INTRODUCTION: Geographic variation across China

The 2,400 counties that comprise rural China, with an average population of a few hundred thousand per county, differ greatly from each other in the ways the local populations live and in the main diseases by which they die. Many of these differences in lifestyle and disease rates have persisted for centuries. Even though in recent decades there has been a nationwide reduction in death from infectious disease (particularly in childhood), there is still great heterogeneity among counties in childhood mortality rates, as well as in the age-standardised mortality rates from the main chronic diseases of middle age.

This geographic study describes the variation across 69 mainly rural Chinese counties (figure 1) in mortality, blood biochemistry, diet and lifestyle. The chief comparisons are among counties, not among individuals. Hence, each county is characterised by the average values for various factors among those living there. Mortality rates are based on whole counties (or, for very large counties, on substantial portions of them), but average values for biochemistry, diet and lifestyle are generally based on special surveys in just two randomly-chosen rural villages per county, with particular emphasis on adults aged 35-64. Major components of the study in mainland China were replicated in 16 areas of Taiwan, which range from urban to rural in character.

The chief purpose of the study is to describe the wide range of differences among different counties in lifestyles and disease-specific mortality rates, rather than to analyse these differences in search of direct evidence of causes. A few of the geographic correlations of particular factors with particular diseases do yield good evidence of causality (e.g., schistosomiasis rates in different counties are correlated with intestinal cancer mortality rates, because in endemic areas chronic infection of the wall of the large intestine with S. japonicum greatly increases the incidence of colorectal cancer, which is otherwise low), but the main value of this study is descriptive: the extraordinary range of mortality rates and of lifestyles across different Chinese counties deserves to be more widely known.

INTRODUCTION: 地域差异

中国大陆农村有 2400 个县，每个县平均有几十万人口。在这些县之间，人们的生活方式和主要疾病死亡率有很大的差异，其中许多差异已持续了数百年。最近几十年，尽管传染性疾病的死亡率在全国（特别是儿童中）均呈下降趋势，但不同县之间的儿童死亡率仍有很大区别；同样，中年人年龄标准化后的主要慢性疾病死亡率在不同县之间也不相同。

本次地区性研究描述了中国大陆的 69 个农村县（图 1）在死亡率、血液生化指标、膳食以及生活方式上的不同。主要的选择每个县为基础，并不是个体间的比较；因此，每个县的各种特征均以其居民的均值来表示。特别是大的县是部分人口外，县死亡率是全县的数据。但是，生化指标、膳食及生活方式的均值是基于每个县随机抽样的两个村进行的专门调查，调查对象主要是 35-64 岁的成年人，一些在大陆进行的主要调查内容，在台湾的 16 个城市和农村地区进行了重复调查。

本研究的主要目的是描述不同县之间在生活方式和各种疾病死亡率上的巨大差异，而不是分析这些差异来寻找造成这些差异的直接证据。一些特殊的因素与一些特殊的疾病之间的地区性相关确实提供了因果关系的良好证据（例如，不同县之间的血吸虫病患病率与肠癌死亡率之间的关系，是由血吸虫病流行地区人群大肠壁长期感染日本血吸虫而增加了大肠癌的患病率，否则将会很低），但本研究的主要价值是描述信息，让读者更广泛地了解不同调查县之间在死亡率分布以及生活方式上的巨大不同。
**Survey areas in 1989 survey**

1989 年的调查地区

### Inland Provinces (内地)

<table>
<thead>
<tr>
<th>省份</th>
<th>县市</th>
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<tbody>
<tr>
<td>C</td>
<td>Shang (山东省)</td>
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<td>D</td>
<td>Hain (河南省)</td>
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<td>F</td>
<td>Jilin (吉林省)</td>
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<td>G</td>
<td>Heilongjiang (黑龙江省)</td>
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<td>J</td>
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<td>M</td>
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<td>S</td>
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<td>T</td>
<td>Shaanxi (陕西省)</td>
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<tr>
<td>V</td>
<td>Guansu (甘肃省)</td>
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<tr>
<td>W</td>
<td>Xinjiang (新疆自治区)</td>
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<td>X</td>
<td>Ningxia (宁夏自治区)</td>
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<tr>
<td>Y</td>
<td>Neimonggol (内蒙古自治区)</td>
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### Coastal Provinces (沿海)

<table>
<thead>
<tr>
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<th>AC</th>
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<tbody>
<tr>
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<td>B</td>
<td>Hebei (河北省)</td>
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<td>E</td>
<td>Liaoning (辽宁省)</td>
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<td>I</td>
<td>Jiangsu (江苏省)</td>
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<td>L</td>
<td>Fujian (福建省)</td>
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<td>P</td>
<td>Guandong (广东省)</td>
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<td>U</td>
<td>Guangdong (广东省)</td>
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### TW Taiwan (台湾)

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<tr>
<th>县市</th>
<th>ZA</th>
<th>ZB</th>
<th>ZD</th>
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<tbody>
<tr>
<td>ZA</td>
<td>Taipei City, Kaohsiung City (台北, 高雄市)</td>
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<tr>
<td>ZB</td>
<td>Taitung City, Tainan City (台中, 台南市)</td>
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<tr>
<td>ZD</td>
<td>Chungsho City, Fengshen City (中和, 凤山市)</td>
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**Figure 1:** Location of 69 mainland study counties, and of Taiwan. The first letter denotes the province, the second identifies the study area. In 1989 there were 69 study areas in mainland China, 65 of which were also included in a 1983 survey, and in the island of Taiwan (marked TW). Note: The municipality of Shanghai [province A] included some rural counties, one of which [AA] has since been absorbed into the city of Shanghai, and part of Sichuan [province S] is now the municipality of Chongqing.

As an example of these geographic differences in disease, age-standardised mortality rates (male versus female) from oesophagus cancer, stomach cancer, liver cancer, chronic lung disease, ischaemic heart disease and stroke in the 69 study counties are shown in figure 2, along with the corresponding rates in the United Kingdom (UK). Together, these six diseases account for more than half of all Chinese deaths in middle age (which, throughout this monograph, is defined as ages 35 to 69). For each disease, there is more than ten-fold variation among the counties, and these differences are not chiefly genetic. Although some important causes are known (for example, within each county, high blood pressure greatly increases the risk of death from stroke and heart disease; and chronic hepatitis B greatly increases the risk of death from liver cancer), little of the heterogeneity among counties in mortality from particular diseases can be explained by heterogeneity in the prevalences of the known causes of those diseases. Thus, for none of these six diseases are the main reasons for wide geographic variation properly understood, and wherever any of these diseases is relatively common, there must be some major avoidable cause, or causes, still awaiting discovery.

Each of these six diseases can be caused by smoking, but, for each of them, the wide geographic variation in mortality rates is not chiefly due to geographic variation in tobacco use: in rural China, few women smoke, and the prevalence of smoking among men does not vary greatly among counties. Chronic lung disease, for example (figure 2d), is the main cause of death in many parts of rural China, but the reasons for this are not properly understood. The generally higher rates among males than among females is chief due to geographic variation in tobacco use: in rural China, however, can plausibly account for most of the ten-fold variation among county rates, nor for the much higher average rates in rural China than in the UK. In contrast, ischaemic heart disease (IHD; which also shows ten-fold variation between one part of China and another) is, in every county, much less common than in the UK. Dietary factors might well account for much of this—average fat intake in rural China (18% of dietary calories) was less than half that in the UK, and average plasma cholesterol was only about two-thirds that in the UK (figure 3). Among the study counties, however, the variation in IHD mortality is not significantly correlated with the variation in fat intake, possibly because fat intake is correlated about as strongly with HDL cholesterol (which cardioprotective particles carry) as it is with non-HDL cholesterol.

STUDY COMPONENTS

Two surveys of mainland county mortality rates
(1973-75 and 1986-88)

- County mortality rates during the three-year period 1973-75, subdivided into a limited number of specific causes (or groups of causes), were taken from a previous nationwide study.
- County mortality rates during the three-year period 1986-88, subdivided into many specific causes, were derived from our individual review and ICD-9 coding of 300,000 deaths. Our parallel survey of 800,000 urban deaths in 24 cities during 1986-88, conducted mainly for other purposes (Liu et al., 1998), is used in this monograph chiefly to compare rural and urban cause-specific mortality rates in mainland China. In the Annex, from page 803, cause-specific mortality rates by sex and 5-year age groups are given for urban China (24 cities), rural China (67 counties) and all China (weighted average, 0.3 urban + 0.7 rural).

作为疾病地区性分布具有巨大差异的一个例子，图 2 介绍了 69 个研究县的男性食管癌、胃癌、肝癌、慢性肺疾病、恶性心脏病及中风的年龄标准化死亡率的不同，同时提供了英国相应疾病的标准死亡率。上述六种疾病引起的死亡占中国中年人群（在本专著中，定义为 35-69 岁）死亡总数的一半以上。对于每一种疾病，在不同县中有十倍以上的变化，而遗传并不这些差异的主要决定因素。尽管一些重要的病因已经清楚（例如：在每一个县中，高血压会导致增加于风及心脏病的危险；慢性乙型肝炎大大增加死于肝癌的危险），但是不同县之间的某些疾病死亡率的不同并不能说明这些疾病已知病因的流行差异来解释。因此，对于造成这六种疾病死亡率如此巨大地理差异的主要原因还没有完全的了解。在任何地方，只要这些疾病是常见原因，肯定有一些可避免的原因有待发现。

这六种疾病均可由吸烟引起，但每种病死亡率的地区性差异并不主要是由于吸烟使用的地区性差异造成的，在中国农村吸烟的地区很少，而男性的吸烟率在不同县之间又有明显不同。慢性肺疾病（图 2d）是农村地区的主要死因，但原因并不十分清楚。男性死亡率总体上高于女性的主要原因是由于烟草消费的差异，而在夏威县（R）女性慢性肺疾病死亡率很高，其原因由于在室内使用烟草而没有烟囱。然而，不管是在烟案还是烟案，都不能完全合理地解释各地区之间患病率的十倍以上的差别，也不能解释大陆农村平均患病率大大高于英国的结果。相反，每个县的出血性心脏病（IHD，在中国不同县之间也有十倍以上的差别）都比英国要低。膳食可能是这些不同的主要原因因素。大陆农村人群膳食脂肪的摄入（占膳食总能量的 18%）较英国人均少一半，同时大陆农民的血脂胆固醇水平是英国人的三之二（图 3）。然而，在中国的调查中，出血性疾病死亡率的变化与脂肪的摄入却没有显著相关。可能是脂肪摄入与 HDL 胆固醇（由对心脏有保护性作用的粒子所带）和非 HDL 胆固醇相关的程度相同。

研究内容

两次大陆县死亡率调查
(1973-75, 1986-88 年)

- 1973-75 年三年的调查县死亡率，只分为有限的疾病类型（或几种几种类的组合），资料来源于全国第一的一次全国性调查。
- 1986-88 年的三年的调查县死亡率，分为多种具体死因，资料来源于我们对 300,000 例死亡进行的个体回顾调查和 ICD-9 编码。我们要为其它目的于 1986-88 年在 24 个城市同时进行的 800,000 例城市人口死亡调查（刘等，1998）。在本专著中主要用于比较大陆农村与城市的死亡率。从 803 页的附录给定中国大陆(24市)下(67县)及全国(加权平均，0.3 城镇 + 0.7 农村)性别和五岁年龄组的死亡率。
Figure 2: Standardised mortality rates from six major chronic diseases in 69 different counties in rural China, showing wide variation, and hence much avoidability. The mortality rate is the mean of the 7 age-specific annual rates per 100,000 at ages 35-39, 40-44, …, 65-69. Hence, a rate of 300 would mean that a 35-year-old would (in the absence of other causes of death) have about a 10% risk of death from this particular cause at ages 35-69; a rate of 600 would correspond to about a 20% risk of death at ages 35-69; and a rate of 30 to a 1% risk.

图2：中国农村69个不同县的6种主要慢性疾病的标准化死亡率有很大差异，因此这些慢性疾病在很大程度上是可以避免的。所表示的死亡率是35-39、40-44、…、65-69岁7个年龄组的年死亡率（1/100,000）的平均值。因此，死亡率为300/100,000意味着一个年龄为35岁的人（在不考虑其它死因的情况下），在35-69岁时死于某种疾病的风险为10%；同理，若死亡率为600/100,000，意指在35-69岁时死于某种疾病的风险为20%；若死亡率为30/100,000，那么风险则为1%。
Two surveys of mainland county biochemistry, diet and lifestyle (1983 and 1989)

- In 1983, a survey of biochemistry, diet and lifestyle was undertaken in 65 of the 69 counties.
- In 1989, a more detailed survey was undertaken in all 69 of the counties, involving:
  - analyses of samples from adults aged 35 to 64 of plasma, of red blood cells, and, from men only, of urine;
  - a three-day weighed household dietary survey, used to estimate average daily intakes of a wide variety of foods and nutrients per "reference man";
  - questionnaires (including some physical measurements) about dietary, lifestyle, anthropometric, social and economic factors, representing either the individuals being interviewed, their families, or their communities; and
  - geographic characteristics of the county.

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  - geographic characteristics of the county.

Figure 3: Total dietary fat intake versus total plasma cholesterol (TC): mean values among adults in 69 rural Chinese counties in 1989. Fat intake as a percentage of total dietary calories averaged 18% in these counties, which is less than half the percentage typically seen in UK adults, and total plasma cholesterol averaged 3.8 mmol/L (148 mg/dL), which is only about two-thirds that in the UK and three-quarters that now seen in rural China (Gu et al, 2005). But, there is in these 69 counties a similarly strong positive geographic correlation of total dietary fat intake with the total plasma cholesterol, with the plasma cholesterol in low-density lipoprotein particles (LDL cholesterol), which are hazardous, and with the plasma cholesterol in high-density lipoprotein particles (HDL cholesterol), at least some of which are cardioprotective.

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  - questionnaires (including some physical measurements) about dietary, lifestyle, anthropometric, social and economic factors, representing either the individuals being interviewed, their families, or their communities; and
  - geographic characteristics of the county.
Reliability re-survey in selected mainland counties (1993)

To help assess the reliability of the methods used in the 1989 survey, a repeat survey using those same methods was carried out in 1993. Thirteen counties in mainland China that represent a good north-south mix and a range of affluence levels were included (counties AC, BA, CB, CC, FA, HA, KB, LC, ND, QA, AC, RA and TD). In each, the re-survey was carried out at the same time of year as the 1989 survey, to avoid seasonal differences. After a refresher training course, the same 1989 personnel (where available) conducted the re-survey, during which they had no access to the 1989 values.

The following elements of the 1989 survey were included in the reliability re-survey:

- a subset of questions from the individual-level questionnaire
- pulmonary function (using the same equipment and methods)
- blood pressure (using the same equipment and methods)
- household dietary survey
- blood sample (sodium ascorbate was used as a preservative in 1993, although ascorbic acid had been used in 1989)
- 12-hour urine collection (males only)

Overall, 70% of the 1989 participants in these 13 counties were re-interviewed in 1993. Replacements, of the same gender and age, were recruited for the other 30% because the aim was to study the reproducibility of aggregate means, rather than the reproducibility of individual values.

Taiwan: survey of mortality (1986-88) and of biochemistry, diet and lifestyle (1989)

To compare mainland China with Taiwan, 16 areas in Taiwan were selected for study. Mortality rates during 1986-88 were calculated from review of death certificates, and a survey of biochemistry, diet and lifestyle similar to that in mainland China was undertaken in 1989. The three-day weighed household dietary survey was not conducted in Taiwan.

METHODS

Selection of study sites and participants in mainland China

Selection of study sites in mainland China

In the early 1980s, 69 counties were randomly chosen from the total of about 2400 largely rural counties in China to represent the full range of mortality rates (in the previous 1973-75 nationwide survey) for seven major types of cancer: nasopharynx, oesophagus, stomach, liver, lung, colorectal and leukaemia. These counties are distributed throughout China and are, in aggregate, reasonably representative of rural mainland China as a whole.

Mortality rates for these counties during 1973-75 (from the nationwide survey) and 1986-88 (from our own survey) were determined retrospectively. Surveys of the characteristics of cluster-randomised samples of the local populations were carried out in 1983 (only 65 of the counties), in 1989 (all 69 counties) and in 1993 (13 of the counties). The 1989 survey was more detailed than the previous one, and the 1993 survey duplicated its methods to assess their reliability.

所选部分大陆县可信性重复调查（1993 年）

为评估 1989 年调查方法的可信性，1993 年采用相同方法进行了重复调查。在大陆重复调查的 13 个县较好地代表了南北方及经济水平的不同（这些县的编码为 AC、BA、CB、CC、FA、HA、KB、LC、ND、QA、AC、RA 和 TD）。为避免季节性差异，每个县重复调查的时间与 1989 年相同，调查员也与 1989 年相同（在可能情况下），并经过重新培训。重复调查期间，调查员并不掌握 1989 年调查数据。

下面这些 1989 年曾调查过的项目被列入 1993 年的可信性调查：

- 个人问卷中的部分内容
- 肺功能测定（用相同的仪器和方法）
- 血压测量（用相同的仪器和方法）
- 家庭膳食调查
- 血样收集（尽管 1989 年使用的保存剂为抗坏血酸，1993 年用的是抗坏血酸钠盐）
- 12 小时尿样（男性）

在 13 个县中，1993 年重复调查了 70% 的 1989 年的调查对象。鉴于重复调查的目的是评价人群均值而不是个体值的可重复性，因此按照同性别和同年龄的原则，新补充了另外 30% 调查人群。

台湾：死亡率调查（1986-88 年）和生化指标、膳食以及生活方式调查（1989 年）

为了比较大陆与台湾的不同，在台湾选择了 16 个地区进行调查。1986-88 年的死亡率来源于对死亡证明的回顾调查，在 1989 年进行了与大陆类似的生化指标、膳食及生活方式调查。在台湾没有进行家庭三日称重膳食调查。

方法

大陆现场现况及研究对象的选择

大陆现场选择

在二十世纪八十年代初，从中国大陆 2400 个大部分是农村的县中随机抽取了 69 个县，以代表鼻咽癌、食管癌、胃癌、肝癌、肺癌、大肠癌及白血病七种主要癌症的全部死亡率范围（在早前 1973-75 年全国性调查中）。这些抽取的县分布在整个大陆，在总体上很好地代表了全部农村地区。

Within each county, two smaller administrative areas, “xiangs”, were randomly selected, and within each xiang, either one village or two adjacent villages (depending on their size) were then randomly selected as the actual sites of the interviews and other data collection. All survey sites had to be within four hours travel time from the county laboratory, resulting in the replacement of six (4%) of the xiangs.

The average results for the two-xiang pairs were used to estimate the average values for each county. The 69 pairwise differences between two xiangs in each county helped to assess how reliably the pairwise averages were likely to represent entire counties: if the values in one xiang are closely correlated with those in the other, then their pairwise average is likely to be reliably informative.

The same xiangs that were studied in 1983 were studied again in 1989, but administrative reorganizations in China during the 1980s led to changes in nomenclature, which are reflected in different terms used in the monograph on the 1983 study (Chen et al., 1990) and in this monograph. The current “xiang” was, in 1983, called a “commune”, which was both a collective farm and a unit of rural government, and the commune was made up of “production brigades”—for the most part natural villages—that are now referred to as “villages”.

Selection of study participants in each xiang

Within each study site, 50 households (in 1983) or 60 households (in 1989) were randomly selected from an official registry of residences. One individual per household (involving roughly equal numbers of males and females) aged 35-64 (in approximately equal numbers for age groups 35-44, 45-54, and 55-64) was randomly selected, and these individuals and their households were the focus of data gathering. If the selected individual was absent or, less commonly, declined to participate (<1% declined), an individual in a neighbouring household was selected and asked to participate. Half the households were also asked to participate in a detailed 3-day dietary survey. The 1989 survey attempted to reinterview the 1983 study participants, replacing those who were either no longer available or 65 or older in 1989, and adding 10 individuals and households per village by random selection of new participants. A similar random sampling scheme was used in each of the four new counties first surveyed in 1989 to identify 60 study participants, age 35-64.

Each individual in the study was assigned a unique identifier, denoting province, county, xiang (as xiang I or xiang II), gender, and sequential number. For instance, participant ‘DBIIM24’ is the 24th male interviewed in xiang II of county B (Linxian) of province D (Henan). This identifier was used for both questionnaire data and biological samples.

In 1989, 8307 individuals were interviewed, data were gathered from 7888 households, and the dietary survey was completed for 4140 households across the 69 counties.

Selection of study sites and participants in Taiwan

Taiwan was not included in the 1983 study, but the 1989 study included 16 sites in Taiwan, ranging from highly urban to rural (unlike the exclusively rural sites in mainland China). The method used to select the sites was also different from that used in mainland China. In Taiwan, 16 types of area were defined (by 3-digit postal codes):

- In each county, two smaller administrative areas, “xiangs”, were randomly selected, and within each xiang, either one village or two adjacent villages (depending on their size) were then randomly selected as the actual sites of the interviews and other data collection. All survey sites had to be within four hours travel time from the county laboratory, resulting in the replacement of six (4%) of the xiangs.

  - The average results for the two-xiang pairs were used to estimate the average values for each county. The 69 pairwise differences between two xiangs in each county helped to assess how reliably the pairwise averages were likely to represent entire counties: if the values in one xiang are closely correlated with those in the other, then their pairwise average is likely to be reliably informative.

  - The same xiangs that were studied in 1983 were studied again in 1989, but administrative reorganizations in China during the 1980s led to changes in nomenclature, which are reflected in different terms used in the monograph on the 1983 study (Chen et al., 1990) and in this monograph. The current “xiang” was, in 1983, called a “commune”, which was both a collective farm and a unit of rural government, and the commune was made up of “production brigades”—for the most part natural villages—that are now referred to as “villages”.

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A Metropolitan cities
B Provincial cities
C County cities
D Hakka area 1
E Hakka area 2
F “Black foot disease” area (where the groundwater is contaminated by arsenic)
G Penghu Islands
H Northern mountainous area
I Central mountainous area
J Southern mountainous area
K Northern coastal area
L Southwestern coastal area
M Eastern coastal area
N Rural towns in Ilan county
O Rural towns in Changhua county
P Rural towns in Tainan county

These 16 types of area were chosen to vary widely in:

- population density and socioeconomic status,
- ethnicity (Hakka, Han and aboriginal Taiwanese),
- crude cancer mortality rates, and
- geographic location.

For each of these 16 types of area (A, B…P) in Taiwan, specific study sites (ZA, ZB…ZP) were chosen. Two towns or districts (depending on the level of urbanization) were selected randomly (with probability proportional to size), and, within each, two villages (or equivalent administrative units) were selected by a similar procedure, for a total of 64 “villages”. Thirty-six individuals per village aged 35-64 (evenly divided among the six 5-year age groups and between males and females) were selected, based on household registration information, and invited to participate. The target was to interview at least five of these individuals in each sex and age group, and households were sampled until this was achieved in each village.

Mortality rates (1973-75 and 1986-88)

Mainland China

Mortality rates for 1973-75 were taken from the nationwide survey that had been done during the mid-1970s for other purposes, and mortality rates for 1986-88 were from a special survey carried out in 1989-90 as part of the present study. Many of the causes assigned in the 1973-75 survey are less specific than those assigned in the later survey, although overall mortality and, in most counties, mortality rates from the main causes of death are reasonably reliable from both periods. Age-standardised mortality rates for particular age ranges were always calculated as the unweighted average of the component five-year mortality rates (e.g., 35-39, 40-44,…,65-69 for the age range 35-69).

1973-75 Mortality. In the mid-1970s, a nationwide retrospective review was undertaken that sought to classify the causes of all 20 million deaths in mainland China during 1973-75, with particular emphasis on those attributed to certain types of cancer (Atlas of Mortality from Main Death Causes in China; Atlas of Cancer Mortality in the People’s Republic of China). The Chinese population at the time was about 850 million. About 96% of all 1973-75 mortality is due to cardiovascular diseases, cancer, chronic respiratory diseases, and digestive diseases.

1973-75 Mortality Rates. The 1973-75 mortality rates for mainland China are based on the nationwide survey carried out in the mid-1970s for other purposes. The mortality rates for 1986-88 are from a special survey carried out in 1989-90 as part of the present study. The Chinese population in 1973-75 was about 850 million. About 96% of all deaths in 1973-75 were classified under this classification system. The Chinese population in 1986-88 was about 1 billion. About 95% of all deaths in 1986-88 were classified under this classification system.
deaths were included. In some counties specific causes were to be assigned only to deaths from cancer (grouping together those due to all other causes), but in most counties the non-cancer deaths were grouped into various broad categories, some of which correspond approximately to ICD-9 categories. The present monograph takes from that nationwide review all of the available information on age- and cause-specific mortality rates for the 69 randomly-chosen counties. In all 69 of these counties, overall mortality rates, overall cancer mortality rates, and mortality rates from each of the main types of cancer were available, and in 52 of them the non-cancer deaths during 1973-75 were grouped into various informative categories, e.g., stroke, ischaemic heart disease, other vascular causes, pneumonia, chronic lung disease, etc. (The chief anomaly in the 1973-75 survey is that respiratory heart disease, a common cause of death, was classified as vascular; in this monograph, we reclassify it as part of chronic lung disease.)

For the nationwide review of deaths during 1973-75, the National Office of Cancer Control and Research developed survey methods and data forms, and the Ministry of Public Health developed standardized terms for classifying causes of death, which did not use ICD codes. Local survey teams were trained to gather information from a variety of sources, including records and key individuals, on each death within the previous three years. The age and sex distribution of the local population was determined from xiang records and from the Departments of Public Security and of Statistics.

1986-88 Mortality. For each county, the numbers and underlying causes of the deaths in 1986-88 were obtained by a retrospective review undertaken in 1989 specifically for this project. We were unable to get reliable mortality data for two of the 69 counties (both in the southern province of Guangdong). In the other 67 counties, we estimate that about 90% of all deaths were recorded in the sources available to us. Hence, in calculating mortality rates in 1986-88, the estimated numbers at risk are taken as 90% of the population.

Most counties had populations of a few hundred thousand, but a few were substantially larger or substantially smaller. In the larger counties, deaths from randomly-chosen parts of the county (yielding a population of about 300,000) were used to estimate mortality rates for the whole county. For two northern counties in nomadic areas (Tuoli in Xinjiang Autonomous Region and Xianghuangqi in Neimongol Autonomous Region) that had populations too small for statistical stability, we used the mortality rates for the prefectures to which these counties belong, which comprised six (Xinjiang) and 12 (Neimongol) counties.

Deaths were identified primarily from village or other administrative records (e.g., Departments of Public Security), at least one of which usually included name, address, gender, age, and cause of death. The information on causes in those records was supplemented by review of medical records, which were still available for most deaths, or by discussion (a few years after the death) with local health workers, community leaders, and family. The information obtained by our field workers was recorded as parts I and II of a standardised death certificate (following WHO ICD-9 recommendations; WHO, 1977). Specific causes were assigned to the vast majority of the deaths, particularly before age 70.

The fieldwork for this study of 300,000 rural deaths and a parallel study, done for other purposes (Liu et al., 1998), of 800,000 urban deaths in 1986-88, involved 500 interviewers. The interviewers usually worked in teams of four, at least one of whom was medically trained. Consistency of the information obtained by these interviewers from family members was checked by repeat

1986-88 Yearly Mortality. The number of deaths per 100,000 persons per year was calculated using the annual mid-year population (ascertained during a separate household survey). For each age group, we included deaths that occurred during the year of the survey and deaths that occurred during the previous year. The number of deaths was divided by the population at the middle of the year to yield the death rate per 100,000 persons per year.

In the analysis, we excluded deaths caused by accidents and violence and deaths caused by malignant neoplasms (WHO ICD-9 codes 140-208). We also excluded deaths due to infectious diseases (WHO ICD-9 codes 001-099). The remaining deaths were classified by cause according to the International Classification of Diseases, 9th Revision (WHO, 1977).

1986-88 Mortality by Cause. The mortality rates for each cause of death were calculated for each county and for the total population. The counties were then ranked by cause-specific mortality rates, and the rates were compared with those of other counties in the same region and with those of counties in other parts of the country. The results were also compared with those of previous studies.
Interviews of random households by team leaders. Underlying causes of death in 1986-88 were coded by 100 specially trained clerks in five teams, each under a trained nosologist from the Ministry of Health with previous experience in coding standard death certificates using ICD-9. Some early batches of data sheets were coded by two teams and the differences discussed, leading to the development of consistent coding conventions. Double data entry was followed by extensive computerised checks and queries to correct gaps, duplications, inconsistencies, and implausibilities. After these checks were completed, the proportions recorded as "ill defined" (ICD9 codes 780-799) were, taking the present survey of rural deaths and the parallel survey of urban deaths together (Liu et al., 1998), only 1.0% at ages 0-34, 0.5% at ages 35-69, and 2.7% at ages 70-79.

Population Estimates. In some counties, the official population estimates at ages 0-4 in 1986-88 were, in 1989, substantially too low (perhaps because some of the individuals were too young for the 1984 national census). In view of the sharp increase in the birth rate during the late 1980s, the populations aged 0 and 1-4 in this study would be expected to be about 0.25 and 0.85 times the population aged 5-9. If, therefore, in any particular county, the estimated male or female populations at 0 or at 1-4 were less than this, they were replaced by the above estimate. Taking the study as a whole, this increased the estimated population at ages 0 and 1-4 by 41% and 21%, respectively.

Taiwan

1986-88 Mortality. For each of the 16 types of area in Taiwan (A, B…P), age-specific mortality rates were computed from the certified causes of death (as ICD-coded by the Department of Health—denominators) and from official population census data (denominators). Death certificates in Taiwan are filled out by a physician, usually from a hospital where the person had been treated, but sometimes from the local public health station.

Blood samples (plasma and red blood cells)

Fasting 10 ml venous blood samples were collected from 8,280 individuals in mainland China in trace-mineral-free heparinized vacutainers, which were placed on ice in light-free vacuum jars. Samples were transported to the county laboratory within about four hours of the last blood draw of the day. Upon arrival at the county laboratory, blood samples were immediately separated into three fractions:

1. 3 ml of packed red blood cells (RBCs), washed three times with saline, haemolysed with 3 ml preservative buffer, then mixed and frozen.
2. 0.3 ml plasma, with 0.9 ml trichloroacetic acid added as a preservative, then mixed and frozen. (This sample was to be used for ascorbic acid analysis, which could not be done on plasma with added ascorbate.)
3. remaining plasma (usually about 4-5 ml), with 20 mg ascorbate added as a preservative, then mixed and frozen.

All fractions were stored temporarily at -15 to -20°C in the local laboratories, then shipped on dry ice to the Chinese Academy of Preventive Medicine (CAPM) in Beijing, where they were again stored at -20°C. "Pools" were created, which involved mixing individual blood samples of a particular type. The main purpose of these blood samples was to determine the sex-specific mean values of many different factors in each study area, and for many factors this average can be obtained by a single assay of a "pool"

Dead returns had the following characteristics. In 1986-88 years, 20% of deaths were confirmed by recoding from the cause of death for the population of the death certificate (ICD9 codes 780-799) were, taking the present survey of rural deaths and the parallel survey of urban deaths together (Liu et al., 1998), only 1.0% at ages 0-34, 0.5% at ages 35-69, and 2.7% at ages 70-79.

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Properties of the different factors in the blood samples included:

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of blood that combines samples from all the relevant individuals. (Some measurements, e.g., of various antibodies or tobacco metabolites, had to be done on individual samples to be meaningful.) These pools were prepared (and aliquoted into small portions) in the CAPM laboratories in Beijing. Three types of pools were prepared for each of the three fractions:

1. County pools: Sex- and xiang-specific pools were created for each county (resulting in four pools per county).
2. Twelve sex- and age-specific “superpools” (i.e., six 5-year age groups times two sexes) were created for all 69 counties.
3. What remained of each individual sample was retained, labelled with the individual’s unique identifier.

Specific laboratory analyses were carried out in various sites, including Beijing, Taibei, Oxford, London, Tokyo, Ithaca (Cornell University), and other places in the United States. Samples were always shipped between laboratories on dry ice. The pools were shipped to Cornell in 1992 as large samples and then aliquoted into smaller samples, so that small amounts could be thawed for each analysis. In 1996, the samples that remained were sent from Cornell to Oxford and put in long-term liquid nitrogen storage.

Similar procedures were followed for the 2112 samples collected in Taiwan, except that the processing and initial pooling was carried out in Taibei.

Urine samples

A 12-hour urine collection was to be done in mainland China and Taiwan (from males only) on two separate days, once after a small (500 mg) oral dose of proline and once after the same dose of proline together with enough ascorbate (200 mg) to inhibit virtually all gastric nitration of amino acids for as long as the proline was still in the stomach. Samples of the collected urine were frozen at -15 to -20°C prior to transport on dry ice to Beijing, and aliquots were then sent to the World Health Organisation International Agency for Research on Cancer in Lyon, France, for nitrosamine analyses. The urine was also analysed in Beijing for other factors.

The “ascorbate-inhibitable proline nitrosation”, defined as the difference between the urinary N-nitroso-proline excretion in the paired samples, indicates the extent to which the stomach contents could, under normal circumstances, nitrosate other amino acids (which, unlike proline, then yield potentially carcinogenic nitrosamines; Ohshima and Bartsch, 1981; Wu et al., 1993).

Diet survey: household three-day weighed food intake

A three-day household dietary survey was carried out in 60 households per county in mainland China (a total of 60 x 69 = 4140 household), split roughly equally between the two study xiangs in that county. These included the same households surveyed in 1983, to the extent possible, with replacements to compensate for attrition due to death or migration.

In each household, all raw and cooked foods available at the beginning of, all foods obtained during, and all foods left over at the end of, the 3-day survey period were weighed and recorded. Foods consumed by the whole household were estimated on the basis of the disappearance of each food during the survey period. Plate wastes and discarded foods were recorded and subtracted from the total household food consumption. The number of people partaking of each meal, and each person’s age, gender, occupation, lactation and pregnancy status (for women) and physical activity level were also recorded.

血液样本的分析在不同的地方进行，包括北京、台北、牛津、伦敦、东京、依塞加(康奈尔大学)和美国其它地方。样本送往各自实验室的过程中均用干冰保存。混合样品于1992年被集中送到康奈尔大学后被分成小份样品，以便每次分析只需解冻小份样品。1996年，剩余的样品被送到牛津并放在液氮中长期保存。

除血样处理和最初的混合是在台北进行的，在台湾采集的2,112份血样按相同程序进行了处理。

尿样

在大陆和台湾，分两天收集了12小时尿样(仅对男性)。一次是口服小剂量(500毫克)脯氨酸后，一次是口服相同剂量脯氨酸和足量的抗坏血酸(200毫克)后。第二次的目的是当脯氨酸仍在胃中的时候，能有效的阻止全部胃中氨基酸的硝基化。尿样在-15到-20°C冰箱中冷冻保存，然后用于冰运至北京。装成小样送到在法国里昂的国际癌症研究机构，进行亚硝胺含量分析。在北京还分析了尿样的其它指标。

“可被抗坏血酸盐抑制的脯氨酸亚硝基化”定义为两次尿样中N亚硝基脯氨酸排出量之差。表明在正常状态下，胃内容物能亚硝化其它氨基酸(和脯氨酸不同，会产生潜在的亚硝胺类致癌物：Phshima and Bartsch, 1981; Wu et al, 1993)的程度。

膳食调查:三日秤重家庭食物摄入量

在大陆的每个调查县，都选择60户家庭，进行三日家庭膳食调查（共有60×69=4140户）。这60户基本上均匀地分布在每个县的两个调查乡中，并尽可能地包括1983年被调查的家族，并补充了由于死亡和移民而减少的家族数。

在每个调查家庭，对调查开始前所有生熟食物，调查三日内购入的各种食物，以及调查结束后剩余的各种食物都进行称重并记录。全家总的食物消费量是按调查期间消耗的食物量为基础计算的，盘中剩余食物和废弃的食物被从总消费量中扣除。调查同时记录了每次就餐的人数，每个人的年龄、性别、职业、体力活动水平，以及妇女的哺乳和妊娠情况。
Food intakes were standardised, through appropriate conversion factors, to intake per “reference man”, defined as a male aged 19-59 years old, weighing 65 kg and undertaking very light physical activity.

**Food Composition Data**

The nutrient values assigned to the diet in each xiang combine the amount of each food eaten locally (estimated from the 3-day dietary survey) with “average” nutrient values for each food in China as a whole. This procedure does not take account of local variation in the nutrient content of foods (which, in the case of selenium and certain other trace elements, is substantial).

Nutrient values for foods were based on *The Composition of Chinese Foods* (Wang, Parpia, and Wen, 1997), which lists “average” nutrient contents for more than 1300 foods. The tables include 28 general nutrients in 1358 foods, 18 essential and nonessential amino acids in 456 foods, 21 saturated and unsaturated fatty acids in 356 foods, and the cholesterol content of 400 foods.

**Questionnaire administration, and summarised questionnaires**

**Mainland China**

Local survey teams were trained to administer the questionnaires, make physical measurements, collect blood and urine samples and conduct the dietary survey. Aggregate information about the survey xiangs and villages was also gathered, through interviews with officials at the appropriate administrative levels. Two questionnaires focusing on mothers and children—although somewhat external to the main study design—were also included.

Each of the six study questionnaires is described briefly below, and the questionnaires themselves are appended (pp787-801) in the original Chinese and in English translation.

**Questionnaire A: Xiang (formerly Commune) survey**

In each xiang, an official was interviewed to gather information characterising the xiang in 1989 according to:

- Geographical size and location, including proximity to a city and accessibility by road
- Size and makeup of population, including proportions belonging to the various minority groups
- Health care facilities and personnel; private vs. cooperative health care system
- Schools, including numbers of each type
- Major employers and ownership (public vs. private) of businesses
- Communications facilities (post offices, cinemas and other theatres, telegraph offices and public telephones)
- Transportation facilities
- “General statistics”, including literacy rates, economic indicators, health and health care indicators
- Xiang government structures, including characteristics of participating citizens
- Numbers and types of markets
- Vaccination coverage of children born in or after 1987.
Questionnaire B: Village survey

In each village, an official was interviewed to gather information characterising the village in the following respects:

- Size and makeup of population
- Village markets
- Village institutions and facilities
- Post offices
- Cinemas
- Theatres
- Stores for farm equipment
- Banks or lending co-operatives
- Agricultural technical station
- Department stores
- Parks and public gardens
- Sports facilities
- Public telephones
- Places of worship
- Health care institutions and personnel
- Type of health care system(s)
- Selected health indicators (e.g., presence of goitre or cretinism)
- Schools and teachers, including numbers at each educational level
- Indicators of household prosperity (e.g., proportion with radio, television)
- Types and extent of agricultural activities
- Village government
- Household-level business enterprises
- Migration from village
- Changes in characteristics between 1983 and the date of the survey in 1989.

Questionnaire C: Household questionnaire

In each survey household, a single respondent was interviewed (most often, the head of the household). Questions were asked about:

- Demographic and occupational information on all household members, and more detailed information about the head of the household (regardless of who was interviewed)
- Water and sanitation facilities for the house
- Use of pesticides and fertilizer
- Household income, including family members working away from home
- Amounts and categories of household expenditures
- Housing and household possessions.

Questionnaire D: Adult questionnaire

One adult (age 35-64) per household (resulting in approximately equal numbers of males and females) was interviewed. Height, weight, blood pressure, and lung function of each participant were measured, the thyroid was examined, and questions were asked about:

- Household income, including family members working away from home
- Amounts and categories of household expenditures
- Housing and household possessions.
• Age, gender and occupational information
• Educational history
• Smoking and alcohol drinking
• Dietary habits
• Reproductive history (for women)
• Cooking and heating fuels used in childhood and adulthood
• History of major medical conditions.

Questionnaire E: Recent pregnancy, infant feeding and vaccination

All mothers in survey villages who had given birth between January 1, 1987 and the time of the survey in 1989 were invited to bring their children and to answer a series of questions about them. In total, data were collected on 7774 children.

Questions were asked about both the mother and child, including:

• Basic birth information for the child (gender, weight, birth order)
• Mother’s occupational history (before, during, and after pregnancy), marital status, reproductive history
• Feeding of baby (including role of breastfeeding)
• Child’s health history
• Mother’s feeding practices if the child were to become ill
• Child’s immunization history

Questionnaire F: Anthropometry and smoking in primary schools

In each county, at least 200 students, age 5-15, from 2-4 primary schools were measured and interviewed. In total, data were collected from 15,772 students.

Measurements and questions included:

• Age and gender
• Weight and height
• Current smoking status.

Taiwan

Questionnaire 1: Diet and lifestyle (partially equivalent to mainland China Questionnaire D)

One adult (age 35-64) per household (resulting in approximately equal numbers of males and females) was interviewed. Height, weight, blood pressure, and lung function of each participant were measured, the thyroid was examined, and questions were asked about:

• Education, use of mass media, religion
• Smoking habits
• Drinking habits
• Food habits
• Cooking and heating
• Previous medical history
• Current medical conditions
• Personal hygiene

• 年龄、性别及职业
• 教育史
• 吸烟及饮酒情况
• 饮食习惯
• 生育史（妇女）
• 儿童和成人后家庭烹调及取暖的能源
• 主要就医史

台湾

问卷 1：膳食和生活方式（部分内容与大陆问卷 D 等同）

对每个调查家庭中一名年龄在 35－64 岁成年人（男女性别比例均衡）进行询问调查，对身高、体重、血压、肺功能进行测量，对甲状腺进行检查，并询问如下信息：

• 教育、媒体和宗教
• 吸烟情况
• 饮酒习惯
• 饮食习惯
• 烹调和取暖情况
• 既往疾病史
• 目前健康状况
• 个人卫生状况
Childbearing and menstruation (females only)

Questionnaire 2: Lifestyle, health and nutrition (partially equivalent to mainland China Questionnaire C)

In each survey household, a single respondent was interviewed (most often, the head of the household). Questions were asked about:

- Head of household information
- Household composition
- Water supply
- Latrines
- Pesticide and fertilizer use
- Housing and household possessions

REFERENCES


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Authors

Junshi CHEN, Richard PETO, Wenharn PAN, Boqi LIU, and T. Colin CAMPBELL—the five principal authors—conceived the study, developed its structure and bear ultimate responsibility for its completion, analysis, and reporting. Major responsibilities were assumed by the eleven other authors from the same home institutions. Their roles are described briefly below.

如果没有成千上万人的劳动与合作，这项研究是不可能的。那些从事现场工作——询问调查，收集样本以及记录数据的大多数工作人员没有单独列出来。同样也没有列出那些参与询问调查和调研的其它方面的个人及家庭。许多在中国大陆及台湾的人参与了最初的样本处理和贮存以及早期的实验室分析，我们在此对所有这些人所做出的重要贡献表示感谢。

作者

陈君石，Richard PETO，潘文涵，刘伯齐，和 T. Colin CAMPBELL—五个主要作者—构思了这项研究，发展了其架构并且对这项研究的完成，分析和报告负最终的责任。来自各主要作者研究机构的其他十一位作者也应负主要的责任。他们的职责分工简短地描述如下：
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Martin ROOT was responsible for specifying specimen handling procedures and analysis, and oversaw many of the laboratory assays.

Patricia A. CASSANO had primary responsibility for lung function testing and for the 1993 reliability re-survey.

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Zulin FENG coordinated the shipment of biological samples to Oxford, Cornell and other laboratories, and was responsible for carrying out some of the assays.

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Junyao Li helped design the study and its individual components.

Yanping WU was responsible for preparing mortality data for all counties in the study.

Clinical Trial Service Unit and Epidemiological Studies Unit, University of Oxford

Jillian BOREHAM had overall responsibility for data programming and analysis.

Hongchao PAN was responsible for all programming of graphical and numerical presentations, and for much of the Chinese translation and all dual language type-setting.

Linda YOUNGMAN was responsible for a large number of laboratory assays, which included, in some cases, the development or adaptation of methods.

Hellen GELBAND compiled the notes and introductory text in collaboration with the study team.

Zhengming CHEN assisted with study design and planning, and liaised with China for transfer and validation of mortality data.

Other collaborators

Listed below are the many people who provided assistance with specific tasks, including giving guidance and advice, designing questionnaires, conducting specialised laboratory analyses and checking and correcting data.

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