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GEOGRAPHICAL PATTERNS OF CANCER MORTALITY IN CHINA

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Abstract—This research note discusses the China cancer mortality data and the methodological problems involved in spatial analysis of these data. Some of the research findings produced by mapping and analyses of the cancer data at the provincial level are also summarized. The two most common cancers in China, stomach and esophagus, were found to have no significant correlation with some selected physical variables and population density, suggesting the need to examine other socio-economic variables such as dietary habit. The study also suggests that the type of diet which may be responsible for these two cancers could be very different from each others. Colon and rectum, leukemia, and breast cancers were found to have very high positive spatial autocorrelation and high correlation with population density—a result contrary to previous findings in the West. Future research using a geographic information system approach and county data is suggested.

Key words—China, cancer mortality, geographic information systems, computer mapping, spatial autocorrelation, factor analysis

INTRODUCTION

The study of geographical variations in cancer mortality has often been regarded as an effective means of deriving etiologic hypothesis [1]. Numerous studies on the geographical patterns of cancer mortality in the United States and other parts of the world have been made (see for examples [2] and [3]). The geographical pattern of cancer mortality in China, however, has not yet been systematically studied, partly because of the unavailability of data in the past. This is unfortunate since China has almost a quarter of the world's population and has a wide variety of environments. Studies on the geographical variations of cancers in China can provide a better understanding of how these cancers affect China and could also enhance comparisons among different countries with particular reference to the search for the causes of cancers.

The recent publication of an atlas of cancer mortality in China, based on data collected in 1973–75, emphasizes the importance of such geographical variations [4]. In the atlas, the sex-specific rates of the nine most common cancers by xian (i.e. county) are generalized and shown in the form of choropleth maps. In addition, the original sex-specific mortality rates by provinces are listed as tables. (There are 2392 counties in mainland China, belonging to 29 provinces, autonomous regions and municipalities; Fig. 1.) These mortality rates are age-adjusted to the 1964 census population of China, the 1960 world standard population, and the 1960 world standard population between 35 and 64 years old. This is perhaps the earliest set of data in China that has been systematically collected and recorded at the county level.

Many researchers believe that most cancers are caused by environmental factors and are therefore theoretically preventable once the causal factors have been identified [5]. It will be useful to study the case of China so that preventive measures could be made promptly during China's rapid pace of modernization. Since the cancer data at the county level are not yet available outside China, a geographical study based on the provincial data is made. In this study, the nine most common cancers in China, which lead to a total of 16 sex-specific sites, were mapped by computer. Spatial autocorrelation analysis and factor analysis were applied to examine the cancer map patterns and their relationships with environmental factors. The findings from this study may not be further generalized simply because the study was based on provincial data. Conclusive statements about cancer patterns in China must await data of a finer resolution (i.e. by county). The objective of this study is to illustrate the geographical patterns at the provincial scale [6, 7], which serves as a useful supplement to future studies of this region using more detailed data.

The purposes of the present research note are: (1) to outline the data and to discuss some methodological problems involved in studying China's cancer mortality patterns; (2) to highlight some of the interesting findings from the study, focusing on the two most common cancers, stomach and esophagus, in China; and finally (3) to identify possible research directions in the China case.

METHODOLOGICAL PROBLEMS

In studying the geographical patterns of disease mortality, at least six methodological problems should be considered [1, 7]. First, the mortality rate used does not necessarily reflect the rates of occurrence because some cancers are more likely to lead to mortality than others. Second, the place of death may be different from the place of residence where the disease was acquired. This is particularly the case

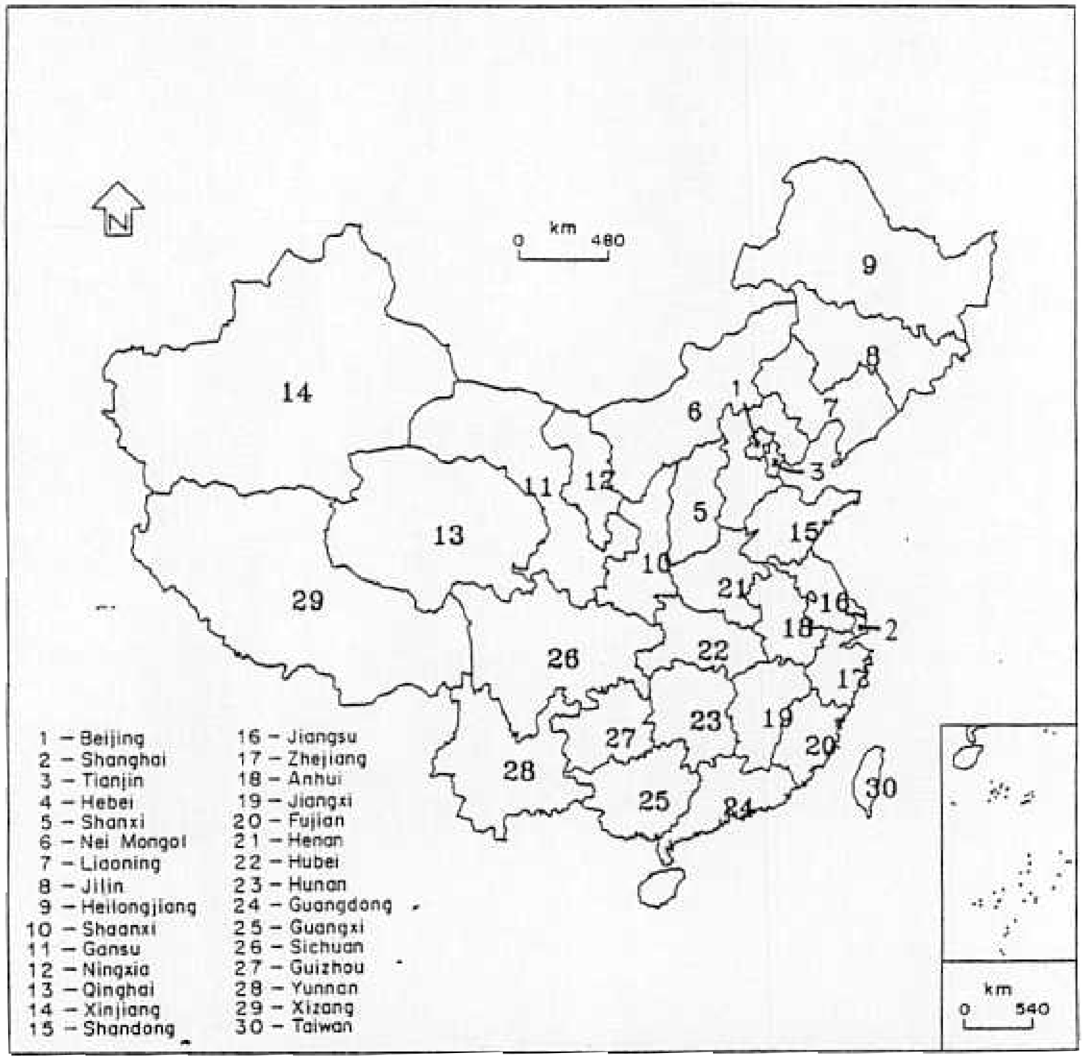

Fig. 1. Provinces, municipalities and autonomous regions of China.

where migration occurs frequently. However, it should be noted that migration is fairly restricted in China. Therefore, if environmental factors do play an important role in causing cancers, they should be detected more easily in China than in other countries such as the United States where migration is frequent among the population. Third, the findings from data of one scale may be different from those of another scale. Therefore, we should interpret the findings with due consideration to the effect of scale in order to avoid the ecological fallacy. On the other hand, scale may also help to determine the nature of more intensive studies in the future.

Fourth, high mortality does not necessarily suggest prevalence of certain environmental factors but may be a result of lack of preventive health measures. This problem has seldom been mentioned, but it may be a significant aspect particularly in developing countries. Fifth, correlations found between environmental factors and cancer sites do not necessarily imply causation. The results of this type of study may be suggestive but they can rarely be definitive. Last but not least, a comprehensive analysis of the geographical variations of cancers using more detailed data for a large region is often a major task of data processing, analysis, and mapping. This is perhaps why studies using more detailed data for a large region have rarely been made. The problem is further complicated by the fact that attempts are often made to correlate cancer data with other types of data (e.g. census, soil type, vegetation cover), but these various sets of data may not be based on the same areal units [8, 9]. Recent developments in geographic information systems which permit the use of more detailed data could contribute to the study of the geographical variations of cancers as well as to health prevention in general [10].

CANCER MORTALITY PATTERNS IN CHINA—SOME HIGHLIGHTS

The data collected for the period 1973–75 reveal that the total number of deaths due to cancer is about 700,000 per year, or about 11% of the annual total mortality. The national average age-adjusted cancer mortality rate is 80.17 per 100,000 for male, and 54.27

Table 1. Rank-order of the 16 most common sex-specific cancers

Rank	Cancer site	National rate (deaths/100,000)*
1	Stomach-M	20.93
2	Stomach-F	10.16
3	Esophagus-M	19.68
4	Esophagus-F	9.85
5	Liver-M	14.52
6	Liver-F	5.61
7	Cervix uteri	9.98
8	Lung-M	6.82
9	Lung-F	3.20
10	Colon and rectum-M	4.08
11	Colon and rectum-F	3.03
12	Leukemia-M	2.79
13	Leukemia-F	2.23
14	Breast-F	2.61
15	Nasopharynx-M	2.49
16	Nasopharynx-F	1.27

*Age-adjusted to the 1964 census population of China.

per 100,000 for female. On average, one person will die of cancer every 45 sec in China. During the 1973–75 period, cancer was the second cause of death for male and the third for female. Furthermore, cancer severely affects the young and working population. It was the leading cause of death for the age group of 35–74, and the second leading cause of death for the age group of 15–34.

The nine most common cancers in China are, in decreasing order of magnitude, stomach, esophagus, liver, cervix uteri, lung, colon and rectum, leukemia, breast, and nasopharynx. Table 1 lists the sex-specific rates of these nine most common cancers. It shows that for the same cancer female always has lower mortality than male. With regard to the spatial patterns, both the maps at the provincial scale and at the county scale show the existence of large spatial variations within and among various cancers, whereas the spatial patterns between male and female for the same cancer are generally very similar. This is also reflected by the spatial autocorrelation analysis and the factor analysis using provincial data, in which male and female for the same site were found to have similar spatial autocorrelation statistics and generally belong to the same factor.

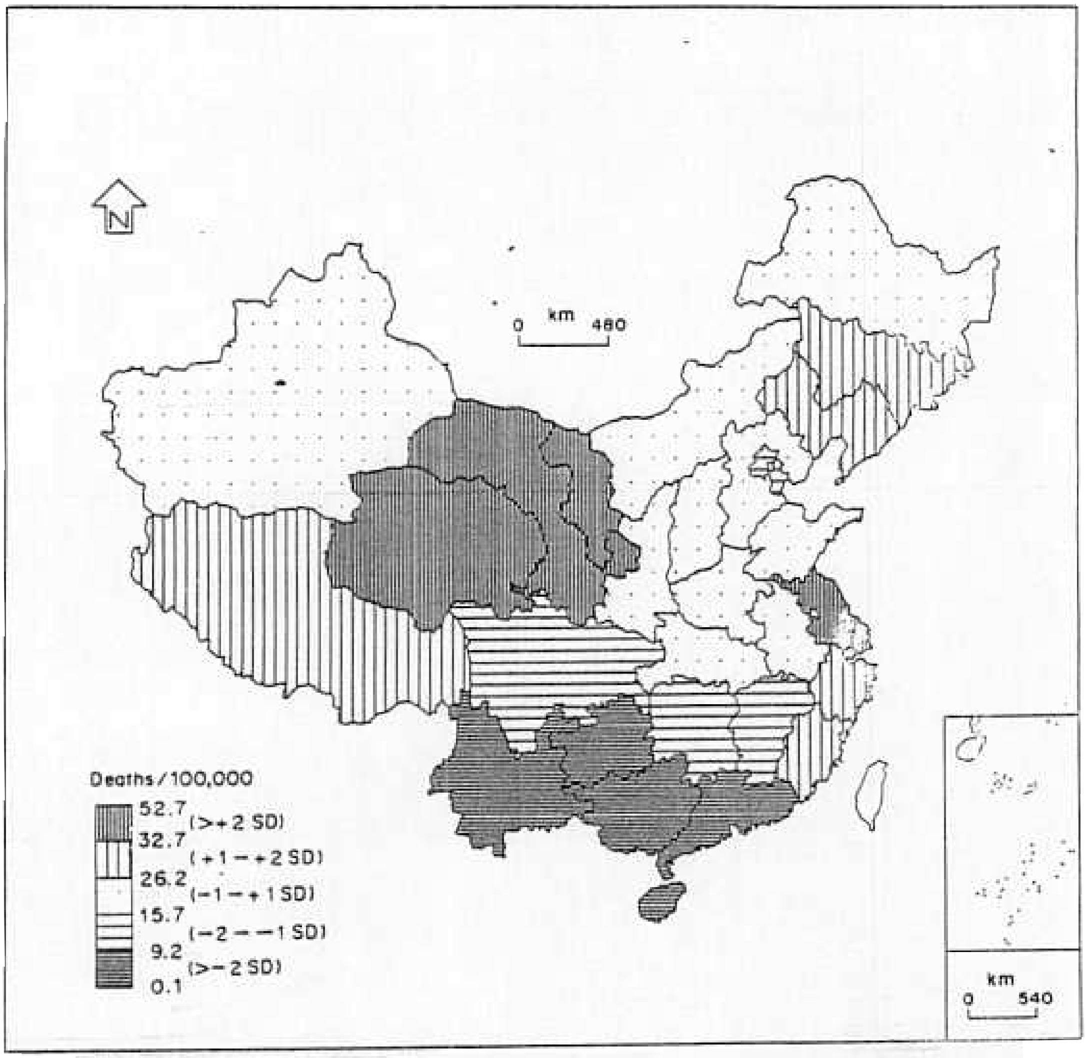

Fig. 2. Mortality map of stomach cancer for male, by province, municipality and autonomous region. Age-adjusted to 1964 census population of China.

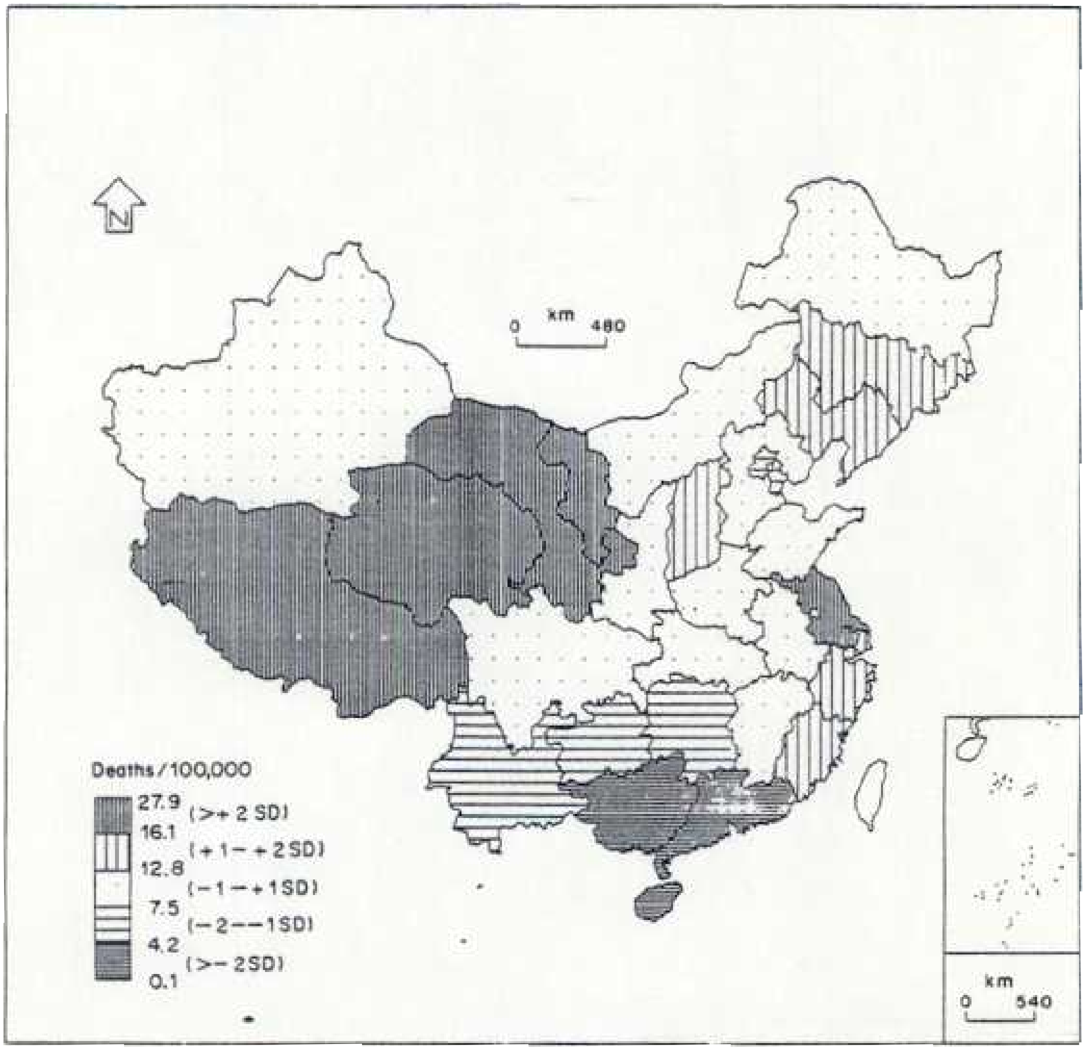

Fig. 3. Mortality map of stomach cancer for female, by province, municipality and autonomous region. Age-adjusted to 1964 census population of China.

When the mortality rates are mapped at the provincial scale, the spatial patterns of some of the cancer sites can be detected and compared more easily. The patterns of the two most common cancers, stomach and esophagus, are used as examples here. For stomach cancer, China's leading form of cancer deaths, both male and female have high rates in the west and north-west, including Xizang, Qinghai, Ningxia and Gansu (Figs 2 and 3). These provinces are characterized by a cool and dry climate, low population density, high concentration of minority groups, and a low level of economic development. However, the Jiangsu Province on the east coast with a warm and wet climate, high population density, low concentration of minority groups, and a high level of economic development also has high stomach mortality rates for male and female.

In comparison, Japan, Chile and the northern European countries have high rates of stomach cancer. In the United States, Canada, England, Australia and New Zealand, stomach cancer mortality is still high but has been declining. Previous studies suggested that stomach cancer was associated with indices of poor social conditions [11], rural and semi-rural areas [12], poor drinking water quality [13] and special dietary and ethnic background [14, 15]. On the other hand, conflicting reports on the relationships between stomach cancer and the rate of primary industry in Japan have also been made [2]. Based on the map patterns shown here, it is expected that stomach cancer in China is generally related to the dietary and ethnic background, and the level of economic development.

Esophagus cancer, the second highest cancer deaths in China, has a very different spatial pattern from stomach cancer. Areas of high stomach mortality generally coincide with low esophagus mortality, and vice versa. Both male and female esophagus cancers show high rates clustering in the north-central and eastern parts of China (Figs 4 and 5). An exception is Jiangsu Province where mortality rates for both cancers are high. Esophagus cancer is less common in the United States, Canada and England but more common in central Asia. Previous studies indicated a strong association between this cancer and dietary habits as well as hygiene condition [16, 17]. However, based on the map patterns shown here, it is suspected that the dietary habits could be very different from those associated with stomach cancer. It is also noted that the southern part of China has very low mortality rates in both stomach and esophagus cancers. This region is characterized by a warm and wet climate, and the dietary habit in this region is also quite different from the north-central and western part of China. For example, pickled vegetables, which were found to be related to esophagus cancer, are much more common in the diet of the north and central part of China than in the south [16]. On the other hand, salted fish, a common diet in the south (especially in the Guangdong Province), was found to be related to nasopharyngeal cancer.

The difference in the spatial patterns between stomach and esophagus cancers is also highlighted by factor analysis. Factor analysis of the 16 sex-specific cancer sites reveals that these two cancers are associated with different factors. Pearson correlation coefficients between the factor scores of these two factors and some selected variables were calculated. These variables include: population density in 1973 [18, 19], elevation, temperature, rainfall, latitude and longitude [20, 21]. No significant correlation was found between these two factors and the selected variables, indicating the need to examine other variables in the future, particularly those related to socio-economic condition and dietary habit.

Another interesting finding from this study relates to colon and rectum, leukemia and breast cancers. These cancers exhibit a random pattern at the county level, but when the data are aggregated at the provincial level, the patterns become highly concentrated. In the cases of colon and rectum cancer and leukemia for both sexes, high rates occur along the east coast, especially in Jiangsu, Zhejiang, Fujian and Shanghai. These provinces are generally more populated and urbanized. Highest rates of breast cancer occur in the three municipalities of Beijing, Tianjin and Shanghai, and their surrounding areas. It is

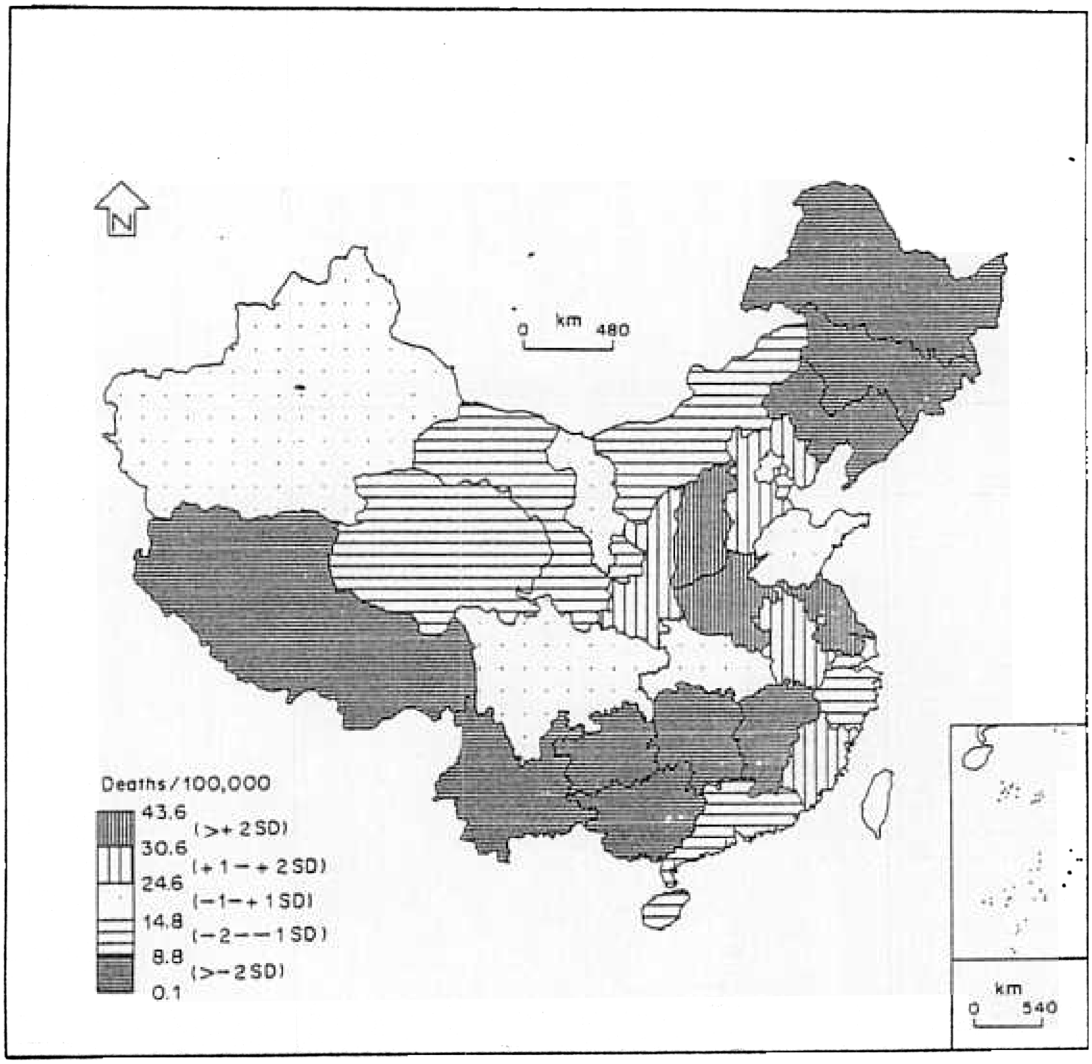

Fig. 4. Mortality map of esophagus cancer for male, by province, municipality and autonomous region. Age-adjusted to 1964 census population of China.

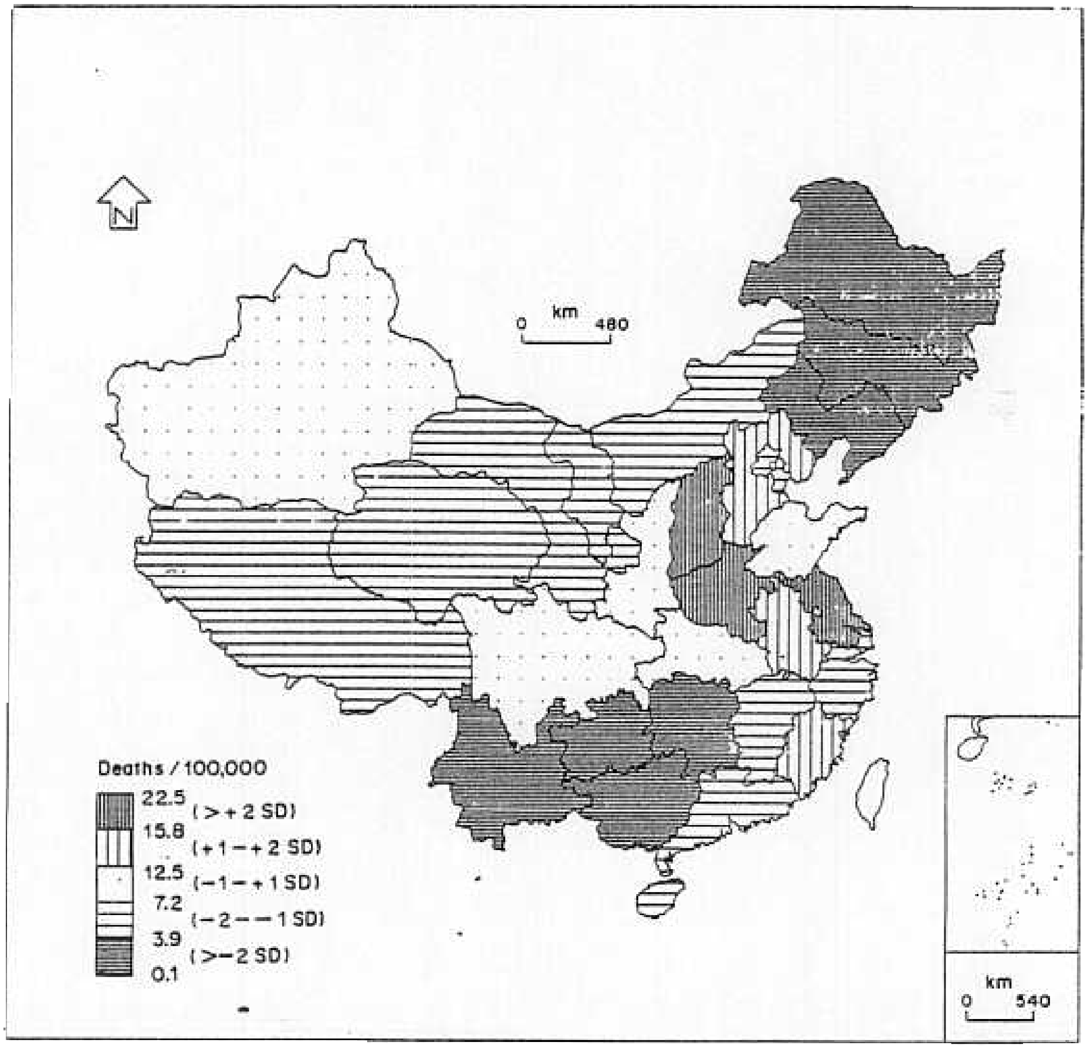

Fig. 5. Mortality map of esophagus cancer for female, by province, municipality and autonomous region. Age-adjusted to 1964 census population of China.

notable that colon and rectum and breast cancers are also the predominant causes of cancer deaths in highly developed countries such as United States, Canada and England, but these two cancers are less common in China. Based on their map patterns, it is expected that these cancers are related to factors generated from areas of intensive urbanization and population density. These factors may include, for example, high degrees of air, water and noise pollution produced by intensive automobile use, and a high density of factories and population.

The factor analysis shows that colon and rectum, leukemia and breast cancers for both male and female, together with male and female lung cancers, form a distinct group and score high on factor I. Factor I was found to be highly correlated with population density, a result of urbanization and industrialization. Factor I was also found to be significantly related to elevation and longitude. These relationships seem to be indirect because lower elevation is likely to attract more people and the east coast of China has all the major urban centers.

The highly clustered patterns of the above cancers are also reflected by the high positive spatial autocorrelation statistics calculated from their patterns. This is quite different from Glick's study of the cancer patterns in Pennsylvania [6] where leukemia and breast cancers were found to have very low and insignificant autocorrelation at the county level. It is not clear at this stage whether such difference is solely due to differences in scale or a result of environmental differences between these two places.

FUTURE RESEARCH

This research note focuses attention on the methodological problems involved in spatial analysis of cancer data in general and with special reference to China. It also highlights some of the findings produced by mapping and examining the cancer mortality rates at the provincial level. Some of the findings agree with results from other regions (e.g. those related to stomach and esophagus cancers), but some do not (e.g. those related to colon and rectum, leukemia and breast cancers).

This study also points to the need for data at the county level in order to thoroughly examine the spatial patterns of cancer mortality and to accurately identify the environmental factors. This means a major task of data collection because both the age- and sex-specific rates and a set of physical and socio-economic variables will be required. Such detailed studies involving voluminous data (about 2392 counties) could be made more efficiently by using a geographic information system approach. Research along these lines is being conducted by the author.

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REFERENCES

1. Mayer J. D. The role of spatial analysis and geographic data in the detection of disease causation. *Soc. Sci. Med.* **17**, 1213, 1983.
2. Inaba Y., Yanai H., Takagi H. and Yamamoto S. A study of the geographical patterns of cancer mortality for selected sites by means of factor analysis. *Soc. Sci. Med.* **15D**, 233, 1981.
3. Babin E. United States cancer mortality regions: 1950–69. *Soc. Sci. Med.* **13D**, 39, 1979.
4. Editorial Committee. *The Atlas of Cancer Mortality in the People's Republic of China.* China Map Press, Beijing, 1979.
5. Glick B. J. The spatial organization of cancer mortality. *Ann. Ass. Am. Geogr.* **72**, 471, 1982.
6. Glick B. J. The spatial autocorrelation of cancer mortality. *Soc. Sci. Med.* **13D**, 123, 1979.
7. Cleek R. K. Cancers and the environment: the effect of scale. *Soc. Sci. Med.* **13D**, 241, 1979.
8. Goodchild M. F. and Lam N. S-N. Areal interpolation: a variant of the traditional spatial problem. *Geoprocessing* **1**, 297, 1980.
9. Lam N. S-N. Spatial interpolation methods: a review. *Am. Cartograph.* **10**, 129, 1983.
10. Pyle G. F. *Applied Medical Geography*, Chap. 8. Wiley, New York, 1979.
11. Stocks P. *Regional and Local Differences in Cancer Death Rates.* General Register Office, Studies on Medical and Population Subjects, No. 1, London, HMSO, n.d.
12. Statistics Canada. *Mortality Atlas of Canada, Vol. I: Cancer.* Canadian Government Publishing Center, Hull, Quebec, 1980.
13. McGlashan N. D. European male stomach cancer in South Africa: a cartographic appraisal. In *Medical Geography* (Edited by McGlashan N. D.), pp. 187–198. Methuen, London, 1972.
14. Chalkin A. V. The geographical distribution of cancer in the Soviet Union. *Sov. Geograph.* **3**, 59, 1962.
15. Mason T. J., Mackay F. W., Hoover R., Blot W. J. and Fraumeni J. F. Jr. *Atlas of Cancer Mortality for U.S. counties 1950–1969.* U.S. Government Printing Office, Washington, D.C., 1975.
16. WGBH/BBC. The cancer detection of Lin Xian. *Nova Series*, 1981.
17. McGlashan N. D. Food contaminants and oesophageal cancer. In *Medical Geography* (Edited by McGlashan N. D.), pp. 247–257. Methuen, London, 1972.
18. Pannell C. W. and Ma L. J. C. *China—The Geography of Development and Modernization*, p. 111. Halsted Press, New York, 1983.
19. *Tai Kung Pao* (Tai Kung Newspaper), Hong Kong, October 30, 1982.
20. Wu J. Y. (Ed.) *The Vegetation of China*, pp. 33–120. Science Press, Beijing, 1980.
21. Central Meteorological Office. *The Climatic Atlas of China.* China Map Press, Beijing, 1978.