

# Prevalence, Risk Factors, and Approach to Control of Comorbidities Among Hospitalized Patients: Evidence From A 4-Year Longitudinal Study in China

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## Research

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# Abstract

**Background:** The disease burden of comorbidity is growing steadily in many developing countries, affecting residents' physical and mental health. General Practitioners are considered as the suitable service providers for the prevention and control of comorbidity. However, the current knowledge on the clinical and epidemiological characteristics of comorbidity among inpatients in the general practice departments of hospital is limited, which hinders the precise promotion of the service capacity and quality of GPs.

**Objective:** The current study aimed to analyze the clinical prevalence of comorbidities in central China and to provide evidence-based policy recommendations for quality improvement in general medical services.

**Methods:** The study was conducted at the general practice departments of all 27 tertiary grade-A hospitals of Henan Province, China. 3 registered GPs of each hospital were selected by random, and all direct admissions of the 81 GPs from December 2016 to November 2020 were followed up. The clinical epidemiological characteristics and influencing factors of comorbidity were evaluated using descriptive statistical analysis and logistic regression models.

**Results:** Comorbidity was present in 93.1 percent of the 2385 direct admitted patients, with a male-to-female ratio of 1: 1. Comorbidity was significantly more prevalent in patients aged 45-59 years (OR=3.018, 95% CI=1.945-4.683), 60-74 years (OR=4.349, 95% CI=2.574-7.349),  $\geq 75$  years (OR=7.804, 95% CI=3.665-16.616), and those with body mass index (BMI)  $\geq 28$  kg/m<sup>2</sup> (OR=3.770, 95% CI =1.453-9.785). The circulatory system is the most commonly involved human body system in comorbidity, accounting for 79% of all cases. The endocrine, nutritional, and metabolic systems, as well as the digestive and respiratory systems, were all significantly affected, with prevalence rates of 62 percent, 48 percent, and 37 percent, respectively.

**Conclusion:** Comorbidity is common among the inpatients attending the provincial tertiary grade-A hospitals. Since old age and obesity are independent risk factors for comorbidity, healthy lifestyle interventions should be strengthened, as should the implementation of the patient-centered prevention and control model. Meanwhile, quality improvement priorities should be given to improving GPs' clinical diagnosis and treatment of the circulatory system, endocrine system, metabolic system, digestive system, and respiratory system.

## 1. Introduction

Comorbidity (multimorbidity) refers to patients suffering from two or more chronic diseases at the same time (1, 2). As the course of comorbidities progresses, the interaction between chronic diseases causes greater health damage (3), necessitating more comprehensive and continuous clinical treatments (4–6). Since the 2009 healthcare reform, China placed high expectations on general medical services in terms of lowering medical costs and improving health status of the population with comorbidity. China now has more than 365,000 GPs, comprising 210,000 registered GPs and 155 qualified GPs (7). However, there is still a huge gap between the service capacity and quality of these new GPs and that of developed countries (8–10). In order to build an effective and efficient health service system based on GPs, the government began to require all tertiary hospitals to set up general practice departments and designates them as engines for increasing general medical service capacity and quality from 2014. This means that promoting the service capacity and quality of GPs in tertiary hospitals based on the clinical evidence from inpatients with comorbidity will contribute to the improvement of general practice service system in China as a whole.

Usually, the conditions of the inpatients admitted to the general practice department of tertiary hospitals are more complex, which provide a unique perspective for understanding inpatient comorbidity, and a clear path of promoting general practice service training and providing system. But the prevalence and risk factors of comorbidities among this population still remain to be explored. Therefore, the purposes of this article are: 1) to analyze the clinical epidemiological characteristics and related factors of general inpatients in a provincial tertiary hospital in Henan Province, and 2) to provide evidence-based policy recommendations for accurately promoting the prevention and control effectiveness of comorbidities, as well as GPs' diagnosis and treatment capabilities.

## **2. Materials And Methods**

### **2.1 Study time and settings**

The whole study was started in December 2016 and accomplished in November 2020. The general practice departments of 27 tertiary grade-A hospitals of Henan Province were selected to conduct the 4-year follow-up investigation (shown in Fig.1). All the general practice departments were designated as standardized general practice residents training centers.

### **Participant recruitment**

A two-stage sampling method was used to obtain GPs and their hospitalized patients. At the first stage, a random sampling method was used to select 3 observation GPs of each hospitals. All the enrolled GPs were (1) qualified and registered as GP; (2) doctors-in-charge or above; and (3) willing to participate and sign the informed consent form. The first stage sampling enrolled 81 GPs in total. At the second stage, a cluster sampling was used to obtain all inpatients of each GP, but transferred patients from other department, patients with repeated hospitalization, referred patients from other hospitals and those refused to participate were excluded. A total of 2385 hospitalized patients were investigated in the longitudinal study.

### **Data collection**

We firstly urged the GPs to collect electronic medical record information through the hospital information system. For ambiguous and missing data, we confirmed with the GPs and patients by telephone to obtain accurate information. This study collected information of the 2385 participants on gender, age, marital status, education level, medical insurance payment method, BMI, smoking history, drinking history, occupation, admission diagnosis, past history, discharge diagnosis according to the International Classification of Diseases (ICD-10) standards, disease counts, and other clinical and epidemiological characteristics as well as influencing factors for comorbid condition.

### **2.2 Statistical analysis**

The rate and composition ratio were used for descriptive analysis of the clinical and epidemiological characteristics of comorbidities while the Chi-squared test was used for single factor analysis. The influencing factors of comorbidities were analyzed using the logistic regression model.  $P < 0.05$  was considered as the difference was statistically significant. SPSS 26.0 software was used for data analysis.

## **3. Results**

### **3.1 Risk factors related to comorbidities among inpatients of the general hospital**

2385 hospitalized patients were included in the analysis. The age range of study participants were 5 to 98 years, with an average age of 60 years. 165 cases (6.9%) had one chronic disease, and 2220 (93.08%) had two or more chronic diseases. Comorbidity in patients over 75 years was 97.5 percent. The prevalence of comorbidities among participants with normal body mass index (BMI) ( $18.5 \leq \text{BMI} < 23.9$ , 89.4%) was significantly lower than those with abnormal BMI ( $\text{BMI} < 18.5$ , 90.1%;  $24 < \text{BMI} \leq 27.9$ , 94.4%;  $\text{BMI} \geq 28$ , 97.2%;  $P < 0.01$ ). The prevalence of comorbidities in the fully out-of-pocket group is lower than in basic health insurance and other groups (Fully out-of-pocket, 88.4%; MIUW, 95.0%; MIUR, 92.3%; NRCMI, 91.0%; CMI, 95.7%;  $P < 0.01$ ). The prevalence of comorbidities among retired personnel was the highest, accounting for 97.6% (civil servants, 95.9%; corporate personnel, 88.9%; farmers, 93.5%; self-employed workers, 91.8%; others, 92.2%;  $P < 0.01$ ). The prevalence of comorbidities was not statistically different among the groups by gender ( $P = 0.548$ ), education level ( $P = 0.619$ ), smoking ( $P = 0.695$ ) and drinking ( $P = 0.066$ ). (See Table 1)

### 3.2 Risk factors for comorbidity among the inpatients

The main study outcome (dependent variable) was whether the inpatients have two or more (2) chronic diseases (assignment: 0=No, 1=Yes). Age (years) (Assignment: 0=<45, 1=45-59, 3=60-74, 4= $\geq 75$ ), marital status (assignment: 0=unmarried, 1=married, 2=divorced/widowed/unknown), BMI ( $\text{kg}/\text{m}^2$ ) (assignment: 0=<18.5, 1=18.5-23.9, 2=24-27.9, 3= $\geq 28$ ), medical insurance payment method (assignment: 0=urban employees, 1=urban residents, 2=new agricultural Combined, 3=others, 4=full self-finance), occupation (assignment: 0=civil servant, 1=employee, 2=farmer, 3=student, 4=self-employed, 5=retired (retired) personnel, 6= Others) were used as independent variables to perform Logistic regression analysis. The findings indicate that age and obesity are independent risk factors for comorbidity among the inpatients. Compared with patients in the 45-59-year-old age group, patients in the  $\geq 75$ -year-old group are 7.804 times more likely to develop comorbidities ( $\text{OR} = 7.8046$ ,  $95\% \text{CI} = 3.665-16.616$ ). Patients with a BMI of  $28 \text{kg}/\text{m}^2$  were 3.770 times more likely to develop comorbidities than patients with a BMI of  $18.5 \text{kg}/\text{m}^2$ . ( $\text{OR} = 3.770$ ,  $95\% \text{CI} = 1.453-9.785$ ). (Refer to Table 2)

### 3.3 Clinical epidemiological characteristics of comorbidities disaggregated by gender, age, and BMI.

Table 3 shows the distribution of comorbid condition by gender, age and BMI. Just 165 people (6.9%) had only one chronic illness, while 8.8% had two, 13.5% had three, 15.9% had four, and 14.5% had five and 40.4% were diagnosed with six. Comorbidity condition was found more in male participants than in females. The prevalence of chronic diseases among participants with  $\text{BMI} \geq 24 \text{kg}/\text{m}^2$  was significantly higher than that of those with normal BMI. The number of chronic diseases were found to increase with age, especially in patients with more than 6 chronic diseases. In the age groups of 45-59 years, 60-74 years, and  $\geq 75$  years, the proportion of patients with more than 6 chronic diseases was the highest (34.6%, 45.4%, 59.4% respectively).

### 3.4 Clinical characteristics of comorbidities involved in the body system

Among the 2385 hospitalized patients, the circulatory system was the most common linked body system to comorbidities, with a prevalence rate of 79%, which was much higher compared to other systems. The other systems associated in comorbidities were Endocrine, nutritional and metabolic systems (62%), Digestive system (48%), Respiratory system (37%), Nervous system (23%), Genitourinary system (23%), Mental and Behavioral disorders (18%), Musculoskeletal system and connective tissue (18%) and Tumors (11%). (see Figure 2)

## 4. Discussion And Policy Recommendations

The number of patients with comorbidities will continue to rise in developing countries as the population ages, life expectancy increases, and lifestyles change (11,12). Compared with a single chronic disease, comorbid patients have complex causes, high medical expenses, and poor quality of life, resulting in a heavy burden of disease to the country, society and family (13-16). In view of this, in December 2016, NICE released the United Kingdom "Comorbidity: Clinical Evaluation and Management", stating that the clinical guidelines for a single disease are not applicable to patients with comorbidities. Medical staff should formulate effective management plans for comorbid patients as part of their overall strategy (17). At present, China and many developing countries have not issued special clinical treatment guidelines for comorbidity. The diagnosis and treatment of comorbidities is still based on specialist diagnosis. The advantages of general medicine in the field of comorbidity prevention and treatment have not been systematically studied. This article comprehensively analyzes the clinical epidemiological characteristics and influencing factors of comorbidities in general medicine inpatients in a provincial tertiary hospital in Henan Province, and provides representative evidence for effective prevention and control of comorbidities.

#### **4.1 Establishing a GP-PCIC comorbidity prevention and control model**

"The Mortality, Morbidity, and Risk Factors in China and Its Provinces from 1990 to 2017" published by The Lancet showed that the prevalence of hypertension and diabetes was 25.2% and 9.7% respectively. The overall prevalence of chronic diseases is gradually increasing, indicating that the current situation of chronic disease management is still severe (18). Due to the combined effects of multiple chronic diseases, patients with comorbidities face reduced quality of life, heavy psychological burden, prolonged hospital stay, increased number of readmissions, increased emergency visit rate, high incidence of multiple medications and adverse drug events and waste of medical resources (19-21). This study shows that the prevalence of comorbidities among inpatients in the general medicine department of provincial-level tertiary hospitals is extremely high, reaching 93.1%, which is close to the results reported by Feng Mei et al.(22), but higher than that of foreign Ge L et al.(23), Gupta S et al.(24) and Carolina IC et al. (25). This may be due to the fact that the study participants were enrolled from provincial medical center where the overall complexity and likelihood of the cases admitted is relatively high. It can be seen that the prevention and control of comorbid condition should be the key content of the prevention and control of chronic diseases.

Based on the experience of developed countries, the establishment of a patient-centered integrated service system (Patient Centered Integrated Care, PCIC) provides comprehensive, continuous, and proactive services for patients with comorbidities, and raises their awareness on disease risk factors. A healthy lifestyle can prolong the life of patients, improve the quality of life, reduce the economic burden of patients, and reduce medical expenses. General hospitals in China are of large-scale, with many departments, high-quality medical teams, high-tech equipment, and strong first aid capabilities. However, the cost of diagnosis and treatment is relatively high, characterized with longer waiting times. In addition, primary medical institutions have better access to services and lower cost advantages. Therefore, there should be a link between general medicine department in general hospitals and general practitioners in primary medical institutions to build a general practitioner-based patient centered integrated service system (General Practitioner Based Patient Centered Integrated Care, GP-PCIC). It is hence expected to play an important role in the clinical diagnosis and treatment and comprehensive prevention and control of comorbid diseases.

#### **4.2 Building the integrated two-way referral model between tertiary hospitals and primary hospitals**

As the general medicine department of the provincial tertiary hospitals support hierarchical diagnosis and treatment and maintains close contact with the grass-roots community health service centers, thereby building a bridge linking grass-roots medical institutions and comprehensive clinical specialties is important. There should be an

establishment of chronic disease management system so as to realize the effective sharing of electronic medical records between hospitals and community health services. The general medicine department of a tertiary hospital should be transferred to a ward or to a lower-level hospital or community health service center for treatment according to the patient's condition and needs. Through chronic disease management platforms, comprehensive, coordinated and continuous medical services should be provided to patients. Constructing a hierarchical diagnosis and treatment system is an important measure for the allocation of medical resources and the promotion of the equalization of basic medical and health services. This can be achieved through the integration and sharing of medical and health resources in the medical consortium, innovative health management, medical consortium operation management, hierarchical diagnosis and treatment, and medical insurance payment models.

#### **4.3 Strengthening comprehensive interventions for comorbidity in elderly and obese patients from both clinical and healthy lifestyle levels**

This study found that old age and obesity are risk factors for comorbidity. As age increases, the prevalence of comorbidities increases significantly, which is consistent with the findings of SCHRAM et al (26). The increase in age causes the body's metabolic rate to slow down, the body and organs gradually decline in function, and the possibility of chronic diseases in various body systems increases. Obesity is another major factor that increases the risk of chronic diseases. Obesity will increase the risk of heart disease, hypertension, diabetes and other diseases. The "Report on the Status of Nutrition and Chronic Diseases of Chinese Residents (2020)" issued by the National Health and Family Planning Commission shows that more than 50% of adult residents in China are overweight and obese (27). As a result, treating comorbidities is more complicated than simply diagnosing and treating a single disease. Hence, it is necessary to effectively cope with multiple risk factors at the same time. According to the clinical characteristics of patients with comorbidities, there is a need to explore the connection between clinical treatment and healthy lifestyle. From a practical standpoint, a clinical diagnosis and treatment plan for comorbid patients is established based on general practitioners, with "patient-centered, clinical, and healthy lifestyle integration" to achieve a hospital-community-family trinity health management model (28).

Relevant studies point out that lifestyle medicine plays an irreplaceable role in improving the health outcomes of most chronic diseases and hence significantly reduces medical expenses. Main interventions include weight control, reasonable diet, adequate exercise, adequate sleep, smoking cessation and alcohol restriction (29-32) (see Table 4). In the future general practice diagnosis and treatment, general practitioners should explore healthy lifestyle intervention programs suitable for hospitalized patients with comorbidities as one of the core contents of clinical treatment programs.

#### **4.4 Improving general practitioners' ability to diagnose and treat diseases in key systems and their comprehensive prevention and control capabilities.**

This study found that the most commonly affected systems of comorbidities are the circulatory system, endocrine, nutrition and metabolism, digestive system, and respiratory system. Therefore, general practitioners in provincial-level tertiary hospitals should be targeted to improve the clinical treatment of common diseases and frequently-occurring diseases in the corresponding system. At the same time, given that patients with comorbidities often have multiple health risk factors, general practitioners also need to have the ability to identify, mitigate and control the main system-specific health risk factors. Therefore, the ability of general practitioners to effectively prevent and control comorbidities should have the following capabilities: (1) Diagnosis and processing capabilities of diseases and disorders Rapid diagnosis of the circulatory, endocrine, nutrition, and metabolism systems, as well as the

digestive, respiratory, and other systems; (2) Ability to respond effectively to patients' family problems (33) and (3) To Detect, control, and propose healthy lifestyle intervention programs suitable for the residents.

Correspondingly, the education and training system of general practitioners in China should be updated so as to better meet the needs of residents for the diagnosis and treatment capabilities of the practitioners. To be specific, there is a need to scale up the residency training model (5+3) and rapidly increase the number of general practitioners familiar with general medicine concepts, all of which can serve as a foundation for establishing a GP-PCIC comorbidity prevention and control model. Secondly, on the basis of harmonizing national audit standards and training quality monitoring systems for general practitioner transfer training (34, 35), specific capacity improvement training for specific chronic disease epidemic trends in specific regions should be provided to address the problem of general practitioners in the circulatory system. Thirdly, there is a need to provide more trainings to the general practitioners, and the focus to establish and improve the mechanism for the comprehensive prevention and control of diseases and comorbidities.

## 5. Strengths And Weaknesses

In most health service systems, GPs are classified as primary health care providers. However, in the special health care context of China, GPs in tertiary hospitals play a dual role of service provider and primary general practitioner trainer. Exploring prevalence, risk factors, and approach to control of comorbidities among hospitalized patients of these GPs working at tertiary hospitals contributes to the improvement of general practice service system in China as a whole. Therefore, the advantage of this article is that it makes use of four years of continuous inpatient data from GPs working at tertiary grade-A hospitals, as well as a prospective analysis of clinical epidemiology of comorbidities among hospitalized patients at the provincial-level tertiary hospital. The true status of comorbid admissions is expected to serve as a decision-making basis for the development of a general medicine service system and the precise enhancement of general practitioners' diagnostic and treatment capabilities. The defect of this study is that only 81 GPs in tertiary hospitals were investigated, and follow-up surveys involving multiple centers and a large sample size should be enhanced.

## 6. Conclusions

Given the escalating severity of aging population and chronic diseases, it is critical to prioritize the effective prevention and control of comorbidities. As far as the findings of this article are concerned, the prevention and control of comorbidities should focus on the elderly and obese people. Effective countermeasures include establishing a GP-PCIC comorbidity prevention and control model and enhancing the comorbidity of elderly and obese patients at both the clinical and healthy lifestyle levels. We also call upon timely intervention and improvement in the diagnosis and treatment capabilities and comprehensive prevention and control measures of general practitioners on the circulatory, endocrine, digestive, respiratory and other systems.

## Declarations

### **Ethics approval and consent to participate**

All enrolled patients gave written informed consent before the clinical treatment in the sampled hospitals. The ethics committee of Henan Provincial People's Hospital ruled that no formal ethics approval was required in this particular case.

## Consent for publication

All authors have approved the final manuscript and consented for the publication.

## Availability of data and material

The anonymized dataset of this article is available through the email of the corresponding authors.

## Competing interests

The authors declare that there is no conflict of interest.

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## Author contributions

L. M. and C. S. T. are responsible for the conception and design of the article, data analysis, thesis writing and revision; W. L., L. Q. and W. J. are responsible for the implementation of the research and data analysis; M. Y. and S. M. are responsible for the statistical results, analysis and interpretation of the results; G. J. is responsible for the quality control and the overall review of the article.

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## Tables

**Table 1: Demographic characteristics and prevalence of comorbidities in general hospital inpatients (n=2385)**

Demographic Characteristics	Total	Comorbidity		$\chi^2$	P
		Number	Prevalence (% [95% CI])		
<b>Gender</b>				0.361	0.548
Male	1407	1306	92.8(91.5-94.2)		
Female	978	914	93.5(91.9-95.0)		
<b>Age [year]</b>				111.895	<0.01
<45	352	282	80.1(75.9-84.1)		
45-	812	763	94.0(92.3-95.6)		
60-	733	699	95.4(93.8-96.9)		
75-	488	476	97.5(96.2-98.9)		
<b>Marital status</b>				45.152	<0.01
Unmarried	42	24	57.1(41.5-72.8)		
Married	2168	2033	93.8(92.8-94.8)		
Divorced/Widowed/Unknown	175	163	93.1(89.4-96.8)		
<b>Education level</b>				1.784	0.619
Below elementary school	539	500	92.8(90.6-95.0)		
junior high school	506	470	92.9(90.6-95.1)		
High school technical secondary school	511	471	92.2(89.9-94.5)		
College degree and above	829	779	94.0(92.3-95.6)		
<b>BMI [kg/m<sup>2</sup>]</b>				33.366	<0.01
<18.5	91	82	90.1(83.9-96.4)		
18.5-23.9	812	726	89.4(87.3-91.5)		
24-27.9	1014	957	94.4(93.0-95.8)		
≥28	468	455	97.2(95.7-98.7)		
<b>Smoking</b>				0.154	<0.695
Yes	945	882	93.3(91.7-94.9)		
No	1440	1338	92.9(91.6-94.2)		
<b>Drinking</b>				3.369	<0.066
Yes	971	915	94.2(92.8-95.7)		
No	1414	1305	92.3(90.9-93.7)		
<b>Health insurance</b>				19.407	<0.01
MIUW	762	724	95.0(93.5-96.6)		

MIUR	351	324	92.3(89.5-95.1)		
NRCMI	681	620	91.0(88.9-93.2)		
CMI	418	399	95.7(93.7-97.7)		
None	173	153	88.4(83.6-93.3)		
<b>Occupation</b>				61.518	<0.01
Civil servant	197	189	95.9 <del>93.2-98.7</del>		
Corporate personnel	414	368	88.9 <del>85.8-91.9</del>		
Farmer	690	645	93.5 <del>91.5-95.5</del>		
Student	16	7	43.8 <del>16.4-71.1</del>		
Self-employed persons	170	156	91.8 <del>87.6-95.9</del>		
Retired personnel	499	487	97.6 <del>96.2-98.9</del>		
Others	399	368	92.2 <del>89.6-94.9</del>		

MIUW: Medical Insurance for Urban Workers; MIUR: Medical Insurance for Urban Residents;

NRCMI: The New Rural Cooperative Medical Insurance; CMI: Commercial Medical Insurance.

**Table 2: Logistic regression models of patients with chronic diseases and comorbidities (n=2385)**

Variables	Univariate model			Multivariate model		
	OR	95%CI	P	OR	95%CI	P
<b>Age(year)</b>						
<45	-	-	<0.001	-	-	<0.001
45-59	3.865	2.618-5.708	<0.001	3.018	1.945-4.683	<0.001
60-74	5.103	3.312-7.864	<0.001	4.349	2.574-7.349	<0.001
≥ 75	9.846	5.245-18.485	<0.001	7.804	3.665-16.616	<0.001
<b>Marital status</b>						
Unmarried	-	-	<0.001	-	-	0.021
Married	11.294	5.983-21.323	<0.001	2.551	1.006-6.467	0.049
Divorced/Unknown	10.187	4.368-23.760	<0.001	1.279	0.413-3.967	0.670
<b>BMI (kg/m<sup>2</sup>)</b>						
<18.5	-	-	<0.001	-	-	<0.001
18.5-23.9	0.927	0.449-1.910	0.836	0.740	0.332-1.649	0.461
24-27.9	1.843	0.881-3.856	0.105	1.406	0.622-3.179	0.413
≥28	3.841	1.590-9.278	0.003	3.770	1.453-9.785	0.006
<b>Health insurance</b>						
MIUW	-	-	<0.001	-	-	0.190
MIUR	0.630	0.378-1.049	0.076	0.707	0.396-1.264	0.243
NRCMI	0.533	0.351-0.811	0.003	0.623	0.354-1.096	0.100
CMI	1.102	0.627-1.938	0.735	1.093	0.603-1.982	1.093
None	0.402	0.22-0.709	0.002	0.538	0.283-1.025	0.538
<b>Occupation</b>						
Civil servant	-	-	<0.001	-	-	0.119
Manager	0.339	0.157-0.732	0.06	0.407	0.184-0.901	0.027
Farmer	0.607	0.281-1.309	0.203	0.650	0.269-1.572	0.339
Student	0.033	0.01-0.111	<0.001	0.355	0.077-1.572	0.186
Self-employed	0.472	0.193-1.153	0.100	0.777	0.298-2.527	0.606
Retired	1.718	0.691-4.269	0.244	0.946	0.354-2.527	0.912
Others	0.502	0.227-1.115	0.90	0.619	0.264-1.451	0.270

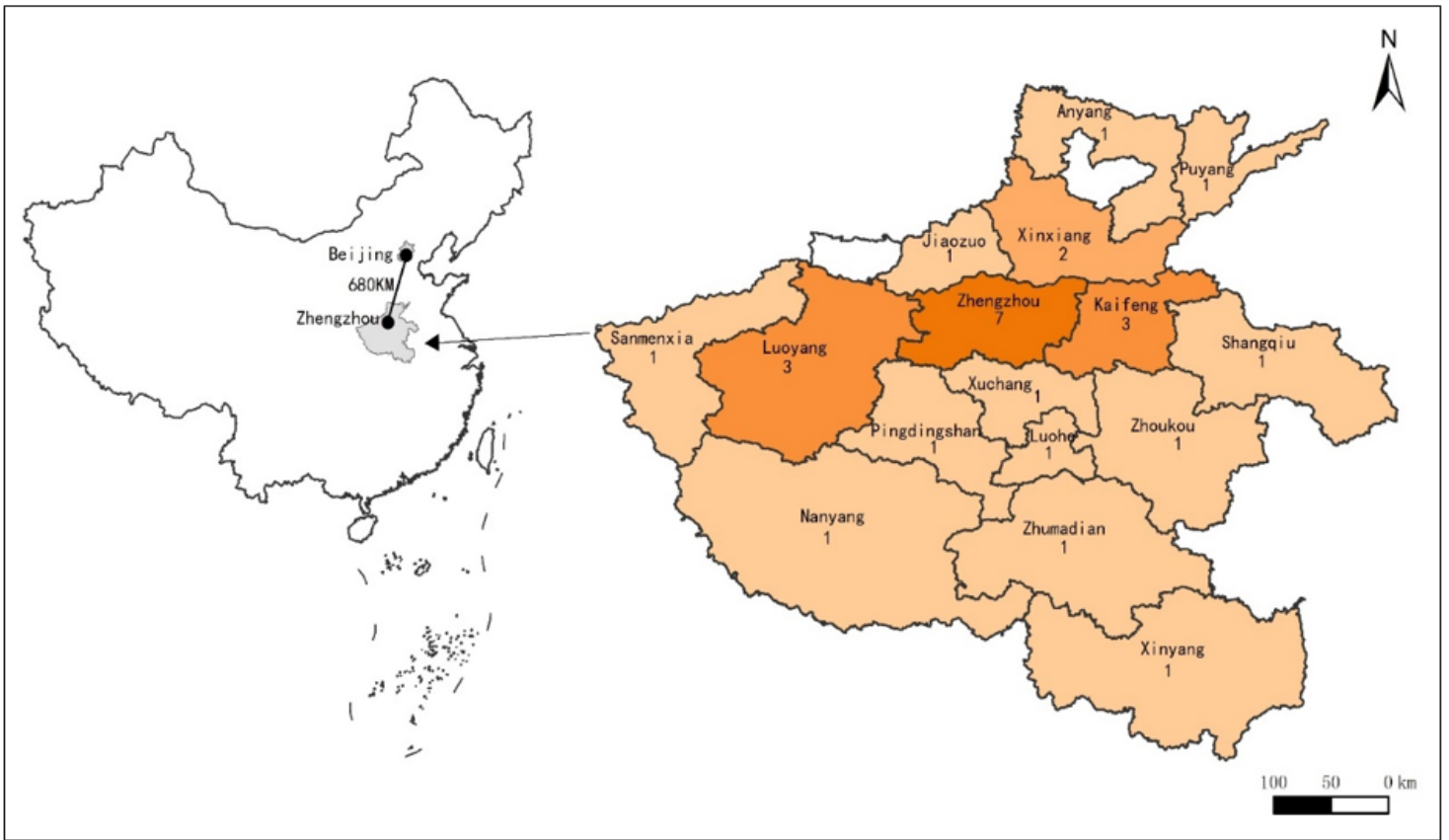
**Table 3: Clinical epidemiological characteristics of comorbidities (n=2385)**

Demographic characteristics	1		2		3		4		5		≥6	
	n	%	n	%	n	%	n	%	n	%	n	%
Total	165	6.9	209	8.8	322	13.5	379	15.9	346	14.5	964	40.4
Gender												
male	101	7.2	120	8.5	178	12.7	212	15.1	231	16.4	565	40.2
Female	64	6.5	89	9.1	144	14.7	167	17.1	115	11.8	399	40.8
Age(year)												
<45	70	19.9	55	15.6	60	17.0	70	19.9	37	10.5	60	17.0
45-59	49	6.0	85	10.5	127	15.6	139	17.1	131	16.1	281	34.6
60-74	34	4.6	53	7.2	92	12.6	118	16.1	103	14.1	333	45.4
≥ 75	12	2.5	16	3.3	43	8.8	52	10.7	75	15.4	290	59.4
BMI(kg/m <sup>2</sup> )												
<18.5	9	9.9	9	9.9	18	19.8	14	15.4	9	9.9	32	35.2
18.5-23.9	86	10.6	90	11.1	117	14.4	135	16.6	110	13.5	274	33.7
24-27.9	57	5.6	79	7.8	128	12.6	161	15.9	154	15.2	435	42.9
≥28	13	2.8	31	6.6	59	12.6	69	14.7	73	15.6	223	47.6

**Table 4: The 10 dimensions of lifestyle medicine and healthy lifestyle**

<b>Project</b>	<b>Description</b>
<b>Weight</b>	Maintain a reasonable weight;
<b>Diet</b>	Diversified, mainly based on plant-based whole-grain diets; reduce the intake of salt, sugar and sweeteners, oils, red meat, and polished rice noodles; consume supplement vitamins; eat sufficient fruits and vegetables
<b>Exercise</b>	Regular, appropriate and moderate aerobic exercise; avoid sitting for a long time; do not promote extreme sports (such as marathons)
<b>Sleep</b>	Sufficient sleep; Ensure that you get at least 7 hours of sleep each night; refrain from staying up late
<b>Smoking cessation</b>	Do not smoke; avoid secondhand smoke; E-cigarettes should be banned.
<b>Limit alcohol</b>	The best course of action is to abstain from alcohol consumption; avoid drug addiction and dependence
<b>stress reliever</b>	Reduce stress levels through yoga, singing, vacations, etc.
<b>Social</b>	Establish good interpersonal relationships; travel, frequent companion tours and visits for learning
<b>Occupation</b>	Retirement is delayed, old age has something to do, something to do; learning, continuous learning and education and training;
<b>Physical examination</b>	Health information collection and evaluation of routine comprehensive items: A baseline assessment should be performed for 35-40 years old; an assessment once in 12-18 months for 40-50 years old (according to the level of cardiovascular risk factors and lifestyle/behavioral status); after 50 years of age, to be evaluated once a year.

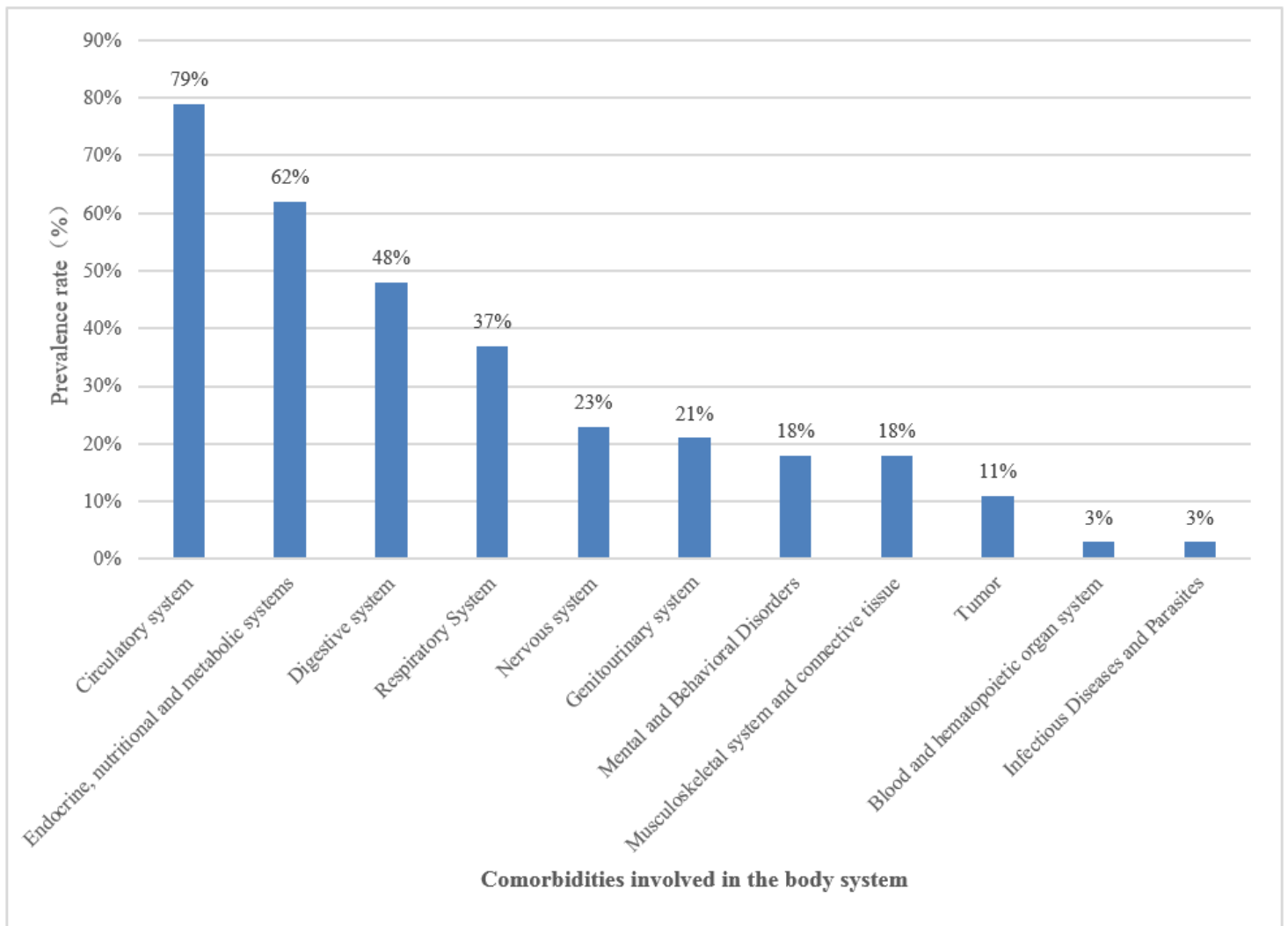
## Figures



**Figure 1**

Study setting and distribution of sampled hospitals. Note: \* Henan Province, with a population of 100 million, is a most representative province in China in terms of social economy, geographical area, and health resources allocation. \*\* In China's hospital system, tertiary Grade-A hospitals are medical institutions with the most comprehensive service ability, which undertake three main functions of clinical service, teaching and scientific research (followed by tertiary Grade-B, tertiary Grade-C, secondary and primary hospitals). Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.





**Figure 2**

The cumulative system ranking of chronic diseases in hospitalized patients