Human Resources for Health in Rural China:

An assessment of the current situation and a proposed approach to project future needs

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Final Report Supplementation

[This report has been prepared by Jiming Zhu, Tian Zhao and Proochista Ariana with input from Mengjie Sun, Xiangshu Dong, and Xueqiong Gan]

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Country/Region: China
Full Name of Research Institution:
Center for Human and Economic Development Studies (CHEDS), Peking University

Name(s) of Principal Researcher/Members of Research Team and Contact Information:
Minquan Liu
Center for Human and Economic Development Studies (CHEDS), Peking University;

Junhua Zhang
Health Human Resources Development Center (HHRDC), Chinese Ministry of Health

Proochista Ariana
Departments of Public Health & International Development, University of Oxford

1. Overview on models for forecasting medical doctors

1.1 A brief introduction to existing models

Diverse models

Projecting and planning medical doctors is a highly interdisciplinary field. It has attracted a large number of experts from various backgrounds such as demography, epidemiology, economics, computer science and even engineering. Thus, it is not surprising to find a diverse set of models defined by the different disciplines.

From a conceptual perspective, models for forecasting medical doctors can be divided into two main groups, namely supply-side and requirement-side models. Supply-side modelling is relatively simple in theory, though technically more complicated. Supply-side models mainly take into account inflow and outflow of health workforce. Outflow indicates attrition of medical doctors due to retirement, death, emigration, alternative activities, etc. In addition to the international immigrants which deserve consideration in some developed countries, inflow pays considerable attention to the health workforce education system. The education and training systems for medical workforce vary in different countries and regions, but the key factors are the same: the number of qualified medical graduates, residency positions, and the length of education and training. The debate on the factors for inclusion is the focus of the supply side modelling .

When it comes to requirement-side modelling, it is even theoretically controversial. The dispute over the need-based and demand-based approach has lasted for almost a century (Weiner et al., 1987). The need-based approach intends to discern people's *need* for health services and related workforce independent of their demand for such services. Ideally, need is based on medically defined pathologies and indicators such as morbidity, mortality, or measures of established risk factors (e.g. smoking). Accordingly, it is not surprising to see that the measure of need relies on technical standards and professional judgment. The most discussed need-based model was developed by the Graduate Medical Education National Advisory Committee (GMENAC) from 1976 to 1980. A set of expert panels for each specialty played a central role in GMENAC's model. They were given the best available epidemiological data in the relevant fields to assist their judgment (McNutt, 1981).

Classical demand-based models also fall under the broad category of utilization models but are quite distinct from the need-based approach. To ascertain demand, the general idea is to apply the current utilization of health care services and workforce according to gender, age, race, insurance and other social-economic status variables to the future population structure and characteristics. A typical model of this category, established by the US Bureau of Health Professionals, is BHPr model (Anderson et al., 1997).

The controversy between need-based and demand-based models reflects modellers' views on idealism and realism. Some may argue that need-based models are forecasting "what should be" while demand-based models emphasize "what is likely to be". However, given the limitations of each, many modellers tend to use a combination of the two approaches and subsequently blur the boundaries. For example, even the above mentioned typical need-based model, GMENAC, considered some factors common in demand-based models such as the provision of care and care-seeking behaviour. GMENAC tried to identify a “realistic should” (McNutt, 1981). It might not be easy to judge whether this “reasonable-idealism” was closer to need or demand. GMENAC also called its model adjusted need-based model. Similarly, a demand-based model for projecting oncologists also used cancer incidence and prevalence estimates, which were usually considered in need-based models, to forecast utilization rates (Erikson et al., 2007).

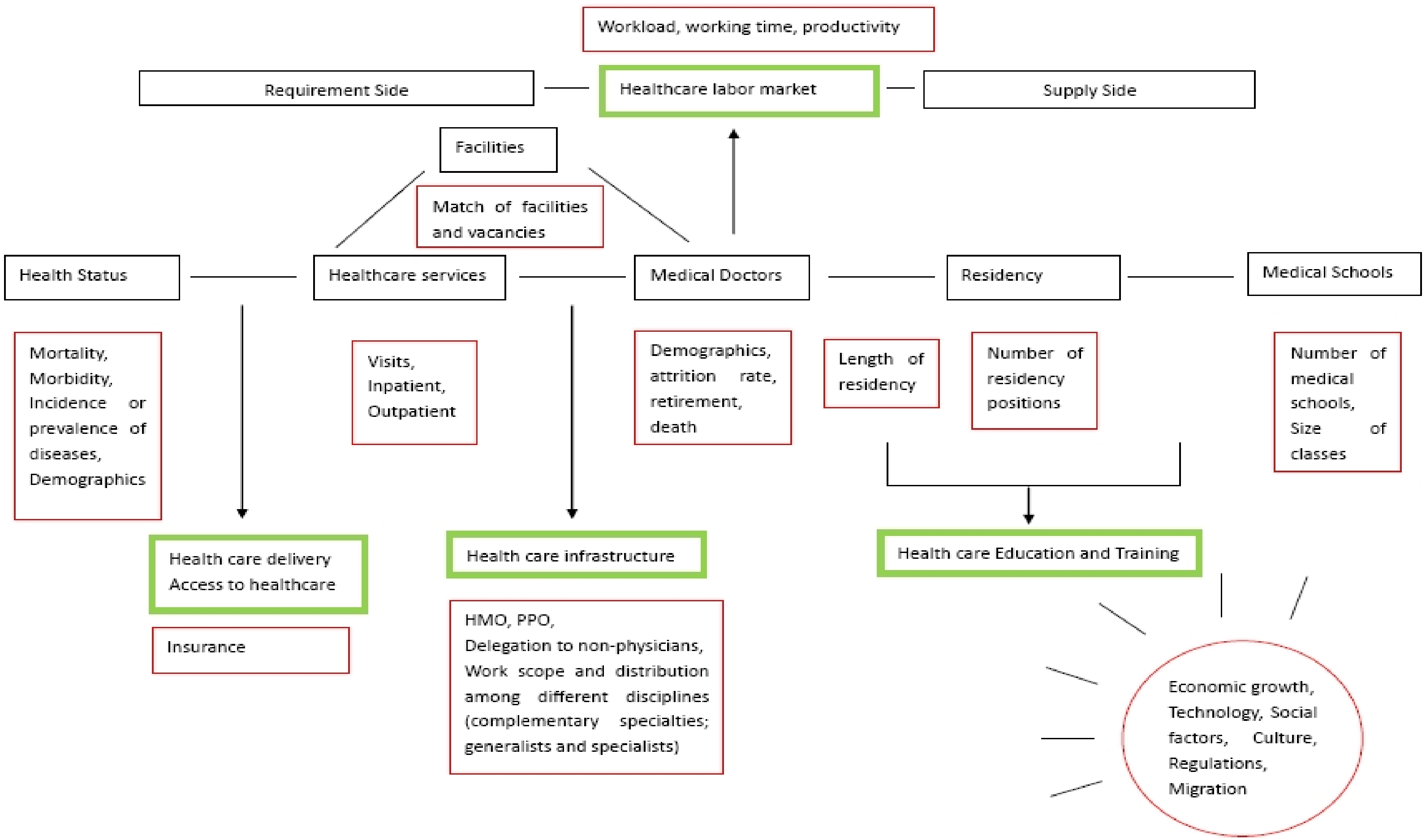
Behind these conceptual frameworks are the detailed methodologies – all kinds of technical models- to realize them. Such models include simulation models (Grover et al., 2009, Takata et al., 2011), computer spreadsheet models (Holliman et al., 1997), Markov projection models (Deal et al., 2007), system dynamics (Barber and Lopez-Valcarcel, 2010, Tuulonen et al., 2009), dynamic programming (Ikem and Reisman, 1990), stochastic simulation (Joyce et al., 2006), discrete actuarial model (Pearse et al., 2000, Jacoby et al., 1998), mathematical model (Miller, 1993, Close and Miller, 1995), regression (Scheffler et al., 2008), etc. To further complicate matters, sometimes these models are not well defined and modellers may use the same terminology but mean different things.

Abundant variables

Following the summary of models above, it is also important to consider the broad range of variables required. Some of the major variables associated with these different models are listed in figure 1-1. The long process of forecasting medical doctors implies its complexity. Forecasting models usually choose variables according to the data available and the models’ focus. Each variable, on its own, can potentially affect the final result of projection significantly. Although taking into account more variables allows the model to deal with more aspects of the process, it introduces more opportunities to increase errors and inaccuracies.

The complexity and uncertainty of forecasting medical doctors, gives space for manipulation of data in order to achieve particular ends. That is one reason why the debate as to whether there will be a surplus or shortage of medical doctors never ends. It also explains why forecasting medical doctors is still an underdeveloped field. Some would consider it “an inexact science” (Powell et al., 2004) while others would go as far as to say it is “an art rather than a pure science” (McNutt, 1981).

Figure 1-1 Variables associated the models for forecasting medical doctors



1.2 The models in this study

The conceptual framework of this study, which consists of four logical blocks, has been presented in the Methodology section of the main report submitted in November 2012. The whole framework by itself is of great value by involving the complete process of human resources for health (HRH) planning. It attributes the requirement for HRH to people's need for health which is further affected by some key risk factors. From this perspective, it aims to establish a mechanistic model rather than an empirical model.

Technically, given that the available data are cross-sectional, regression analysis is conducted for each block, as detailed in the following sections. Many key relationships and parameters are thus analyzed and some scenarios are explored for the forecasting.

The following sections will:

1 concisely describe the sampling methods and data collection of this study

2 present population health and demographic forecasting in the surveyed three provinces

3 describe demand-side analysis and forecasting

4 explore the supply-side analysis and forecasting as well as the productivity of medical doctors

5 discuss the imbalance between the forecasted supply and demand of medical doctors

6 summarize our methodological contributions and its limitations

7 present some key policy recommendations based on our analysis.

1.3 Sampling and data collection

We carried out a household and institutional survey from December 2010 to September 2011 in three provinces in China: Gansu, Henan and Guangdong (figure 1-2) using multi-stage stratified random sampling. Six counties from each province were selected, intended to represent that province. Four townships were then selected from each county, one village was selected from each township, and 25 households were selected per village resulting in a total of 600 households per province. The survey consisted of three parts: households, community and providers (i.e. healthcare facilities at the county, township and village levels). Detailed information about the survey can be found in the Methodology section and Appendix A, B, C in the main report submitted in November 2012.

Figure 1-2 Sampled provinces

2 **Population health and demographic forecasting**

2.1 General health profile

The health profile for our population is based on the adult (age 16 and above) household survey. It focuses on overall self rated health status, self reporting of ten major categories of diseases, reporting of diseases symptoms as well as family history of diseases (table 2-1).

Table 2-1 Health profile

Health outcomes			Total	Gansu	Henan	Guangdong
Self rated heath (unhealthy)			28.7 (4.5)	30.1	28	27
Serious psychological distress (yes)[1]			6 (11.3)	6.9	6.2	4.1
Hypertension	Self reported		14.8 (3.8)	13.9	19.3	10.8
	Measured stage 1		17.9 (14.1)	18.8	18.8	15.5
	Measured stage 2		11.3	11.4	13.9	8.2
	Family history		19 (6.5)	18.3	23.2	14.6
Heart disease	Self reported (yes)		6.8 (4.5)	9.6	6.3	2.7
	Angina	Highly likely	0.1	0.1	0	0.1
		Likely	0.7	0.7	0.7	0.7
		Possibly	0.7	0.5	0.5	1.2
	Family history		6.1 (5.4)	8.8	5.4	2.2
DM	Self reported		1.9 (4.9)	1.7	2.5	1.3
	DM (very likely)		0.6			
	Family history		3.3 (5.4)	2.6	4.3	3.4
Stroke	Self reported		2.9 (6.9)	1.9	4.8	2.2
	Family history		4.2 (5.4)	3.9	4.8	4
Hypercholesterolemia (self reported)			4 (12.7)	2.9	6.8	2.1
Hepatitis (self reported)			1.3 (6)	1.4	0.8	1.8
Liver cancer Family history			1.3 (5.3)	0.9	2	1.2
COPD (plus elderly chronic bronchitis)	Self reported		3.9 (5.3)	3.9	4.6	3.2
	Symptom tested	Likely	0.8			
		Possibly	1.5			
Lung cancer (self reported)			0.5	0.2	0.4	1
Lung cancer Family history			1.1 (5.9)	0.7	1.4	1.2
Other cancer Family history			2.6 (7.2)	2	3.8	2.1

[1] For the measurement of psychological distress, the study uses Kessler 6 (K6) scale.. Those who scored 13 or above on the scale are classified as having serious psychological distress (SPD), according to Kessler and his colleagues who developed the K6 scale.

Further to the descriptive provided in table 2-1, there are some important features of the distribution of diseases in the populations to point out.

Firstly, gender difference is significant for some diseases. For self rated health, females are more prone than males to report themselves unhealthy. In Henan, 32.8% female respondents considered themselves to be unhealthy while this figure for males is 22.3%. The contrast also exists in Gansu and Guangdong. 33.4% female in Gansu and 30.6% female in Guangdong reported to be unhealthy compared to 26.5% male in Gansu and 22.5% male in Guangdong. According to our findings, women also seem more likely to suffer from serious psychological distress (SPD) in each province. Moreover, the prevalence of heart disease is higher in females than in males. This is particularly evident in Henan, where the prevalence of self reported heart disease in females is twice that found in males (8% and 4.3% respectively).

Secondly, also in addition to asking for self reports of hypertension, we also took blood pressure measures among 86% of the respondents. Of those measured, 29.2% were found to have high blood pressure according to the latest protocol for hypertension, more than double the self reported rates; 17.9% of them were classified with stage 1 and 11.3% with stage 2 hypertension. The figure for Henan is slightly higher than average for both stage 1 and 2, while Guangdong exhibits lower figures than the average. In addition, 19% of the respondents reported a positive family history of hypertension. Henan reported the highest family history of hypertension (23.2%), consistent with both self reported and measured high blood pressure.

2.2 Risk profile

2.2.1 Intermediate risk factors

Smoking, alcohol consumption, diet, body mass index (BMI) and physical activity are surveyed as intermediate risk factors. Smoking and harmful alcohol use is distinctly different between genders.

Table 2-2 Intermediate risk factors profile

Risk		All 3 provinces		Gansu			Henan			Guangdong		
		M^	F^	M	F	T^	M	F	T	M	F	T
Ever smokers		68	2.6	38.4	75.5	3.3	28.3	59.5	1.3	33.8	65.1	3.1
Current smokers		57.3	1.6	33.3	66.0	2	22	46.5	0.9	28.4	55.3	2.1
Harmful alcohol use[1]		13.5	0.2	17	0.5	6.7	14.1	0.4	6.7	5.8	0	2.8
Vegetable (daily)		80.7		70			84.2			93.9		
Fruit (daily)		19.6		24			16.5			16.1		
BMI	Overweight[2]	19.8		17.7			25.6			16.3		
	Obese	3.8		2.8			6.5			2.1		
	Underweight	6.5		6.9			2.4			10.7		
PA*	Inactive[3]	15.1		15			14.5			15.8		
	Insufficient	6.4		7.7			5.7			5.1		
	sufficient	78.5		77.3			79.8			79.1		

^M indicates Males, F indicates Female and T indicates Total. The gender differences were only

reported here for smoking and alcohol consumption.
* Physical activity
[1] The WHO AUDIT questionnaire was used to assess the level of drinking problem in our survey population. A total score of 8 or more is recommended as an indication of 'hazardous and harmful alcohol use', as well as possible alcohol dependence.
[2] According to our anthropometric measures and WHO guidelines for adults, BMI>=30 are classified as obese; BMI< 30 & >=25 are overweight and BMI<18.5 are underweight.
[3] The classification is according to the scoring criteria for the 2001 Behavioural Risk Factor Surveillance System (BRFSS) physical activity module and the short, interviewer-administered International Physical Activity Questionnaire (IPAQ).

For smokers, the majority of ever smokers (77.2%) reported using filter tip cigarettes. In Gansu, 20.9% of ever smokers smoke hand-rolled cigarettes or tobacco, much higher than the other two provinces. The median age when people started smoking is 20. The median number of cigarettes smoked per day is also 20 (a pack). The median duration of smoking is 26 years. The median consumption of cigarettes among smokers is 15.8 pack years in Gansu, 21.5 in Henan and 26 in Guangdong.

2.2.2 Distal risk factors

Socioeconomic and environmental factors were also considered in our survey. For the purposes of this investigation, classification of unimproved water source follows the guidelines recommended by WHO/UNICEF and includes: unprotected dug well or spring, rainwater (into tank or cistern), tanker-truck - vendor, water taken directly from pond-water, or stream.

Meanwhile, the type of fuel, type of cooking stove and whether cooking is done in the living room are used as indicators to capture the level of indoor air pollution. Solid fuels shrubs/grass, wood, agriculture/crop, charcoal, animal dung, and coal are considered as unclean fuel source according to most studies, while kerosene, gas, solar energy, marsh gas and electricity are classified as clean fuel (table 2-3). We also collected data for occupation and education level (table 2-4 and table 2-5). Occupation was classified as primary, indicating agriculture, secondary as related to manufacturing or industry and tertiary which relates to the service sector (as used by the World Bank).

Table 2-3 Distal risk factors profile

Risk at household level	Total (%) (missing)	Gansu (%) (missing)	Henan (%) (missing)	Guangdong (%) (missing)
Water source (unprotected)	10.7 (0.5)	25.8 (1.2)	5.2 (0.2)	1.5 (0.2)
Type of fuel (unclean)	72.8 (6.7)	92.9 (5.3)	70.3 (14.2)	56.5 (0.5)
Cooking stove (poor ventilation)	25 (2.9)	7.2 (1.9)	42.1 (5.6)	25.3 (1.2)
Cook in living room (yes)	8.7 (1.3)	16.7 (1.6)	3.4 (0.8)	6.3 (1.5)

Toilet (non-flush)[1]	62.9 (1.5)	89.2 (2.2)	84.6 (1.2)	15.9 (1.2)
Poverty/low income group	17.2 (0.3)	29.7 (0.2)	13.9 (0.5)	8.3 (0.2)

[1] Non-flush toilet is considered as unimproved sanitation

Table 2-4 Occupation

	Gansu	Henan	Guangdong	Total
Primary	88.1	84.2	71.9	82.5
Secondary	2.3	3.3	7.3	4
Tertiary	9.6	12.5	20.8	13.6

Table 2-5 Education level

Education level[1]	Gansu	Henan	Guangdong	Total
No/Incomplete primary	30.8	21.8	24	26.2
Primary	27.4	24.8	30.2	27.3
Junior middle	29.1	37.5	32.4	32.6
Senior middle	9.7	12.7	12	11.2
Diploma or above	3	3.3	1.4	2.7

[1] No or incomplete primary education is regarded as illiterate or semi-illiterate in China.

2.3 Disease and Risk Factor trends

This section attempts to forecast the future prevalence of CVD, Overweight and Obesity, and Hypertension prevalence of study population in the next 10 years. It is acknowledged that the forecasting of diseases is very complex and often requires far more data than we have from our household survey. Nevertheless, an attempt is made using the limited data we have.

2.3.1 CVD forecasting

For the purpose of our project, we used the simplified CVD risk evaluation tool developed for the Chinese population. The sex-specific best prediction models were developed using Cox proportional hazard model, based on the 17 years follow-up data from the PRC-USA Collaborative Study of Cardiovascular and Cardiopulmonary Epidemiology cohort. Ten year risk of CVD was developed and adjusted for major risk factors. The methodology of the development of the prediction tool is discussed in detail by YF Wu (2003). It firstly scores systolic blood pressure (SBP), Age, body mass index (BMI), total cholesterol (TC), smoking and diabetes mellitus (DM) separately, and then adding them together to arrive at the CVD risk based on the total score. The following table (table 2-6) provides an example of the scoring of CVD risk for males in the next ten years (further details are available upon request).

Table 2-6 Scoring for CVD (Male)

		SBP	score	BMI	score	Smoking	score
Age	score	<120	-2	<24	0	no	0
<=39	0	120~	0	24~	1	yes	2
40-44	1	130~	1	>=28	2		
45-49	2	140~	2	TC(mmol/L)	score	DM	score
50-54	3	160~	5	<5.20	0	no	0
55-59	4	>180	8	>5.20	1	yes	1

To apply the prediction tool to our data, we made some assumptions and adjustments. The prediction is only made for the current study population without taking into account population change such as birth, mortality or migration. Total cholesterol and Diabetes is not measured in our household survey rather self reported doctor diagnosed high blood cholesterol and Diabetes was taken as the proxy for TC and DM in the evaluation of 10 year CVD risk. Therefore, the risk of having CVD is expected to be underestimated if high blood cholesterol and Diabetes is underreported.

The size of study population is 3378 (this is across the three provinces for household data on the adult population where all the variables were available). Current prevalence of CVD is 9.1% in the study population (male 7.96%, female 10.16%). Using our prediction tool, we estimate that in the next 10 years, the overall prevalence will rise to 10.1% (male 9.5%, female 10.7%). To be explicit, there will be 24 new CVD cases in male and 10 in female. This may appear relatively minor but would nevertheless have implications for HRH need. Moreover, we are likely providing a conservative estimate in that we are using self-reports which, as our data on hypertension suggest, may be under-reporting the prevalence of the disease.

The following graph (figure 2-1) depicts the current and predicted prevalence of CVD by gender and province.

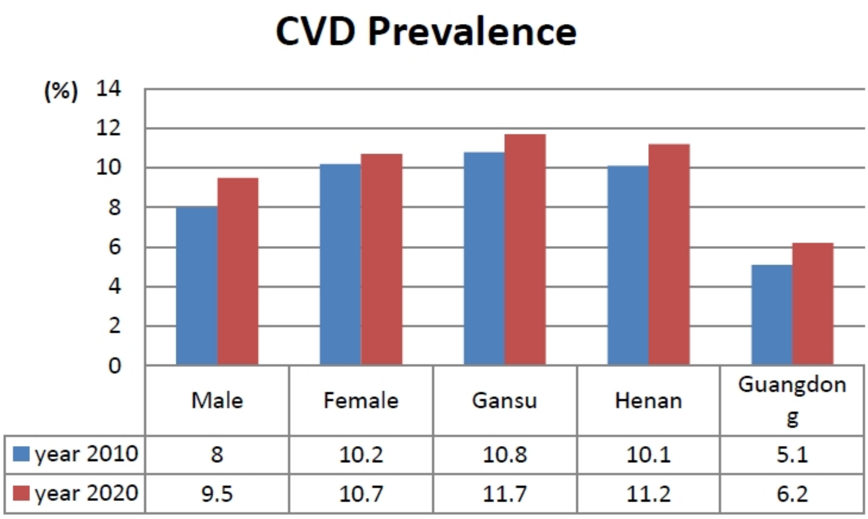
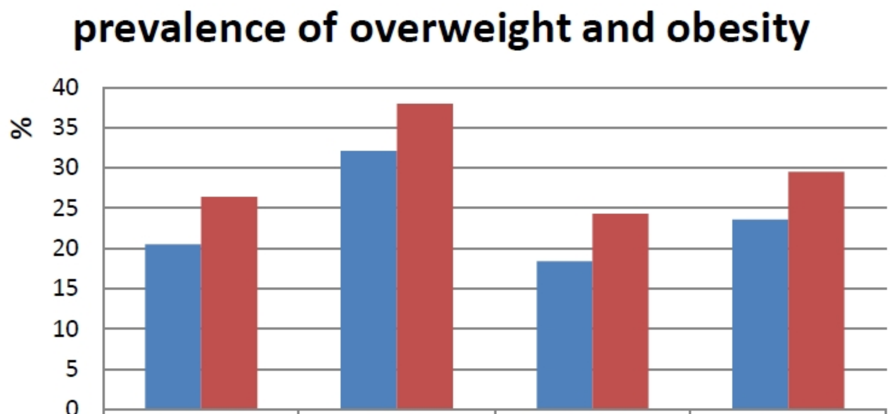


Figure 2-1 Current and predicted prevalence of CVD by gender and province

2.3.2 Overweight and obesity forecasting

In order to calculate the annual increase of the prevalence of overweight and obesity, we chose existing data on adults (aged 16 and above) that conform to the following criteria: were at a national level, follow WHO standards, and combined prevalence of overweight and obesity. We fit the data into a linear regression model to obtain the annual increase rate with prevalence as the dependent variable and the survey year as the independent variable. The regression result gives an annual increase rate of 0.59% resulting in an estimated 6% increase over the ten year period. Although seemingly marginal an increase, given the population size of China, it poses a considerable burden on the healthcare system.

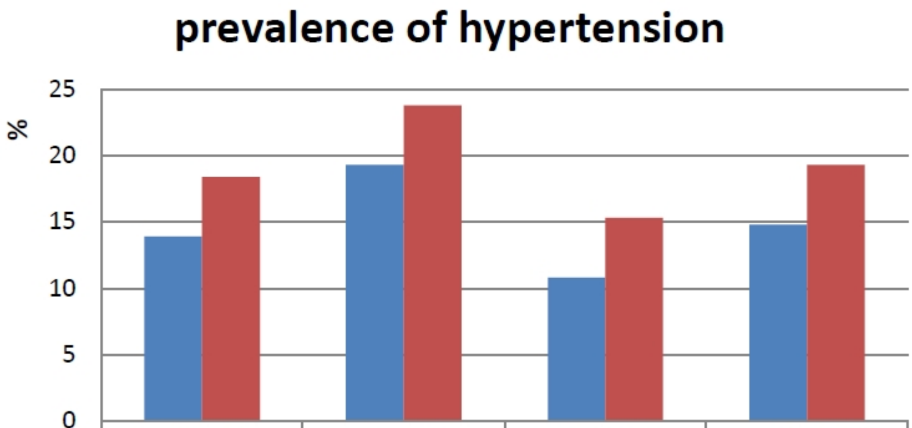


	Gansu	Henan	Guangdong	Total
2010	20.5	32.1	18.4	23.6
2020	26.4	38	24.3	29.5

Figure 2-2 Current and predicted prevalence overweight and obesity by province

2.3.3 Hypertension forecasting

To calculate the annual increase rate of hypertension, we selected national data for those aged over 15 years to fit into linear regression model. Similar to overweight and obesity, the regression results indicate an annual increase rate of 0.45%. This suggests an estimated 5% increase in hypertension over a period of ten years. Again, although seemingly small, we must appreciate the likely under-reporting of hypertension and the large population size to appreciate the growing pressure this is likely to have on HRH.



	Gansu	Henan	Guangdong	Total
2010	13.9	19.3	10.8	14.8
2020	18.4	23.8	15.3	19.3

Figure 2-3 Current and predicted prevalence hypertension by province

2.4 Population projection

The China Population Projection System (CPPS) software is used here to forecast the population. This software was developed by China Population Research Centre to meet the needs of population projection and family planning for China. It is commonly used by different levels of Chinese government family planning centres. It uses cohort survival method, with the strength of giving detailed projections of population structure. However, the data requirement for this method is relatively high. Age, gender specific population cohort data on population size for each cohort, mortality and fertility are required to run the projection.

The methodology is as follows: Firstly, a life table is created from the baseline data on mortality for each age and gender, and then a survival transition matrix is created, followed by a fertility model to get the total population which was then adjusted by the urbanization rate for the rural population.

Given the data requirement for CPPS, we decided to use a 1% sample survey of the national population for 2005 for the three surveyed provinces[1]. These population projections are also used for the following sections on demand and supply side projections.

[1] Other than overall rural population of three provinces, we also acquired the population of under five children, women of child bearing age and the elderly which we won't display here.

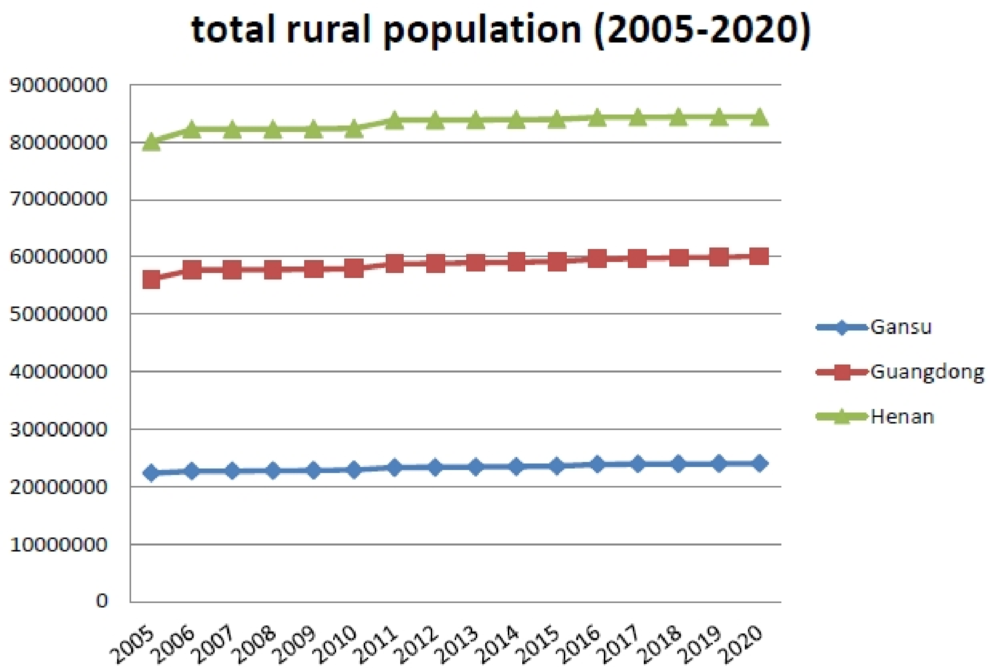


Figure 2-4 Rural population projection to 2020

Summary of Section 2

This section reviewed the health of our surveyed population and provided demographic projections. This need side analysis firstly provided the health profile to describe health status of surveyed sample according to their self reports. We then carried out risk factor analysis for both intermediate and distal elements. We also provided projections to estimate the prevalence of CVD, overweight & obesity, and hypertension in 2020.

The following major conclusions can be drawn:

1. In addition to the provincial differences in the health conditions measured, females tend to report poorer general health than their male counterparts;

2. The surveyed population appears to underreport hypertension compared to measured blood pressure. Determinants for hypertension were found to include age, education, current smoking status, overweight, obesity, salt intake and positive family history;

3. Smoking is highly prevalent among the rural population surveyed and the consumption of cigarettes among current smokers is alarming. However, this problem is largely found among males. Very few females in our survey were found to smoke. Harmful alcohol consumption was found to be strongly associated with smoking;

4. Our estimates suggest that the prevalence of CVD will be moderately higher in 2020 (an

estimated 1% increase over a period of 10 years) with females bearing the larger burden. Furthermore, our conservative estimates predict an annual increase rate of overweight and obesity of 0.59%, and an annual increase rate of 0.45% for hypertension;

5. Our projections show that there will be a steady increase in population size across all three provinces surveyed. The proportion of elderly, however, will grow more rapidly, resulting in a shift in the demographic structure.

3 Demand-side analysis and forecasting

3.1 Patients' choice of healthcare institutions at different levels

China's healthcare system allows people to go directly to any-level healthcare institutions from village clinics to tertiary hospitals. Accordingly, when people initially do not feel well, their first decision is whether to resort to self-treatment or seek care from one of the three available levels. This first healthcare-service choice is one of the most important health care seeking behaviours, and is the focus of section 3.1. Multinomial Logit Model, Conditional Multinomial Logit Model and Nested Multinomial Logit Model will be applied based on our household data.

3.1.1 Variables

The dependent variable is the healthcare choice, namely, self-treatment, village clinic, private clinic, township hospital or county hospital and above. Table 3-1 describes these choices among the three surveyed provinces.

Table 3-1 People's first choice of healthcare institutions at different levels (%)

Treatment options	Total	Gansu	Henan	Guangdong
Self-treatment	43.80	59.60	34.11	29.75
Village clinic	31.11	15.40	44.49	40.64
Private clinic	6.34	8.08	5.06	5.06
Township hospital	8.69	6.94	6.87	13.65
County hospital and above	10.06	9.98	9.47	10.89

It is informative to note that for Henan and Gansu the rural population is more likely to use the village clinic when ill whereas in Gansu, the preference is to self-treat. Moreover, in Gansu and Henan, the county hospital is preferred to the township hospital but this is not the case in Guangdong. It also appears that as of the time of the survey, use of private clinics is not too high (except in Gansu where it is higher than the township level). However, it is not clear at what level the private clinic exists in the respective provinces.

Independent variables, which we considered based on the literature to affect healthcare choice, are categorized into social demographic factors, economic factors, existing healthcare needs, healthcare quality (objective as well as subjective evaluation) and region. Descriptive statistics for these variables are shown in table 3-2. To get an indication of the contribution the level of income poverty has to healthcare choice, table 3-2 provides summary statistics for the poor and non-poor as determined by an income poverty line of $1.25 per day PPP.

Table 3-2 The descriptive analysis of independent variables(%)

Variable	Total	Non-poor	Poor[1]	Variable	Total	Non-poor	Poor
Age				Transport facilities			
1: [0 30)	25.16	27.41	21.92	0:Don't have	33.98	26.16	45.89
2: [31 45]	24.43	23.76	25.40	1: have	66.02	73.84	54.11
3: [45 60)	29.15	30.31	27.49	Social medical insurance			
4: [60 ~)	21.15	18.52	25.19	0:Don't have	3.49	3.23	3.88
Gender				1: have	96.51	96.77	96.12
0: Male	50.95	51.09	50.74	Private medical insurance			
1: Female	49.05	48.91	49.26	0: Don't have	96.80	96.04	97.89
Educational level				1: Have	3.20	3.96	2.11
1:Illiterate/semi-illiterate	21.73	18.68	26.00	Symptoms severity			
2: Primary	25.24	25.78	24.47	1:Not severe	39.62	42.22	36.17
3:Junior middle	37.78	38.80	36.34	2:Somewhat severe	42.43	41.43	43.77
4:Senior middle and above	15.25	16.74	13.18	3: Severe	17.95	16.35	20.06
Marital status				Self-rated health			
0:Single/ Devoiced/ Windowed	12.04	12.34	11.59	1: Healthy	12.10	10.28	14.35
1: Married	87.06	87.66	88.41	2: A bit unhealthy	51.83	55.71	47.02
Household size	4.96	4.98	4.94	3: General	22.60	22.03	23.31
Wealth index	2.00	2.47	1.26	4: Unhealthy	11.77	10.60	13.22
Per capita income				5: Very unhealthy	1.70	1.38	2.10
1: <5000	58.52	31.28	100	Disease history			
2: [5000,8000)	17.03	28.22	0	0: no	31.52	30.87	32.51
3: [8000,16000)	14.37	23.81	0	1: yes	68.48	69.13	67.49
4: ≥16000	10.08	16.69	0	Region			
Medical burden of household				Gansu	32.63	25.04	44.19
1: Lowest	25	32.29	13.92	Henan	33.77	32.13	36.27
2: Lower	25	30.62	16.42	Guangdong	33.60	42.83	19.55

3: Higher	25	22.30	29.10	Sample size of sick people
4: Highest	25	14.78	40.56	2915

[1] The income poverty line of $1.25/day is used to divide the sample into poor and non-poor groups. In accordance with the PPP in 2005, the income poverty line is 2518.5 Yuan per year.

3.1.2 Regression results

The regression outcomes of running Multinomial Logit Model, Conditional Multinomial Logit Model and Nested Multinomial Logit Model are presented in table 3-3, table 3-4 and table 3-5, respectively.

Table 3-3 The results of the multinomial logit model for outpatient (control group: self-treatment)

Variable	Village clinic		Private clinic		Township hospital		County and above hospital	
	Coef.	RRR	Coef.	RRR	Coef.	RRR	Coef.	RRR
Age								
[31 45]	-0.393	0.675	0.242	1.274	-1.290 ***	0.275	-1.090 **	0.336
[45 60)	-0.510	0.601	-0.828	0.437	-1.085 **	0.338	-0.688	0.503
[60 ~)	-0.789 **	0.455	-0.364	0.695	-0.521	0.594	-1.563* ***	0.209
Gender (female)	0.161	1.175	0.329	1.390	0.560 **	1.750	0.322	1.380
Educational level								
Primary	0.201	1.223	0.431	1.539	0.307	1.359	0.648 **	1.911
Junior middle	0.044	1.045	0.581	1.788	0.046	1.047	0.337	1.400
senior middle and above	0.045	1.046	0.538	1.712	0.102	1.108	0.475	1.608
Marital status (married)	0.459	1.582	-0.232	0.793	1.514 **	4.545	1.117 *	3.056
Household size	-0.072	0.930	0.097	1.102	-0.133 **	0.876	-0.089	0.915
Wealth index	0.141 **	0.869	0.228 *	0.796	0.082	0.921	0.013	0.986
Per capita income								
Lower	0.172	1.187	0.172	1.188	0.298	1.347	1.009 **	2.742
Higher	0.090	1.094	0.028	1.028	-0.083	0.921	1.309 ****	3.703
Highest	0.691 *	1.996	1.319 *	3.741	0.562	1.754	1.587 ***	4.887

Medical burden of household								
Lower	0.011	1.011	0.843	2.322	0.831 **	2.295	0.184	1.202
Higher	0.304	1.355	0.838	2.312	0.476	1.610	0.150	1.101
Highest	0.263	1.301	1.177 **	3.244	0.187	1.206	0.373	1.452
Transport facilities	0.334 *	1.396	0.643 *	1.903	0.356	1.428	0.310	1.364
Social health insurance	0.253	1.288	0.186	1.205	-0.358	0.699	0.628	1.874
Private health insurance	0.296	1.345	1.335 *	3.800	0.193	1.213	0.977 *	2.656
Symptoms Severity								
Somewhat severe	0.189	1.208	-0.146	0.865	1.479 ****	4.388	0.701 *	2.015
Severe	0.734 **	2.083	0.254	1.290	2.142 ****	8.513	1.904 ****	6.711
Self-rated health								
Healthy	-0.410	0.664	0.566	1.761	0.200	1.222	-0.164	0.849
A bit unhealthy	-0.103	0.902	1.740 **	5.696	-0.879 *	0.415	0.518	1.679
Unhealthy	0.425	1.530	2.071****	7.931	-0.289	0.749	0.463	1.589
Very unhealthy	0.481	1.618	1.758	5.799	0.757	2.133	0.311	1.365
Disease history	1.477 *	4.380	1.454	4.282	1.260	3.526	0.456	1.578
Per capita Income ×poverty	0.094	1.099	-0.804	0.447	3.800 ***	44.714	-0.178	0.836
Disease history ×poverty	0.381	1.464	0.135	1.144	-2.323 **	0.008	0.474	1.606
Symptoms Severity ×poverty								
Somewhat severe ×poverty	0.335	1.397	0.456	1.578	-1.020	0.361	0.552	1.737
Severe×poverty	0.121	1.129	0.603	1.827	-0.656	0.519	-0.065	0.937
Self-rated health ×poverty								
Healthy×poverty	0.120	1.127	0.658	1.930	-2.081 **	0.125	0.296	1.344
General ×poverty	-0.976 **	0.377	1.762 *	5.822	-1.475 **	0.229	0.214	1.238

Unhealthy×poverty	-0.165	0.848	-0.196	0.822	0.231	1.260	0.948	2.580
Very unhealthy ×poverty	-0.035	0.965	2.686 *	14.674	-1.499	0.223	0.675	1.964
Henan	2.027****	7.592	0.313	1.368	0.495	1.641	0.790 ***	2.203
Guangdong	2.388****	10.889	0.690	1.993	1.340 ****	3.819	0.700 **	2.014
Cons	-4.150****		-7.183****		-5.410		-5.624****	
N				1168				
Log likelihood				-1275.1422				
Prob>chi2				0.0000				
（χ）				454.57				

P-value： **** p<0.005, *** p<0.01, ** p<0.05, * p<0.1

Table 3-4 The results of the conditional logit model for outpatient (control group: village clinic)

Variable	Private clinic		Township hospital		County and above hospital	
	Coef.	Std. Err	Coef.	Std. Err	Coef.	Std. Err
Age						
[31 45]	0.443	0.741	-0.547	0.657	-0.441	0.694
[45 60)	-0.116	0.783	-0.348	0.632	-0.002	0.666
[60 ~)	0.834	0.825	0.668	0.671	-0.726	0.754
Gender (female)	0.117	0.385	0.474	0.335	-0.283	0.324
Educational level						
Primary	-0.430	0.502	0.076	0.401	-0.068	0.420
Junior middle	0.210	0.512	-0.162	0.459	0.060	0.419
senior middle and above	-0.054	0.704	0.210	0.575	0.327	0.549
Marital status (married)	-0.874	0.919	1.089	0.990	0.272	0.856
Household size	0.178	0.118	-0.038	0.103	-0.097	0.104
Wealth index	0.057	0.181	0.340 **	0.146	0.147 *	0.142
Per capita income						
Lower	-0.348	0.601	-0.176	0.465	0.581	0.544
Higher	-0.890	0.795	-0.121	0.583	1.504 ***	0.566
Highest	0.240	0.897	-0.162	0.781	0.545 **	0.864
Medical burden of household						
Lower	0.471	0.616	1.607	0.562	0.474	0.491

			****			
Higher	0.552	0.634	1.236 **	0.597	0.022	0.523
Highest	0.916	0.656	0.848	0.638	0.192	0.574
Transport facilities	0.082	0.422	-0.197	0.364	-0.217	0.342
Social health Insurance	0.004	1.308	-0.271	1.254	0.846	1.335
Private health insurance	1.438 *	0.824	-0.238	0.978	1.160	0.829
Symptoms severity						
somewhat severe	-0.609	0.598	0.718	0.481	0.212	0.516
Severe	-1.005	0.766	0.962	0.585	1.189 **	0.527
Self-rated health						
Healthy	1.762 **	0.831	1.009 *	0.553	0.067	0.607
A bit unhealthy	1.208	0.911	-0.941	0.684	0.562	0.599
Unhealthy	1.512 *	0.858	-0.598	0.582	-0.149	0.649
Very unhealthy	-0.304	1.713	-0.357	1.277	-0.960	1.375
Disease history	0.157	1.448	-0.041	1.394	-1.244	1.102
Per capita income ×poverty	2.095	2.561	2.251	2.318	-0.075	2.358
Disease history ×poverty	0.123	2.034	-2.585 *	1.677	1.177	1.578
Symptoms severity ×poverty						
Somewhat severe ×poverty	-0.669	1.052	0.479	0.873	-0.402	0.844
Severe×poverty	-0.557	0.983	-0.892	0.780	0.501	0.734
Self-rated health ×poverty						
Healthy×poverty	-3.060	1.975	-1.672	1.873	-1.000	1.818
General ×poverty	-0.234	2.009	0.232	1.835	-0.019	1.834
A little bit unhealthy ×poverty	-2.496	2.002	0.840	1.863	-0.371	1.817
Unhealthy × povert y	-3.507 *	2.079	0.614	1.821	-1.229	1.869
Very unhealthy ×poverty	-1.842 ****	0.465	-1.397 ****	0.465	-1.189 ****	0.428
Henan	-2.229 ****	0.737	-0.841	0.516	-3.239 ****	0.676
Guangdong	-1.951	2.351	-2.335	2.259	-0.055	2.030
Cons						
Quality			0.153	0.389		
Waiting time			-0.697	0.267		
Attitude			2.544	0.781		

Environment	0.601	0.566	
N	1860		
Log likelihood	-428.492		
Wald chi2(92)	150.69		
Prob>chi2	0.0000		

P-value：**** p<0.005, *** p<0.01, ** p<0.05, * p<0.1

Table 3-5 The results of the nested logit model for outpatient (control group: village clinic)

Variable	Private clinic		Township hospital		County and above hospital	
	Coef.	Std. Err	Coef.	Std. Err	Coef.	Std. Err
Age						
[31 45]	-0.035	0.042	-0.630	0.630	-0.418	0.661
[45 60)	-0.028	0.036	-0.368	0.607	0.127	0.640
[60 ~)	-0.057	0.062	0.525	0.643	-0.735	0.724
Gender (female)	-0.004	0.011	0.367	0.327	-0.251	0.316
Educational level						
Primary	-0.005	0.014	0.030	0.389	-0.014	0.412
junior middle	-0.019	0.022	-0.300	0.446	0.021	0.407
senior middle and above	-0.013	0.022	0.097	0.552	0.306	0.531
Marital status (married)	0.043	0.049	1.166	0.960	0.328	0.815
Household size	-0.002	0.004	-0.066	0.099	-0.127	0.100
Wealth index	-0.011	0.011	0.254 *	0.141	0.119 *	0.137
Per capita income						
Lower	0.008	0.019	-0.072	0.450	0.646	0.529
Higher	0.018	0.027	0.049	0.570	1.467 ***	0.551
Highest	-0.016	0.028	0.011	0.722	0.432 ***	0.836
Medical burden of household						
Lower	-0.024	0.028	1.516 ***	0.554	0.372	0.480
Higher	-0.022	0.027	1.187 **	0.584	-0.048	0.514
Highest	-0.014	0.021	0.647	0.627	0.084	0.557
Transport facilities	-0.004	0.012	-0.146	0.355	-0.231	0.332
Social health insurance	0.002	0.040	-0.144	1.234	0.799 **	1.289
Private health insurance	-0.032	0.039	-0.765	0.921	0.666	0.763
Symptoms severity						
somewhat severe	0.018	0.024	0.773 *	0.467	0.317	0.500
Severe	0.035	0.042	1.147 **	0.569	1.255 **	0.508
Self-rated health						
Healthy	-0.058	0.063	0.869 *	0.526	-0.026	0.590

A bit unhealthy	-0.042	0.049	-1.033	0.675	0.407	0.582
unhealthy	-0.056	0.060	-0.669	0.560	-0.261	0.626
Very unhealthy	0.005	0.072	-0.275	1.232	-0.878	1.342
Disease history	-0.014	0.071	-0.253	1.307	-1.252	0.979
Disease history ×poverty	-0.008	0.077	-2.426 **	1.533	1.070	1.413
Symptoms severity ×poverty						
Somewhat severe ×poverty	-0.019	0.029	-1.317 *	0.788	0.878	0.770
Severe×poverty	-0.053	0.060	-0.632	0.849	0.236	0.815
Self-rated health ×poverty						
Healthy×poverty	-0.051	0.095	2.670	1.642	-0.634	1.560
General ×poverty	0.037	0.088	1.102	1.671	-1.239	1.621
A little bit unhealthy ×poverty	0.032	0.084	3.594 **	1.731	-0.499	1.542
Unhealthy×poverty	0.064	0.103	3.456 **	1.717	-1.380	1.666
Very unhealthy ×poverty	-0.062	0.110	1.777	2.174	-1.134	2.230
Henan	0.075	0.077	-1.372 ****	0.392	-0.805 **	0.355
Guangdong	0.072	0.078	-0.496	0.462	-1.928****	0.593
Cons	0.022	0.090	-2.470	2.186	-0.964	1.936
Quality			0.343	0.339		
Waiting time			-0.010	0.020		
Attitude			0.065	0.083		
Environment			0.394	0.391		
N			1860			
Log likelihood			-408.853			
Wald chi2(92)			100.19			
Prob>chi2			0.000			
LR test for ⅡA						
Chi2(2)			39.28			
Prob > chi2			0.0000			

P-value：**** p<0.005, *** p<0.01, ** p<0.05, * p<0.1

Some of the main findings from the regressions for healthcare choice include:

1 Village clinics are the main formal healthcare institution chosen by rural patients after appearance of symptoms. With the aging population and the increase in prevalence of chronic diseases, it is likely that the burden on village clinics will be exacerbated in the near future.

2 Income prevents the rural patients from choosing the formal medical services when making an initial treatment decision. 32.7% of the surveyed population reported not using formal healthcare services due to financial constraints. Income also appears to limit the use of higher levels of healthcare (e.g. township or county level).

3 Having social health insurance does not appear to affect the level of health care choice. One possible reason is that the New Rural Cooperative Medical Scheme has successfully covered most rural areas.

4 Those reporting "a disease history" are more likely to choose the less costly village clinics. Whereas those who report severe symptoms are more likely to use the township or county level facilities.

5 The choice of healthcare facility appears to be significantly different between the three provinces as described above.

3.2 Healthcare-service-seeking intensity

After choosing a certain level of healthcare (i.e. village clinic, township hospital, or county hospital), the next decision is how much health service an individual will use within a certain period. This is another key healthcare seeking behaviour which deserves great attention. This study calls it healthcare-service-seeking intensity. Three models, namely Poisson Regression Model, Negative Binomial Regression Model and Negative Binomial Distributed Hurdle Model, are chosen to explore the healthcare-service-seeking intensity.

3.2.1 Variables

The healthcare-service-seeking intensity is measured through two indicators separately – outpatient visits within the past 3 months and inpatient days within the past year. These two indicators are used as the dependent variables, respectively. Their distributions among the surveyed individuals are illustrated in table 3-6 and table 3-7.

The independent variables are the same to those in section 3.1.

Table 3-6 Frequency of clinic visits of rural patients within the past 3 months

Outpatient visits	Total	Poor	Non-poor group
0	54.58	58.21	52.62
1	22.31	23.28	21.83
2	9.04	6.17	10.48
3	6.91	6.40	7.16
4	2.17	1.40	2.56
5	1.51	0.81	1.86
6	1.28	1.16	1.34

7	0.47	0.81	0.29
8	0.39	0.47	0.35
More than 8	1.44	1.29	1.51

Table 3-7 Inpatient days within the past year

Inpatients days	Total	Poor	Non-poor
1-10	68.40	66.26	69.21
11-20	15.97	15.95	15.97
21-30	8.07	9.20	7.64
31-40	1.51	1.23	1.62
41-50	1.18	1.23	1.16
51-60	1.85	1.84	1.85
61-90	1.18	1.23	1.16
More than 90	1.85	3.07	1.39

3.2.2 Regression results

The regression outcomes for outpatient visits and inpatient days are shown in table 3-8 and table 3-9, respectively.

Table 3-8 Results of the three regression models for outpatient visits

Variable	Poisson Regression Model		Negative Binomial Regression Model		Negative Binomial Distributed Hurdle Model	
	Coef.	Std. Err	Coef.	Std. Err	Coef.	Std. Err
Age						
[31 45]	-0.167	0.130	-0.138	0.153	-0.154	0.288
[45 60)	0.132	0.120	0.157	0.143	0.391	0.269
[60 ~)	0.050	0.133	0.067	0.158	0.190	0.300
Gender (female)	0.160 ***	0.058	0.153 **	0.069	0.261 **	0.127
Educational level						
Primary	0.041	0.070	0.030	0.084	0.009	0.152
Junior middle	-0.027	0.082	-0.017	0.098	-0.021	0.179
Senior middle and above	0.178 *	0.103	0.192	0.123	0.396 *	0.225
Marital status (married)	0.385 **	0.172	0.375 *	0.197	0.970 *	0.396
Household size	-0.015	0.015	-0.013	0.018	-0.015	0.035
Wealth index	-0.086 ****	0.022	-0.082 ****	0.027	-0.125 **	0.051
Per capita income						
Lower	0.008	0.081	0.010	0.097	0.032	0.179
Higher	0.130	0.086	0.120	0.105	0.172	0.194

Highest	-0.143 **	0.126	-0.143 **	0.149	-0.248 **	0.266
Medical burden of household						
Lower	0.030	0.089	0.025	0.107	0.013	0.200
Higher	0.111	0.090	0.095	0.109	0.072	0.204
Highest	0.200 **	0.101	0.191	0.123	0.270	0.234
Transport facilities	0.061	0.064	0.064	0.077	0.111	0.142
Social health Insurance	0.076 **	0.237	0.055 *	0.278	0.036 *	0.506
Private health Insurance	0.079	0.151	0.082	0.182	0.126	0.345
Self-rated health						
Healthy	0.003	0.094	0.019	0.112	0.086	0.210
A bit unhealthy	0.141 **	0.092	0.153	0.111	0.287	0.203
Unhealthy	0.062	0.090	0.083	0.110	0.226	0.202
Very unhealthy	-0.133	0.207	-0.129	0.248	-0.189	0.459
Disease history	0.295 **	0.248	0.309 *	0.298	0.729 *	0.558
Mobility Impairments	0.060	0.085	0.066	0.104	0.123	0.198
Per capita income ×poverty	-0.485	0.366	-0.642	0.528	-1.191 *	0.821
Self-rated health ×poverty						
Healthy×poverty	-0.198	0.163	-0.053	0.398	-0.374	0.369
General ×poverty	-0.332	0.168	-0.177	0.404	-0.657	0.384
A little bit unhealthy ×poverty	-0.245	0.160	-0.099	0.400	-0.399 *	0.367
Unhealthy×poverty	-0.154	0.337	0.149	0.396	-0.327	0.727
Disease history ×poverty	0.605 *	0.338	0.613	0.394	1.387 *	0.743
Mobility Impairments×poverty	-0.074	0.134	-0.077	0.164	-0.093	0.310
Henan	0.173 **	0.088	0.172 *	0.101	0.400 **	0.190
Guangdong	0.764 ****	0.091	0754 ****	0.108	1.358 ****	0.206
Cons	0.096	0.406	0.111	0.481	-1.310	0.911
N	604		604		603	
Log likelihood	-1147.418		-1110.634		-935.482	
LR test	231.21		145.20		130.71	

Table 3-9 Results of the three models for inpatient days

Variable	Poisson Regression Model		Negative Binomial Regression Model		Negative Binomial Distributed Hurdle Model	
	Coef.	Std. Err	Coef.	Coef.	Std. Err	Coef.
Age						
[31 45]	0.331 ****	0.069	0.314	0.347	0.497	0.260
[45 60)	0.657 ****	0.066	1.021 ***	0.376	0.801 ****	0.259
[60 ~)	1.044 ****	0.069	1.346 ****	0.417	1.082 ****	0.292
Gender (female)	-0.453 ****	0.033	-0.200	0.222	-0.244	0.154
Educational level						
Primary	0.294 ****	0.042	0.597 **	0.292	0.364 *	0.201
Junior middle	0.430 ****	0.045	0.338	0.297	0.095	0.210
Senior middle and above	-0.187 ****	0.064	-0.147	0.349	-0.313	0.246
Marital status (married)	-0.813 ****	0.072	-1.127 **	0.538	-1.171****	0.391
Household size	0.009	0.010	-0.021	0.067	-0.023	0.044
Wealth index	0.030 **	0.015	0.155 *	0.091	0.113 *	0.064
Per capita income						
Lower	0.112 **	0.054	-0.057	0.289	0.144	0.212
Higher	0.771 ****	0.051	0.481	0.345	0.425 *	0.243
Highest	0.452 ****	0.086	0.325	0.471	0.152	0.324
Medical burden of household						
Lower	-0.712 ****	0.063	-0.313	0.310	-0.365	0.236
Higher	0.105 **	0.053	0.425	0.310	0.194	0.224
Highest	0.721 ****	0.054	0.998 ***	0.369	0.465 *	0.258
Transport facilities	0.022	0.039	-0.211	0.229	-0.097	0.164
Social health Insurance	1.298 ****	0.260	1.306 *	0.739	0.697 *	0.696
Private health Insurance	-0.833 ****	0.142	-1.122 **	0.563	-0.543	0.447

Self-rated health						
Healthy	-0.169 ****	0.054	0.067	0.353	-0.009	0.248
A bit unhealthy	-0.135 **	0.065	-0.167	0.402	-0.098	0.271
Unhealthy	-0.600 ****	0.068	-0.370	0.392	-0.141	0.268
Very unhealthy	0.236 ***	0.090	0.413	0.662	1.098 **	0.488
Disease history	-0.352	0.097	-0.426	0.551	-0.064	0.375
Mobility Impairments	0.179 ****	0.056	-0.248	0.318	-0.208	0.227
Per capita income ×poverty	-1.970 ****	0.170	-1.026 *	1.019	-0.850 *	0.708
Self-rated health ×poverty						
Healthy×poverty	0.269 ***	0.098	-0.218	0.683	0.171	0.490
General ×poverty	0.394 ****	0.097	0.185	0.617	0.359	0.436
A little bit unhealthy ×poverty	0.305 ****	0.108	0.441	0.710	0.156	0.478
Unhealthy×poverty	-0.200	0.149	-0.699	1.192	-1.498 **	0.762
Disease history ×poverty	1.450 ****	0.156	0.442	0.885	0.468	0.608
Mobility Impairments×poverty	0.981 ****	0.078	1.169 **	0.529	1.134 ****	0.373
Henan	-0.393 ****	0.045	-0.331 **	0.285	-0.484 **	0.210
Guangdong	-0.321*****	0.053	-0.347****	0.332	-0.817****	0.235
Cons	1.289 ****	0.298	1.373****	1.177	2.805 ****	0.961
N	556		556		279	
Log likelihood	-5507.785		-1393.020		-983.197	
LR test	3285.400		80.07		104.66	

From the above models, we may conclude that household income and/or wealth is an affects the intensity of inpatient and outpatient service with high level income groups consuming more inpatient services but less outpatient services. This finding may be explained by suggesting that household assets are more likely to facilitate use of more costly inpatient care. If income is less available, people may be more likely to settle for outpatient care. Moreover, social health insurance significantly increases health care consumption (both inpatient and outpatient). For the poor, those reporting a disease history tend to consume more healthcare services.

3.3 Projection for heath care service demand

Forecasting of heath care service demand is built upon the regression results from two models, namely Multinomial Logit Model in section 3.1 and Negative Binomial Regression Model in section 3.2. By changing the age and income of sampled individuals (age is increased by 10 naturally; income projection is based on previous time-trend data), and applying the projected population from section 2, the demand for health care services in 2020 is estimated in table 3-10..

Table 3-10 Projected probability of facility choice and demand for healthcare services in 2020

Facility	Probability of choosing the facility	Service demand
	Adjusted by age and income	
Outpatient		
Gansu		
Village clinic	0.392	9592649
Private clinic	0.131	3205707
Township hospital	0.223	5457043
County hospital	0.185	4527143
Henan		
Village clinic	0.702	60332715
Private clinic	0.085	7305243
Township hospital	0.087	7477131
County hospital	0.127	10914893
Guangdong		
Village clinic	0.718	43959289
Private clinic	0.094	5755116
Township hospital	0.119	7285732
County hospital	0.068	4163275
Inpatient		
Gansu		
Township hospital[1]	0.348	27052054
County hospital	0.652	50683734
Henan		
Township hospital	0.361	98557907
County hospital	0.639	174455687
Guangdong		
Township hospital	0.535	104051540
County hospital	0.465	90437319

[1] There are no inpatient services in village clinics and private clinics.

Summary of Section 3

Demand side analysis firstly describes people's first choice of healthcare institutions at different levels then implements regressions analyses taking first choice as the dependent variables and age, education level, income, insurance, health status, and interaction variables with poverty as independent variables. Similar analysis is carried out for healthcare service seeking intensity using different models. Finally, the demand for healthcare service is projected by changing the income and age of the surveyed population and applying the pattern to the overall population projected for 2020.

The following major conclusions can be drawn from the analysis:

1. Overall, combining all three provinces, more than half the surveyed population chose self-treatment when ill. The reported reason was either they thought it unnecessary or were confronted with financial difficulties. Income appeared to be an obstacle for both first healthcare choice and intensity of healthcare utilization;

2. Social health insurance did not significantly affect first healthcare choice, but did affect the intensity of healthcare use;

3. The projection of healthcare service demand varies for different provinces. Village clinic services are likely to be the most frequently used level of service within all three provinces. Gansu and Guangdong are projected to require more outpatient services at the county level compared to the township level. For inpatient service, Gansu and Henan are projected to demand more county level service while Guangdong will require more township level services.

4 Supply-side analysis and projection

4.1 Current supply of medical doctors

According to *China Health Statistical Yearbook 2003 – 2010*, Table 4-1 describes the quantity of doctors at the provincial level. In China, rural doctors are defined as registered doctors and assistant doctors at the county level and below. It can be seen from Figure 4-1 that there was an abnormal increase in the quantity of rural doctors from 2009 to 2010. This was largely due to the change of rural doctors' definition. Before 2010, rural doctors did not include those working in the county-level cities.

In addition, certified village doctors are a subgroup of rural doctors. Thus, certified village doctors may be either registered doctors or assistant doctors. However, there are a significant proportion of village doctors who only hold a special certificate which is below the training level of assistant doctors. In this context, rural doctors only include certified village doctors rather than the whole group of village doctors. This phenomenon also implies the general low qualification of village doctors – the majority of them (around 90%) have even less training than assistant doctors (who have passed a standard certification examination).

Table 4-1 Number of doctors at different levels in three surveyed provinces

Province \ Year		2003	2004	2005	2006	2007	2008	2009	2010
Gansu	Rural doctors	16999	16394	16336	16574	15150	15669	16332	20674
	Township doctors	7150	6823	6792	6829	6657	6887	7110	7433
	Certified village doctors	1465	1238	936	1111	1160	1043	1820	2154
	Village doctors	17694 (8.28) [1]	17437 (7.1)	16642(5.62)	17086(6.5)	16192(7.16)	16050 (6.5)	18893 (9.63)	20974 (10.27)
Henan	Rural doctors	46224	47399	48023	48875	48925	51367	71648	97784
	Township doctors	22365	23310	24293	25107	25263	26940	34297	34681
	Certified village doctors	7659	6318	11043	10502	9052	9566	16659	17283
	Village doctors	83553 (9.16)	87793 (10.19)	103555 (9.66)	109703(9.57)	113457 (7.98)	114881 (8.33)	133490 (12.48)	137679(12.55)
Guangdong	Rural doctors	20377	20049	19574	20087	20224	20452	23464	62490
	Township doctors	23456	22782	22744	22462	23213	23643	23552	27914
	Certified village doctors	1888	2297	2535	4077	6031	7100	7637	8448
	Village doctors	29087(6.49)	29883(7.69)	29781 (8.51)	34151(11.94)	35576(16.95)	37384 (18.99)	38437 (19.87)	39270 (21.51)

[1] Figures in parenthesis are percentage of the certified village doctors in the whole village doctors.

Source: *China Health Statistical Yearbook 2003 – 2010*

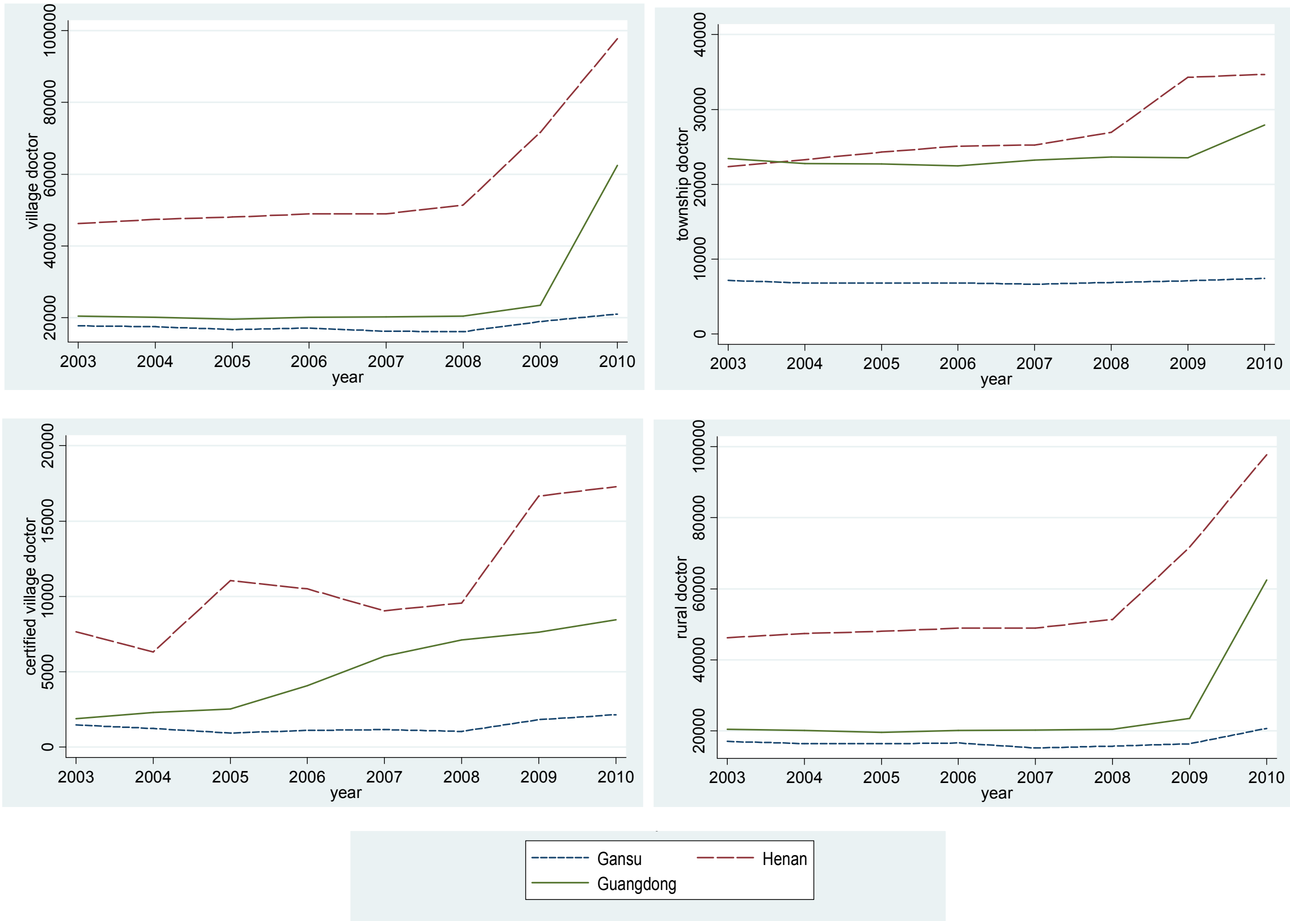


Figure 4-1 Number of doctors at different levels for each surveyed province

The corresponding number of doctors per thousand population is shown in table 4-2 .

Table 4-2 Number of doctors per thousand population at different levels

Province \ Year		2003	2004	2005	2006	2007	2008	2009	2010
Rural doctors per thousand population	Gansu	0.94	0.90	0.90	0.94	0.85	0.86	1.02	1.10
	Henan	0.70	0.71	0.73	0.73	0.71	0.77	0.88	1.09
	Guangdong	0.80	0.79	0.76	0.77	0.77	0.74	0.89	1.20
Village doctors per thousand population	Gansu	0.88	0.87	0.835	0.858	0.809	0.8	1.614	1.632
	Henan	1.069	1.128	1.313	1.369	1.399	0.942	0.969	1.043
	Guangdong	0.72	0.745	0.78	0.876	0.906	1.396	0.941	0.96
Certified village doctors per thousand population	Gansu	0.073	0.062	0.047	0.056	0.058	0.052	0.213	0.205
	Henan	0.098	0.081	0.140	0.131	0.117	0.179	0.201	0.107
	Guangdong	0.047	0.057	0.066	0.105	0.153	0.116	0.094	0.207
Township doctors per thousand population	Gansu	0.394	0.209	0.341	0.343	0.335	0.343	0.411	0.410
	Henan	0.346	0.172	0.308	0.313	0.311	0.596	0.588	0.370
	Guangdong	0.670	0.293	0.596	0.576	0.592	0.328	0.353	0.684

When surveyed data is combined with data from the statistic year books, we get a table with relatively complete information[2]. If both sources cannot directly provide the data we need, then we calculated the figures from existing patterns[3].

Table 4-3 Number of doctors at various levels

		County level	Township	Village level	Total
Gansu	1	209	598	2135	2943
	2	190	80	550	820
	3	167[1]			
	4	165			
	5	184	605	534	1323
	6	253	49		

2 The rule is firstly, we use the data from our survey directly, then we use the data from the Direct Report of Health System, then we use what the statistic year books can provide.

3 However, there are still some counties that lack data, so we leave them blank and only predict those where accurate data is available.

Henan	7	400	242[2]	763	1405
	8	364	298	2123	2785
	9	600		1292[3]	1892
	10	307	98	1415	1820
	11	467	114	1310	1891
	12	312	318	852	1482
Guang dong	13	1346	818	721	2885
	14	1338	690	1301	3329
	15	354	271	655	1280
	16	212	135	270	617
	17	525	386	425	1336
	18	483	230	233	946

[1] The green numbers are from the direct report of health system.

[2] The red colored number are transformed from statistic year book of Henen 2009

[3] The blue numbers are calculated from the ratio of township doctors and village doctor of the province of Henan in 2009.

4.2 Productivity of medical doctors

Productivity of doctors serves as a bridge to combine medical services and human resources. For the supply side, productivity is a very important characteristic of doctors, and is the outcome stemming from both input from facilities and individual doctors themselves.

There is no clear definition or measurement of doctors' productivity in the existing literature. In this section, we use the average number of outpatients and inpatients per day from the survey as an individual providers' productivity. Table 4-6 and figure 4-2 depict the productivity of doctors from the analysis of our surveyed sample.

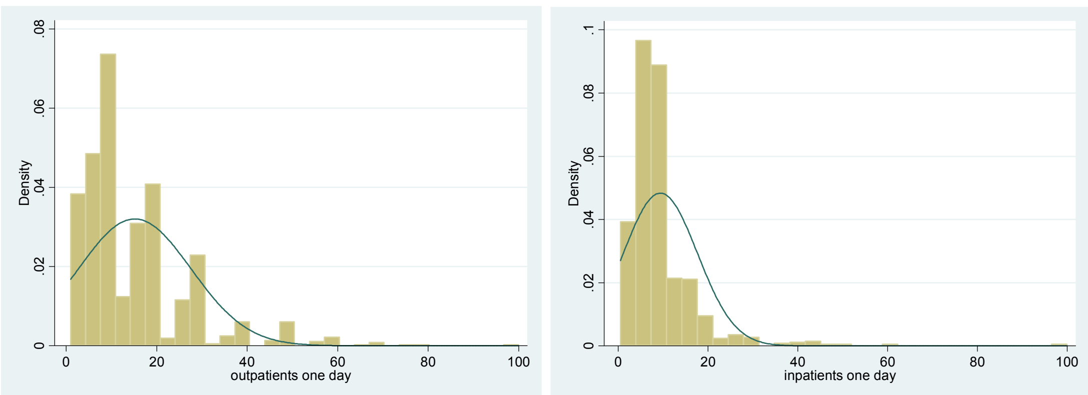


Figure 4-2 The distribution of numbers of outpatients/inpatients per day as reported on our institutional survey

We use the number of outpatients/inpatients per day as independent variables respectively, and run regression using STATA 10. As table 4-4 shows, for the productivity of outpatient, age, qualification, being in the department of pediatricians, and province have significant effect on productivity. While for productivity of inpatient, the relevant factors include age, gender, education, specialty, and county level hospital (table 4-5).

Table 4-4 Outcome of linear regression model for outpatient

ln(Outpatient)	Coef.	Std. Err.	P>t	[95% Conf.] Interval	
Gender	-0.1268	0.0546	-2.3200	0.0200	-0.2339
ln(Age)	0.5353	0.1385	3.8600	0.0000	0.2635
Qualification	0.1955	0.0394	4.9600	0.0000	0.1182
Gansu	-0.4417	0.0596	-7.4100	0.0000	-0.5586
Henan	-0.1956	0.0602	-3.2500	0.0010	-0.3138
Surgery	-0.2224	0.0670	-3.3200	0.0010	-0.3540
Pediatrics	0.1884	0.0778	2.4200	0.0160	0.0358
Constant	0.2964	0.4455	0.6700	0.5060	-0.5778

Table 4-5 Outcome of linear regression model for outpatient

ln(Inpatient)	Coef.	Std. Err.	P>t	[95% Conf.] Interval	
County level	0.3116	0.0484	0.0000	0.2167	0.4065
Qualification	0.1403	0.0362	0.0000	0.0693	0.2114
Gansu	-0.2735	0.0438	0.0000	-0.3595	-0.1875
Education level	0.0895	0.0328	0.0060	0.0252	0.1539
ln(Age）	0.1850	0.1284	0.1500	-0.0670	0.4369
Qualification	0.7499	0.4369	0.0860	-0.1075	1.6073

The variables of age, gender, wage, qualification, education level in the surveyed year are randomly distributed. However, given our sampling strategy for healthcare providers, the variables of area, specialty and institution level are not randomly distributed. So we will provide forecasts for the province level, the county level and township level respectively.

We can get the relationship of productivity and various factors from the above regressions. Using the outcome and setting different scenarios, we run some forecasting analyses. In this part, we consider two main scenarios: without policy shift and with policy shift. The former means there will be no external shocks related to policy changes, all the doctors in the pool will naturally develop (get older, promoted, retired, and etc.). The latter means doctors will be affected by policy shifts as well.

Table 4-6 Description of doctors' productivity

variables			Mean	Max	Min	P50
Outpatient per day	Gansu	County	9.6268	19.8706	3.9723	9.2577
		Town	8.1630	16.1470	4.2949	7.8391
	Henan	County	12.3127	25.4145	5.0805	11.8406
		Town	10.4404	20.6520	5.4931	10.0262
	Guangdong	County	14.9729	30.9055	6.1782	14.3988
		Town	12.6961	25.1140	6.6799	12.1924

	Total		11.7237	30.9055	4.2949	11.1977
Inpatient per day	Gansu	County	7.8009	11.0353	4.9424	7.5821
		Town	4.8760	7.5268	3.5268	4.7987
	Henan	County	10.3559	14.5066	6.4971	10.4217
		Town	6.6040	9.8944	4.8316	6.4706
	Guangdong	County	10.1678	14.0029	7.1619	9.7146
		Town	6.3882	8.8993	4.6362	6.3270
	Total		7.8074	14.5066	3.8208	7.2468

4.2.1 Without policy shift

The baseline of the forecast is the condition in 2009 of doctors' productivity and other characteristics. During the 10 years, doctors will naturally get older by 10 years. We assume there is no accidental death of doctors in the pool, and retirement begins when they reach the year of 65. Moreover, another factor will also change, the qualification, while we can estimate the likelihood of promotion in qualification by considering an individual's education background and working experience and the requirements for promotion (table 4-7). At the same time, we also account for inflow. It is assumed that, the amount of inflow each year is as same as that of the past 10 years, meaning 2000-2009, as well as their characteristics. So we can add the inflow sample to our surveyed sample to arrive at the new sample for 2020.

Table 4-7 Qualification in 2020 based on current education level and qualification

		Current qualification			
		None	Primary	Intermediate	Senior
Current education level	Technical Secondary school	Primary	Primary	Intermediate	Senior
	Junior college	Intermediate	Intermediate	Intermediate	Senior
	Under graduate	Intermediate	Senior	Senior	Senior
	Master and above	Senior	Senior	Senior	Senior

Table 4-8 Description of productivity in 2020

Variables			Mean	Max	Min	P50
Outpatient per day	Gansu	County	11.5760	20.9642	3.9723	11.8336
		Town	9.5552	21.3178	4.2949	9.4532
	Henan	County	14.8057	26.8132	5.0805	15.1352
		Town	12.2211	27.2655	5.4931	12.0907
	Guangdong	County	18.0046	32.6063	6.1782	18.4052
		Town	14.8615	33.1563	6.6799	14.7029
	Total		13.9484	32.6063	4.2949	13.4395
	Gansu	County	8.7678	11.4538	4.9424	9.3983

Inpatient per day		Town	5.3901	7.8002	3.5268	5.0176
	Henan	County	12.1483	15.0567	7.9921	12.8035
		Town	7.1837	10.2539	4.8316	6.9452
	Guangdong	County	11.3844	14.8921	7.1619	11.4348
		Town	7.1335	10.1864	4.6362	6.7451
	Total		8.6724	15.0567	3.8208	8.0228

4.2.2 With policy shift

The assumption that there will be no change of external policy in the next 10 years is unreasonable. We therefore consider possible policy scenarios in our next set of forecasts. Firstly, when we forecast the change of qualification, we base this on current standards, which may be changed in the future. Secondly, when we forecast the inflow above, we simply assumed the same condition over the past 10 years, but education policies may change, as well as policies in rural healthcare. Lastly, what we are calling *productivity* here is actually *workload*, because we don't know the kind of diseases the doctors are treating, some of them may legitimately take more time than others, leading to a designation of "low productivity" here, which may not be the case of the disease is accounted for. To solve this issue, future surveys ought to ask more details about the working time of doctors (e.g. what types of diseases take how much time).

(1) If education policy changes in 10 years

Future inflow of medical graduates is likely to change in the next 10 years with the reform of medical education.

Table 4-9 Education level of the recent 10-year's inflow in our surveyed sample

Year/education level	Technical Secondary school	Junior college	Under graduated	Master and above	Other
2000	9	18	18	0	0
2001	3	11	13	0	0
2002	4	9	7	0	0
2003	11	22	12	1	0
2004	5	10	12	0	0
2005	3	16	15	0	0
2006	3	23	28	1	0
2007	2	7	26	0	0
2008	2	18	28	0	0
2009	2	33	21	2	0

According to table 4-9, the number of technical secondary school graduates gradually decreased over the last ten years, undergraduates were stable in the past five years, while there were no patterns observed for master and above. From the data on medical graduates (table 4-10), the number of high education level graduates were increasing, but the proportions were decreasing. So if we make assumptions based on historical trends, it would be unreasonable to think the inflow with high education background will increase in the coming ten years.

Table 4-10 Number of medical graduates of the past 10 years

Year	Medical graduates	Master and above	Proportion
2000	59857	6166	10.30122
2001	69630	6722	9.653885
2002	88177	6992	7.929505
2003	123563	12207	9.879171
2004	170315	16128	9.469512
2005	221982	21923	9.876026
2006	279667	26415	9.445162
2007	332842	32453	9.750272
2008	408983	37402	9.145123
2009	428422	34629	8.082918
2010	483611	35582	7.357566

However, in the history of China's medical reforms, medical personal is always an important aspect. In "the reform of medical and healthcare system of China's the twelfth 5-year-plan[4]", it emphasizes the training and continuing education of doctors. This is likely to have a positive impact on the productivity of doctors.

(2) If more active rural healthcare policies

The government of China has made great efforts to improve the condition of rural healthcare in the recent years, and specifically 10 or 15 year plans have been made to regulate the rural healthcare situation. Those plans will encourage or even dictate that rural areas improve many aspects of their hospitals, especially the township hospitals and village clinics.

From our research, we have acquired basic information from county level hospitals (Central hospital, Chinese medicine hospital, MCH and CDC) related to their equipment and working capacity. So we use the number of patients' visits in the year 2009 divided by the number of doctors as the depended variable, and use the value of equipment that worth more than 10 thousands as the only independent variable to run a bivariate regression. The outcome shows that those two variables are highly related, and one percent of the value increase will bring 0.2 percent of average working productivity of doctors taking charge of outpatient, while for the inpatient, the number is 0.25 percent.

4.2.3 Result and discussion

There are many factors that we have not analyzed which may affect physician productivity. Future surveys and investigations would be advised to take this into account.

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[4] Every five years, Chinese State Council will release a five-year plan to instruct every inspect of china's development. The twelfth 5-year plan is from 2010 to 2015.

In conclusion, taking account of the future policy changes and other uncertainties, we can see the forecasting without policy shift underestimates the productivity. So here we subjectively raise the result from the analysis above to account for policy shifts. We then arrive at a prediction that in the year of 2020, the number of outpatients that a doctor can take care of per day is around 15, and for the inpatient, the number should around 9.

Table 4-11 Outcome of forecasting in the year 2020

Variable	Province	Level	Productivity
Outpatient per day	Gansu	county	12
		town	10
	Henan	county	16
		town	13
	Guangdong	county	19
		town	15
	Total		15
Inpatient per day	Gansu	county	9
		town	6
	Henan	county	13
		town	8
	Guangdong	county	12
		town	8
	Total		9

For the village level, the data insufficient to support a productivity analysis, but we assume (considering their lower level of training) that village doctors' productivity would be a little lower than that at the township level. However, for our analyses below, we assume the same level of productivity.

4.3 supply projection

As we can see from the section of current situation and demographics of medical doctors in rural China, there is no significant pattern observed in the numbers. Moreover, it is hard forecast based on information regarding the inflow and outflow of doctors. So it is necessary to set a series of scenarios. The variables in the following table are considered to be influential for the supply of doctors. We divided the variables into different forecasting scenarios.

Table 4-12 influential factors on the supply side

Influential factors		Result on doctors numbers	Scenarios
Population change	Natural Increase of rural population	Positive	Baseline
	Urbanization of population	Negative	Scenario 1

Continuing policy shift	Motivation policy on rural doctors	Positive	Scenario 2 and 3
	Policy on the reform of medical education	Positive	
	Direct regulation of distribution of rural doctors	Positive	
Possible policy (based on the change of characteristics of doctors)	Retention rate	Uncertain	
	Increase of productivity	Negative	

4.3.1 baseline projection-natural population change

In the baseline projection, we only consider the changing population. This assumption is based on the fact that although the forecast of supply does not take the demand-side into consideration, demand still creates supply on so many levels. For example, the hospitals will recruit doctors based on the workload of doctors from previous years, and medical schools will decide their enrollment policies by considering the job market. There are all kinds of uncertainties, which are likely accounted for by adjusting for population dynamics. We assume the number of doctors in 2020 per thousand population is the same as that in 2009, and the total number of doctors at different levels will change with population increases. The forecast of population is based on the detail of characteristic of population in the year 2005 for each province, so we also have to assume that the increase rate of rural population of the county is the same with that of the province.

4.3.2 Scenario one- with changing urbanization

During the survey, we found that doctors of rural areas were mainly the local residents, which means they came back to their hometown to work after graduation from medical school. Although some of them were from other places, they were usually from the adjacent counties. Therefore, changes in urbanization matter when forecasting the future supply of doctors.

In the baseline projection, the forecast of population of rural China have already taken into account urbanization and assumed it with a stable rate in 2010-2020. While with the economy and social change of China, the rate of urbanization is actually not a constant at all.

It seems that the levels of urbanization rate of three provinces are significantly different, especially in Guangdong, due to its highly developed economy. There are also some obvious trends in urbanization that we can depend on to deduce the future change. For Gansu, there was approximately 0.5% increase every year, so we use this for the next ten years' rate; for Henan, the increase rate is 1.5% for the next ten years; as for Guangdong, the high level of urbanization should be stable in the year 2020, so we make an assumption and set it at 65%. The final urbanization rate in 2020 is shown in table 4-13.

Table 4-13 urbanization of the three provinces (%)

Year / Province	Gansu	Henan	Guangdong
2000	24.01	23.20	55.00
2001	24.51	24.43	
2002	25.96	25.80	
2003	27.38	27.20	
2004	28.61	28.91	
2005	30.02	30.65	60.68
2006	31.09	32.47	63.00
2007	31.59	34.34	63.14
2008	32.15	36.03	63.37
2009	32.65	37.70	63.40
2020	38.15	54.20	65.00

Urbanization affects the rural population with people immigrating to cities. In the last section, we forecast the number of doctors based on the natural increase of population in the baseline, and in this section, based on the forecast of urbanization rate we will revise the rate of increase of doctors. Since the immigration may happen from village to county, as well to big city, and only the former condition can affect the rural population, we assumed that half of the immigration will affect the forecasting of rural doctors[5].

4.3.3 Scenarios two and three -number of doctors per thousand population change

In these two scenarios, we consider that in the future 10 years, the number of county level, township level and village level doctors per thousand population will change. The scenarios are determined by the evaluation of the policy shifts and changing characteristics of doctors, such as retention rate and increase of doctors' productivity.

The number of doctors in rural areas mainly depends on policy shifts. According to the plan of reform of medical and healthcare system released by the Chinese State Council, the objective in 2010 is to "make sure everyone can enjoy basic medical care[6]". We can deduce from this that the supply of doctors is likely to increase in order to realize such objectives. For example, "...every city doctor that want to be promoted to intermediate or high qualification should work in the rural at least for one year", and it also emphasized the training of rural doctors. There are also some pilot schemes currently in operation in each province.

Also, we have to account for the change in doctors’ productivity. We used information for this from the above section of productivity projection that doctors' productivity will increase in the future 10 years, this may have an influence on the policy makers if they take account of this change. Therefore, the increase of doctors may be counterbalanced a bit by such considerations.

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[5] For example, the rate of province of Henna is calculated by [(1-38.15%)/(1-32.65%)-1]/2

[6] www.moh.gov.cn [accessed 01 June 2013]

From the above, we can infer that the supply of doctors will likely increase in the year 2020.While there are enormous uncertainties, we have to make bold assumptions based on the information we have. And although we do not know the exact numbers from those policies, we can assume that the growing rate of the number of doctors is 15% as the lower scenario. Moreover, we also know that the graduates are increasing too at 25% on average. Since we do not know how many graduates will enter into the medical system, we still cannot give an accurate assumption. However based on the fact that graduates will see a dramatic rise, we can set a higher scenario at 40%.

4.3.4 Result

In the above discussion, we set three different scenarios for projection. For the missing counties, we will base our analysis on the combination of population, GDP, and the size of the county to arrive at our estimated results (table 4-14). We use the same method above to forecast the number of doctors at the provincial level (table 4-15)

Table 4-14 Forecasting result of supply of doctors of 2020 in different scenarios (Counties)

		County level				Township				Village level				Total			
		Baseline	Scenario1	Scenario2	Scenario3	Baseline	Scenario1	Scenario2	Scenario3	Baseline	Scenario1	Scenario2	Scenario3	Baseline	Scenario1	Scenario2	Scenario3
Gansu	1	220	210	263	294	629	601	751	841	2246	2147	2684	3006	3095	2958	3698	4141
	2	200	191	239	267	84	80	100	112	579	553	691	774	863	825	1031	1155
	3	176	168	210	294	503	481	601	675	1797	1718	2147	2405	2476	2366	2958	3313
	4	174	166	207	290	450	430	537	602	1129	1079	1349	1511	1783	1705	2131	2386
	5	149	185	231	259	637	609	761	853	562	537	728	815	1392	1331	1664	1863
	6	266	254	318	445	52	49	62	86	112	107	134	149	430	410	513	718
Henan	7	410	356	445	498	248	215	269	301	782	679	849	951	1440	1250	1563	1750
	8	373	324	405	454	306	266	333	372	2176	1889	2361	2645	2855	2478	3098	3469
	9	410	356	445	498	205	178	222	249	1325	1150	1437	1610	1940	1684	2105	2357
	10	315	273	341	382	100	87	109	122	1451	1259	1574	1763	1866	1620	2025	2268
	11	479	416	520	582	117	102	128	143	1343	1166	1458	1632	1939	1683	2104	2356
	12	320	278	348	389	326	283	354	396	873	758	948	1061	1519	1318	1648	1845
Guangdong	13	1398	1386	1733	1940	850	843	1054	1180	749	742	928	1039	2997	2971	3714	4159
	14	1390	1378	1723	1929	717	711	889	995	1351	1339	1674	1875	3458	3428	4285	4799
	15	368	365	456	511	282	280	350	392	680	674	843	944	1330	1318	1648	1845
	16	220	218	273	305	140	139	174	195	280	278	348	389	641	635	794	889
	17	545	540	675	756	401	397	496	556	441	437	546	612	1388	1376	1720	1926
	18	502	498	623	697	239	237	296	332	242	240	300	336	983	974	1218	1364

Table 4-15 Forecasting result of supply of doctors of 2020 in different scenarios (Provinces)

Province/ Scenarios	Rural doctor				County doctor				Township doctor				Certified village doctor				Village doctor			
	Baseline	Scenario1	Scenario2	Scenario3	Baseline	Scenario1	Scenario2	Scenario3	Baseline	Scenario1	Scenario2	Scenario3	Baseline	Scenario 1	Scenario 2	Scenario3	Baseline	Scenario1	Scenario2	Scenario3
Gansu	21690	20733	25917	29027	11665	11151	12824	15611	7798	7454	9318	10436	2266	2166	2491	3033	22005	21034	26293	29448
Henan	100143	86924	108656	121694	45820	39772	45738	55680	35518	30829	38537	43161	17718	15379	17686	21531	141001	122389	152986	171344
Guangdong	64822	64251	80314	89952	35917	35601	40941	49842	28956	28701	35876	40181	8776	8698	10003	12178	40735	40377	50471	56528

Summary of Section 4

This part of supply side analysis describes the current supply of medical doctors and the time trend at the provincial level and in surveyed counties. The productivity projection is made by firstly regressing the influential factors, and then getting the result of projection of the year 2020 for different levels in each province. At last, through setting different scenarios, we get the number of doctors for 2020.

The following major conclusions can be drawn from the analysis:

1. All three provinces experienced stable growth in supply of doctors from 2003 to 2010, with Henan having more doctors than the other two provinces;

2. Gender, qualification, level of the institution, province and age have significant effect on the productivity of medical doctors. Increase rates of productivity in 2010 are different for each province, each level, and outpatient productivity is higher than inpatient, considering all the possible policy shifts;

3. Population growth, changing urbanization rate, increase in productivity, policies which encourage work in rural areas, regulation of doctors' distribution etc. have different effects on supply projection. Overall, both county level and provincial level will face increased supply in 2020.

5 Imbalance of future medical doctors

Section 3.3 provided projections of the demand for health care services in 2020 at different levels. Section 4.2 analyzed the productivity of medical doctors in 2020, as measured by the load of outpatients or inpatients per day one doctor can manage. If it is assumed that each doctor works 5 days a week (20 days per month and 240 days per year), as is prescribed by professional guidelines, the number of medical doctors which would be needed to meet the demand at different levels in 2020 is calculated and presented in table 5-1.

On the supply side, the relatively moderate projection presented in scenario 2 will be used to compare with the number of medical doctors required to meet the demand (table 5-1). Such a comparison allows us to estimate the shortcoming or surplus of doctors at the different levels for the three provinces in 2020 and facilitates the formulation of some policy recommendations presented in section 7.

Table 5-1 Demand for and supply of medical doctors at different levels in 2020

		Demand			Supply (Scenario 2)
		Outpatient	Inpatient	Total	
Gansu	Village clinic	15988		15988	26293 (2491) [1]
	Private clinic	5343		5343	
	Township hospital	9095	18786	27881	9318
	County hospital	6288	23465	29753	12824
Henan	Village clinic	77350		77350	152986 (17686)
	Private clinic	9366		9366	
	Township hospital	9586	51332	60918	38537
	County hospital	11370	55915	67285	39772
Guangdong	Village clinic	48844		48844	50471 (10003)
	Private clinic	6395		6395	
	Township hospital	8095	54194	62289	35876
	County hospital	3652	31402	35054	40941

[1] The figures in parenthesis are the number of certified village doctors

5.1 Village doctors

As depicted in table 5-1, in 2020 we estimate a surplus of village doctors. In other words, the estimated supply outnumbers the projected demand for the village doctors. However, it should be noted that the majority of village doctors (around 90%) have only the special qualification certification which ranks lower than assistant doctors. According to the International Standard Classification of Occupations, they would not be considered doctors. If, therefore, we only enumerate the certified village doctors (shown in parenthesis in table 5-1) to meet the projected demand for medical doctors at that level, there will be a clear shortage. In 2020 we estimate that the supply of certified doctors will account for 15.58%, 22.86% and 20.48% of the requirement for medical doctors in Gansu, Henan and Guangdong, respectively.

Moreover, certified village doctors are all full-time doctors whereas the village doctors who only hold a special qualification certification tend to also be farmers. Indeed, according to our survey, some uncertified village doctors earn a higher proportion of their income from farm work compared to medical practice. The estimated surplus of village doctors is partially attributed to the assumption that all the village doctors work full time. If we adjust our calculation such that only certified village doctors work full time and the remainder of the work (i.e. the shortfall) is covered by the uncertified village doctors, we arrive at the conclusion that the uncertified village doctors need to spend 57%, 44% and 99% of their time on medical practice in Gansu, Henan and Guangdong, respectively in order to fill the gap (table 5-2).

Table 5-2 required percentage of time spent on medical practice by uncertified village doctor

	Gansu	Henan	Guangdong
Service requirement	9592649	60332715	43959289
Full-time productivity	10	13	15
Demand for village doctors	15988	77350	48844
Supply of total village doctors	26293	152986	50471
Supply of certified village doctors	2491	17686	10003
Supply of uncertified village doctors	23802	135300	40468
Gap between demand and supply of certified doctors	13497	59664	38841
Required productivity to meet the gap	5.67	5.73	14.4
Percentage of time spent on medical practice (%)	57	44	96

5.2 Township and county doctors

Although the quantity of doctors at the village level in 2020 does not appear to be a problem based on our estimations, at the township and county level there will be a serious shortage. Especially in

Gansu Province, one of the more underdeveloped provinces, the supply of medical doctors in 2020 may only cover 33.42% and 43.10% of the estimated demand at the township and county level, respectively. The only surplus of medical doctors appears at the county level in Guangdong Province, one of China's more developed province. This demonstrates considerable regional disparities in health care resources across China.

Furthermore, the working time in the projection may play a significant role in the general broad gap between the expected demand and supply. We assume doctors in China work for 5 days per week. This is a reasonable and acceptable workload for most medical doctors, and is one of the long-term goals of the healthcare workforce planning. However, in reality, medical doctors in China bear heavier burdens. Through our survey we found that township doctors work on average 6.21 days per week, while county doctors work 6.08 days. Nevertheless, even if we apply these actual days of working per week to our forecasting, the shortage of medical doctors at both the township and county levels remains, albeit less serious (table 5-3).

If no measures are taken to deal with this shortcoming of supply with respect to demand, township and county doctors may see an increase in their working time in 2020. Given that they already report working more than 6 days per week, there is not much space for already overburdened medical doctors to further contribute. A more likely scenario, therefore, is a compromise to the quality of health care services as doctors attempt to increase their level of productivity (i.e. they try to enhance their efficiency).

According to our survey, only 37% of county and township doctors expressed satisfaction towards their job, 59% said they were not satisfied with salary, 54% were not satisfied with hospital management and 31% reported dissatisfaction in their relationship with patients. Moreover, half said they had the intention to quit their job. The excessive working time and huge disparities were often reported as the reasons for medical doctors' dissatisfaction. Our survey shows that 84% of medical doctors identify the long working time as one of the leading sources of pressure in Gansu, while this figure is only 58% in Guangdong. Moreover, 16% of medical doctors in Gansu Province, which is projected to have the most serious shortage, report feeling dissatisfied with their work. The dissatisfaction rate in Henan and Guangdong is 13% and 12%, respectively. Considerable research exists to suggest that medical doctors' dissatisfaction compromises the quality of health services and reduces their productivity. This may potentially lead to a vicious circle.

Table 5-3 Demand for medical doctors by using the current days of working

Province			Service requirement	Demand for doctors (by applying the current days of working)	Total Demand	Supply (scenario 2)	Demand/Supply
Gansu	Township level	Outpatient	5457043	6760	20722	9318	2.22
		Inpatient	27052054	13962			
	County level	Outpatient	4527143	4773	22585	12824	1.76
		Inpatient	50683734	17812			
Henan	Township level	Outpatient	7477131	7125	45276	38537	1.17
		Inpatient	98557907	38151			
	County level	Outpatient	10914893	8631	51077	45738	1.12
		Inpatient	174455687	42446			
Guangdong	Township level	Outpatient	7285732	6017	46294	35876	1.29
		Inpatient	104051540	40278			
	County level	Outpatient	4163275	2772	266010	40941	0.65
		Inpatient	90437319	23838			

6 Summary of our methodological contribution

Compared to previous methods for forecasting human resources in health, our method has contributed numerous improvements as detailed below:

1. The conceptual framework of our method is logically straightforward and provides a more holistic approach to HRH forecasting than existing approaches.

2. The regression analyses for the need, demand and supply provide a wealth of quantitative relationships among the abundant variables involved in HRH planning. By discerning these relationships, new scenarios can be investigated, depending on questions policy makers would like to examine. The scenario building in this study is only a paradigm to show how it works. To this extent, it is the modelling process that is of most value. The method can be easily replicated by combining the regression analysis and scenario building, so that it can be adapted to various circumstances and changed assumptions. New concerns can, therefore, readily be incorporated.

3. Our method differentiates medical *need* and *demand* for healthcare and accordingly carries out as detailed analysis as the data allows. Medical need is based on professional judgment and the best available scientific evidence, while demand is affected by perceived need and many other (including, but not limited to, financial) constraints. This method is a meaningful exploration for discussing the under- and/or over-consumption of health care services associated with HRH planning.

4. No previous research to our knowledge has attempted to forecast health care seeking behaviours. The models we presented here have explicit assumptions and clear structures, and serve as powerful tools to systematically qualify people's healthcare seeking behaviors.

5. Many of the existing forecasting models focus on either supply or demand alone. The few which have accounted for both ended up only reporting them together. Our method takes this a step further and provides an imbalance analysis which connects supply and demand to arrive at policy recommendations.

6. Our method offers a practical way to analyze and forecast medical doctors' productivity, which is a key factor often neglected by other research on HRH planning.

However, our method leaves much room for improvement. As a great modeller Professor George E. P. Box said "essentially, all models are wrong, but some are useful". Our method has the following limitations:

1. One drawback of the method is due to the cross-sectional nature of the data. For example, we do not have inflow and outflow of medical doctors for each year, and accordingly it is difficult to conduct a dynamic analysis by using our data alone.

2. Ideally, supply of and demand for medical doctors are interactive at each stage. Our method is still not able to describe this interaction accurately, but we have made every effort to connect supply and demand by carrying out the imbalance analysis.

3. Our method does not take full consideration of other health care professionals, especially nurses. Our data have relatively more complete information about medical doctors, but nurses (as well as other support staff) are an integral element of the healthcare workforce. Nurses share many tasks of medical doctors and help them improve productivity. Their supplementation effect is self-evident and deserves further research. However, it should be noted that the role of uncertified village doctors in China is more close to nurse rather than medical doctors. We have incorporated considerable discussion about the uncertified village doctors. In this case, the definition of medical doctors is broader in this study and does include some of other health care professionals.

7 Key Policy Recommendations

Based on the synthesis of our findings from the need, demand for and supply of HRH in rural Gansu, Henan and Guangdong, we make the following key policy recommendations:

1. Given the persistent shortage of Pediatricians in China, we recommend strengthening the role of village doctors in preventing common childhood diseases. Much of this may be achieved by addressing water and sanitation infrastructure and providing education for nutrition and hygiene.
2. In addition, given the rise in non-communicable diseases such as hypertension, diabetes and CVD in the rural context, we recommend the village doctors' role and training be expanded to support the prevention, monitoring and management of such diseases. This would include providing education programs related to smoking, diet and physical activity; screening the population to identify individuals who would need further targeting; and monitoring the treatment of existing patients, including providing referrals where needed.
3. Similarly we recommend an expanded role for the township level public health workers to facilitate the development of training materials and support for village doctors in dealing with the growing problem of non-communicable diseases.
4. At the county level, we recommend strengthening and equipping the doctors' ability to deal with complications arising from NCDs. This would include training of the doctors in the rural county hospitals on international guidelines and recommendations related to the treatment and management of NCDs.
5. To meet the growing demand for healthcare at the county and township levels, we recommend several approaches:
    a. Allow medical schools to expand their enrolment rates to increase the pool of available doctors. However, increased numbers does not ensure that graduates will practice medicine at all or opt to practice in a rural context.
    b. Improve doctors' working environment by reducing hours, increasing salaries, and providing more training and promotion opportunities.
    c. Introduce an incentive scheme to attract new medical graduates to rural hospitals and villages.
    d. In order to address the problem of poor relationship between patients and doctors, we recommend setting up an independent doctor industry group to provide neutral arbitration for medical disputes.

6. In addition to further training and access to support systems, we also recommend more stringent regulations and quality control mechanisms for village doctors.
7. Lastly, we recommend increasing and stabilizing payment of village doctors to limit career shifts.

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