SPECIAL ARTICLE

Major Causes of Death among Men and Women in China

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ABSTRACT

BACKGROUND

With China's rapid economic development, the disease burden may have changed in the country. We studied the major causes of death and modifiable risk factors in a nationally representative cohort of 169,871 men and women 40 years of age and older in China.

METHODS

Baseline data on the participants' demographic characteristics, medical history, lifestyle-related risk factors, blood pressure, and body weight were obtained in 1991 with the use of a standard protocol. The follow-up evaluation was conducted in 1999 and 2000, with a follow-up rate of 93.4 percent.

RESULTS

We documented 20,033 deaths in 1,239,191 person-years of follow-up. The mortality from all causes was 1480.1 per 100,000 person-years among men and 1190.2 per 100,000 person-years among women. The five leading causes of death were malignant neoplasms (mortality, 374.1 per 100,000 person-years), diseases of the heart (319.1), cerebrovascular disease (310.5), accidents (54.0), and infectious diseases (50.5) among men and diseases of the heart (268.5), cerebrovascular disease (242.3), malignant neoplasms (214.1), pneumonia and influenza (45.9), and infectious diseases (35.3) among women. The multivariate-adjusted relative risk of death and the population attributable risk for preventable risk factors were as follows: hypertension, 1.48 (95 percent confidence interval, 1.44 to 1.53) and 11.7 percent, respectively; cigarette smoking, 1.23 (95 percent confidence interval, 1.18 to 1.27) and 7.9 percent; physical inactivity, 1.20 (95 percent confidence interval, 1.16 to 1.24) and 6.8 percent; and underweight (body-mass index [the weight in kilograms divided by the square of the height in meters] below 18.5), 1.47 (95 percent confidence interval, 1.42 to 1.53) and 5.2 percent.

CONCLUSIONS

Vascular disease and cancer have become the leading causes of death among Chinese adults. Our findings suggest that control of hypertension, smoking cessation, increased physical activity, and improved nutrition should be important strategies for reducing the burden of premature death among adults in China.

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All investigators participating in this study are listed in the Appendix.

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Rapid economic development and the consequent improvement in living conditions, nutrition, and health care have resulted in declines in infant mortality and deaths from infectious diseases and therefore in increases in life expectancy in many developing countries, including China.[1,2] In contrast, adverse changes in lifestyle (such as a high intake of dietary fat and increased physical inactivity) that tend to accompany industrialization and urbanization have become increasingly prevalent in these countries, and such changes may have increased the risk of chronic disease, including vascular disease and cancer.[2-4] However, there are few data to support this epidemiologic transition of disease burden in developing countries.[1] Unlike the situation in developed countries, in developing countries valid data on vital statistics are not usually available, owing to a lack of coherent systems for national registration of deaths.[5]

Cross-sectional studies, which provide a point estimate of disease burden, have indicated that the prevalence of chronic diseases and their risk factors has increased in developing countries.[6-8] However, large, prospective cohort studies involving representative samples of the general population are needed to provide valid information on cause-specific mortality in the populations of these countries and to provide a scientific basis for rational allocation of health care resources. We conducted a large, prospective cohort study involving a representative sample of the general adult population 40 years of age and older in China to determine cause-specific mortality and to examine major preventable risk factors for total mortality.

METHODS

STUDY POPULATION

In 1991, a multistage, random cluster-sampling design was used to identify a representative sample of the general Chinese population 15 years of age and older from all 30 provinces for the China National Hypertension Survey.[9] In 1999, investigators from each province were invited to participate in the China National Hypertension Survey Epidemiology Follow-up Study. Of the 30 provinces included in the initial study, 13 were not included in the follow-up study because contact information for the study participants in those provinces was not available. However, sampling was conducted independently within each province for the 1991 China National Hypertension Survey, and study participants in the 17 provinces that were included in the follow-up study were evenly distributed among the different geographic regions of the entire country representing various stages of economic development. Therefore, our study participants probably represent the general adult population in China. Overall, 83,533 men and 86,338 women who were 40 years of age or older at the time of their baseline examinations were eligible for participation in the follow-up study. Of these, a total of 158,666 participants or their proxies (93.4 percent) were identified and interviewed as part of the follow-up study.

BASELINE EXAMINATION

Baseline data were collected during a single clinic visit by physicians and nurses trained in the use of standard methods and with stringent quality control.[9] Data on demographic characteristics, medical history, and lifestyle-related risk factors were obtained. The assessment of physical activity involved only work-related physical activity. Cigarette smoking was defined as smoking at least one cigarette per day for one or more years. Data were collected on the amount and type of alcohol consumed during the previous year.

Three blood-pressure readings, measured with the use of a mercury sphygmomanometer according to a standard protocol, were obtained after the participant had been sitting quietly for five minutes.[10] The first and fifth Korotkoff sounds were recorded as systolic and diastolic blood pressure, respectively. Hypertension was defined as one or more of the following: a mean systolic blood pressure greater than or equal to 140 mm Hg, a mean diastolic blood pressure greater than or equal to 90 mm Hg, or the use of antihypertensive medication.[11] Body weight and height were measured when the participant was wearing light indoor clothing but not shoes, with the use of a standard protocol. Underweight was defined as a body-mass index (the weight in kilograms divided by the square of the height in meters) of less than 18.5 and overweight or obesity as a body-mass index of 25.0 or greater.[12]

FOLLOW-UP DATA

Follow-up examinations, which were conducted in 1999 and 2000, included tracking participants or their proxies to a current address; conducting in-depth interviews to obtain information on the history of disease, hospitalizations, and death; and ob-

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taining hospital records and death certificates. All deaths identified in interviews with participants' proxies were verified by death certificates obtained from the local departments of public health or police. If death occurred while a participant was hospitalized, the participant's hospital records, including medical history, findings on physical examination, laboratory findings, autopsy findings, and discharge diagnosis, were abstracted by trained staff using a standard form. In addition, photocopies of selected sections of the participant's inpatient record, discharge summary, electrocardiogram, and pathology reports were obtained.

An end-point assessment committee in each province reviewed and confirmed (or rejected) the hospital's discharge diagnosis and the cause of death on the basis of the abstracted information, using prespecified criteria. A study-wide end-point assessment committee at the Chinese Academy of Medical Sciences in Beijing reviewed all death records and determined the final underlying cause of death. Two committee members independently of each other verified the cause of death, and discrepancies were adjudicated by discussion involving other members of the committee. All members of the local and study-wide end-point assessment committees were unaware of information about the baseline risk factors of the study participants. The causes of death were coded according to the *International Classification of Diseases, Ninth Revision* (ICD-9).

The current study was approved by the Tulane University Health Sciences Center's institutional review board. Written informed consent was obtained from all study participants at their follow-up visit.

STATISTICAL ANALYSIS

Person-years of follow-up were calculated for each study participant and grouped according to sex and to age in five-year categories. Age-standardized mortality was calculated with the use of the five-year age-specific mortality and the age distribution of the Chinese population, obtained from the 2000 census data. Age-standardized cause-specific mortality was calculated separately for men and women, for residents of urban and rural areas, and for those living in northern and southern China, where diet and other lifestyle-related risk factors were different.[13] For example, the dietary intake of sodium was higher among residents of northern China, as compared with those of southern China, whereas physical activity was lower.

Cox proportional-hazards models were used to estimate the relative risk of death for preventable risk factors. Heavy alcohol consumption (i.e., three or more drinks per day) was not related to an increase in total mortality, but we included alcohol consumption as a covariate because it was strongly related to other risk factors included in the study. A self-reported history of diabetes was also included as a covariate, because it was significantly associated with total mortality. Because the total mortality for current and former cigarette smokers was similar, the relative risk of ever having smoked as compared with never having smoked was calculated. As compared with normal weight (a body-mass index of 18.5 to 24.9), overweight or obesity was not associated with increased mortality. In contrast, because underweight was associated with increased total mortality, the relative risk of underweight was estimated.

In the final multivariate models, all preventable risk factors, such as hypertension, cigarette smoking, physical inactivity, and underweight, as well as the covariates, including baseline age, sex, the presence or absence of a high-school education, alcohol consumption, self-reported history of diabetes, geographic region (north vs. south), and urbanization (urban vs. rural residence), were included simultaneously. The population attributable risk, measured as the percentage of deaths that could be prevented in the total population if the risk factor of interest were eliminated, was calculated.[14] Statistical analyses were conducted with the use of SAS software, version 8 (SAS Institute).

RESULTS

The baseline characteristics of the study participants according to sex are presented in Table 1. Overall, 49.2 percent of the study participants were men and 50.8 percent were women. The mean age was 55.8 years, with a range from 40 to 105 years.

During an average follow-up period of 8.3 years (1,239,191 person-years), we documented 20,033 deaths. The total mortality was 1345.2 per 100,000 person-years (1480.1 per 100,000 person-years among men and 1190.2 per 100,000 person-years among women). Age-standardized mortality and the percentage of total deaths for the 10 leading causes of death are shown in Table 2. The three leading causes of death (diseases of the heart, malignant neoplasms, and cerebrovascular disease) accounted for 66.0 percent of deaths from all causes (68.7 percent in men and 62.6 percent in women).

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The five leading causes of death from vascular disease were cerebrovascular disease (mortality, 276.9 per 100,000 person-years), chronic pulmonary heart disease (137.6), coronary heart disease (85.5), heart failure (14.5), and rheumatic heart disease (9.7). (The *International Classification of Diseases, 9th Revision*, code for chronic pulmonary heart disease is 416, and the codes for rheumatic heart disease are 391 through 398.) The rank order of deaths from vascular disease was consistent in men and women (Fig. 1). The five leading causes of death from cancer were malignant neoplasms of the lung (mortality, 71.5 per 100,000 person-years), liver (54.7), stomach (48.6), esophagus (31.3), and colon and rectum (17.4). However, stomach cancer was the second leading cause of death from cancer among women (Fig. 1). Among women, mortality from malignant neoplasm of the breast was 11.1 per 100,000 person-years and from malignant neoplasm of the uterus was 18.0 per 100,000 person-years.

Age-specific mortality for the five leading causes of death (40 to 64 years of age vs. 65 years of age or more) and age-standardized mortality according to urbanization (urban vs. rural) and geographic region (north vs. south) are shown in Figure 2. The pattern of cause-specific mortality was consistent between men and women (data not shown). Overall, diseases of the heart, malignant neoplasms, and cerebrovascular disease accounted for more than half of deaths from all causes in each subgroup. For example, the percentages of total deaths due to these causes were 62.1 percent among older study participants and 71.4 percent among younger participants, 70.3 percent among urban residents and 61.7 percent among rural residents, and 75.2 percent among those living in northern China and 53.9 percent among those living in southern China. Deaths from diseases of the heart and cerebrovascular disease were significantly higher in northern China than in southern China.

The multivariate adjusted relative risk and population attributable risk of death for major preventable risk factors are presented in Table 3. Hypertension appeared to be responsible for 11.7 percent of the total mortality in the study population. This estimated population attributable risk did not vary substantially according to sex, urbanization, or geographic region. Cigarette smoking was responsible for 7.9 percent of the total mortality; the estimated risk was higher among men than among women and higher among urban residents than among rural residents. Physical inactivity accounted for 6.8 percent of the total mortality, with the estimated risk of death being slightly higher among men than among women and higher among urban residents than among rural residents (especially among women). Underweight accounted for 5.2 percent of the total mortality; the estimated risk of death was consistent between men and women, but it was higher among rural residents than among urban residents, and higher among those living in southern China than among those in northern China. The association between underweight and an increased risk of death remained significant after the exclusion of study participants who were current or former smokers; those who had prevalent cardiovascular disease, stroke, cancer, or end-stage renal disease;

Table 1. Baseline Characteristics of the 169,871 Study Participants.*

Characteristic*	Men (N=83,533)	Women (N=86,338)
Age (yr)	55.5±10.6	56.2±11.0
High-school graduate (%)	31.0	17.2
Current cigarette smoker (%)	63.0	13.7
Current drinker of alcohol (%)	37.4	2.8
Physical activity (%)†		
Low	38.9	34.5
Moderate	15.0	33.3
High	46.2	32.2
Body-mass index	22.4±3.4	22.8±3.9
Body-mass-index category (%)		
<18.5	10.8	12.5
18.5–24.9	67.9	61.4
≥25.0	21.3	26.1
Blood pressure (mm Hg)		
Systolic	126.2±21.1	126.8±23.9
Diastolic	78.4±12.0	76.3±12.2
Hypertension (%)‡	27.4	28.0
Self-reported history of diabetes (%)	1.7	1.8
Living in northern China (%)	61.9	59.0
Urban residence (%)	60.5	56.0

* Plus–minus values are means ±SD.
† Physical activity was assessed by categorizing the physical labor involved in a participant's work at the time of the study. Those who did not work were assigned to the group with low physical activity. Percentages do not necessarily sum to 100 because of rounding.
‡ Hypertension was defined as one or more of the following: a systolic blood pressure greater than or equal to 140 mm Hg, a diastolic blood pressure greater than or equal to 90 mm Hg, or the use of antihypertensive medications. Among the study participants with hypertension, only 9.9 percent were being treated with antihypertensive medication, and only 2.4 percent had their blood pressure controlled (defined as blood pressure of <140/90 mm Hg).

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those who had chronic obstructive pulmonary disease at the baseline examination; or those who died during the first three years of follow-up.

DISCUSSION

Our study indicates that diseases of the heart, malignant neoplasms, and cerebrovascular disease are the leading causes of death in the Chinese population of adults 40 years of age and older. Together, these causes accounted for approximately two thirds of the total mortality in the study population.

These findings have important public health implications. Historically, infant mortality and death from infectious diseases have been the major causes of death in developing countries.[15] Even in recent years, the public health priorities, which are set by government policymakers in these countries and by international agencies, have been to reduce infant and maternal mortality and to control infectious diseases.[16,17] The results of the present study call for serious attention to be given to the consequences of chronic diseases in developing countries.

Few previous studies have reported cause-specific mortality in China.[18-20] According to vital statistics available for 13 cities in China, diseases of the respiratory system, acute infectious diseases, and tuberculosis were the leading causes of death in 1957, accounting for 16.9 percent, 7.9 percent, and 7.5 percent of the total deaths, respectively. In the same period, diseases of the heart, cerebrovascular disease, and malignant neoplasms were the

Table 2. Age-Standardized Mortality and the Percentage of Total Deaths for the 10 Leading Causes of Death in China.

Cause of Death*	No. of Deaths	Mortality†	Percentage of Total Deaths	Rank Order
		per 100,000 person-yr		
All causes				
Total	20,033	1345.2	100.0	—
Men	11,311	1480.1	100.0	—
Women	8,722	1190.2	100.0	—
Diseases of the heart (ICD-9 codes 390–398 and 401–429)‡				
Total	4,506	296.3	22.5	1
Men	2,489	319.1	22.0	2
Women	2,017	268.5	23.1	1
Malignant neoplasms (ICD-9 codes 140–208)				
Total	4,459	293.3	22.3	2
Men	2,833	374.1	25.0	1
Women	1,626	214.1	18.6	3
Cerebrovascular disease (ICD-9 codes 430–438)				
Total	4,260	276.9	21.3	3
Men	2,446	310.5	21.6	3
Women	1,814	242.3	20.8	2
Pneumonia and influenza (ICD-9 codes 480–487)				
Total	641	43.9	3.2	4
Men	317	40.6	2.8	6
Women	324	45.9	3.7	4
Infectious diseases (ICD-9 codes 001–139)§				
Total	612	43.2	3.1	5
Men	367	50.5	3.2	5
Women	245	35.3	2.8	5

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fifth, sixth, and seventh leading causes of death, accounting for 6.6 percent, 5.5 percent, and 5.2 percent of total deaths, respectively.[18] Although there are differences in the reporting and classification of deaths between these studies and ours, our data support the notion that a transition in disease burden has occurred in China.

Typically, chronic diseases have been considered a public health problem only in developed countries and among the elderly.[3] Our study suggests that chronic diseases affect a much higher proportion of people during their prime working years in China, as compared with developed countries.[21] For example, the mortality was 265.9 per 100,000 person-years for malignant neoplasm, 171.5 per 100,000 person-years for cerebrovascular disease, and 159.1 per 100,000 person-years for diseases of the heart in the Chinese population

Table 2. (Continued.)

Cause of Death*	No. of Deaths	Mortality†	Percentage of Total Deaths	Rank Order
		per 100,000 person-yr		
Accidents (ICD-9 codes E800–E949)¶				
Total	564	42.2	2.8	6
Men	363	54.0	3.2	4
Women	201	29.4	2.3	6
Chronic obstructive pulmonary disease (ICD-9 codes 490–496)				
Total	366	24.3	1.8	7
Men	212	27.3	1.9	7
Women	154	21.0	1.8	8
Chronic liver disease and cirrhosis (ICD-9 code 571)				
Total	306	21.3	1.5	8
Men	193	26.7	1.7	8
Women	113	16.0	1.3	10
Diabetes mellitus (ICD-9 code 250)				
Total	304	19.5	1.5	9
Men	143	17.8	1.3	9
Women	161	21.2	1.8	7
Nephritis, nephrotic syndrome, and nephrosis (ICD-9 codes 580–589)				
Total	272	19.2	1.4	10
Men	141	20.5	1.2	10
Women	131	17.9	1.5	9
All other causes				
Total	3,754	265.7	18.7	—
Men	1,809	239.3	16.0	—
Women	1,945	279.7	22.3	—

* The causes of death were coded according to the *International Classification of Diseases, Ninth Revision* (ICD-9). Percentages do not necessarily sum to 100 because of rounding.
† Mortality (per 100,000 person-years) was standardized according to the 2000 census data for China's population.
‡ Diseases of the heart included acute rheumatic fever, chronic rheumatic heart disease, hypertensive disease, ischemic heart disease, diseases of the pulmonary circulation, and other forms of heart disease.
§ The major infectious diseases affecting the study population were tuberculosis, septicemia, typhus, syphilis, schistosomiasis, infectious diarrhea, and cholera.
¶ The major types of accidents affecting the study population included vehicular accidents, falls, drowning, and poisoning.

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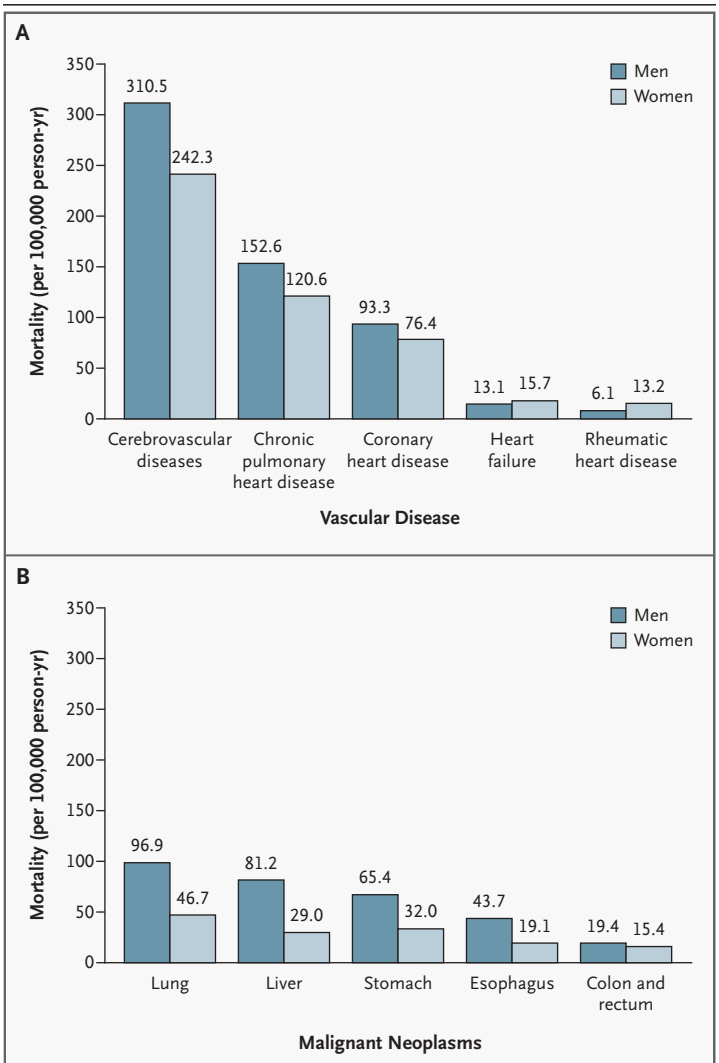

Figure 1. Age-Standardized Mortality for the Five Leading Causes of Death from Vascular Disease (Panel A) and Malignant Neoplasms (Panel B) among 169,871 Study Participants.

Chronic pulmonary heart disease (cor pulmonale) is an abnormality of right ventricular structure or function, which in China is usually caused by chronic obstructive pulmonary disease.

Figure 2 (facing page). Age-Specific or Age-Standardized Mortality for the Five Leading Causes of Death among Study Participants 65 Years of Age or Older or Younger Than 65 Years (Panel A), Those Who Were Urban or Rural Residents (Panel B), and Those Living in Northern or Southern China (Panel C).

Diseases of the heart classified according to the *International Classification of Diseases, Ninth Revision* (ICD-9) include acute rheumatic fever (ICD-9 codes 390 through 392), chronic rheumatic heart disease (ICD-9 codes 393 through 398), hypertensive disease (ICD-9 codes 401 through 405), ischemic heart disease (ICD-9 codes 410 through 414), diseases of the pulmonary circulation (ICD-9 codes 415 through 417), and other forms of heart disease (ICD-9 codes 420 through 429). Age-specific mortality is shown in Panel A, and age-standardized mortality in Panels B and C.

40 to 64 years of age in our study. In the U.S. population 45 to 64 years of age, the corresponding mortality rates in 2002 were 215.1, 23.8, and 150.5 per 100,000 person-years.[21] The economic impact of chronic disease on society, including the direct costs of health care and the indirect costs resulting from lost productivity due to illness and death, is substantial. The higher number of deaths due to chronic disease among rural residents, as compared with urban residents, in China is a particular concern because of the scarce health care resources available in rural China and the fact that infant mortality and infectious diseases remain serious public health challenges in this setting.

Hypertension is the most common risk factor for cardiovascular and cerebrovascular diseases worldwide.[6] The prevalence of hypertension has been increasing in China in recent decades, whereas rates of awareness, treatment, and control remain unacceptably low.[22] Our results indicate that hypertension is the leading preventable risk factor for death among Chinese adults 40 years of age and older; total mortality was 48 percent higher among study participants who had hypertension than among those who did not have hypertension. Furthermore, our findings suggest that the prevention and control of hypertension could reduce the total mortality by 11.7 percent in the total study population. These results are consistent with other analyses that have suggested that hypertension is the leading risk factor for the global burden of disease.[3,4]

Our study also indicates that cigarette smoking is a major preventable risk factor for death in China. If cigarette smoking were eliminated, we estimate that the total mortality could be reduced by 10.0 percent among men and by 3.5 percent among women in China. This estimate does not take into account the possible effects of passive smoking.[23] Our data are in agreement with those from several prospective cohort studies and case–control studies conducted in China, which have documented that cigarette smoking increases the mortality from cancer, respiratory disease, and cardiovascular disease.[24-28] Although our study did not detect a

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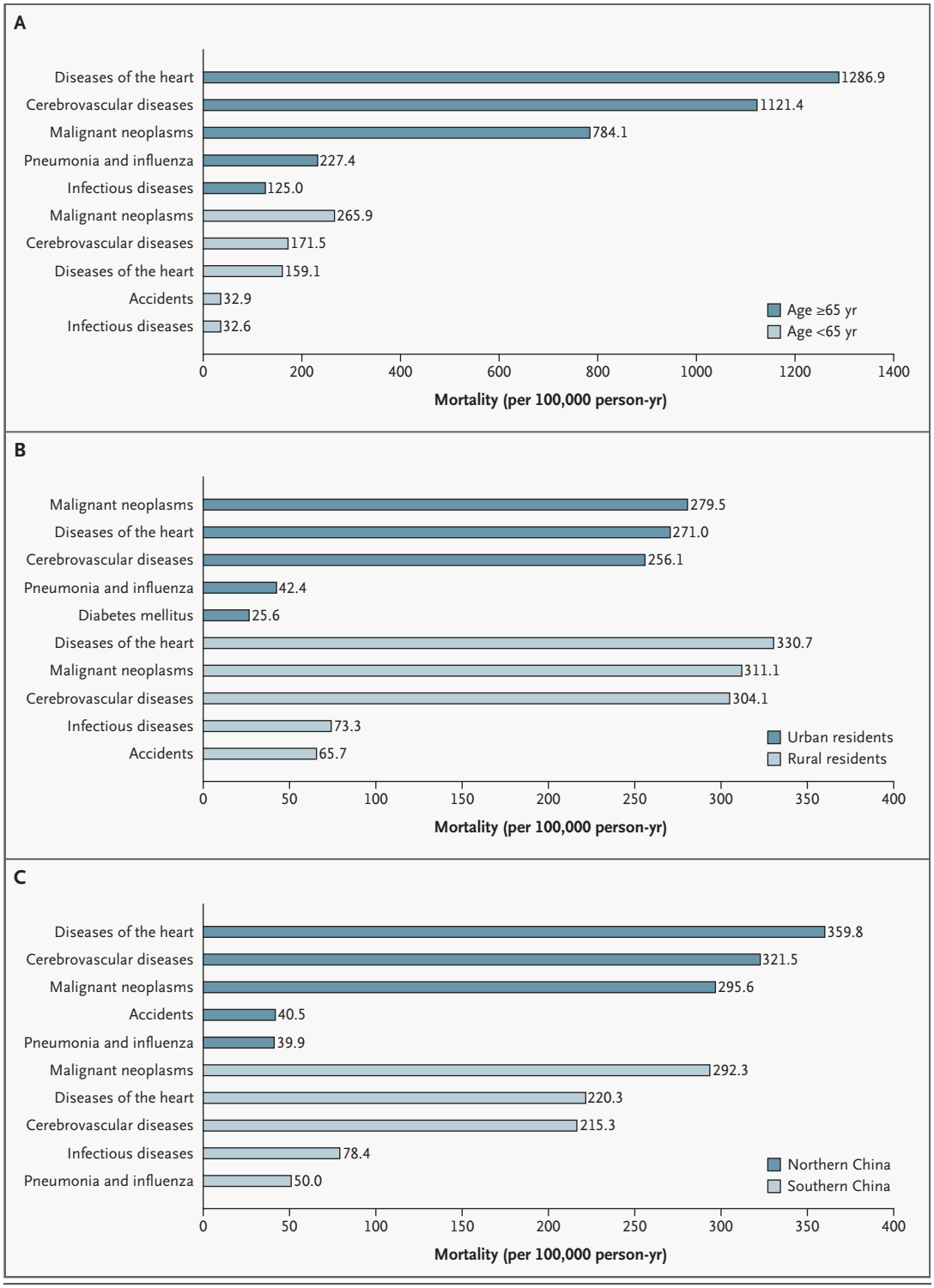

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Table 3. Relative Risk and Population Attributable Risk of Death Associated with Hypertension, Cigarette Smoking, Physical Inactivity, and Underweight in China.*

Variable	Hypertension		Cigarette Smoking		Physical Inactivity		Underweight	
	Relative Risk (95% CI)	Population Attributable Risk (%)	Relative Risk (95% CI)	Population Attributable Risk (%)	Relative Risk (95% CI)	Population Attributable Risk (%)	Relative Risk (95% CI)	Population Attributable Risk (%)
Overall								
Total	1.48 (1.44–1.53)	11.7	1.23 (1.18–1.27)	7.9	1.20 (1.16–1.24)	6.8	1.47 (1.42–1.53)	5.2
Men	1.48 (1.43–1.55)	11.7	1.18 (1.13–1.23)	10.0	1.21 (1.16–1.27)	7.7	1.45 (1.38–1.53)	4.6
Women	1.48 (1.41–1.55)	11.8	1.27 (1.19–1.34)	3.5	1.20 (1.14–1.26)	6.5	1.49 (1.41–1.58)	5.8
Residence								
Urban								
Total	1.48 (1.42–1.55)	13.2	1.32 (1.26–1.38)	10.5	1.13 (1.08–1.18)	6.3	1.63 (1.53–1.73)	4.3
Men	1.50 (1.42–1.58)	13.6	1.29 (1.22–1.37)	14.3	1.07 (1.01–1.14)	3.6	1.61 (1.49–1.76)	4.1
Women	1.47 (1.38–1.57)	12.8	1.36 (1.26–1.46)	5.0	1.19 (1.12–1.27)	9.1	1.63 (1.50–1.78)	4.5
Rural								
Total	1.49 (1.42–1.56)	10.0	1.10 (1.04–1.16)	3.9	1.43 (1.35–1.51)	4.2	1.40 (1.33–1.47)	6.9
Men	1.48 (1.39–1.57)	9.1	1.08 (1.02–1.16)	5.7	1.49 (1.39–1.60)	5.3	1.39 (1.30–1.48)	6.3
Women	1.50 (1.40–1.61)	10.8	1.12 (1.02–1.23)	1.5	1.34 (1.23–1.45)	3.1	1.41 (1.31–1.52)	7.5
Geographic region								
Northern China								
Total	1.43 (1.38–1.48)	11.6	1.23 (1.18–1.28)	8.2	1.20 (1.15–1.25)	6.8	1.47 (1.40–1.56)	3.4
Men	1.44 (1.37–1.51)	11.8	1.17 (1.11–1.23)	9.2	1.17 (1.11–1.24)	5.9	1.45 (1.35–1.56)	3.0
Women	1.42 (1.34–1.51)	11.5	1.28 (1.20–1.37)	4.7	1.25 (1.17–1.33)	8.1	1.49 (1.38–1.62)	3.9
Southern China								
Total	1.59 (1.51–1.68)	12.0	1.25 (1.18–1.33)	8.0	1.21 (1.14–1.28)	7.3	1.48 (1.40–1.56)	8.5
Men	1.59 (1.48–1.71)	11.6	1.23 (1.14–1.32)	13.3	1.36 (1.25–1.49)	13.5	1.46 (1.36–1.58)	8.0
Women	1.59 (1.47–1.72)	12.2	1.23 (1.10–1.38)	1.6	1.12 (1.03–1.21)	3.6	1.50 (1.39–1.63)	9.0

* Hypertension was defined as one or more of the following: a systolic blood pressure greater than or equal to 140 mm Hg, a diastolic blood pressure greater than or equal to 90 mm Hg, or the use of antihypertensive medication. Cigarette smoking was defined as smoking at least one cigarette per day for one year or longer. Work-related physical activity was assessed on the basis of the participant's occupation. Underweight was defined as a body-mass index of less than 18.5. For each risk factor, the relative risk and population attributable risk were adjusted for the other three risk factors, as well as for baseline age, sex, the presence or absence of high-school education, alcohol consumption, the presence or absence of a self-reported history of diabetes, geographic region (north vs. south), and urbanization (urban vs. rural). CI denotes confidence interval.

significant difference in total mortality between current and former smokers, epidemiologic investigations indicate that a reduction in mortality occurs gradually after smoking is stopped.[29] In our study, the average interval since a participant had stopped smoking was only seven years. In addition, we found that physical inactivity was related to an increase in total mortality in China. These findings suggest that increasing physical activity could play an important role in the reduction of total mortality in China.

Finally, our study identified underweight as a preventable risk factor for total mortality. The population attributable risk for underweight was slightly higher among rural residents than among urban residents. Underweight, which may reflect malnutrition, was reported as the leading cause of the disease burden in developing countries with high mortality and an important contributor to the burden of disease in developing countries with low mortality, in a recent report from the World Health Organization.[30]

Some limitations of our study should be noted. We did not collect data on dietary patterns, leisure-time physical activity, serum lipid levels or results of other laboratory tests, or changes in

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body weight (or changes in other risk factors) over time. Therefore, the contribution of these factors to total mortality could not be estimated. A diagnosis of diabetes was based only on self-reports; it is likely that this resulted in an underestimation of the population attributable risk of death due to diabetes. The lack of autopsy data to confirm causes of death may have introduced some misclassification bias. However, we maintained a very high follow-up rate and used a stringent approach to classifying outcomes on the basis of medical records.

In summary, our study indicates that diseases of the heart, malignant neoplasms, and cerebrovascular disease account for approximately two thirds of the total deaths in the Chinese population 40 years of age and older. Furthermore, hypertension, cigarette smoking, physical inactivity, and underweight are leading preventable risk factors for death. Control of hypertension, smoking cessation, increased physical activity, and improved nutrition are likely to be important strategies for reducing the burden of mortality in China.

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APPENDIX

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REFERENCES

1. Sen K, Bonita R. Global health status: two steps forward, one step back. Lancet 2000;356:577-82.
2. Yusuf S, Reddy S, Ounpuu S, Anand S. Global burden of cardiovascular diseases: part I: general considerations, the epidemiologic transition, risk factors, and impact of urbanization. Circulation 2001;104:2746-53.
3. Yach D, Hawkes C, Gould CL, Hofman KJ. The global burden of chronic diseases: overcoming impediments to prevention and control. JAMA 2004;291:2616-22.
4. Ezzati M, Lopez AD, Rodgers A, Vander Hoorn S, Murray CJL, Comparative Risk Assessment Collaborating Group. Selected major risk factors and global and regional burden of disease. Lancet 2002;360:1347-60.
5. The world health report 1999: making a difference. Geneva: World Health Organization, 1999.
6. Kearney PM, Whelton M, Reynolds K, Muntner P, Whelton PK, He J. Global burden of hypertension: analysis of worldwide data. Lancet 2005;365:217-23.
7. King H, Aubert RE, Herman WH. Global burden of diabetes, 1995-2025: prevalence, numerical estimates, and projections. Diabetes Care 1998;21:1414-31.
8. He J, Gu D, Reynolds K, et al. Serum total and lipoprotein cholesterol levels and awareness, treatment, and control of hypercholesterolemia in China. Circulation 2004; 110:405-11.
9. Wu X, Duan X, Gu D, Hao J, Tao S, Fan D. Prevalence of hypertension and its trends in Chinese populations. Int J Cardiol 1995; 52:39-44.
10. Frohlich ED, Grim C, Labarthe DR, Maxwell MH, Perloff D, Weidman WH. Recommendations for human blood pressure determination by sphygmomanometers. Circulation 1988;77:501A-514A.
11. Chobanian AV, Bakris GL, Black HR, et al. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. JAMA 2003;289:2560-72. [Erratum, JAMA 2003;290:197.]
12. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults — The Evidence Report: National Institutes of Health. Obes Res 1998;6:Suppl 2:51S-209S. [Erratum, Obes Res 1998;6:464.]
13. Huang Z, Wu X, Stamler J, et al. A north-south comparison of blood pressure and factors related to blood pressure in the People's Republic of China: a report from the PRC-USA Collaborative Study of Cardiovascular Epidemiology. J Hypertens 1994;12: 1103-12.
14. Kahn HA, Sempos CT. Attributable risk. In: Kahn HA, Sempos CT, eds. Statistical methods in epidemiology. New York: Oxford University Press, 1989:73-84.
15. Gwatkin DR, Guillot M, Heuveline P. The burden of disease among the global poor. Lancet 1999;354:586-9.
16. Group of Seventy-Seven. Final Communiqué adopted by the thirty-fourth Meeting of Chairmen/Coordinators of the Chapters of the Group of 77, Geneva, 26-27 June 2003 (press release). (Accessed August 22, 2005, at http://www.g77.org/news/pr062703.htm.)
17. United Nations Development Programme (UNDP). Millennium development goals. (Accessed August 29, 2005, at http://www.undp.org/mdg/abcs.html.)

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18. Ministry of Public Health, People's Republic of China. Health statistics information in China, 1949-1988. Beijing: Ministry of Public Health, 1990. (In Chinese.)
19. Zhang Z. Major causes of deaths in Harbin city, 1957-1986. Chin Health Stat 1991; 8:39-41. (In Chinese.)
20. Li Y, Gu S, He L. Statistical analysis of causes of deaths among Shanghai county residents. Chin Health Stat 1985;2:18-21. (In Chinese.)
21. Kochanek KD, Smith BL. Deaths: preliminary data for 2002. National vital statistics reports. Vol. 52. No. 13. Hyattsville, Md.: National Center for Health Statistics, 2004. (Accessed August 22, 2005, at http://www.cdc.gov/nchs/data/nvsr/nvsr52/nvsr52_13.pdf.)
22. Gu D, Reynolds K, Wu X, et al. Prevalence, awareness, treatment, and control of hypertension in China. Hypertension 2002; 40:920-7.
23. Gu D, Wu X, Reynolds K, et al. Cigarette smoking and exposure to environmental tobacco smoke in China: the International Collaborative Study of Cardiovascular Disease in Asia. Am J Public Health 2004;94: 1972-6.
24. Yuan JM, Ross PK, Wang XL, Gao YT, Henderson BE, Yu MC. Morbidity and mortality in relation to cigarette smoking in Shanghai, China: a prospective male cohort study. JAMA 1996;275:1646-50.
25. Lam TH, He Y, Li LS, He SF, Liang BQ. Mortality attributable to cigarette smoking in China. JAMA 1997;278:1505-8. [Erratum, JAMA 1998;279:1350.]
26. Chen ZM, Xu Z, Collins R, Li WX, Peto R. Early health effects of the emerging tobacco epidemic in China: a 16-year prospective study. JAMA 1997;278:1500-4. [Erratum, JAMA 1999;281:1893.]
27. Liu BQ, Peto R, Chen ZM, et al. Emerging tobacco hazards in China: 1. Retrospective proportional mortality study of one million deaths. BMJ 1998;317:1411-22.
28. Niu SR, Yang GH, Chen ZM, et al. Emerging tobacco hazards in China: 2. Early mortality results from a prospective study. BMJ 1998;317:1423-4.
29. Hays JT, Hurt RD, Dale LC. Smoking cessation. In: Manson JE, Ridker PM, Gaziano JM, Hennekens CH, eds. Prevention of myocardial infarction. New York: Oxford University Press, 1996:99-129.
30. World Health Organization. The world health report 2002 — reducing risks, promoting healthy life. Geneva: World Health Organization, 2002.

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