage urbanisation, but in a controlled manner. In March of this year, the State Council of China released their "National New-type Urbanization Plan for 2014–2020". Central to this plan is the goal of having 60% of its population living in cities by 2020. The hukou rules are now being used to encourage people to move to certain cities, particularly smaller factory towns in the middle of the country, while discouraging movement to the more cosmopolitan and wealthier eastern cities, such as Shanghai and Beijing. For example, a rural migrant working in Shanghai might be offered hukou in an inland industrial city, creating an incentive for them to live and work in this less desirable place. Beijing has pledged to gradually loosen its hukou rules in coming years to accommodate young migrants who generally spend more freely than their elders, thereby boosting the city's economy⁵.

Urbanisation in India

Mahatma Gandhi did not necessarily oppose urbanisation in India, but he felt it was important that villages maintain their self-sufficiency and autonomy.

Only about one-third of the population lives in cities. Even city dwellers and Indian living abroad retain a close connection to their ancestral villages.

Unlike China, urbanisation in India is far less regulated. This has led to a rise in the number of urban slums.

Figure 3:
A “notified” slum – recognised by the government

At the dawn of the modern era, Mahatma Gandhi encouraged Indians to keep the ideal of village life central to their development plans, stating, “The future of India lies in its villages”⁷. Gandhi did not necessarily oppose urbanisation, but he felt it was important that villages maintain their self-sufficiency and autonomy, a philosophy that he termed *swadeshi*. He emphasised the importance of small communities continuing to function as independent entities, not just adjuncts to the growing cities.

Gandhi’s ideal continues to shape India. With only about a third of its population living in cities, the village remains an important touchstone in the lives of most Indians. In fact, city dwellers and even Indians living abroad often retain a close connection to their ancestral villages. Unlike China, where agricultural lands are owned by the state, and rights to farm the land are distributed more or less equally among all farmers, India has a wealthy class of landowners, whose extended families have lived for generations in their villages. These connections tend to keep people close to their home villages, where they contribute to its cultural and economic life. However, there are fewer opportunities for landless rural workers, and they are far more likely to become migrants. Some reports estimate that migrants make up as many as one-third of India’s population. However, many of these migrants remain in the rural workforce, following harvests and returning home periodically. Others move to the cities in search of better opportunities⁸.

Compared to China, urbanisation in India is far less regulated, with migrants freely settling in large cities. This has led to the expansion of urban slums, which are estimated to number 49 000, and to house some 65 million people⁹. Some slums, known as “notified” slums, are set aside by the cities as housing for migrants. While they may lack running water, they often have electricity and can provide minimal housing for labourers and even office workers. They are also home to many cottage businesses, such as leather work and sewing. Other “non-notified” slums, which house about half of India’s slum dwellers, are makeshift structures under bridges or along sidewalks¹⁰. The lack of even the most basic facilities makes it difficult for people residing in these slums to find work in the formal sector.



Notes: Notice satellite dishes on several of the units, indicating electrical service and disposable income.

Source: author

Figure 4:
Tents crowd many Delhi sidewalks



Source: author

Rural poverty rates are on the decline, while urban poverty is on the rise.

While incomes are generally lower in the countryside, rural poverty rates are declining; meanwhile, urban poverty is growing. This change is largely the result of poor farm workers leaving the countryside and becoming poor urbanites. For most migrants, the hope of a better life in the city fails to materialise. A recent report by UNICEF shows that across India, poor children in the cities fare no better than poor children in rural areas. About 48% of poor urban children are malnourished, as are 47% of poor rural children. Poor urban mothers are slightly more likely to be anaemic (59%) than their rural counterparts (57%). Cultural traditions, such as child marriage occur at equal rates among the poor in the city and the countryside, at 48%⁸.

The impact of urbanisation on cardiovascular risk is unclear. In low and middle income countries (LMICs), greater wealth tends to be associated with higher risk of obesity and diabetes. Air pollution in cities in developing countries is notably bad.

How does city living affect cardiovascular risk?

The impact of urbanisation on cardiovascular risk is unclear. People who live in cities tend to be better educated and wealthier than people in rural areas, two factors that are associated with better health in general. In addition, city dwellers have access to a more varied diet, including fresh fruits and vegetables. They also have better access to running water, transportation and health care. However, in low and middle income countries (LMICs), greater wealth tends to be associated with higher risk of obesity and diabetes. In addition, air pollution in cities in developing countries is notably bad.

It is difficult to assess the health impact of urban life by comparing the life expectancy of city dwellers to that of people who live in rural districts.

It is tempting to assess the health impact of urban life by comparing the life expectancy of city dwellers to that of people who live in rural districts. However, such a comparison is confounded by the large numbers of migrants in both India and China. A person who migrates to the city as a young adult has had very different dietary and other exposures, relative to a person who lived their whole life in the city or in a village. For countries undergoing such rapid change, these numbers do not tell the complete story.

Table 1:
Data showing a longer life expectancy in the cities may not tell the whole story

Life expectancy	Urban	Rural
China (2005)	75	69.2
India (1998–02)	67.9	61.2

Sources: China Human Development Report 2005¹¹; ABRIDGED LIFE TABLES: 2003–07 to 2006–10 of India¹²

It is more meaningful to assess the impact of urbanisation on health by considering differences in known risk factors between cities and the countryside.

A more meaningful way to assess the impact of urbanisation on health is to consider differences in known risk factors between cities and the countryside. This gives us an idea of the exposures that occur in both places, and also provides targets for improving health in either locale.

We consider these variables individually.

Diet

Most migrants who move to the city experience dramatic changes in diet due to the higher cost of food in cities.

For most migrants, moving to the city leads to dramatic changes in diet. In India, basic foods, such as fruits, vegetable and milk cost about 1.5 times more in the cities than in the countryside. Furthermore, the cost of these foods more than doubled between 2007–08 and 2011–12, putting stress on food budgets of rural to urban migrants who can no longer supplement their diet with home grown foods¹³. In addition, small living spaces with inadequate kitchens make it difficult to prepare food from scratch.

Fast food companies have entered the urban food market in India with dishes that are often high in calories and sodium.

Given these constraints, it is inevitable that homemade dishes will increasingly be supplanted by the abundant array of street food available at every turn in the city. Fast food companies have aggressively entered the urban food market as well. Chain restaurants account for an estimated USD 2.5 billion in revenue in 2013, and are expected to earn USD 8 billion by 2020¹⁴. Some western chains have even co-opted Indian street food specialties, like the aloo tikki, a deep fried potato patty. Dubbed the McAloo tikki, McDonalds offers their version of this food – a sandwich made with a deep fried potato patty, served with a side order of french fried potatoes, which when accompanied by a medium soft drink, adds up to about 1000 calories and more than 1200 mg of sodium, according to the McDonald’s website.

The risk of obesity among urban factory workers is far higher than that of people living and working in the countryside.

It is not surprising, therefore, that the risk of obesity among urban factory workers is far higher than that of people living and working in the countryside, with migrant factory workers falling in between the two groups¹⁵.

Table 2:
Obesity odds ratio in among urban, migrant and rural workers in India

	Male	Female
Urban	3.83 (2.95–4.98)	4.89(3.56–6.72)
Migrant	3.12 (2.44–3.98)	3.86 (2.88–5.19)
Rural	1	1

Notes: Risk of obesity, (BMI >25 kg/m²), in urban dwellers and migrants relative to rural dwellers. The migrants were paired with a non-migrant (rural) sibling, 2005–2007.

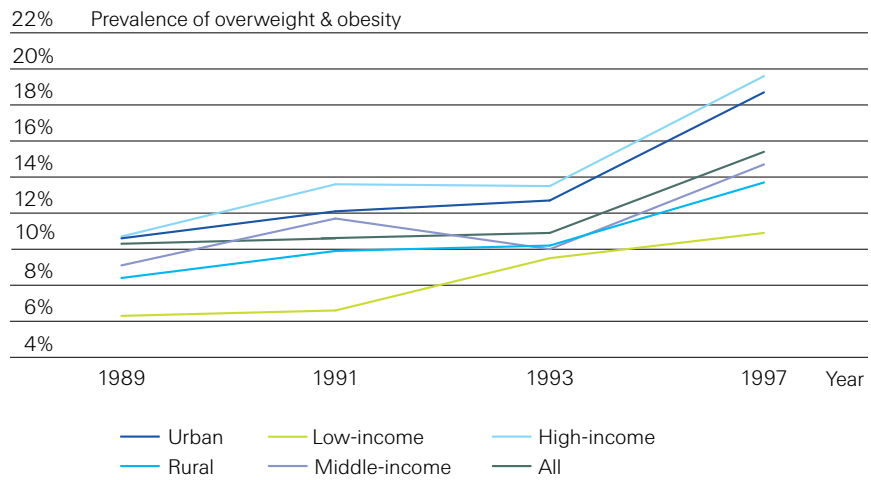
Source: Ebrahim S et al (2010)¹⁵

Urbanisation in China and India: Impact on cardiovascular risk factors

City dwellers in China are more prone to obesity, particularly people with disposable income.

Figure 5: Prevalence of overweight and obesity in China

Similar trends are seen in China, which accounts for nearly half of the global revenue of Yum Foods, owner of Taco Bell, KFC and Pizza Hut¹⁶. City dwellers in China are more prone to obesity, particularly people with disposable income (Figure 5)¹⁷.



Source: Wang et al (2006)¹⁷

India and China have gained notoriety for their levels of air pollution.

Air pollution

India and China seem to be locked in competition for the world's worst air quality. In 2013, China was embarrassed by off-the-charts levels of particulate air pollution, which were measured at the US embassy in Beijing, and widely reported in the media¹⁸. This year the attention turned to India, whose cities were reported by the WHO to have the highest level of especially dangerous PM_{2.5} particles. The WHO air quality guidelines recommend annual mean levels of PM_{2.5} be less than 10 µg/m³. High levels are associated with an increased risk of heart attack and stroke¹⁹.

In 2010, air pollution is thought to have contributed to 1.2 million deaths in China, and 620 000 deaths in India.

According to the WHO report, ambient air pollution was estimated to contribute to 3.7 million deaths worldwide in 2012, 88% of which occurred in low and middle income countries. In 2010, air pollution is thought to have contributed to 1.2 million deaths in China, and 620 000 deaths in India, reflecting the larger urban population of China. However, Indian cities are more polluted than cities in China. Delhi has the world's highest levels of PM_{2.5} at 153 µg/m³. The next three highest cities are also in India, and they range from 134–149 µg/m³. The most polluted city in China is number 36 on this list, the city of Lanzhou with 71 µg/m³ of PM_{2.5}²⁰.

Cardiovascular health suffers in China and India due to the rise in the number of less physically demanding jobs, air pollution and traffic problems that make it difficult to walk or bike.

Physical activity

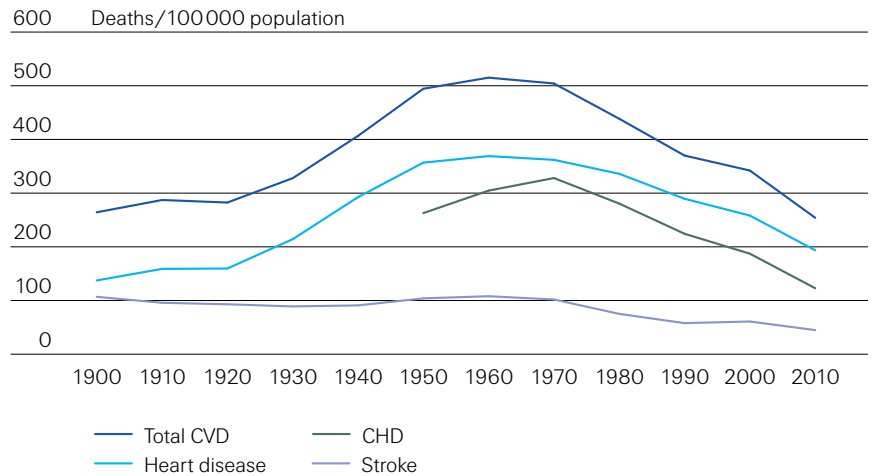
Many factors combine to reduce the level of physical activity in China and India. Most rural migrants leave farming jobs, which provide aerobic exercise, to take jobs in factories or in construction sites, which, while physically demanding, do not generally improve cardiovascular health. Air pollution and traffic problems in both countries make it difficult for people to walk or bike. China's bicycle fleet decreased by 35%, from 670 million to 435 million, between 1995 and 2005²¹. However, there are some signs of a resurgence in the popularity of cycling, particularly with newly engineered bicycle paths in some cities²². In India, streets are often obstructed by vendors or make-shift housing that impede walking and cycling, making exercise difficult.

Urbanisation in India and China resembles that of the United States and Europe in the early 20th century.

Figure 6:
Death rates for cardiovascular diseases in the US, 1900–2010

Is healthy urbanisation possible?

When public health professionals look at the urban lifestyle that is emerging in many parts of India and China, what they see resembles the United States and Europe in the early 20th century. They see a rapidly urbanising population that has enough money to purchase tobacco products, and a diet high in processed meats, soft drinks, and sugary and salty snacks. They seek work that requires less physical labour, and highly polluted urban air from growing industrial economies. It was these conditions that led to the rapid rise in heart disease mortality in the United States, which peaked in the 1960s and has declined steadily since then.



Notes: This data is not age-adjusted.
Source: National Heart, Lung and Blood Institute Factbook, 2012²³

Heart disease declined in the US in large part due to lower rates of cigarette smoking, improved diets and leisure time physical activity.

While some of the decline in heart disease mortality is due to medical control of cardiovascular risk factors, as well as better treatments for heart attacks and strokes, much has come from lifestyle changes – particularly among wealthier and better educated people – such as lower rates of cigarette smoking, improved diets and leisure time physical activity²⁴. So while the wealthy city dwellers were the first to experience this increase in cardiovascular risk, they have also been the first to make the changes necessary to reduce their risk, and to reap the benefits of these changes. In the US, smoking and obesity, the two largest behavioural risk factors, are now far more common among the poor than the wealthy.

In China, heart disease incidence is higher among city dwellers than rural residents. In India, cardiovascular risk factors are also higher in the urban and migrant population than in the rural population.

These trends are beginning to play out in China, where the age-adjusted standardised coronary heart disease incidence among city dwellers is 73–81 per 100 000 higher than among the rural population²⁵. In India, cardiovascular risk factors, including hypertension, diabetes, and glucose intolerance are higher in the urban and migrant population than in the rural population¹⁵.

India and China can make the transition to becoming wealthier, more urbanised societies without experiencing a surge in heart disease mortality by emphasising walkable streets, clean air and healthy diets.

The hope is that India and China will make the transition to becoming wealthier, more urbanised societies without experiencing the surge in heart disease mortality that occurred in the US and Europe in the mid-20th century. One key to making this transition is to focus on the physical environment of the city, emphasising walkable streets and clean air. Food policy should make it easier for city dwellers to afford the abundance of fruits and vegetables available in the cities, while discouraging the spread of fast food and snacks. Since cardiovascular risk is likely to trickle down to the poor, policies should be in place to enable migrants to experience the benefits that cities offer, including education and economic opportunities.

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Lost life expectancy due to air pollution in China

Douglas W. Dockery, C. Arden Pope III

Smog in Beijing and other Chinese cities has caused pollution to reach unprecedented levels. It is impossible to measure the health costs or loss of life due to air pollution with absolute accuracy or certainty. Nonetheless, data suggests that poor air quality imposes a significant health burden on the urban population. When the Prime Minister quipped that living in Beijing would shorten his life by 5 years, he succinctly captured the risk air pollution poses to Chinese city dwellers. Chinese authorities are now looking at ways to address air pollution and other environmental concerns, both to manage public health costs and to lessen the impact on economic growth.

Introduction

Air quality in the US and Europe has improved in recent decades, but has deteriorated in much of the developing world.

Air quality in the United States and Europe has substantially improved over the last couple of decades, and cleaner air has contributed to increased life expectancy¹. However, in many countries in the developing world, air pollution control has been sacrificed in the name of economic development.

Poor air quality in Beijing is harming not only the health of its residents, but also its economy.

The severe and deteriorating air pollution situation in China is a case in point. The high particulate air pollution readings in Beijing have been documented and reported on the web by the US Embassy. The Chinese government has begun publishing real time measurements of air quality in most cities. There is increasing concern that poor air quality is not only harming the people, but may also be harming economic growth in China.

In October 2013, the city of Harbin reported that the air quality index had soared to 500, its highest possible level.

Winter air pollution events in the north of China are common, and the hazard is well recognised. "If I work in your Beijing, I would shorten my life by at least five years," Zhu Rongji told city officials when he was prime minister in 1999². However, the government is just beginning to try and control or at least mitigate these air pollution events. In October 2013, a particularly severe air pollution episode in the northern city of Harbin was reported around the world. In blogs, people reported not being able to see their hands in front of their faces or other people. The Harbin government reported an air quality index (AQI) score of 500, the highest possible reading, and concentrations of PM_{2.5} – ie fine particulate matter that are 2.5 microns or smaller in diameter and especially harmful to health – of 1 000 micrograms per cubic meter (mg/m³).

When London's smog level in 1952 reached that of the level recently recorded in Harbin, 4000 deaths occurred.

These anecdotal reports and quantitative measurements from Harbin (Figure 1) are remarkably similar to those from London during the 1952 Great Smog (Figure 2). Health data from Harbin have not been reported, but in London 4 000 excess deaths were attributed to this event. Recent analyses have suggested that the true number of excess deaths could be 12 000³.

Harbin's pollution levels are believed to be linked to the policy of providing free coal for heating.

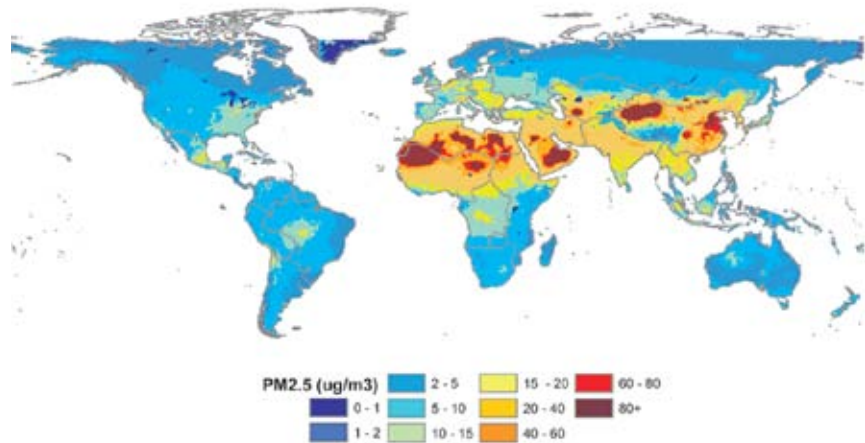
This Harbin episode coincided with the mandated start of heating of the homes and offices. The policy of providing free coal for heating in the north has been associated with persistently high winter particulate air pollution levels in northern cities. A recent analysis⁴ evaluated the effect of this policy. Outdoor ambient concentrations of particulate air pollution (Total Suspended Particulates) were found to be 55% higher and life expectancies 5½ years shorter in the north. Deaths due to cardiorespiratory causes were notably higher.

Lost life expectancy due to air pollution in China

Outdoor air pollution in China was estimated to contribute to 1.2 million premature deaths and 25 million healthy years of life lost.

In December 2012, the Global Burden of Disease analyses were published in The Lancet⁵. As part of that effort, average 2005 fine particle (PM_{2.5}) air pollution was estimated across the world (Refer to Figure 1)⁶. Outdoor air pollution in China was estimated to contribute to 1.2 million premature deaths and 25 million healthy years of life lost⁷. Outdoor air pollution was ranked as the fourth leading risk for loss of life expectancy in China; indoor air pollution from burning solid fuels for heating and cooking was the fifth leading cause.

Figure 1:
Estimated 2005 annual average PM_{2.5} concentrations (µg/m³)⁶.



Source: Brauer et al (2012)⁶

This paper seeks to provide estimates on loss of life expectancy due to exposure to air pollution.

These huge numbers of excess deaths and total years of lost life expectancy are compelling, but fail to communicate the risk to an individual of life-long exposure to extremely high air pollution, or the risk to visitors or temporary residents. The objective of this commentary is to provide useful, comparable effect estimates on loss of life expectancy under various exposure scenarios for exposure to air pollution and, for comparison, to cigarette smoke, a common, well studied risk.

Methods

For this study, the life expectancy for non-smokers is calculated by adjusting the rates of those aged 18 and older.

Our estimates of survival curves and life expectancy are derived using standard life-table techniques and are calculated using 2008 age-specific death rates for the total population of the United States⁹. The counterfactual, baseline, life expectancy for non-smokers is calculated adjusting the rates for ages 18 years and older to 80% of rates from the total population. This provides hypothetical population-based mortality rates and estimates of life expectancy for a contemporary, healthy, non-smoking population. We estimated life expectancy for various exposure scenarios by multiplying the baseline age-specific death rates by the relative risks for each of these scenarios.

Excess risk estimates for air pollution scenarios were based on literature reviews.

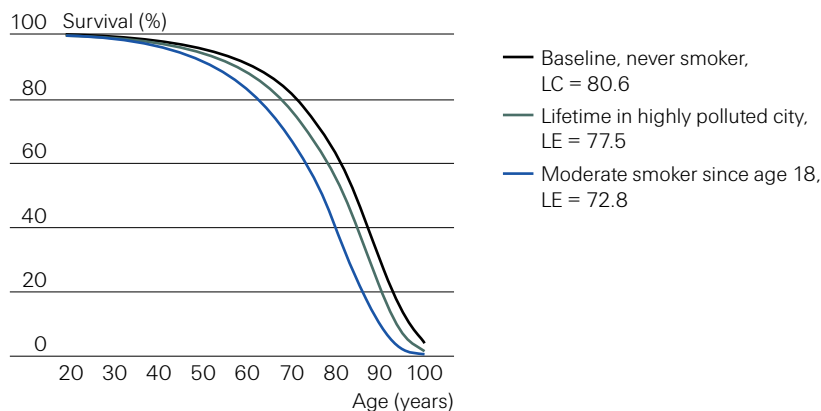
Excess risk estimates for the various air pollution exposure scenarios are based on recent literature reviews^{9, 10}. Specifically, excess risk from exposure to air pollution in a mildly polluted city ($15 \mu\text{g}/\text{m}^3$ mean $\text{PM}_{2.5}$), a moderately polluted city ($25 \mu\text{g}/\text{m}^3$ mean $\text{PM}_{2.5}$), and a highly polluted city ($55 \mu\text{g}/\text{m}^3$ mean $\text{PM}_{2.5}$) relative to a very clean city ($5 \mu\text{g}/\text{m}^3$ mean $\text{PM}_{2.5}$) are estimated to be 7%, 14%, and 30%, respectively. The excess risk estimates for a highly polluted city may somewhat underestimate the effects of air pollution of Beijing for two reasons. First, average $\text{PM}_{2.5}$ concentrations in Beijing are reported to be $58 \mu\text{g}/\text{m}^3$ in 2005⁹ and have been getting worse. Second, we are using more conservative risk estimates than would be obtained by linear extrapolations from US cohort studies because of recent evidence that the exposure-response function flattens out at higher levels of exposure¹¹.

Results and discussion

Cigarette smoking, to a large extent, and exposure to ambient air pollution to a less extent both adversely alter survival curves.

Figure 2 illustrates differences in the life-table derived survival curves and life expectancy for the different exposure stylised scenarios. Cigarette smoking significantly adversely alters the survival curves. A lifetime of exposure to ambient air pollution in a highly polluted city has a similar, but less dramatic impact on the survival curves. Lifetime exposure to second-hand smoke (SHS) has a somewhat smaller, but similar effect (not shown in Figure 2).

Figure 2:
Survival curves 18–100 years and estimated life expectancy (LE) for alternative excess risk assumptions



Source: author

Lost life expectancy due to air pollution in China

Long-term smoking can reduce life expectancy by 4.5 to 12.5 years.

Table 1 presents the estimated years of life expectancy and the estimated reduction in estimated life expectancy, relative to the baseline. Long-term active smoking clearly has a substantial impact on life expectancy ranging from 4½ to 12½ years lost, depending on the level of smoking. The loss of life expectancy is substantially reduced for smokers that quit smoking. How much loss of life expectancy will occur depends on various factors including, level of smoking, the age when an individual began and stopped smoking, and the lagged or residual excess risk from the smoking upon cessation. For an ex-smoker who smoked from age 18–40, life expectancy would be almost two years less than if he/she had never smoked, but nearly 6 years longer than if he/she had continued smoking.

Table 1:
Life-table derived estimates of reduced life expectancy from different exposures to cigarette smoke and ambient fine particulate matter air pollution

Baseline life expectancy (LE)	Years LE	Reduced years LE	Reduced days LE
Baseline LE for never smoker at birth	80.6	–	–
Long-term exposures to active cigarette smoking			
Smoker, heavy, since age 18 (add 200% excess risk since age 18)	68.1	12.5	4,571
Smoker, moderate, since age 18 (add 100% excess risk since age 18)	72.8	7.8	2,851
Smoker, light, since age 18 (add 50% excess risk since age 18)	76.1	4.5	1,653
Ex-smoker, moderate smoker from age 18-40 (add 100% excess risk from age 18-40, 50% at age 41, 25% age 42, 10% thereafter)	78.7	1.9	701
Long-term exposure to second hand cigarette smoke			
Live/Work with smoker 18+ (add 25% excess risk from age 18)	78.1	2.5	903
Live/Work with smoker 18–65 (add 25% excess risk from age 18–65)	79.6	1.0	352
Live with smoker as child with no lagged/residual risk (add 25% excess risk from age 0–18)	80.4	0.2	74
Long-term exposures to air pollution			
Lifetime in mildly polluted city (add 7% excess risk from birth)	79.8	0.8	292
Lifetime in moderately polluted city (add 14% excess risk from birth)	79.0	1.6	569

Source: author

Living with a smoker throughout adult life could reduce life expectancy by 2.5 years.

As can be seen in Table 1, living with a smoker throughout adult life could reduce life expectancy by up to 2½ years. On the other hand, working with a smoker between 18 and 65 years was estimated to reduce life expectancy by only 1 year, assuming the increased risk does not persist once exposure stops. Because of the relatively low baseline risks of mortality for children, exposure to SHS as a child results in a reduction in life expectancy of only about 74 days. If, however, the increased risks of childhood exposure to SHS persist, the reduction in life expectancy may be substantially higher.

Life-time exposure to ambient air pollution, comparable to that found in Beijing, may reduce life expectancy by approximately three years.

The estimated reduction in life expectancy from a lifetime of exposure to ambient air pollution clearly depends on the level of pollution (Table 1). For example, lifetime exposure to air pollution in a mildly polluted city (15 µg/m³ mean PM_{2.5}) or a moderately polluted city (25 µg/m³ mean PM_{2.5}) relative to a clean city (5 µg/m³ mean PM_{2.5}) results in an estimate of 0.8 and 1.6 years reduction in life expectancy. Life-time exposure to ambient air pollution, in a highly polluted city (comparable to Beijing, China) may result in an estimated loss of life expectancy of approximately 3 years.

The net effect on a population from being exposed to ambient air pollution is significant in terms of total loss of years of life.

Thus a lifetime of exposure to air pollution either from outdoor air pollution, indoor air pollution from SHS, or personal smoking can lead to years of lost life expectancy. Living in a highly polluted city has estimated effects comparable to or even greater than that from living with a smoker. Smoking, however, is a personal choice and only a fraction of the population engages in this voluntary exposure. On the other hand, breathing is not. The entire population is exposed to ambient air pollution. The net effect on population of a 3.1 year reduction in life expectancy across everyone breathing ambient air pollution is much larger than a 7.8 year reduction only among those smoking.

One can compare the risks of pollution and smoking in terms of the incremental effect of each year of exposure.

It is useful to compare these risks in terms of the incremental effect of each year of exposure. This helps us appreciate the effect of potential changes in exposures or behaviours. It also provides insights into the comparative risk for a worker or student who temporarily moves to such an environment.

One year of living in an elevated air pollution environment could result in as much as a few days to a few weeks of shorter life expectancy per year, depending on the levels of pollution and age at time of exposure.

To illustrate, Table 2 presents the estimated reduction in life expectancy for a 50-year old non-smoker who spends one year in various modelled cities with mild, moderate and high PM_{2.5} air pollution. Because the incremental reductions in estimated life expectancy for each year of exposure are small, we report these as days lost per year. One year of living in an elevated air pollution environment could result in as much as a few days to a few weeks of shorter life expectancy per year, depending on the levels of pollution and age at time of exposure. If the increased risks from a one year exposure were to persist, even only in part, the reduction in life expectancy would be larger. Because the baseline risk goes up with age, the impact of each year of exposure to high pollution on life expectancy is much larger at age 65 (21 days lost life expectancy) than it is at age 50. Likewise, the impact on lost life expectancy is less at age 35 years (5 days).

Table 2:
Estimates of reduced life expectancy for 1 year exposures to cigarette smoke and ambient fine particulate matter air pollution at 50 years of age

One-year exposure at age 50 with various PM _{2.5} pollution levels	Reduced years LE	Reduced days LE
Living in mildly polluted city (add 7% excess risk)	.008	3
Living in moderately polluted city (add 14% excess risk)	.015	6
Living in highly polluted city (add 30% excess risk)	0.032	12
One-year exposure at age 50 with various smoking exposures	Reduced years LE	Reduced days LE
Smoker, heavy (add 200% excess risk)	.216	79
Smoker, moderate (add 100% excess risk)	.108	39
Smoker, light (add 50% excess risk)	.054	20
Live/Work with smoker (add 25% excess risk)	.027	10

Source: author

What does this mean for the individual?

The estimates provided are for the population life expectancy and do not refer to how much any individual's life is shortened by one year of exposure to pollution.

These estimates are for the population life expectancy and do not provide specific estimates how much any individual's life is shortened by one year of exposure in a polluted city. In fact, in this modelling exercise, we assume that if the person survives this experience, they would go on with the normal expectation of death with no increased residual risk. Evidence from smoking cessation studies suggests that risk of fatal cardiovascular events (ischemic heart or cerebrovascular), the primary cause of death from these exposures, begins returning to near normal within a few weeks/months of cessation of smoking and is only somewhat elevated after a few years. For respiratory conditions, air pollution exposure can contribute to accelerated, irreversible loss of lung capacity. It may take months to years to return to normal risk, and indeed there may be permanent but small elevated risk.

Lost life expectancy due to air pollution in China

For an individual, the implication of these results is not that their life is measurably shortened. Rather these estimates reflect the increased probability of death each year.

Once the air pollution exposure is removed – eg by moving to a cleaner city – the excess risk of dying returns to normal.

Living/working in a moderately polluted city has comparable effects on life expectancy as living with a smoker or working in an environment with substantial second-hand smoke.

Air pollution affects those with pre-existing chronic cardiovascular conditions the most.

Masks are not very effective in preventing individuals from breathing in or limiting exposure to ambient particles.

Air pollution does impact life expectancy in developing countries.

Comparing air pollution and smoking has certain limitations.

It is not possible to measure health costs or loss of life from air pollution accurately.

Failure to address air pollution and other environmental concerns is now being recognised as a significant public health burden and could adversely impact economic growth.

For an individual, the implication of these results is not that their life is measurably shortened. Rather these estimates reflect the increased probability of death in each year. Again to illustrate, among one thousand (1000) non-smoking 50 year olds, we would expect 3½ to die within a year. If all of them smoked, we would expect an additional 3½ to die (ie only a fraction of them would be expected to take up this behaviour). Alternatively, if the non-smokers experience PM_{2.5} air pollution of approximately 55 mg/m³ for a year, we would expect one additional death (ie in this case everyone is at risk).

These individuals would most likely die from acute events such as a myocardial infarction, stroke, asthma attack or traffic accident. It is assumed that once the air pollution exposure is removed – eg by moving to a cleaner city – the excess risk of dying returns to normal.

While these estimates of loss life expectancy for a 50 year old are simplistic, they provide a basis for comparing risks. Thus living/working in a moderately polluted city has comparable effects on life expectancy as living with a smoker or working in an environment with substantial second-hand smoke.

Can individuals take actions to protect themselves, other than leaving?

The most effective strategy is to reduce your own baseline risk of cardiorespiratory death¹². Air pollution affects those with pre-existing chronic cardiovascular conditions. Long-term strategies to reduce risk of cardiorespiratory disease have the added benefit of reducing the likelihood of death due to air pollution.

Masks and other breathing protection are not very effective in preventing individuals from breathing in or limiting exposure to ambient particles¹². Office and home air conditioning has some limited benefit in reducing exposures to ambient outdoor air pollution. Indeed gaseous pollutants (eg sulfur dioxide, ozone, nitrogen oxides and other water soluble gases) are readily removed by air conditioning. However, the normal filters in air conditioners are only modestly helpful in removing inhalable, airborne particles. Office and home filters can be helpful if specifically designed for removal of small particles, eg HEPA filters. However, targeted filtering of inhalable particles is difficult, expensive and requires regular cleaning and maintenance. Thus, the preferred approach is cleaning up the ambient outdoor air.

Summary and conclusions

From these calculations, it becomes apparent that outdoor particulate air pollution is having a substantial effect on life expectancy in much of the developing world.

As George Box reminded us “All models are wrong, but some are useful¹³.” This model of life expectancy valuing the effects of air pollution and cigarette smoking in the currency of days of lost life expectancy is simplistic, ignores many nuances in the actuarial data, and in that sense is clearly wrong. However, this approach helps us understand the comparative impact of air pollution relative to other known risk factors.

It is impossible to measure the total health costs or loss of life due to air pollution in China, or elsewhere with absolute accuracy or certainty. However, when the Prime Minister quipped that living in Beijing would shorten his life by 5 years, he succinctly captured the reality that air pollution imposes a substantial health burden on the population in China.

Most countries have seen a dramatic improvement in life expectancy over the past 50 years that appears to be at least correlated with economic development. Failure to address air pollution and other environmental concerns, however, is now being recognised as a significant public health burden and a potential impediment to economic growth.

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Bicycling, health and weather-related disasters: Potential data to better predict risk

Anne Lusk, Yanping Li

China, the Bicycle Kingdom, has had some of the most outstanding bicycle infrastructure in the world. Though bicyclists are now fewer in China, much bicycle infrastructure remains. Bicycling should still be fostered because of the many health benefits, including lowered risk for obesity, diabetes, stroke, cancer and cardiovascular disease. Yet, due to high pollution levels, bicycling may not be as highly beneficial for health in certain cities. For issuing life insurance, it may be worthwhile to understand the health benefits from bicycling and the potential risks from pollution. For understanding weather-related disaster risk, it may be useful to know if a well-designed bicycle network exists for residents to routinely travel to maintain their health, to flee, or to effectively respond to emergencies.

This article reviews the health benefits of bicycling in different countries and China, health and pollution exposure while bicycling, and how cities are using bicycles to improve response to weather disasters.

Introduction

This article will review the health benefits of bicycling in different countries and China, health and pollution exposure while bicycling, and how cities are using the bicycle to improve their response to weather disasters. The article will also propose future research to add data to better predict risk in issuing life and weather-related disaster insurance. With these new data and initiatives associated with the bicycle, predicting risk could be easier and China could be an example for other nations.

The most common ways of engaging in physical activity include recreational activities, occupational work or active transportation, such as walking or bicycling.

Health benefits of bicycling

Physical activity includes recreational activities (eg swimming or playing tennis), occupational work (eg farming), or active transportation (eg walking and bicycling). Not everyone can engage in recreational activities because this involves discretionary time and often money to go to the pool or tennis club. Unlike labourers or farmers, many individuals now work in an office and sit for long periods. Individuals can burn calories if they walk to work or run errands, but research that involved 18 414 nurses suggested that of the nurses who walked slowly, weight gain was not controlled¹. If they walked briskly, weight was controlled but, in this study population, only 39% reported walking briskly compared with 50% who walked slowly. Bicycling also controlled weight and 48% of the nurses indicated that they bicycled. Bicycling may better control weight because the Metabolic Equivalent of Task (resting state is 1 MET) is highest for bicycling (about 8 METs) compared with slow walking (2.5 METs) or brisk walking (3.3 METs)².

The health benefits of bicycling are higher compared to walking.

Perhaps due to the additional exertion involved in bicycling compared with walking, the health benefits are higher. As cities vary in bicycle infrastructure and pollution, it is worthwhile to note the location of studies about bicycling. In India, bicycling, compared with using private or public transport or walking, was the most beneficial form of active travel to work for lowering the prevalence of overweight/obesity, hypertension and diabetes³. In Australia, compared to driving, men who bicycled to work were significantly less likely to be overweight or obese⁴. In studies in the Netherlands and Denmark, bicycling was associated with lower mortality and cardiovascular risk⁵, all-cause mortality⁶, and inversely associated with all-cause mortality and coronary heart disease if bicycling intensity was high⁷. A study in the US determined that the young men who bicycled vigorously for 45 minutes still had high levels of post exercise energy expenditure for up to 14 hours after bicycling⁸. A study that involved older men in Italy suggested that bicycling positively influenced their psycho-physical well-being⁹.

Bicycling, health, and heather-related hisasters: Potential data to better predict risk

One study found that children who bicycled were more physically and metabolically fit.

If a child or adolescent is overweight, the likelihood of early puberty, metabolic syndrome, type 2 diabetes, or, as an adult, obesity increases. If the child is then obese as an adult, their risk of some types of cancer and cardiovascular disease increases¹⁰. Thus, to improve longevity, it is important to be physically and metabolically fit as a child. Children in Denmark who bicycled had higher levels of cardiovascular fitness compared with walking or being driven¹¹. If children switched from not bicycling to bicycling, they were significantly more fit¹². According to one study, children who did not bicycle at baseline and who started bicycling were more fit and had a better glucose metabolism, cholesterol/HDL ratio, and CVD risk factor profile compared with those who did not bicycle at baseline or the end of the 6 year study¹³. Compared with walkers and car and mass transit users, bicyclists aged 15 to 19 years of age had greater aerobic power, endurance in abdominal muscles, and flexibility¹⁴. In a study in the US, children who rode a bike to school for 2 or more days a week were less likely to be overweight¹⁵.

Bicycling is beneficial for fitness, cardiovascular health, all-cause mortality, coronary heart disease morbidity, mortality, cancer risk and overweight/obesity.

Systematic reviews have been conducted of studies from many countries on biking and health. The conclusion was that bicycling was beneficial for fitness, cardiovascular health, all-cause mortality, coronary heart disease morbidity, mortality, cancer risk and overweight/obesity¹⁶. Health issues of obesity/overweight, hypertension, diabetes, cancer (increased risk with obesity), cardiovascular risk, fitness and psycho-physical well-being all are markers for a long life. Research conducted in Copenhagen followed 5106 healthy men and women between the ages of 21 to 90 over a period of 18 years. A weak association was found between the amount of time spent bicycling and risk of death from all-cause and coronary heart disease. Yet, the research found that the women who bicycled at moderate intensity lived 2.2 years longer and the women who bicycled at fast intensity lived 3.9 years longer. The men who bicycled at average intensity lived 2.9 years longer and the men who bicycled at a fast intensity lived 5.3 years longer⁷.

Research on health and bicycling in China

Research conducted in Hangzhou, China found that car owners were more likely to be overweight/obese.

Recent research conducted in Hangzhou, China indicated that, of those surveyed, 77% of the men and 72% of the women owned a car and, of these car owners, 43.8% bicycled each week¹⁷. Of Hangzhou's non-car owners, 62.2% bicycled each week. There was a statistical difference between percentages for overweight/obese (BMI 24) for individuals who owned a car (28.8%) compared with individuals who did not own a car (21.0%). Hangzhou is a wealthy city and also has the world's largest bicycle rental system¹⁸, wide cycle tracks with mature plantings between the cycle track and the road, and a policy in which cars with certain license plates are not allowed to be driven on specific days. These factors may help explain why, even though more car owners are overweight compared with non-car owners, the percentage for overweight/obese among car owners was 28.8% in Hangzhou. This was relatively low because the percentage for overweight/obese for all of China is 38.5% (45.0% males/32.0% females)¹⁹. In a study of eight provinces in China that included data from 1989 to 1997, odds of obesity were 80% higher for both men and women if a motor vehicle was owned in the household²⁰. In Hangzhou, where the government has enhanced and expanded the bicycle infrastructure as part of its efforts to be a low-carbon city²¹, car ownership was not as strongly associated with being overweight/obese.

A study in Jiangsu, China found that walking and bicycling were not beneficial for health.

Contrary to many studies about walking, biking, and health, a recent study in Jiangsu, China about active transport (walking and bicycling) indicated that walking and bicycling were not beneficial for health. The individuals who walked and bicycled had higher prevalence of cholesterol and risk of diabetes, while the individuals who did not walk or bicycle had lower risk of obesity and cholesterol²². Similarly, a systematic review of 15 studies of active transport (walking and bicycling) also found that walking and cycling may not be strongly associated with lowered obesity. However, in the studies that had separated walking from bicycling, researchers found that bicycling was associated with lower body weight²³.

Research on women in Shanghai found that bicycling provided higher benefits than walking.

As confirmation of this finding about the benefits of biking versus walking, a study that had been conducted on women in Shanghai found that exercise and bicycling were inversely associated with all-cause mortality, but walking for transportation was less strongly associated²⁴. To additionally confirm the finding about biking versus walking, the research conducted in the US on 18414 nurses showed that nurses who walked slowly did not control weight¹. In the Jiangsu study, which found that walking and bicycling were not beneficial for health, the authors defined active transport as walking and/or bicycling for more than 10 minutes, but did not identify the speed of the walkers, and defined a bicyclist as either riding a regular bicycle or an electric bicycle. Many e-bikes exist in China that are powered by a battery and that do not involve vigorous pedalling. The individuals involved in this measure of active transport in Jiangsu might not have been walking or bicycling for enough time, they might have been only walking, the walking speed may have been too slow, and the bicycle may have been an e-bike.

In one study, those who did not exercise were found to be at higher risk for cognitive impairment.

A study of 2030 Chinese individuals who were 70 years of age or older were followed for 36 months to assess cognitive impairment (CI). Of these individuals, 6.7% of the men and 22.2% of the women had CI at the end of the 3 years²⁵. If the participants had listed no exercise at baseline, their risk of CI increased twofold. In a study conducted in Tianjin, China with 2002 males and 1974 females aged 15 to 69 years of age, commuting and leisure-time physical activity were observed. Of the participants, 11% of the males and 7% of the females commuted by bicycle for more than 1 hour to and from work²⁶. Commuting by walking or bicycling for too much of the day may have downsides. If the men and women commuted by walking or bicycling for more than 60 minutes a day and also did leisure-time physical activity, they had the highest mean blood pressure and prevalence of hypertension compared with traveling by bus. This result may be because the long physical daily commute took a mental toll due to stress in rush-hour traffic.

Bicycling, health, and pollution exposure

Individuals who bicycle are also exposed to air pollution.

If all individuals bicycled only inside parks and thus far from vehicle exhaust, the health benefits would be the central measure. Instead, bicycling is a form of transportation and the main routes are often roads on which vehicles also travel, thus exposing the bicyclist to mobile source air pollution. As some cities have higher pollution compared with others, the location where a study was undertaken becomes relevant.

Researchers in Australia found that car occupants were more exposed to pollution than those commuting by bus, train, bicycle or walking.

A study conducted in Australia compared pollution exposure for five methods of commuting (car, bus, train, bicycle and walking) and suggested that car occupants were most exposed to pollution²⁷. Researchers in the Netherlands also compared pollution exposure, specifically particle number counts (PNC) and particulate matter < 2.5 µg PM_{2.5}, and found that PNC was 5% higher and PM_{2.5} 11% higher within the car compared with the concentrations for the bicyclists²⁸. These studies only compared the environment and not breathing. Unlike the car occupant who is sitting still and at a resting state, the bicyclist is pedalling and thus has a higher ventilation rate. At a higher ventilation rate, the bicyclist can be taking more mobile source air pollution particles deep into their lungs compared with car occupants.

Bicycling, health, and heather-related hisasters: Potential data to better predict risk

Studies in Belgium and the Netherlands suggested that bicyclists were more exposed to pollution than motorists because their ventilation rate was higher.

Mobile source air pollution was compared in Sweden between car occupants and bicycle messengers, and though the pollution exposure appeared comparable between the two, the ventilation rate of the bicyclists was four times higher compared to someone at a resting state²⁹. A study in Belgium confirmed this measurement and suggested that the bicyclist ventilation rate was 4.3 times higher compared to individuals within the vehicles, exposing the bicyclists to more PNC and PM³⁰. In comparing exposure to Black Carbon (BC) in Belgium, the bicyclists were exposed to only half the BC exposure of car occupants, but when the ventilation rate was factored in, the bicyclists were exposed to BC at twice the level³¹. A study in the Netherlands indicated that bicyclists traveling along a route with heavy traffic had the highest exposure of PNC (46 600 particles/cm³), a measure higher when compared with being in a diesel bus (38 500 particles/cm³). When the ventilation rate was also factored in, that for bicyclists was twice that of the other modes; the bicyclists were the most exposed compared with riding diesel buses, electric buses, gasoline cars, or diesel cars³².

Bicyclists traveling during the morning commute are more exposed to pollution.

The time when the bicyclists are also traveling can increase their exposure. Individuals traveling to work by bicycle typically have no option but to travel when others are traveling and thus it is impossible to avoid exposure. A study in Belgium determined that the highest concentrations of ultrafine particles (UFP) are in the morning commute³³. Researchers in London confirmed this conclusion by studying Black Carbon (BC) as measured in the airway macrophages. Bicyclists traveling during the morning had 1.6 times the BC of individuals using public transit. Bicyclists were also commuting long distances, and thus were exposed for a longer time, and had 2.6 times higher concentrations of BC³⁴.

Exposure to mobile source air pollution can alter the heart rate.

Heart rate can vary depending on the pollution exposure when bicycling with many vehicles. A study conducted in Canada found that within the hours after bicycling in mobile source air pollution, the autonomic heart modulation can be altered³⁵. Subjects in Germany who spent time in cars, on public transport, on motorcycles, or on bicycles had higher risk of myocardial infarction (odds ratio 2.92) one hour after exposure to traffic pollution³⁶.

Bicyclists might be less exposed by taking alternate routes instead of sharing the road with multiple vehicles and riding between tall buildings.

Bicyclists might be less exposed if they can take alternate routes instead of sharing the road with multiple vehicles and riding between tall buildings. In a study conducted in London, bicyclists, plus walkers, bus riders, car riders and taxi riders in a street canyon were more exposed to PM_{2.5} compared with being on a less travelled back street³⁷. If the bicyclist could bicycle along an off road sea-wall environment, as in Vancouver, British Columbia, they would be far less exposed to PM_{2.5} and PM₁₀ but these alternate routes do not always take the bicyclist to their destination, including work³⁸. A study in Denmark advised bicyclists to not bicycle during rush hour and to also take the routes less travelled, but this alternative is not always feasible for getting to and from work or school³⁹. Boston bicycle routes were also compared for exposure to traffic-related air pollution and, again, paths that were a distance from the road and that had vegetation between the road and the bicyclists, offered the lowest exposure to pollution⁴⁰. A study of bicycle routes in Montreal indicated that having separated lanes, at least some distance from the tailpipe, could reduce exposure by 12%⁴¹. A comparative study of Portland's cycle tracks, ie barrier-protected and bicycle-exclusive paths between the moving cars/parked cars and the sidewalk – and bike lanes, ie painted lanes between parked and moving cars – suggested bicyclists on cycle tracks were less exposed⁴². Exposure to ultrafine particles did increase at intersections with signals as vehicles are idling at these locations.

Morbidity and mortality estimates from bicycling with pollution

Even though exposure to mobile source air pollution can negatively impact morbidity and mortality, studies in different countries have concluded that the physical activity of bicycling, even with pollution, improves health and extends life.

Being exposed to mobile source air pollution can negatively impact morbidity and mortality, but studies in different countries have concluded that the physical activity of bicycling, even with pollution, improves health and extends life. In a study in the Netherlands, the health benefits from bicycling were estimated to extend life 3 to 14 months, while the mortality effect from pollution can take away 0.8 to 40 days⁴³. Spain has recently been promoting bicycling, especially through the bicycle sharing system Bicing. Compared with individuals using cars, the estimated all-cause mortality relative risk associated with the physical activity from biking was 0.80. Instead of the typical number of deaths each year of 52.15, annual deaths were estimated to drop to 12.28 because of the increase in physical activity. The relative risk of all-cause mortality from pollution (less than 2.5 µm) was 1.002, suggesting the benefits from the physical activity were greater⁴⁴. A follow up study in Spain explored replacing car trips with the bicycle or public transport. If 40% of the car trips in Barcelona became bike or transit trips, 66.12 deaths were estimated to be avoided (1.15 more deaths from pollution, 0.17 more deaths from traffic fatalities, and 67.46 deaths avoided due to the benefits from physical activity)⁴⁵. A study in the US explored mortality, mobile source air pollution and the benefits from the physical activity involved in bicycling. If 50% of short car trips could be replaced by the bicycle, the yearly savings would be USD 3.8 billion per year in health care cost reduction and mortality that is postponed. In addition to mortality, measures included reductions in PM_{2.5}, asthma, chronic bronchitis, respiratory problems, cardiovascular problems and work-loss days⁴⁶.

Researchers in Denmark and Spain found that bicycling significantly lowers burden of disease.

Many studies have assessed lowered mortality with an increase in bicycling, but a study conducted in Denmark explored morbidity, or the burden of disease. Using the measure of disability-adjusted life years (DALY), the benefits from physical activity, and negatives from pollution exposure, an increase in bicycling would reduce the study population's burden of disease annually by 19.5 DALY. This estimate combines reducing the burden of disease from physical inactivity (76.0 DALY), increasing the burden of disease from pollution exposure (5.4 DALY) and increasing the burden from traffic accidents (51.2 DALY). When combined, the overall benefits from bicycling are lowered burden of disease⁴⁷. In addition to studying mortality in Spain with the introduction of more bicycling, researchers also assessed the impact on morbidity. If the bicycle and mass transit could result in 40% fewer long car trips, the result would annually be 44 fewer cardiovascular disease cases, 127 fewer diabetes cases, 30 fewer dementia cases, 16 fewer minor injury cases, 11 fewer breast cancer cases, 3 fewer colon-cancer cases, and 0.14 fewer major injuries. With lowered levels of PM_{2.5}, annually, there would be 7 fewer cases of low birth weight, 1 less cardiovascular disease case, 6 fewer pre-term births, and 1 less lower respiratory tract infection⁴⁸.

Pollution exposure in China, bicycling, and health

Few studies exist on bicycling and mobile source air pollution in China.

Studies that explore mobile source air pollution and health in the Netherlands, Denmark, Sweden, Canada, and the US do not compare with the pollution exposures in China. There are fewer studies on bicycling and mobile source air pollution in China, but a study of two Peking university campus gate employees who work by a heavily travelled road in Beijing may provide information. Exposure to high concentrations of PM resulted in oxidative stress with PAHs and metals being biologically active⁴⁹. The differences between this study and studies involving bicyclists were the two individuals were standing, and thus had a lower ventilation rate compared with bicyclists, and were at their station for 8 hours a day, and thus exposed for more time compared with bicyclists riding to and from work.

Bicycling, health, and weather-related disasters: Potential data to better predict risk

It is difficult to assess the impact of bicycling in China on morbidity and mortality due to the lack of data on the ventilation rates of bicyclists.

Without specific studies carried out in China involving bicyclists in the cities with the highest concentrations of mobile source air pollution, it is difficult to determine changes in morbidity or mortality, especially without knowing the typical ventilation rate of bicyclists in China. Still, all humans benefit from higher levels of physical activity. The one study from China indicated that, compared with riding the bus, individuals who had to walk or bicycle for over an hour each day had prevalence of hypertension and high blood pressure, but the authors speculated that the route could have been stressful due to excessive traffic²⁶. Many cities in China have low levels of mobile source air pollution and cities in China with high levels are working to reduce the pollution. In all of the studies conducted in other countries, the health benefits far outnumbered the downsides of pollution exposure.

Stories have surfaced that bicycles have helped individuals flee when a weather-related disaster occurs.

Bicycling, risk assessment and weather-related disasters

Weather-related disasters, primarily as a result of climate change, are hard to assess for risk because the phenomenon is new and little peer-reviewed literature exists. Bicycling may appear to be completely unrelated to weather-related disasters and risk reduction, but stories in the trade market press suggest that the bicycle has been used by many individuals to flee when a disaster hits or has been used to help others during a crisis. If individuals in a community routinely bicycle, their overall health would be better, compared with a city of car owners, and the citizens would be more fit when responding to a crisis. The old model of evacuating a city using the highway system has, during many disasters, been proven untenable as roads quickly become clogged, cars run out of gas and are abandoned, and evacuation routes become impassable due to flooding, downed power lines, or downed trees. If a city has planned for the bicycle as part of its response to weather-related disasters, that city might be assessed for risk at a lower cost due to preparedness.

If a blackout occurs, trains and traffic sensors no longer work. Bicycling would be a better option than walking.

In August 2003, a blackout throughout New England and Canada impacted residents, including those in New York City. Though this blackout was not weather-related, a storm can also cut power. Once power is cut, trains halt and traffic sensors and cameras no longer work⁵⁰. Many can get home by walking but distances can be far, making the bike a better alternative if accessible.

In the aftermath of Hurricane Katrina in 2005, medics traveling by bicycle were able to offer medical assistance to residents.

After Hurricane Katrina hit New Orleans in 2005, the Algiers neighbourhood was one of the few that were not flooded, but there was no power or running water. Several days after the disaster, four medics arrived in the neighbourhood and measured blood pressure, tested for diabetes and asked about depression. These street medics were part of a health professionals group that included individuals who had worked at anti-war demonstrations. Their arrival preceded assistance from the Red Cross or FEMA. They travelled the streets by bicycle⁵¹.

Bicycles were also used after Hurricane Sandy in 2012 to help residents power cell phones.

In 2012, Hurricane Sandy hit New York City causing extreme flooding and a blackout. One enterprise, CSquat, fed the hungry by grilling food, but also set up a bicycle powered generator to charge cell phones, sometimes charging as many as 200 phones a day⁵². Bicycles have been described as “cockroaches of transportation” during such disasters as Sandy because with roads clogged, gas sold out, and mass transit halted, the bicyclist can still travel⁵³.

Bicycles were the only reliable source of transport after the 2011 earthquake and tsunami hit Fukushima, Japan.

The 2011 earthquake and tsunami that hit Fukushima, Japan and, in particular, the nuclear power plant, left people at work with no way to get home. The transit systems were shut down and roads that had not been destroyed became congested. The bike shops in Tokyo quickly sold out because the bike was the one means of guaranteed travel, especially for commuting trips in Tokyo that averaged 16 miles. Some who owned bikes could not get their bikes out of the parking machine that needed an electronic badge⁵⁴. The aftermath of the earthquake meant the nuclear power plant was jeopardised, but workers had to get to the plant to make repairs. One individual, a volunteer, was photographed wearing a nuclear suit and using a mountain bike to travel through the destroyed streets of Fukushima to help residents⁵⁵.

More transportation centres are calling for the use of bicycles in the aftermath of extreme weather events.

Transportation centres are now also seeing the wisdom of using the bike for disaster relief. The University of Minnesota Center for Transportation Studies ran a story in their recent newsletter about reducing the impact of extreme weather through resilient transportation systems. Information from the Center for Climate and Energy Solutions indicated that heat waves could curtail road construction, overheat vehicles, and cause brownouts. Railroad tracks could buckle, airports could limit flights, and road surfaces could be compromised through heat, flooding, or landslides. The call was for preparedness in transportation, but also for post-disaster planning⁵⁶. For a crisis, a city could have planned above-flood water bicycle evacuation routes, access to one's own bicycle if the power is shut down, bicycle storage that is not in the basement in a flood prone area, and solar power light posts with outlets for recharging smart phone and bicycle lights.

Planning for the use of bicycles could be an indication of weather-related disaster preparedness.

An indication for weather-related disaster preparedness by a city could be the number of plans for disaster. In Portland, Oregon, bicyclists, especially those who own cargo bikes, have been training to haul supplies in the event of a disaster⁵⁷. With ambulance cargo bikes, they could even operate an ambulance service if roads are shut down. Having a fleet of trained riders, well-equipped bicycles, and a communications cell phone system powered by solar or generators getting power from pedalled bikes could be the most viable alternative when all roads are shut down. Having trained bicyclists guide citizens as they flee the city on their own bicycles to higher ground shelters would be a better alternative to clogged roads and abandoned cars.

Future research for bicycling and new risk assessment measures

Life insurers and subsequently policyholders may benefit if the census and health surveys collected information about bicycling to work.

Based on the findings from the literature, life insurance providers and subsequently policyholders may benefit if the census and health surveys collected information about bicycling to work, including the amount of time a person spent biking each week and bicycling intensity. This information would help in determining morbidity but also mortality. The new census and health survey data could be coupled with the pollution measurements for that city to better predict risk and longevity. The bicycle infrastructure and congestion of bicyclists could also be studied in the applicant's city to determine the bicycling speed, ventilation rate, and stress from traffic. Key measures would be if the bicyclists are pedalling in traffic or on their own plant-separated cycle track that is somewhat removed from mobile source air pollution.

To determine the resiliency of a community in order to issue weather-related insurance, it may be useful to determine if a community has a high ground bicycle network.

For determining the resiliency of a community in order to issue weather-related insurance, especially with the vagaries of climate change, it may be useful to determine if a community has a high ground bicycle network for movement within the community and for fleeing the community. Determinations could also be made on whether this network might be prone to a washout or landslide and to design alternate routes out of the city. Networks of roads could be similarly studied, but in a disaster the roads most often become clogged due to cars which run out of gas or are abandoned.

A bicycle network would also better guarantee that a higher percentage of the population was physically fit and better able to function during a disaster.

Having a bicycle network would also better guarantee that a higher percentage of the population was physically fit and better able to function during a disaster. Percentages of individuals who bicycle in the community and who own working bicycles could also be assessed. In the event of a power outage, knowing that the vast majority of the bicycles could be accessed without power would be essential. If all of the bikes are in cages for which swipe cards are needed for entry, none of the bikes could be used unless wire cutters were available to cut through the chain link fence walls.

Bicycling, health, and weather-related disasters: Potential data to better predict risk

Having a plan in place for the use of bicycles could signal disaster preparedness.

Having a cadre of bicycle responders, especially riders with cargo bikes, would signal preparedness for disasters. Having bikes that act as generators would mean cell phones could be recharged. Knowing several bicycle generators are scattered throughout the community would be ideal. Questions could be asked including if the bicycle responders could communicate and assemble themselves without power or active phone lines. If medics arrived, additional bicycles would have to be available that could be used as ambulances, to carry water, or as transportation if equipped with baskets for carrying supplies. If a city had a bike share system, the system could have a turnkey to allow all the bikes to be available to the public or at least available to ride for share members.

Further research is needed in China to collect data on bicycling habits, bicycling infrastructure and the use of bicycles in the aftermath of weather-related disasters.

Research could be conducted to determine what questions about biking are currently asked on census and survey forms in China and what would be necessary to add questions to the census forms to collect data on hours spent biking each week and speed of bicycling. Research could also be conducted in several cities in China to determine the existing bicycle infrastructure in order to better predict health (including the ability to bicycle without stress and away from pollution as well as pedal fast). The infrastructure and bicycle programmes could be studied in China to measure emergency preparedness and willingness to improve the bicycle infrastructure and initiate programmes. By providing this new information to assess life insurance risk as well as weather-related risk, cities might be encouraged to improve their bicycle infrastructure and introduce programmes for weather-related disaster response. The work of the insurance company could help communities extend the life of residents and avert disasters.

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In January 2013, Swiss Re and the Harvard School of Public Health (HSPH) launched the research collaboration SEARCH, the Systematic Explanatory Analyses of Risk factors affecting Cardiovascular Health, to better understand the relationship between risk factors and health outcomes. As one of the world's leading reinsurers, Swiss Re seeks more accurate projections of global morbidity and mortality. HSPH seeks to better understand the most important determinants of health and to improve health status globally.

Swiss Re, Swiss Re Foundation and the Swiss Re Centre for Global Dialogue (CGD) have funded this joint research initiative which came to an end in July 2014. The focus of SEARCH was on risk factors for cardiovascular disease and stroke in Brazil, Mexico, China and India. These four countries are flagships for rapid development and rapid evolution of a variety of health risk factors that will determine morbidity, mortality and longevity. The postdoctoral fellows listed below were awarded grants to conduct research based on existing data sets and cohorts, and were accompanied by mentors from HSPH and Swiss Re.

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