

# BMJ Open Examining clinical capability of township healthcare centres for rural health service planning in Sichuan, China: an administrative data analysis

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## ABSTRACT

**Objective** This study aimed to examine the clinical capability of township healthcare centres (THCs), the main primary care providers in rural China, as a basis for rural health service planning.

**Design** Observational study of quantitative analysis using administrative data.

**Setting** Three counties with low, middle and high social economic development level, respectively, in Sichuan province western China.

**Participants** 9 THCs and 6 county hospitals (CHs) were purposively selected in the three counties. Summary of electronic medical records of 31 633 admissions from 1 January 2015 to 30 December 2015 of these selected health institutions was obtained from the Health Information Centre of Sichuan province.

**Main outcome measures** Six indicators in scope of inpatient services related to diseases and surgeries in the THCs as proxy of clinical capability, were compared against national standard of capability building of THCs, among counties, and between THCs and CHs of each county.

**Results** The clinical capability of THCs was suboptimal against the national standard, though that of the middle-developed county was better than that in the rich and the poor counties. THCs mainly provided services of infectious or inflammatory diseases, of respiratory and digestive systems, but lacked clinical services related to injuries, poisoning, pregnancy, childbirth and surgeries. A large proportion of the top 20 diseases of inpatients were potentially avoidable hospitalisations (PAHs) and were overlapped between THCs and CHs.

**Conclusions** The clinical capability of THCs was generally suboptimal against national standard. It may be affected by the economics, population size, facilities, workforce and the share of services of THCs in local health systems. Identification of absent services and PAHs may help to identify development priorities of local THCs. Clarification of the roles of THCs and CHs in the tiered rural health system in China is warranted to develop a better integrated health system.

## INTRODUCTION

Primary healthcare (PHC) is vital to provide essential, accessible, equitable and affordable

## STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This study uses regional objective electronic medical record (EMR) data to portrait clinical capacity of typical township healthcare centres (THCs) with low, middle and high economic level in rural China.
- ⇒ The clinical capacity of THCs was compared against national standards, between counties with typical social-economic and geographic differences, and with local county hospitals (CHs) for understanding their strengths and limitations.
- ⇒ This study looks into essential but absent clinical services and potentially avoidable hospitalisations in THCs, and overlapped hospital services between THCs and CHs, which has been rarely investigated previously.
- ⇒ This study used 2015 data and more recent data is to be used for future research.
- ⇒ EMR was only available for inpatients, future research may include outpatient data to allow a more comprehensive portrait of clinical capability of THCs.

care towards universal health coverage and health-related sustainable development goals.<sup>1</sup> PHC institutions are also the foundation of the three-tiered healthcare system in China, with secondary hospitals (at county-level) and tertiary hospitals (at city-level or provincial-level) at the end.<sup>2</sup> At the bottom of the three-tiered healthcare system, the township healthcare centre (THC) is the main PHC provider for the 650 million rural residents in China,<sup>3–5</sup> with its main workforce of licensed general practitioners and registered nurses.<sup>6</sup> They are responsible for the national essential public health services, primary outpatient services and inpatient services for common illness for rural residents. Although THCs of 35 762 in total in 2020 provided 1.1 billion episodes of healthcare including 34 million episodes of inpatient services, accounted for 15% and 14% of that provided by all health institutions in China,<sup>7</sup> the share of inpatient treated in THCs in the



national healthcare system of China was declining from 26% in 2010 to 17% in 2016.<sup>7</sup>

The declining in inpatient services in the THC<sub>s</sub> could have several reasons. First, due to the fast urbanisation and transportation development in China, patients were more likely to bypass primary care facilities to obtain perceived high-quality clinical services from higher-level hospitals if they were highly accessible and financially affordable.<sup>8</sup> Second, currently there is no mandatory or legitimated gate-keeping role of the government for THC<sub>s</sub>. For patients with more severe or complex conditions, THC<sub>s</sub> are only advised to refer them to visit county or tertiary hospitals for more specialised care.<sup>3,5</sup> In most cases, patients are free to visit any county or tertiary hospitals without restriction. Third, the clinical capability of THC<sub>s</sub> is varied by regions, and is much weaker in remote and mountain areas due to lack of resources and especially qualified health workforce than their counterparts.<sup>9</sup> The weakness of capability of THC<sub>s</sub> would cause more patients losing to higher-level hospitals and thus cause a vicious circle, putting the survival of THC<sub>s</sub> and health of rural residents at risk.<sup>2</sup> Consequently, patients with common chronic illness such as hypertension and diabetes that are supposed to be cared by THC<sub>s</sub> or PHC providers went to seek care in county or tertiary hospitals, which lead to the underuse of THC resources and soaring hospital expenditure.<sup>8,10</sup>

There was evidence that clinical capability was the primary reason limiting patient's choice of primary healthcare,<sup>11</sup> and improving the clinical capability including drug availability, medical professional skills and equipment in rural primary care systems can induce potential medical care-seeking, and redirect patient flow from higher level hospitals to primary level in rural China.<sup>12</sup> Many extrinsic and intrinsic factors were involved in shaping the clinical capability of THC<sub>s</sub>. Local economic status, health finance, facilities and health workforce were positively associated with clinical capability and range of clinical services of THC<sub>s</sub>.<sup>13</sup> The serving population was also an important extrinsic factor besides local economics.<sup>14</sup> Health policies for reducing maternal and neonatal mortality and ensuring the quality of maternal care in China had promoted hospital delivery in secondary or higher-level hospitals,<sup>15,16</sup> which led to terminated maternal services in most THC<sub>s</sub>.

Understanding the clinical capability of THC<sub>s</sub> in regions with different social economic development levels would have important implications in rural health service planning and effectively establish gate-keeping role of THC<sub>s</sub>. To improve the healthcare services in THC<sub>s</sub>, the government has published the national guideline of THC<sub>s</sub> capability building and evaluation.<sup>17</sup> However, few studies have explored the clinical capability of THC<sub>s</sub>, and even fewer had compared that between counties with different socio-economic and health system contexts.<sup>2,18,19</sup> The understanding of the role of THC<sub>s</sub> in rural health systems in China is inadequate. The county hospital (CH), usually one or two located in the county centre in each county, is the first referral destination of the THC<sub>s</sub> and the main origin of transferring discharged patients down to THC<sub>s</sub> for post-hospital care.<sup>20</sup> To understand the similarity and difference

in the clinical capability between the CH and THC<sub>s</sub> could help health authorities to make guideline for patient centred specific care in the healthcare services, which may consequently lead to better quality and integrated healthcare for rural population.

This study aimed to fill the gaps by examining the clinical capability of THC<sub>s</sub> and comparing it with local CH<sub>s</sub>. Considering that clinical capability by definition is a multiple-dimensional system, we previously reported quality of outpatient services of the sampled THC<sub>s</sub>,<sup>21</sup> and of workload in preventive care in the study THC<sub>s</sub>.<sup>22</sup> Hence, this study only focused on scope of inpatient services as a narrow proxy of clinical capability to reflect the coverage of the curative care of THC<sub>s</sub>. It is known that types of inpatients clinical services and their complexity may represent the clinical capability of a medical institution. The research questions were (1) what scope of inpatient services the THC<sub>s</sub> currently provide in terms of disease types and surgery procedures, (2) how much difference in those services provided by THC<sub>s</sub> and by the local county-level hospitals and (3) how much difference in those services among THC<sub>s</sub> with different economic status?

## METHODS

This is an observational study based on administrative data from the national inpatient electronic medical records (EMRs) system. The EMRs have been established by the Committee of Health and Family Planning of Sichuan province and operated among all levels of hospitals in Sichuan province since 2014 for administrative management. Each inpatient admission has a summary or homepage of the EMRs completed at discharge. Every hospital submits the nationally standardised summary of EMRs electronically at monthly basis. This study used data from January to December 2015. The reliability of the inpatient EMRs database has been verified, on which a number of studies have been conducted and published.<sup>23,24</sup>

## Sample county

Sichuan province lies in the Hu (Heihe–Tengchong) line at southern west China. The Hu line has significant geographic and socioeconomic significance. In the south-east of the line, lived 94% of the population of China with 43% of the Chinese territory, while only 6% population lived in the west of line with 57% of the territory.<sup>25</sup> Therefore, Sichuan is a typical province that could reflect China's demographic, geographic and average socioeconomic variations (online supplemental table 1). According to the 2015 Sichuan Province Health and Family Planning Yearbook, Sichuan had 447 CH<sub>s</sub> and 5448 primary healthcare facilities, with 4511 (83%) rural THC<sub>s</sub> and 937 urban community health centres.<sup>20</sup>

We purposively selected three counties in Sichuan province considering their socioeconomic and health system characteristics. Longquanyi (LQY) represented the richest region located in the plain of Sichuan basin, close to the provincial capital Chengdu (23 km) with convenient

**Table 1** Health resources and characteristics of inpatient admission of sampled township healthcare centres in the three counties 2015

	LQY	FS	GL	P value
Number of permanent residents, N	180 961	76 326	65 988	
Licensed physician (assistant), N	79	57	24	
Registered nurse, N	62	29	16	
Beds, N	148	119	36	
Admissions, N	1941	4042	1013	
Male inpatient, N (%)	661 (64.0)	2127 (53.8)	579 (58.2)	≤0.001
Age of inpatients: mean (SD)	55.1 (20.0)	58.3 (20.3)	45.5 (18.2)	≤0.001
Length of stay (day)	6.56 (5.3)	5.01 (5.1)	4.99 (1.6)	≤0.001*
Expenditure per admission, RMB	1160 (769)	1283 (689)	450 (154)	≤0.001*

$\chi^2$  test for sex, analysis of variance for age of inpatients.  
 \*Kruskal-Wallis test for length of day and expenditure per admission.  
 FS, Fushun county; GL, Ganluo county; LQY, Longquanyi district.

transports by bus or metro (about 40 min), with GDP per capita of about US\$17 590 in 2015, two times higher than the national level at 2015 (online supplemental figure 1). By contrast, Ganluo (GL) represented the poorest remote region located in western mountains, 350 km southwest from Chengdu (6 hours by bus or train) and 200 km from its municipal city Xichang (5 hours by bus). Its GDP per capita was about US\$1908, only one-fourth of the national average. Fushun (FS) county represented the middle-developed region located in a hilly area, 215 km southeast from Chengdu (3 hours by bus), and 37 km from its municipal city Zigong, with GDP per capita being half of the national average (table 1 and online supplemental figure 1). The three sample counties had a total population of 1.96 million and rural population of 1.35 million (68.9%) in 2015 (online supplemental table 2).

### Participating institutions

We purposively selected three THC's from each of the three sampled counties based on their distance of being close, average and remote to the county centre considering the accessibility of health services, and two CH's in each county were selected for comparison with that of THC's (online supplemental figure 1).

### Data extraction

Under a research agreement with the data management authority, the Health Information Centre of Health Commission of Sichuan Province, the research team obtained the EMR's data electronically for the required period. All patients admitted and diagnosed in the selected THC's and CH's from January to December 2015 were included in the analysis. Overall, the study data had 31 633 admissions, including 6675 to THC's and 24 958 to CH's. The EMR's contained anonymous information of patients' demographics, admission and discharge status, hospitalisation expense, disease diagnoses coded by the International Classification of Disease (ICD)-10th version, and surgeries coded by the ICD-9-CM.

### Indicators

Given the fact that patients freely choose any hospital for service use in China, inpatients healthcare services represented the most complicated healthcare that would be offered by a health institution for patients to choose from. For the health system assessment, the use of services by patients has been considered an important indicator assessing capacity of primary healthcare institutions by the health authority in the country.<sup>17</sup> A previous study by our team developed a tool to assess clinical care quality of county-level hospitals based on the summary information of EMR's. The tool consisted 25 indicators covering 6 dimensions. The first dimension was clinical capability with types of diseases diagnosed and treated as the key and only indicator.<sup>24</sup> For clinical capability of the THC's in this study, we used six clinical service scopes as a proxy of clinical capability indicators based on the national standard of capability building of THC's,<sup>17</sup> and on the availability of valid information in the data sources:

1. *Coverage of essential clinical services* as listed in the national standard of capability building of THC's,<sup>17</sup> a number count of diseases diagnosed by disease domain.
2. *Coverage of diseases by systems* defined by ICD-10 chapters, a checklist with the number count of diseases diagnosed by disease systems.
3. *Coverage of surgery by systems* defined by ICD-9-CM chapters, a number count of surgery procedures performed by disease systems.
4. *Number of types of diseases* defined by ICD-10 codes.
5. *Top 20 diseases and their relative frequency among all services* defined by ICD-10 codes. From all diseases diagnosed and treated, list the first 20 ranked by counts and relative frequency.
6. *Top 10 surgeries and their relative frequency among all surgeries* defined by ICD-9-CM codes, the same definition to indicator 5 but for surgery services.

The basic unit of all indicators is a curative service for disease or surgery at each hospitalisation of a patient who

could have several units if admitted to and discharged from a hospital several times during the study period. The larger number of indicators in healthcare institutions reflects wider diseases they treated and more surgeries they operated by three levels: disease domain (indicator 1), disease systems (indicators 2 and 3) and specific diseases (indicators 4, 5 and 6).

### Statistical analysis

Indicators of the THC and CHs were derived separately. The formers were grouped by county and compared against those of the CHs within each county. The coverage of essential clinical services of the THC (indicator 1) was presented against the number in the national guideline and compared among three counties using  $\chi^2$  test. Indicators 2 and 3 of the THC were compared among counties, and to that of the CHs too descriptively using frequency and percentages. The number of types of diseases and surgeries (indicator 4), ranks of diseases (indicator 5) and surveys (indicator 6) were also described and compared among counties using frequency and percentage. Larger numbers of indicators demonstrated a wider scope of inpatient services which suggested higher clinical capability in THCs. Where ever necessary,  $\chi^2$  test was used to compare binary indicators between THCs of different counties and between THCs and CHs. One-way analysis of variance was used for continuous variables if they were normally distributed, otherwise Kruskal-Wallis test was used. All analyses were conducted using Stata V.15.0 SE, with two-sided significant level at 0.05.

### Patient and public involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

## RESULTS

### Health resources of sample THCs

The sampled THCs in LQY, FS and GL served 180 961, 76 326, 65 988 permanent residents, respectively. The number of physicians (including assistant physicians) in the sampled THCs was 79, 57 and 24, the number of

registered nurses was 62, 29 and 16, and the number of beds was 148, 119 and 36, respectively, for the three counties in 2017 (table 1).

### Characteristics of inpatients

Overall, 31 633 admissions were included in the analysis, including 6996 of THCs and 24 958 of CHs. The patient number of THCs for the LQY, FS and GL was 1941, 4042 and 1013, respectively. Generally, inpatients of THCs in the LQY were significantly older, with more men, longer length of stay and higher expenditure per admission (table 1).

### Coverage of essential clinical services in national guideline standard

The coverage of 66 essential clinical services listed in the national guideline of THCs capability evaluation varied substantially among the three counties. While similarities between the rich-LQY (46, 70%) and the middle-developed FS (47, 71%) county, the coverage rate was much lower in the poor GL county (16, 24%). For clinical services of internal medicine, surgery, ENT, gynaecology/obstetrics and stomatology, the coverage rate ranged from 66.7% to 85.7% in the rich county, 57.1% to 84.6% in the middle county and 10% to 50% in the poor county, which were all significantly lower in the poor county than its counterparts. The most absented services were ENT (1/10), gynaecology/obstetrics (1/7) and surgical services (1/17) (table 2).

### Coverage of disease systems

The capability of THCs in the middle-developed county was stronger than the other two counties in terms of coverage of disease systems. Among the 19 disease systems classified by the ICD-10, THCs in the middle-developed county covered 18 systems except for perinatal care, the rich county covered 13, absent of perinatal, congenital, mental, blood, eye system and pregnancy/childbirth services, while the poor county covered 14, absent of perinatal, congenital, blood, eye system and pregnancy/childbirth (table 3).

For THCs overall, the top five disease systems with the largest number of admissions were respiratory (50.0%), digestive (14.2%), circulation (7.6%), urinary (7.0%)

**Table 2** Coverage of essential clinical services\* against national guideline of capability development of township healthcare centres in the three counties

Domain	National standard†	LQY N (%)	FS N (%)	GL N (%)	P value‡
Internal medicine	26	20 (76.9)	22 (84.6)	9 (34.6)	≤0.001
Surgery	17	9 (52.9)	11 (64.7)	2 (16.7)	0.005
Ear, nose, throat	10	7 (70.0)	6 (60.0)	1 (10.0)	0.016
Gynaecology and obstetrics	7	6 (85.7)	4 (57.1)	1 (14.3)	0.027
Stomatology	6	4 (66.7)	4 (66.7)	3 (50.0)	0.792
Total	66	46 (70.0)	47 (71.2)	16 (24.4)	≤0.001

\*Number of diseases diagnosed within each disease domain.

†Number of essential services required by the national guideline of capability building of healthcare centres.

‡ $\chi^2$  test to compare among counties.

FS, Fushun county; GL, Ganluo county; LQY, Longquanyi district.

**Table 3** Disease system covered by township healthcare centres in the three counties

No.	Disease system	LQY	FS	GL
1	Respiratory	√	√	√
2	Digestive	√	√	√
3	Circulation	√	√	√
4	Urinary	√	√	√
5	Infectious/parasitic	√	√	√
6	Musculoskeletal	√	√	√
7	Injury poisoning	√	√	√
8	Cancer	√	√	√
9	Abnormal	√	√	√
10	Pregnancy/childbirth		√	
11	Nervous	√	√	√
12	Ear	√	√	√
13	Skin	√	√	√
14	Endocrine	√	√	√
15	Other contacts		√	
16	Blood		√	
17	Mental		√	√
18	External causes	√	√	√
19	Eye		√	
20	Congenital		√	
Total	Disease systems covered, n	14	20	15

FS, Fushun county; GL, Ganluo county; LQY, Longquanyi district.

and musculoskeletal (5.1%) systems, while that of CHs were respiratory (25.8%), digestive (16.9%), circulation (10.3%) systems, injury/poisoning (9.2%) and pregnancy/childbirth (8.4%) (online supplemental table 3).

### Number of disease and surgery types

THCs in the middle-developed FS county had the largest number of types of diagnosis (430), about three times of that in the rich LQY (136) and the poor GL (101) county. The ratio of number of types of diagnosis of THCs against CHs in the middle-developed county FS (47.8%) was also higher than that of the poor (17.4%) and rich county (15.6%) (table 4).

### Top 20 diseases

The top 20 diseases accounted for 69.5% of inpatient admissions in THCs and 42.5% in CHs overall. In THCs,

most of the top 20 diseases were infectious or inflammatory diseases belonging to respiratory, digestive and urinary systems. Non-communicable diseases of cardiovascular and musculoskeletal systems were also involved but had a smaller proportion compared with infectious diseases, with even smaller proportion of pregnancy and childbirth services (online supplemental table 4).

In comparison, the top 20 inpatient diseases in CHs included more severe or acute conditions which may require surgeries, such as acute appendicitis (1.6%), cerebral infarction (1.4%), internal haemorrhoids (1.4%), calculus of gallbladder with acute cholecystitis (1.3%), caesarean delivery (1.3%) and age-related cataract (1.0%). There were also more patients with diabetes complications (0.9%) in CHs, which was not among the top 20 diseases in THCs (online supplemental table 5).

Half of the top 20 diseases were the same between THCs and CHs, mainly infectious or inflammatory diseases, including chronic obstructive pulmonary diseases (COPDs), acute or chronic bronchitis, acute tonsillitis and unspecified upper respiratory infections, and unspecified bacterial pneumonia, chronic gastritis and gastroenteritis and colitis, vertebro-basilar artery syndrome, and full-term uncomplicated delivery (online supplemental tables 4 and 5).

It was notable that a large proportion of patients were hospitalised due to potentially avoidable or preventable hospitalisations (PAHs),<sup>26</sup> such as pneumonia, diabetes, hypertension, COPD, pelvic inflammatory disease, ear, nose and throat infections were among the top 20 diseases of hospitalisation. These hospitalisations were considered potentially preventable because that they could be effectively treated at outpatient clinics or managed by primary healthcare.<sup>26</sup> The finding pinpointed areas that warranted improvement and strengthening of primary healthcare (online supplemental tables 4 and 5).

### Coverage of surgeries by system

There was no surgery in THCs in the rich and poor counties, and only very few in the middle-developed FS county, which were mainly obstetrical (82, 78.1%) and digestive (13, 12.4%) surgeries. In comparison, CHs provided surgeries covering all disease systems, in which the top five were haemic and lymphatic (32.6%), female genital organs (15.4%), obstetrical (11.5%), male genital organs (8.4%) and eye (8.2%) surgeries, followed by digestive (6.0%) and musculoskeletal systems (6.0%) surgeries (online supplemental table 6).

**Table 4** Number of types of diseases and surgeries in township healthcare centres and related county hospitals

	LQY			FS			GL		
	THCs	CHs	%	THCs	CHs	%	THCs	CHs	%
Types of disease, n	136	873	15.6	430	899	47.8	101	580	17.4
Types of surgery, n	0	210	0	13	156	8.3	0	58	0

CHs, county hospitals; FS, Fushun county; GL, Ganluo county; LQY, Longquanyi district; THCs, township healthcare centres.

## Number of surgery types

The number of surgery types in THCs of the middle-developed county was 13 in total, including 4 for female genital organs, 3 for digestive system and 2 for obstetrical procedures. In comparison, CHs in the rich county had the largest number of surgery types (210), followed by the middle (156) and then the poor county (58). Surgical services in CHs of the rich and middle-developed counties covered all disease systems, while surgeries of ear, eye, nose, mouth and pharynx were absent in CHs of the poor county (online supplemental table 7)

## Top 10 surgeries

The top 10 surgeries accounted for 95.3% of all surgeries in THCs and 54.6% in CHs. The top five surgeries provided by THCs in the middle county were other obstetric operations (43.5%), caesarean section (33.3%), procedures on haemorrhoids (7.4%), repair of hernia (3.7%) and repair of vulva and perineum (1.9%), while that for CHs were caesarean section (11.3%), procedures on haemorrhoids (7.9%), cholecystectomy (7.8%), appendectomy (6.2%) and cataract surgery (5.1%) (online supplemental table 8).

## DISCUSSION

This study had four major findings. First, we found that the clinical capability of the nine studied THCs, irrespective of economic development status of their regions, was suboptimal against the national standard (coverage of essential clinical services ranged from 24% to 70%). Their main scope of clinical services were infectious or inflammatory diseases of respiratory and digestive systems, but lacked services of injury, poisoning, pregnancy, childbirth and surgeries. Second, THCs in both rich and poor economic development regions had lower clinical capability than those in the middle-development region, suggesting the impacts of economic and social conditions on inpatient services with possibly different mechanisms. Third, there was a large proportion of PAHs in the sampled THCs and CHs, such as pneumonia, diabetes, hypertension, chronic obstructive pulmonary disease, pelvic inflammatory disease, ear, nose and throat infections,<sup>27 28</sup> which suggested the necessity of strengthening outpatient care of PHC as regard to the management of those diseases. Finally, there was a considerable overlap of inpatient services between the sampled THCs and CHs. Under the current healthcare insurance in China, treatment of the same disease in CHs cost more than in the THCs for both the insurance reimbursement and the out-of-pocket pay of patients.<sup>29</sup> The finding indicates the needs and potentials of clarification and improvement of integrated care between the two levels of health institutions in order to reduce the costs of inpatient care.

It is not surprised to find suboptimal services of the THCs against the national guideline. Health services and resources in western China with weaker health systems are generally lack behind those in Eastern China,<sup>30</sup> which would be reflected in clinical services of THCs in

western China. Our findings in the variation of capability of inpatient services of THCs were in accordance with findings from previous studies.<sup>9 18 19 31</sup> In our study, THCs in the middle-developed county had a relatively higher proportion of health resources, larger share of inpatient services in the local health system and wider capability of services, while THCs in the richer and poorer counties had a relatively smaller proportion of health resource in health systems and smaller share of inpatient services and narrower range of inpatient services. Findings from the study of Zhu *et al*<sup>22</sup> on workloads of basic public health tasks in the same THCs of the same three counties may help to explain the phenomenon. The authors found that the THCs in richer counties being very close to the capital city of Sichuan province could not be able to compete with many higher-level hospitals in providing clinical care. Therefore, the THCs may have focused their resources and services on public health services, which was reflected in their heavy workload in such services. In contrast, THCs in the poor county had the lowest capacity in providing both clinical services and public health services mainly because of their low health resources especially health workforce.<sup>22</sup>

The clinical capability of THCs could be also shaped by other factors. In a study around Chengdu Sichuan, Ma and colleagues found that local economic status, financial subsidies, facilities (area of business accommodation and the number of equipment), number of health workforce and health personnel expenditures were positively associated with clinical capability of PHC institutions.<sup>13</sup> In a study in An Hui province, Shi and colleagues found that GDP per capita, service population were major external factors influencing health service capacity of township hospitals and human resources were the main intrinsic factor, while the contribution of medical equipment was limited.<sup>14</sup> In a study in Sichuan province, Zhu and colleagues found that local economic status and shortage of health workforce were the main factors affected the number and quality of health service of THCs.<sup>22</sup> In a qualitative study in Xinjiang province, Kade'er and colleagues found that factors affected the capability of THCs from the most important to the least were health workforce, financial input, facility and equipment, policy and transport.<sup>32</sup> Previous research also found that patients were more likely to bypass primary care facilities to obtain perceived high-quality clinical services from higher-level hospitals if they were highly accessible and financially affordable, the underuse of primary care services may further diminish the capability of THCs in turn.<sup>8</sup>

The finding of this study on overlapped ranges of inpatient services between the THCs and the CHs just adds another piece of evidence. Keeping patients in the care of THCs for diseases treatable by both THCs and CHs has a number of important implications in reducing care cost of both patients and insurance agency or government,<sup>33</sup> in establishing a practical gate-keeping procedure of the THCs,<sup>34</sup> in setting up integrated continuous care plan of patients after discharge<sup>35</sup> and in strengthening capability

of THCs. However, realising the implications would involve understanding the difference in quality and safety between hospitals for the specific diseases in the two levels, which presents an important research area in near future.<sup>21</sup>

As regards disease composition, there were a large proportion of PAHs both in the THCs and CHs.<sup>36</sup> This finding was supported by a recent national-wide study in china which found that PAHs due to chronic diseases consisted of a large proportion of hospitalisations—14.09% in primary care institutions and 9.20% in CHs, with COPD, diabetes and hypertension as leading causes.<sup>37 38</sup> However, it was a pity that PAHs due to infectious diseases were not measured. Nevertheless, the examination of disease composition from a perspective of PAHs and regional comparisons would help to identify weakness and priorities of improvements of primary care and health systems.<sup>26 39</sup> On the other hand, the largely overlapped inpatient services of THCs and CHs provide an opportunity or need of integrated care among the two levels of health institutions, which might improve quality of care and patient health outcomes.<sup>40 41</sup>

The study has several limitations. First, the use of disease spectrum and surgeries based on only inpatients medical records did not reflect quality of care nor a full clinical capability of THCs. Further study on outpatient clinical services and care quality of THCs using standard patients approach is guaranteed. Second, the analyses of spectrum of clinical services were based on inpatient medical records and relevant coding, and the accuracy of coding among different counties might influence the results. Third, the study purposely selected representative THCs and CHs for the investigation and only data from January to December 2015 was obtained and analysed, the number of sampled institutions was small, the findings warrant further verification with larger sample size, the timeliness of this study was limited and further study using data of more recent years would be valuable. In addition, results based on descriptive analysis cannot be generalised beyond the sampled counties, although the approach to explore clinical capability of THCs could be extendable. Finally, the examination of PAHs would be more meaningful if administrative data of all health institutions were obtained and the prevalence be compared between counties, which warrants further investigation.

The findings in our study have clear implications for further primary healthcare and health systems planning in rural China. First, the clinical service of THCs should be strengthened according to the health needs of local people and the guideline of national standard of capability building of THCs. Second, the clinical services provided in the THCs and CHs should be clearly clarified and coordinated so that the two level of institutions do not compete with each other but form more continuous and integrated healthcare systems in improving the health of rural people. Third, the planning of clinical services of THCs in rural China can be different according to the local socioeconomic, demographic and health system

contexts. For THCs in remote and less developed areas with poor/difficult transportation, more clinical services might be planned to meet local health needs and improve the accessibility of healthcare, which might include oral clinic services, simple surgeries, lifesaving emergency services, etc. For THCs in top affluent and developed areas, clinical services might be strengthened for management of chronic diseases to prompt reasonable use of health services, sparing hospital services for more severe and urgent conditions, reducing the overall consumption of health resources and curbing the rapid increase of health expenditure.

## CONCLUSIONS

The clinical capability of selected THCs was suboptimal according to the national standard, which may be affected by multiple factors including health resources, health workforce of THCs, their shares in local health systems and competition from high-level hospitals, the size of serving population and local economics. The findings also highlighted absent area of clinical services and priorities of clinical capability building of THCs. A large proportion of potentially preventable hospitalisations were among top reasons of admissions in both investigated THCs and CHs, indicating necessities and priorities of improvements of rural primary healthcare and county health systems. The large overlap of inpatient services between THCs and CHs offered opportunities and challenges of integrated care between the two levels of health institutions for better care and health outcomes of rural residents.

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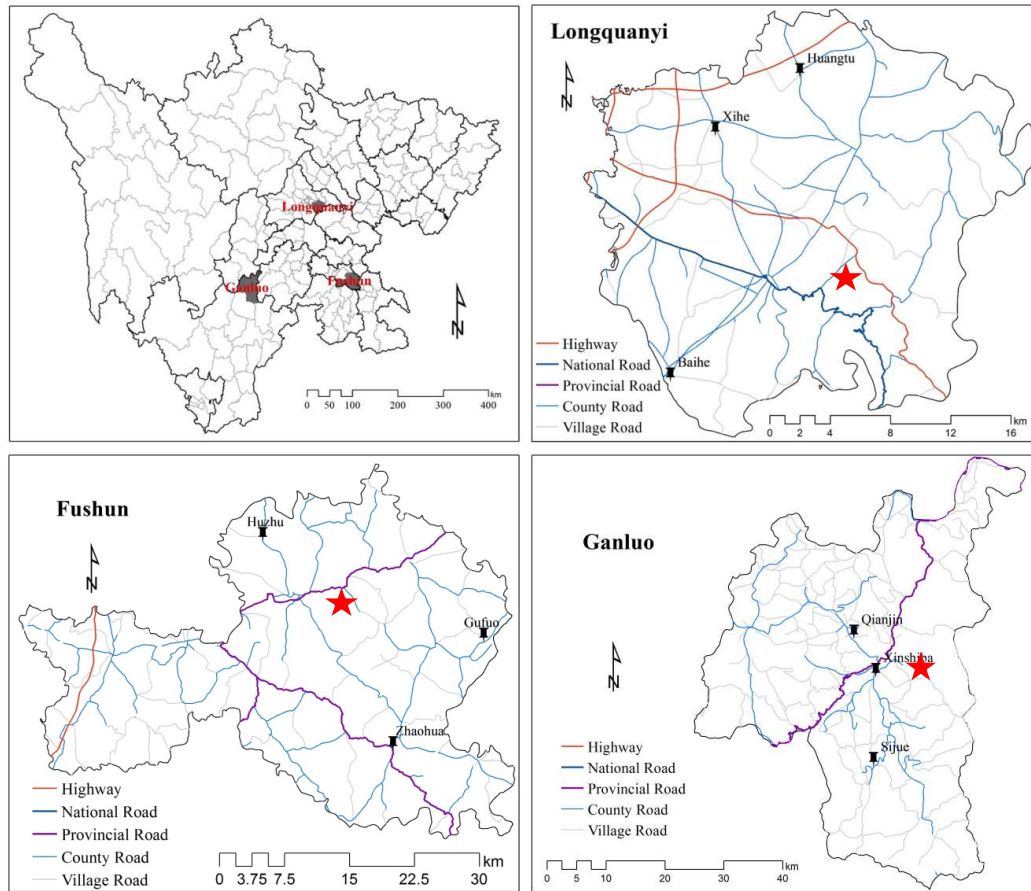
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## Supplementary file



supplementary Figure 1 Study sites in Sichuan Province

Note: red star indicates county centre and the location the county hospitals

Supplementary Table 1 Socioeconomics demographics of Sichuan and China

Characteristics	Sichuan	China
Population	83.7 million	1.41 billion
Male Female ratio	1.05	1.05
No. of races	55	56
Races other than Han (%)	6.59	8.49
Population per KM <sup>2</sup>	174	148
Urban population (%)	6	64
Mean education year of aged 15 above	9.24	9.91
GDP per capita (yuan)	58126	72000
Age expectancy (year)	74.7	76.3
Maternal mortality (1/100 thousand)	16.84	16.90
Infant mortality (‰)	5.22	5.40
Under 5 mortality (‰)	7.3	7.5
Doctors (assistant) per 1000	2.8	2.9
Registered nurses per 1000	3.4	3.3

China and Sichuan Yearbook (Statistics) 2020, and National Bureau of Statistics National data

<https://data.stats.gov.cn/index.htm>

Supplementary Table 2 Socioeconomic, demographic and health system characteristics of the three counties

Dimension	Characteristics	LQY	FS	GL
<b>Geography</b>	Landscape	Plateau	Hills	Mountains
	Land size (KM <sup>2</sup> )	558	1336	2151
<b>Population</b>	Total (thousand)	643	1083	223
	Rural residents, thousand (%)	301(46.8)	835(77.1)	214(95.9)
	Ethnic other Han, thousand (%)	(0.9)	(0.1)	(76.7)
<b>Economics</b>	GDP per capita (RMB)	117,854	24,928	12,781
<b>Health institutions</b>	Hospitalsxinsij	24	12	4
	THCs	9	26	28
<b>Health facilities</b>	Beds	3,820	2,818	845
	Beds per 1000	5.9	2.6	3.8
	THCs beds, n (%)	267 (7.0)	1,095 (38.9)	246 (29.1)
	THCs beds per 1000 rural residents	0.89	1.31	1.15
<b>Health workforce</b>	Licensed doctors (assistant)	1,962	1,346	237
	Licensed doctors per 1000	3.1	1.2	1.1
	Licensed doctors per 1000 rural residents	0.48	0.44	0.41
	Registered nurses	2,109	1,150	272
	Registered nurses in THCs (%)	105 (5.0)	266 (23.1)	59 (21.7)
	Registered nurses per 1000	3.3	1.1	1.2
	Registered nurses per 1000 rural residents	0.35	0.32	0.28
<b>Health services</b>	Total admissions	113,086	146,236	37,058
	THCs admissions (%)	11,241 (9.9)	63,726 (43.6)	8,491 (22.9)
	Admissions per 1000 residents	175.8	135.0	166.1
	THCs admissions per 1000 rural residents	37.35	76.32	39.68
	Average length of stay, day	8.98	8.02	5.36
	Bed days per doctor per day	2.18	3.48	3.49
	Total outpatient visits, thousand	4461	4321	360
	*Primary care outpatient visits, thousand (%)	2,519 (56.5) <sup>#</sup>	3,240 (75.0)	140 (38.7)
<b>Health finance</b>	Expenditure per admission (RMB)	5,674	4,140	2,639
	Expenditure per outpatient visit (RMB)	208	148	95
	Total revenue of health sector (RMB Million)	15,149	8,100	2,128

LQY: Longquanyi district, FS: Fushun county, GL: Ganluo county, Data source: 2015 Health and Family Planning Statistics Yearbook of Sichuan Province. THCs: township health centres. \*Primary health care institutions included both township health centres (and village clinics) in the in rural areas and community health centres in the urban areas.

Supplementary Table 3 Coverage of disease systems in township health centres

System	LQY			FS			GL			All THs			All CHs		
	N	%	Rank	N	%	Rank	N	%	Rank	N	%	Rank	N	%	Rank
Respiratory	967	57.2	1	1,824	45.3	1	546	56.8	1	3,337	50.0	1	6,439	25.8	1
Digestive	199	11.8	2	611	15.2	2	140	14.6	2	950	14.2	2	4,206	16.9	2
Circulation	63	3.7	5	385	9.6	3	58	6.0	4	506	7.6	3	2,582	10.3	3
Urinary	158	9.3	3	177	4.4	4	135	14.0	3	470	7.0	4	1,193	4.8	6
Musculoskeletal	154	9.1	4	166	4.1	5	21	2.2	6	341	5.1	5	834	3.3	8
Nervous	30	1.8	8	150	3.7	6	1	0.1	13	181	2.7	6	823	3.3	9
Injury Poisoning	10	0.6	11	125	3.1	7	5	0.5	9	140	2.1	7	2,300	9.2	4
Infectious & Parasitic	3	0.2	13	99	2.5	10	33	3.4	5	135	2.0	8	869	3.5	7
Cancer	14	0.8	10	110	2.7	9	3	0.3	10	127	1.9	9	722	2.9	10
Pregnancy/Childbirth	0	0.0	/	123	3.1	8	0	0.0	/	123	1.8	10	2,108	8.4	5
Ear	34	2.0	7	86	2.1	11	2	0.2	11	122	1.8	11	117	0.5	18
Skin	16	0.9	9	66	1.6	12	6	0.6	8	88	1.3	12	139	0.6	16
Abnormal	37	2.2	6	35	0.9	13	7	0.7	7	79	1.2	13	282	1.1	15
Endocrine	4	0.2	12	17	0.4	14	1	0.1	14	22	0.3	14	604	2.4	12
Mental	/	0.0	/	17	0.4	15	1	0.1	15	18	0.3	15	110	0.4	19
Blood	/	0.0	/	11	0.3	17	/	0.0	/	11	0.2	17	124	0.5	17
Eye	/	0.0	/	2	0.0	19	/	0.0	/	2	0.0	19	463	1.9	13
Congenital	/	0.0	/	1	0.0	20	/	0.0	/	1	0.0	20	30	0.1	20
Perinatal	/	0.0	/	0	0.0	21	/	0.0	/	/	0.0	/	353	1.4	14
Other contact	2			18			2			22			660	2.6	11
Total	1,691			4,023			961			6,675			24958		

LQY: Longquanyi district, FS: Fushun county, GL: Ganluo county. \*All disease systems were covered in county hospitals of the three counties, respectively

Supplementary Table 4 Top 20 diseases in township health centres

Rank	Longquanyi				Fushun				Ganluo			
	ICD-10	Disease	n	%	ICD-10	Disease	n	%	ICD-10	Disease	n	%
1	J18.9	Pneumonia, unspecified* <sup>#</sup>	489	25.2	J20.9	Acute bronchitis, unspecified*	693	17.1	J06.9	Acute upper respiratory infection, unspecified* <sup>#</sup>	288	28.4
2	J20.9	Acute bronchitis, unspecified	197	10.1	J42.x	Unspecified chronic bronchitis	564	13.9	J20.9	Acute bronchitis, unspecified*	143	14.1
3	J44.1	Chronic obstructive pulmonary disease with (acute) exacerbation* <sup>#</sup>	169	8.7	J06.9	Acute upper respiratory infection, unspecified* <sup>#</sup>	214	5.3	N73.9	Female pelvic inflammatory disease, unspecified <sup>#</sup>	103	10.2
4	H81.0	Gastroenteritis and colitis, unspecified causes	121	6.2	K29.5	Unspecified chronic gastritis	199	4.9	J42.x	Unspecified chronic bronchitis	88	8.7
5	J03.9	Acute tonsillitis, unspecified* <sup>#</sup>	96	4.9	I67.9	Cerebrovascular disease, unspecified	180	4.5	I00.x	Rheumatic fever without heart involvement <sup>#</sup>	52	5.1
6	J18.0	Bronchopneumonia, unspecified* organism	96	4.9	A09.9	Gastroenteritis and colitis, unspecified causes*	134	3.3	K29.7	Gastritis, unspecified	42	4.1
7	N39.0	Urinary tract infection, site not specified	71	3.7	N73.9	Female pelvic inflammatory disease, unspecified <sup>#</sup>	82	2.0	J18.9	Pneumonia, unspecified* <sup>#</sup>	37	3.7
8	M51.9	Intervertebral disc disorder, unspecified	66	3.4	J03.9	Acute tonsillitis, unspecified* <sup>#</sup>	70	1.7	K29.5	Unspecified chronic gastritis*	35	3.5
9	M48.9	Spondylopathy, unspecified	33	1.7	I10.x	Essential (primary) hypertension <sup>#</sup>	61	1.5	A09.9	Gastroenteritis and colitis, unspecified causes*	33	3.3
10	R42.x	Dizziness and giddiness	27	1.4	I25.1	Atherosclerotic heart disease of native coronary artery*	58	1.4	J03.9	Acute tonsillitis, unspecified* <sup>#</sup>	14	1.4
11	G45.0	Vertebro-basilar artery syndrome*	27	1.4	K29.7	Gastritis, unspecified	57	1.4	N73.0	Acute parametritis and pelvic cellulitis <sup>#</sup>	11	1.1
12	K29.1	Unspecified chronic gastritis	26	1.3	O80.0	Encounter for full-term uncomplicated delivery*	55	1.4	K52.9	Noninfective gastroenteritis and colitis, unspecified*	9	0.9
13	N71.0	Acute inflammatory disease of uterus	25	1.3	K29.1	other acute gastritis	51	1.3	A02.0	Salmonella enteritis	6	0.6
14	A09.9	Gastroenteritis and colitis of unspecified origin	24	1.2	I67.2	Cerebral atherosclerosis	48	1.2	K29.1	Other acute gastritis	6	0.6

Rank	Longquanyi				Fushun				Ganluo			
	ICD-10	Disease	n	%	ICD-10	Disease	n	%	ICD-10	Disease	n	%
15	J44.9	Chronic obstructive pulmonary disease, unspecified <sup>#</sup>	23	1.2	J18.9	Pneumonia, unspecified* <sup>#</sup>	46	1.1	J02.9	Acute pharyngitis, unspecified* <sup>#</sup>	6	0.6
16	N20.0	Calculus of kidney	21	1.1	G45.0	Vertebro-basilar artery syndrome*	39	1.0	M06.9	Rheumatoid arthritis, unspecified	5	0.5
17	I67.8	Other specified cerebrovascular diseases*	17	0.9	J44.8	Other chronic obstructive pulmonary disease <sup>#</sup>	35	0.9	N94.8	Other specified conditions with female genital organs and menstrual cycle	5	0.5
18	M51.2	Other specified intervertebral disc displacement	15	0.8	G45.9	Transient cerebral ischemic attack, unspecified	33	0.8	J40.x	Bronchitis, not specified as acute or chronic	5	0.5
19	K29.5	Chronic gastritis, unspecified	15	0.8	J44.1	Chronic obstructive pulmonary disease with (acute) exacerbation* <sup>#</sup>	33	0.8	R42.x	Dizziness and giddiness	4	0.4
20	N73.9	Female pelvic inflammatory disease, unspecified <sup>#</sup>	14	0.7	H81.0	Meniere's disease	32	0.8	M75.0	Adhesive capsulitis of shoulder	4	0.1
		Top 20 total	1572	81.0			2684	66.4			896	88.1

ICD-10: international classifications of diseases 10<sup>th</sup> edition, \*overlapped diseases between township health centres and county hospitals, <sup>#</sup> potentially avoidable hospitalization

Supplementary Table 5 Top 20 diseases in county hospitals

Rank	Longquanyi				Fushun				Ganluo			
	ICD-10	Disease	n	%	ICD-10	Disease	n	%	ICD-10	Disease	n	%
1	I84.2	Internal haemorrhoids without complication	300	3.6	J44.1	Chronic obstructive pulmonary disease with acute exacerbation, unspecified*#	676	6.7	A09.9	Gastroenteritis and colitis of unspecified origin*	720	11.0
2	J44.1	Chronic obstructive pulmonary disease with acute exacerbation, unspecified*#	287	3.5	J03.9	Acute tonsillitis, unspecified*#	541	5.4	O80.0	Spontaneous vertex delivery	579	8.8
3	J20.9	Acute bronchitis, unspecified*	247	3.0	J20.9	Acute bronchitis, unspecified	435	4.3	J18.0	Bronchopneumonia, unspecified	525	8.0
4	E11.7	Non-insulin-dependent diabetes mellitus: With multiple complications#	226	2.7	G45.0	Vertebro-basilar artery syndrome	393	3.9	J06.9	Acute upper respiratory infection, unspecified*#	297	4.5
5	J18.9	Pneumonia, unspecified*#	224	2.7	I25.1	Atherosclerotic heart disease*#	332	3.3	J18.9	Pneumonia, unspecified*#	295	4.5
6	J15.9	Bacterial pneumonia, unspecified#	204	2.5	J18.0	Bronchopneumonia, unspecified	282	2.8	J20.9	Acute bronchitis, unspecified*	283	4.3
7	J03.9	Acute tonsillitis, unspecified*#	199	2.4	J18.9	Pneumonia, unspecified*#	252	2.5	J03.9	Acute tonsillitis, unspecified*#	194	3.0
8	K80.0	Calculus of gallbladder with acute cholecystitis	182	2.2	O82.0	Delivery by elective caesarean section	220	2.2	K29.5	Chronic gastritis, unspecified*	161	2.5
9	I10.x	Essential (primary) hypertension	155	1.9	I63.9	Cerebral infarction, unspecified	181	1.8	K35.9	Acute appendicitis, unspecified	120	1.8
10	K35.9	Acute appendicitis, unspecified	155	1.9	H25.9	Senile cataract, unspecified	164	1.6	K52.9	Non-infective gastroenteritis and colitis, unspecified*	120	1.8
11	J18.0	Bronchopneumonia, unspecified*	152	1.8	M51.2	Other specified intervertebral disc displacement	155	1.5	A16.2	Tuberculosis of lung, without mention of bacteriological or histological confirmation	106	1.6
12	I63.9	Cerebral infarction, unspecified	146	1.8	O80.9	Single spontaneous delivery, unspecified	152	1.5	T00.9	Multiple superficial injuries, unspecified	104	1.6
13	Z51.1	Chemotherapy session for neoplasm	145	1.7	A09.9	Gastroenteritis and colitis of unspecified origin	134	1.3	O82.0	Delivery by elective caesarean section	96	1.5



Rank	Longquanyi				Fushun				Ganluo					
	ICD-10	Disease	n	%	ICD-10	Disease	n	%	ICD-10	Disease	n	%		
14	N13.2	Hydronephrosis with renal and ureteral calculous obstruction	133	1.6	K35.9	Acute appendicitis, unspecified	124	1.2	I67.8	Other specified cerebrovascular diseases	85	1.3		
15	E11.4	Non-insulin-dependent diabetes mellitus: With neurological complications	123	1.5	A16.2	Tuberculosis of lung, without mention of bacteriological or histological confirmation	118	1.2	K80.1	Calculus of gallbladder with other cholecystitis	70	1.1		
16	H25.9	Senile cataract, unspecified	116	1.4	S06.0	Concussion	112	1.1	J62.8	Pneumoconiosis due to other dust containing silica	61	0.9		
17	G45.0	Vertebro-basilar artery syndrome*	110	1.3	J06.9	Acute upper respiratory infection, unspecified	108	1.1	O47.1	False labour at or after 37 completed weeks of gestation	58	0.9		
18	J06.9	Acute upper respiratory infection, unspecified	110	1.3	C34.9	Malignant neoplasm: Bronchus or lung, unspecified	107	1.1	I25.1	Atherosclerotic heart disease	55	0.8		
19	Z43.6	Attention to other artificial openings of urinary tract	98	1.2	K80.0	Calculus of gallbladder with acute cholecystitis	106	1.1	J44.1	Chronic obstructive pulmonary disease with acute exacerbation, unspecified <sup>#</sup>	49	0.8		
20	I67.8	Other specified cerebrovascular diseases*	95	1.1	N20.1	Calculus of ureter	89	0.9	N13.2	Hydronephrosis with renal and ureteral calculous obstruction	47	0.7		
Top 20 Total			3407	41.0				4681	46.5				4025	61.2

ICD-10: international classifications of diseases 10<sup>th</sup> edition, \*overlapped diseases between township health centres and county hospitals, <sup>#</sup> potentially avoidable hospitalization

Supplementary Table 6 Number of admissions with surgery or procedure by disease system

ICD-9-CM	System	THs			CHs		
		Fushun	%	Rank	N	%	Rank
00	Procedures and interventions, NEC	/	/	/	0	0	18
01~05	Nervous	/	/	/	129	2.5	9
06~07	Endocrine	/	/	/	26	0.5	16
08~16	Eye	/	/	/	429	8.2	5
17	Others	/	/	/	18	0.3	17
18-20	Ear	/	/	/	140	2.7	8
21-29	Nose, mouth and pharynx	/	/	/	94	1.8	12
30-34	Respiratory	1	1.0	4	36	0.7	14
35-39	Cardiovascular	/	/	/	28	0.5	15
40-41	Haemic and lymphatic	/	/	/	1,701	32.6	1
42-54	Digestive	13	12.4	2	315	6	6
55-59	Urinary	/	/	/	109	2.1	11
60-64	Male genital organs	1	1.0	4	441	8.4	4
65-71	Female genital organs	6	5.7	3	803	15.4	2
72-75	Obstetrical procedures	82	78.1	1	601	11.5	3
76-84	Musculoskeletal system	1	1.0	4	312	6	7
85-86	Integumentary system	1	1.0	4	37	0.7	13
87-99	Miscellaneous	/	/	/	129	2.5	10
Total		105			5348		

THCs: township hospitals, CHs: county hospitals

Supplementary Table 7 Number of surgery types by disease system

ICD-9-CM	System	THs	CHs		
		FS	LQY	FS	GL
00	Procedures and interventions, NEC	/	0	0	0
01~05	nervous system	/	11	5	2
06~07	endocrine system	/	3	3	2
08~16	eye	/	17	12	0
18~20	Ear	/	3	1	0
21~29	Nose, mouth and pharynx	/	12	10	0
30~34	Respiratory system	1	12	7	1
35~39	Cardiovascular system	/	4	2	1
40~41	Haemic and lymphatic system	/	3	2	2
42~54	Digestive system	3	44	25	13
55~59	Urinary system	/	21	16	4
60~64	Male genital organs	1	9	10	2
65~71	Female genital organs	4	22	25	4
72~75	Obstetrical procedures	2	10	5	1
76~84	Musculoskeletal system	1	26	19	20
85~86	Integumentary system	1	8	12	6
87~99	Miscellaneous	/	5	2	0
Total		13	210	156	58

THs: township hospitals, CHs: county hospitals, LQ: Longquanyi county, GL: Ganluo county,

FS: Fushun county

Supplementary Table 8 Top 10 surgeries in township hospitals and county hospitals

Fushun township health centres					All county hospitals			
Rank	ICD-9-CM	Operation name	N	%	ICD-9-CM	Operation name	N	%
1	75.9	Other obstetric operations	47	43.5	74.1	Caesarean section	587	11.3
2	74.1	Cesarean section	36	33.3	49.4	Procedures on haemorrhoids	413	7.9
3	49.4	Procedures on haemorrhoids	8	7.4	51.2	Cholecystectomy	407	7.8
4	53.0	Repair of hernia	4	3.7	47.0	Appendectomy	324	6.2
5	71.7	Repair of vulva and perineum	2	1.9	13.7	Cataract surgery	265	5.1
6	86.0	Incision of skin and subcutaneous tissue	2	1.9	79.3	Open reduction of fracture with internal fixation	258	5.0
7	34.0	Incision of chest wall and pleura	1	0.9	53.0	Repair of hernia	161	3.1
8	49.1	Incision or excision of anal fistula	1	0.9	73.6	Episiotomy	150	2.9
9	64.0	Circumcision	1	0.9	78.6	Removal of implanted devices from bone	139	2.7
10	67.3	Other excision or destruction of lesion or tissue of cervix	1	0.9	69.0	Dilation and curettage of uterus	136	2.6
Top 10	Total		103	95.3	Top 10	Total	2840	54.6