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THE DISTRIBUTION AND IMPACT OF HEALTH RESOURCE AVAILABILITY IN CHINA*

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SUMMARY

Since 1949, China's progress in mortality reduction has far exceeded that experienced by other developing countries with comparable levels of national income. This achievement has taken place in the context of a development strategy oriented, in part, to the elimination of the worst aspects of poverty. Using recent cross-section data, this paper provides a statistical assessment of the extent to which health resources are evenly distributed in contemporary China, and the degree to which improvements in health resource availability may account for the observed variation in mortality levels. Contrary to expectation, the analysis finds that substantial inequalities do remain in the distribution of health resources, and that these differentials are principally associated with levels of urban income and urbanization. However, these differences in health resource availability do not appear to explain the significant variation which also persists in mortality levels, a finding consistent with the results of similar analyses for developed countries.

KEY WORDS: China; Mortality; Hospital beds; Health manpower; Regression analysis

INTRODUCTION

Before 1949, China's population suffered a crippling burden of disease and premature death. Perhaps the most striking success of China's subsequent struggle against poverty and inequality has been a dramatic increase in life expectancy, accompanied by a reduction in the burden of illness. Life expectancy has more than doubled from only about 32 years in 1950 to 69 years in 1982—some twenty years greater than the average for other low-income countries, and only six years less than in the industrialized market economies.

The successes associated with modern Chinese health policy have attracted considerable attention throughout the developing world. Indeed, China's policy emphases on prevention, barefoot doctors, and community resource mobilization strongly influenced the 1978 Alma-Ata declaration on achieving Health for All by the Year 2000 through a strategy of primary health care. The implementation of these policies has also been accompanied by a rapid growth in the availability of conventional health resources, as measured in terms of hospital beds and health manpower. Since 1952 the availability of hospital beds has increased sevenfold from 0.28 to 2.07 per 1000, while that of doctors has nearly doubled from 0.74 to 1.32 per 1000 (State Statistical Bureau, 1984).

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These developments in policy, resource availability and mortality reduction provoke important practical questions about the lessons that may be learned from China's experience to help guide other developing countries which have set ambitious goals for health improvement. To what extent has China equalized the distribution of health resource availability? And to what extent can these improvements in resource availability account for the dramatic gains in life expectancy which China has achieved? In this paper we provide a statistical assessment of evidence relevant to answering these questions. Related papers assess factors influencing fertility levels in China (Birdsall and Jamison, 1984) and nutritional status (Jamison *et al.*, in preparation). Extensive background material and data sources for the Chinese health sector are provided in Jamison *et al.* (1984) and Prescott *et al.* (1983).

Most previous literature attempting to assess the impact of aggregate measures of health resource availability has examined cross-country variation. To take an example that used countries as the unit of analysis, and data from 131 member states of the World Health Organization, Fulop and Reinke (1981) found that, controlling for a country's income level and other characteristics, an increase in the number of physicians per capita was statistically significantly associated with higher levels of life expectancy. The magnitude of the effect was, however, small; they estimated that a 35 per cent increase in the number of physicians per capita would be required to effect a one-year gain in a country's life expectancy. Auster *et al.* (1969) conducted an early study of this genre; using data on individual states of the USA they found availability of medical services to have a beneficial (though weak) effect on mortality rates. Higher average levels of education, on the other hand, had a strong beneficial effect on mortality. Mendelson and Orcutt (1979) have used similar methods to assess the impact of air pollution on mortality; they showed that specific pollutants can be clearly related to mortality of particular types in particular age ranges. Cochrane and her co-workers (Cochrane, 1980; and Cochrane *et al.*, 1982) have reviewed many analyses, concluding that improved education levels lead to reduced mortality and improved health. Paradoxically, the evidence relating health service availability to improvements in mortality reveals a mixed picture. In contrast to Fulop and Reinke, Cochrane *et al.* (1978) and Newhouse and Friedlander (1980), to take two examples, found no beneficial relation between medical inputs and mortality or physiological measures of health status, respectively. The reviews of Cochrane (1980) and Preston (1976) concerning the effect of income levels on mortality also showed mixed results.

In the sections that follow in this paper, we utilize similar methods to examine the case of China and extend previous research by assessing determinants of the distribution of resources. We begin with a discussion of data and methods; then follow sections presenting the main results. A final section draws conclusions.

DATA AND METHODS

The empirical basis for our analysis is provided by cross-sectional data available for the 29 provincial-level administrative units in China (provinces, autonomous regions and municipalities). These data are relatively recent, relating in most cases to the years 1981 or 1979, and for the most part are available for all 29 provincial units. The definitions for the variables used are presented in Table 1.

Our measures of health resource availability are both physical and financial. Data on hospital facilities are for total hospital beds of all types; general hospital beds (excluding hospitals of traditional medicine, hospitals affiliated with medical colleges, mental hospitals, tuberculosis hospitals, commune health centers and certain other categories); and commune health center beds only. Data on health manpower are for all salaried health workers; all doctors (including senior plus assistant doctors of Western and traditional medicine, but excluding barefoot doctors); and barefoot doctors only. With the exception of commune health centers and barefoot doctors, each of these physical resources does, in principle, serve the entire population of each province, so that its

Table 1. Provincial variables: Definitions

*HOS*81	Total hospital beds per 1000 population, 1981
*HOS*79	Total hospital beds per 1000 population, 1979
*GENHOS*81	General hospital beds per 1000 population, 1981
*SHW*81	Salaried health workers per 1000 population, 1981
*SHW*79	Salaried health workers per 1000 population, 1979
*DOC*81	Total doctors (senior plus assistant Western and traditional) per 1000 population, 1981
*CHC*81	Commune health center beds per 1000 rural population, 1981
*BFD*81	Barefoot doctors per 1000 rural population, 1981
*REXP*81	Public recurrent expenditure on health, 1981 (yuan)*
*CEXP*81	Public capital expenditure on health, 1981 (yuan)*
*LEXP*75	Life expectancy at birth, 1973–75 (years)
*CDR*81	Crude death rate, 1981 (per 1000)
AUT	Dummy variable indicating autonomous region or not
*ILLIT*82	Per cent of population who are illiterate or semiliterate and aged over 12 years, 1982
*TOTINC*81	Total income per capita, 1981 (yuan)*
*URBINC*81	Urban income per capita, 1981 (yuan)*
*RURINC*81	Rural income per capita, 1981 (yuan)*
*TOTINC*79	Total income per capita, 1979 (yuan)*
*URBINC*81	Urban income per capita, 1981 (yuan)*
*RURINC*79	Rural income per capita, 1979 (yuan)*
*URB*81	Proportion of population in urban areas, 1981
*URB*79	Proportion of population in urban areas, 1979

*US$1.00 = Yuan 1.71 in 1981 and US$1.00 = Yuan 1.55 in 1979.

availability can be measured as the ratio per 1000 population in the province. In contrast, barefoot doctors and commune health centers serve exclusively the rural population and, hence, are measured as ratios per 1000 rural population in each province. Our financial measures of health resource availability refer to budgetary appropriations through the Bureau of Public Health at provincial and lower levels (prefecture and county) of government, excluding state subsidies to the Government and Labor Insurance schemes. These budgetary outlays, measured separately for recurrent and capital expenditure per capita, are quantitatively important and account for about one quarter of estimated total health expenditure in China (Prescott and Jamison, 1984).

Our measures of mortality are limited and somewhat unsatisfactory. The life expectancy data refer to levels prevailing between 1973 and 1975: they have been estimated by Young (1981) for 24 of the 29 provincial-level units on the basis of data generated by the national cancer survey, which was undertaken during those years. The data on crude death rates for 1981 were generated by the Population Census carried out in 1982. More recent provincial data on life expectancy or age-specific death rates would have been preferable, but await publication of the detailed results of the 1982 Census.

Our data set also includes estimates of total, urban and rural income per capita; and the percent urban population for 1979 and 1981. Since official estimates of the provincial distribution of incomes are not available, or are incomplete, we have constructed our own estimates for both 1979 and 1981. Urban income per capita is measured as the average urban wage rate in each province, weighted by the national average urban participation rate in those two years. Rural income per capita, for 1979 and 1981 respectively, is estimated by inflating provincial collectively distributed income per capita and rural household expenditure per capita by the national ratios of rural net income to these variables. For each province, total income per capita is then derived as the population-weighted average of urban and rural income per capita. The data on percent urban population in each province are official estimates defined to include the population of cities, county towns, and some towns below the county level, but to exclude their agricultural sub-populations. Finally, we use the illiteracy rate in 1982 as an inverse proxy for the level of education. This measures the percent of the population who are aged over 12 years and who are illiterate or only semiliterate.

The statistical procedures we use are straightforward. First, we analyze coefficients of variation in the cross-sectional data on health resource availability, in order to evaluate the distribution of these variables across provinces. In general, our hypothesis is that these variables are relatively evenly distributed given the egalitarian emphasis of China's development strategy. We then use ordinary least squares to regress these dependent variables on other independent variables in order to test hypotheses about the determinants of the interprovincial variations that we observe specifically we test and expect to reject the hypothesis that provincial differences in resource availability are systematically associated with different levels of income and urbanization, and to confirm the hypothesis that mortality levels are not determined by the availability of health resource inputs (as found in some of the analyses referred to previously).

We recognize that the aggregated and cross-sectional nature of our statistical observations precludes the inference of firm causal conclusions, but the empirical results are nonetheless strongly suggestive.

EMPIRICAL RESULTS: HEALTH RESOURCE AVAILABILITY

Interprovincial variations

The summary statistics, for the variables we have used, are given in Table 2. This Table shows that the range of variation, from minimum to maximum values, in our measures of provincial health resource availability is quite large. For example, the availability of total hospital beds in 1981 (*HOS* 81) varied from only 1.38 per 1000 in Guangxi to 4.29 per 1000 in Shanghai; while recurrent expenditure per capita in the same year (*REXP* 81) varied from 2.24 yuan in Anhui to 15.33 yuan in Tibet.

A more revealing test of relative equality is, however, provided by examining the shape of these distributions. For this purpose, we use the coefficient of variation across provinces, measured as the ratio of the standard deviation to the mean of the distribution of provincial resource availability. The greater the

Table 2. Provincial variables: summary statistics

	Mean (*unweighted*)	Min	Max	Standard deviation	*N*
*HOS*81	2.29	1.38	4.29	0.71	29
*HOS*79	2.00	1.32	4.26	0.68	29
*GENHOS*81	1.21	0.65	2.29	0.49	29
*SHW*81	3.69	2.07	9.00	1.74	29
*SHW*79	3.30	1.79	8.28	2.55	29
*DOC*81	1.57	0.88	4.20	0.80	29
*CHC*81	0.87	0.35	1.48	0.30	29
*BFD*81	1.73	0.56	2.85	0.58	29
*REXP*81	4.39	2.24	15.33	2.84	29
*CEXP*81	0.77	0.27	2.41	0.56	28
*LEXP*75	65.53	59.25	71.97	3.65	24
*CDR*81	6.54	4.95	9.92	1.14	29
AUT	0.17	0	1	0.38	29
*ILLIT*82	36.38	15.10	78.30	14.48	29
*TOTINC*81	270.66	183.81	471.03	69.60	29
*URBINC*81	438.57	369.24	613.43	56.20	29
*RURINC*81	238.31	158.35	456.51	69.48	29
*TOTINC*79	186.34	99.63	386.22	64.15	29
*URBINC*79	370.08	311.58	517.63	47.42	29
*RURINC*79	152.59	73.51	359.40	55.22	29
*URB*81	0.19	0.08	0.58	0.14	29
*URB*79	0.18	0.07	0.57	0.14	29

coefficient of variation the greater the degree of inequality, and conversely. Contrary to our hypothesis these estimates, shown in Table 3, clearly indicate the existence of substantial inequalities in all types of health resource availability. The degree of inequality is less pronounced for hospital beds and health manpower, but is extreme for the distributions of both recurrent and capital expenditure per capita.

Table 3. Coefficients of variation in health resource availability

	Coefficient of variation
Hospital beds:	
*HOS*81	0.31
*GENHOS*81	0.41
*CHC*81	0.35
Health manpower:	
*SHW*81	0.47
*DOC*81	0.51
*BFD*81	0.34
Health expenditure:	
*REXP*81	0.92
*CEXP*81	1.04

Determinants

Our hypothesis of a relatively equal distribution of resources reflected the expectation that China's redistributive development strategy would have modified the influence of inequalities of income level and urbanization which typically account for the unequal distribution of resource availability in other developing countries. We now provide a multivariate test of the hypothesis that these determinants are unimportant in explaining the inequality which we do observe.

Our resource availability variables for each province are weighted averages of their urban and rural values which we do not observe directly. Thus, in general, our dependent variable in province i, which we denote Z_i, can be written as an identity:

$$Z_i = (URBZ_i)URB_i + RURZ_i\,(1-URB_i), \qquad (1)$$

where URB_i denotes the proportion urban in the province and $URBZ_i$ and $RURZ_i$ denote the value of Z_i in urban and rural areas, respectively. We hypothesize that the urban and rural values of Z_i are linear functions of urban and rural incomes, respectively. Thus:

$$URBZ_i = \alpha_0 + \beta_0\,(URBINC_i); \text{ and} \qquad (2)$$

$$RURZ_i = \alpha_1 + \beta_1\,(RURINC_i). \qquad (3)$$

Substituting equations (2) and (3) into equality (1) we obtain the reduced form:

$$Z_i = \alpha_1 + (\alpha_0 - \alpha_1)URB_i + \beta_0(URBINC_i)^* + \beta_1(RURINC_i)^*, \quad (4)$$

where

$$URBINC_i^* = (URBINC_i)(URB_i), \text{ and } RURINC_i^* = (RURINC_i)(1 - URB_i).$$

Estimation of the reduced form equation (4) as a multiple regression equation enables us to assess the direction, magnitude and statistical significance of the relationship between our measures of resource availability and levels of urban income, rural income and urbanization. It also enables us to estimate elasticities measuring the percentage change in resource availability that is statistically associated with a percentage change in each of these independent variables.

The regression results for equation (4) are presented in Table 4. These results are extremely powerful, with high values of $\bar{R}^2$ indicating that this specification of the regression model explains much of the observed variation in all types of health resource available, especially in the density of health manpower. In addition, the individual regression coefficients estimated for urban income and urbanization are consistently significant at the 95% confidence level. Rural income levels, however, are generally not statistically significant, except in the determination of recurrent expenditure levels. These results clearly fail to support our initial hypothesis; rather, they strongly indicate that all types of health resources are more densely available in a province the greater the level of its urban income and the higher the level of urbanization.

The magnitude of the impact of these independent variables is shown by the estimated elasticities presented in Table 5. These are defined as the partial

Table 4. Determinants of health resource availability

Independent variables	Dependent variables					
	*HOS*81	*GENHOS*81	*SHW*81	*DOC*81	*REXP*81	*CEXP*81
*URBINC*81*	0.028	0.037	0.045	0.029	0.161	0.026
	(2.944)	(5.681)	(4.572)	(4.418)	(4.005)	(2.538)
*RURINC*81*	***	***	***	***	0.025	***
	(0.256)	(−0.483)	(1.069)	(0.930)	(3.624)	(0.395)
*URB*81	−9.417	−15.466	−9.524	−8.700	−63.291	−10.148
	(−2.066)	(−4.987)	(−2.030)	(−2.758)	(−3.315)	(−2.057)
AUT	...	...	...	...	1.857	...
					(2.193)	
Constant	1.596	1.099	1.323	0.519	−2.438	0.302
$\bar{R}^2$	0.673	0.688	0.943	0.878	0.681	0.405

Notes: *** denotes a value less than 0.001
t-statistics are given in parentheses

derivative of the dependent variable with respect to the independent variable, divided by the ratio of the dependent to the independent variable. For equation (4) the relevant partial derivatives are:

$$\frac{\partial Z}{URBINC} = \beta_0(URB), \tag{5}$$

$$\frac{\partial Z}{URBINC} = \beta_1(1-URB), \tag{6}$$

$$\frac{\partial Z}{URB} = (a_0-\alpha_1) + \beta_0(URBINC) - \beta_1(RURINC). \tag{7}$$

We evaluate the elasticities using the estimated regression coefficients (from Table 4) together with the relevant sample means (from Table 2). The results indicate that levels of urban income have the greatest quantitative impact on resource availability. With reference to Table 5, it can be seen that a one per cent increase in urban income is associated with: a 1.0 per cent increase in the density of hospital beds and salaried health workers; a 1.5 per cent increase in the density of doctors; a 2.5 per cent increase in the density of general hospital beds; and, about a 3.0 per cent increase in levels of both recurrent and capital expenditure. The impact of levels of urbanization is quantitatively much smaller, although consistently positive. In this case the pattern of results is somewhat different, with urbanization exerting greater impact on the availability of health manpower and less on recurrent expenditure levels. The impact of rural income levels is negligible except for recurrent expenditure.

Table 5. Elasticities of health resource availability

Dependent variables	Independent variables		
	*URBINC*81	*RURINC*81	*URB*81
*HOS*81	1.02	0.00	0.24
*GENHOS*81	2.55	0.00	0.12
*SHW*81	1.02	0.00	0.53
*DOC*81	1.54	0.00	0.49
*REXP*81	3.10	0.33	0.02
*CEXP*81	2.85	0.00	0.31

Urban–rural differentials

Our regression estimates also permit us to extend our analysis of inequalities in resource availability by providing indirectly the parameters of the structural equations (1) and (2) from the coefficients estimated for the reduced form equation (4). Again, using these coefficients and the sample means given in Table 2, we can estimate levels of urban and rural resource availability given

Table 6. Urban–rural differentials in health resource availability

	Urban	Rural	Ratio
*HOS*81	4.45	1.60	2.78
*GENHOS*81	1.84	1.10	1.67
*SHW*81	11.54	1.32	8.74
*DOC*81	5.54	0.52	10.65
*REXP*81	4.88	3.52	1.39
*CEXP*81	1.56	0.30	5.20

average levels of urban and rural income in China. These estimates are provided in Table 6 and again indicate that levels of resource availability are typically much higher in urban than in rural areas. Most striking are the estimates that there are approximately nine times as many salaried health workers, eleven times as many doctors, and five times as much capital expenditure per capita in urban areas as in rural areas.

EMPIRICAL RESULTS: MORTALITY LEVELS

China's impressive achievements in mortality reduction have not been uniform throughout the country. Life expectancy in the mid-1970s was estimated to vary from 59 years in Guizhou to 72 years in Shanghai. Crude death rates, estimated from the 1982 Census, ranged from 4.95 per 1000 in Heilongjiang to 9.92 in Tibet. However, we can note that the degree of variation in provincial mortality levels is far less than for the availability of health resources. Indeed, the coefficient of variation is only 0.06 for life expectancy and 0.18 for the crude death rate.

Based on the results of similar analyses conducted for other countries, we would expect that these provincial differences in mortality levels are not systematically associated with provincial differences in the availability of physical health resources. As before, we test this hypothesis using multivariate regression analysis to relate our mortality measures to our variables on resource availability. In this case, however, the lack of data on urban and rural values of resource availability precludes using the original reduced form specification of the model. Instead, we simply regress provincial mortality on provincial resource availability, while controlling for average income and education. For the life expectancy analysis, severe data limitations require us to use 1979 values, and in some cases 1981 or 1982 values, of the independent variables as proxies for their relative values up to the period 1973–75, a distinctly unreliable procedure.

In all of the regression results, presented in Tables 7 and 8, we find no statistically significant favorable effects, on life expectancy or the death rate, of any measure of health resource availability. Indeed, the pattern of results suggests the opposite conclusion. The only consistently significant finding is that increases in life expectancy, and reductions in the crude death rate, do appear to

Table 7. Determinants of life expectancy, 1973–1975

Independent variables	*LEXP75* [1]	[2]	[3]	[4]	[5]
TOTINC79	0.018 (2.078)	0.035 (2.574)	0.034 (1.672)	0.033 (1.894)	0.016 (1.666)
ILLIT82	−0.125 (−3.142)	−0.130 (−3.66)	−0.128 (−3.188)	−0.122 (−3.059)	−0.127 (−3.143)
HOS79	···	−2.071 (−1.575)	···	···	···
SHW79	···	···	−0.693 (−0.852)	···	···
DOC81	···	···	···	−1.325 (−0.984)	···
BFD81	···	···	···	···	0.697 (0.718)
Constant	66.521	68.241	66.013	65.676	65.840
$\bar{R}^2$	0.527	0.559	0.521	0.527	0.579

Note: *t*-statistics are given in parentheses.

be associated with improvements in literacy. However, the measurement errors inherent in these analyses severely qualify the value of these inferences.

DISCUSSION AND CONCLUSIONS

The analysis presented in this paper suggests two principal conclusions. The first is that, despite the egalitarian emphasis of China's development strategy (Trescott, 1985), the distributions of both physical and budgetary resources in the health sector remain substantially unequal, not only between provinces but also between urban and rural areas. Contrary to expectation, these inequalities appear to be very largely determined by levels of urban income and urbanization. This finding would not be at all surprising in almost any other developing country. But the fact that it appears to be also true in China emphasizes the great practical difficulty in achieving an effective redistribution of health resources to benefit poor rural populations. Indeed, current trends in Chinese economic policy are likely to increase these inequalities. The fiscal decentralization reform introduced in 1980 is intended to promote self-reliance on own fiscal revenues to finance services provided at each level of government. The resulting loss of fiscal transfers from higher levels of government has, if anything, made it more

Table 8. Determinants of the crude death rate, 1981

Independent variables	*CDR*81				
	[1]	[2]	[3]	[4]	[5]
*URB*81	0.600 (0.378)	−3.381 (−1.549)	−11.955 (−2.877)	−7.759 (−2.366)	0.337 (0.201)
*ILLIT*82	0.047 (3.067)	0.042 (2.928)	0.032 (2.268)	0.029 (1.909)	0.046 (2.929)
*HOS*81	...	0.946 (2.447)	...	...	...
*SHW*81	...	...	1.003 (3.199)	...	...
*DOC*81	...	...	...	1.442 (2.823)	...
*BFD*81	...	...	...	...	0.192 (0.570)
Constant	4.657	3.425	3.843	4.618	4.417
$\bar{R}^2$	0.268	0.386	0.460	0.423	0.249

Note: *t*-statistics are given in parentheses.

difficult to finance expansion of rural health services, and is likely to further increase differentials between urban and rural areas. Furthermore, increasing income inequalities generated by the recent rural responsibility reforms will also tend to exacerbate existing inequalities in health services provision within rural areas.

The second conclusion is that there appear to be no significant improvements in life expectancy that are associated with higher per capita availability of health manpower or hospital beds in a province. This finding must, however, be regarded as very tentative in view of the unsatisfactory nature of the data analyzed, although it is consistent with the results of some analyses in other countries. One explanation for the result may be that preventive policies and activities have accounted for much of the mortality decline experienced in China, and that these activities have been more uniformly distributed than health resource inputs. Health workers and hospital facilities may, nevertheless, play an important role in providing access to care, and in reducing the incidence and adverse consequences of morbidity. The analysis suggests that limited, if any, further gains in life expectancy can be expected from *quantitative* increases in the supply of health resources of the kind that have been analyzed. Furthermore, related analyses in Prescott *et al.* (1983) conclude that increases in income levels are associated with increases in age-adjusted morbidity rates for hypertension and in age-adjusted mortality rates for cancer. Thus, neither quantitative expansion of the existing health system nor general improvements in living standards hold much hope for further gains in life expectancy. Hence, an important priority may be to develop *qualitative* improvements in health manpower and hospital facility management combined with new preventive policies directed against the chronic diseases that are emerging from the epidemiological transition induced by China's past successes in communicable disease control.

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