



# Research on Fairness and Prediction of Health Technical Personnel Allocation in Hainan Province Under the Background of Free Trade Port

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**Abstract:** *Objective:* To evaluate the fairness of health technical personnel resource allocation in Hainan Free Trade Port in 2021, forecast the development of health technical personnel in Hainan Province in 2022–2030, and provide reference for further optimizing the allocation of health human resources. *Methods:* The descriptive analysis method was used to systematically study the current situation of health technical personnel allocation in Hainan Province from 2016 to 2021. The fairness of health technicians in Hainan Province in 2021 was analyzed by the agglomeration degree evaluation method. The grey GM(1,1) model was used to predict the development trend of health technicians in Hainan Province from 2022 to 2030. *Results:* The number of health technicians in Hainan Province from 2016 to 2021 showed an increasing trend. In Hainan Province, the fairness and accessibility of health technicians based on geographical allocation are generally poor, only Haikou City, Sanya City, and Qionghai City are better, and the fairness of health technicians based on population is better than that based on geographical allocation, and Haikou City has an excess of health technicians. It is predicted that by 2030, the total number of health technicians will reach 155,175.78, and the scale will reach 1.9 times that of 2021. *Conclusion:* The number of health technicians in Hainan Province shows an overall growth trend, but the gap is still large. The structure needs to be further optimized and adjusted, and fairness and accessibility need to be further improved. By persisting in system integration and innovation, improving health personnel policy, innovating talent governance systems, increasing cultivation and introduction, and making full use of big data platforms, these can provide sufficient guarantees for the construction of Hainan Free Trade Port.

**Keywords:** Health Technician, Fairness, Prediction, Agglomeration Degree, Grey GM(1, 1) Model, Free Trade Port

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## 1. Introduction

Health human resources are the core of medical and health undertakings [1]. In the field of health, health technicians, also known as medical personnel, are an important part of health human resources and the main team to provide health protection for the people. Health technicians are directly related to the national health of a country and affect the medical level and service quality of health undertakings. The Outline of the "Healthy China 2030" Plan clearly takes the number of practicing (assistant) doctors per 1,000 population in the field of health services and security as the main indicator of the construction of healthy China [2]. In 2018, the CPC Central Committee decided to support Hainan in

gradually exploring pilot projects and steadily advancing the construction of free trade ports with Chinese characteristics. On June 1, 2020, the CPC Central Committee and The State Council issued the Overall Plan for the Construction of the Hainan Free Trade Port [3], ushering in new development opportunities for Hainan Province and comprehensively deepening reform and innovation. Hainan Province has adhered to institutional integration and innovation, and has made certain achievements in health care. However, with the continuous deepening of the construction of the free trade port, the population of Hainan Province has increased sharply, the aging has intensified, and the requirements for medical services are more prominent. This study used the agglomeration degree evaluation method to analyze the equity

of health technical personnel allocation in Hainan Province in 2021. The grey GM(1,1) prediction model was used to model and analyze the related indicators of health technical personnel in Hainan province from 2016 to 2021, and to predict the resource demand of health technical personnel in Hainan Province from 2022 to 2030. This is to provide the reference for the optimal allocation of health human resources and the rational and scientific formulation of health policies.

## 2. Data and Methods

### 2.1. Data Sources

The data were collected from the Hainan Statistical Yearbook from 2017 to 2022, and the number of health technicians, practicing (assistant) physicians, registered nurses, health technicians per thousand permanent residents, practicing (assistant) physicians per thousand permanent residents, registered nurses per thousand permanent residents, and doctor-nurse ratio were selected as the research indicators.

### 2.2. Research Methods

#### 2.2.1. Status Research

Descriptive analysis: The number of health technicians, practicing (assistant) physicians, registered nurses, health technicians per thousand permanent residents, practicing (assistant) physicians per thousand permanent residents, and registered nurses per thousand permanent residents in Hainan Province were recorded with the data input of Microsoft Excel 2013.

#### 2.2.2. Agglomeration Degree

Agglomeration degree can reflect the concentration degree of a certain factor in a certain region relative to that factor in the next level of region [4]. In the health field, it can be used to evaluate the equity of health resource allocation in a certain region. Agglomeration degree generally refers to the degree of health resource agglomeration degree (HRAD) and population agglomeration degree (PAD).

Health resources agglomeration degree (HRAD) refers to a geographical area and area per unit area at the next higher level within the average ratio of the number of health resources. Its formula is as follows:

$$HRAD_i = \frac{(HR_i/HR_n) \times 100\%}{(A_i/A_n) \times 100\%} = \frac{HR_i/A_i}{HR_n/A_n} \quad (1)$$

Among them,  $HR_i$  refers to the number of certain health resources possessed by region  $i$ ,  $HR_n$  refers to the total number of certain health resources in the province corresponding to  $HR_i$ ,  $A_i$  refers to the geographical area of region  $i$ , and  $A_n$  refers to the geographical area of the province. When  $HRAD_i$  is greater than 1, the fairness and accessibility of health resources based on geographical allocation in the region is better, and vice versa [5, 6].

Population aggregation degree (PAD) is the ratio of the average number of people in a unit area of a certain geographical area to that of the previous level. Its formula is as

follows:

$$PAD_i = \frac{(P_i/P_n) \times 100\%}{(A_i/A_n) \times 100\%} = \frac{P_i/A_i}{P_n/A_n} \quad (2)$$

Among them,  $P_i$  refers to the population of a certain region, and  $P_n$  refers to the population of the province. From the perspective of population allocation, when  $HRAD_i$ - $PAD_i$  is equal to or close to 0, the equity and accessibility of health resources in the region are better and can meet the medical needs of residents in the region. If it is greater than 0, the health resources in the region are excess. If it is not, the equity is poor and the medical needs of the population in the region cannot be met [7-9].

#### 2.2.3. Grey GM(1,1) Model

The grey GM(1,1) model was established by MATLAB 2018 to predict the development trend of health human resources in Hainan Province from 2022 to 2030. The theory of the grey prediction model GM(1,1) is based on the existence of grey correlation in all data, taking known factors as the influence base, constructing a continuous differential equation with time as the variable by means of accumulation and subtraction of discrete data scattered on the time axis, and then determining parameters in the equation by mathematical method, so as to achieve the prediction goal [10]. The characteristics of this model are that it can be applied to a small number of data samples, the short-term prediction effect is good, and the calculation process is simple. The modeling steps of the grey prediction model GM(1,1) are as follows:

Step 1: Modeling feasibility analysis.

Let the original sequence be  $X(0)$

$X^{(0)} = [X^{(0)}(1), X^{(0)}(2), \dots, X^{(0)}(n)]$ , to an accumulation of  $X(0)$ , to:  $(1) = X[X^{(1)}(1), X^{(1)}(2), \dots, X^{(1)}(n)]$ .

Step 2: Establish the differential equation of GM(1,1) model

$$u = \frac{dX(1)}{dt} + aX(1)$$

By constructing data matrix  $B$ , data vector  $Y$  and least square method, the parameters  $a$ ,  $b$ ,

$\bar{a}$  is the parameter to be estimated, assuming  $a = (\bar{a}, b)^T$ ,  $(B^T B^{-1})B^T Y_n = \bar{a}$

Step 3: Find the GM(1,1) model

$$\hat{X}^{(1)}(t+1) = (X^{(0)}(1) - \frac{b}{a})e^{-at} + \frac{b}{a} \quad (t=1, 2, 3, \dots, n) \quad (3)$$

Where  $t$  represents time,  $a$  represents the development gray number, and  $b$  represents the gray action.

Step 4: Model accuracy check.

The prediction accuracy of the grey GM(1,1) model was tested by the posterior difference ratio ( $C$ ) and small error probability ( $P$ ). If  $C$  is greater than 0.65 and  $P$  is less than 0.70, it is level 4 and considered unqualified. If  $C$  is between 0.50 and 0.65 (including 0.65) and  $P$  is between 0.70 and 0.80 (including 0.70), it is level 3 and deemed to be barely qualified. If  $C$  is between 0.35 and 0.50 (including 0.50) and  $P$  is between 0.80 and 0.95 (including 0.80), it is level 2 and qualified. If  $C$  is less than or equal to 0.35 and  $P$  is greater than

or equal to 0.95, the accuracy of the model is level 1 and is considered excellent [11]. See Table 1.

**Table 1.** Accuracy test of grey prediction model.

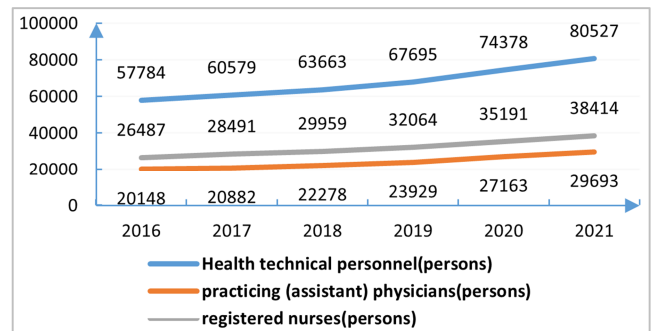
Level	C	P
Level 4 (unqualified)	$>0.65$	$<0.70$
Level 3 (Barely qualified)	$0.50 < C \leq 0.65$	$0.70 \leq P < 0.80$
Level 2 (qualified)	$0.35 < C \leq 0.50$	$0.80 \leq P < 0.95$
Level 1 (Excellent)	$\leq 0.35$	$\geq 0.95$

### 3. Results

#### 3.1. Analysis on the Status Quo of Medical and Health Human Resources Allocation in Hainan Province

On the whole, the number of health technicians, practicing (assistant) physicians and registered nurses in Hainan Province showed a good growth trend from 2016 to 2021 (Figure 1). By the end of 2021, compared with 2016, the number of health technicians increased by 22,743, an increase of 39.36%; The number of practicing (assistant) physicians increased by 9545, an increase of 47.37%; The number of registered nurses increased by 11,927, an increase of 45.03%, and there were far more registered nurses than practicing (assistant) physicians. The number of health technicians per thousand permanent residents, the number of practicing (assistant) physicians per thousand permanent residents, and the number of registered nurses per thousand permanent

residents also showed a steady upward trend year by year, and the doctor-nurse ratio was always hovering in the range of 0.73-0.77 (Table 2). According to the "Hainan Provincial Health Allocation Standard (2015–2020)", the number of practicing (assistant) physicians, registered nurses, practicing (assistant) physicians per 1,000 permanent residents, and registered nurses per 1,000 permanent residents have reached the prescribed target value in 2020, and the target has been well achieved. The doctor-nurse ratio is also very close to the 2020 target value of 1:1.25. It can be clearly seen that the growth rate of research indicators after 2018 is faster than that before 2018, and it is showing better development momentum in 2021.



**Figure 1.** Basic situation of medical and health human resources allocation in Hainan Province from 2016 to 2021.

**Table 2.** Health human resources per 1,000 permanent residents in Hainan Province from 2016 to 2021.

Year	Health technicians per 1,000 resident population (persons)	Practicing (assistant) physicians per 1,000 resident population (persons)	Registered nurses per 1,000 resident population (persons)	Doctor-nurse ratio
2016	6.30	2.20	2.89	0.76
2017	6.54	2.26	3.08	0.73
2018	6.81	2.38	3.21	0.74
2019	7.17	2.53	3.39	0.75
2020	7.35	2.68	3.48	0.77
2021	7.89	2.91	3.76	0.77

#### 3.2. Analysis of Resource Agglomeration Degree and Population Agglomeration Degree of Health Technical Personnel in Cities and Counties of Hainan Province in 2021

##### 3.2.1. Analysis of the Agglomeration Degree of Health Technical Personnel Resources from the Geographical Perspective

It can be seen from Table 3 that in 2021, the equity and accessibility of the geographical allocation of health technicians in Hainan Province are generally poor. The agglomeration degrees of health technicians, practicing (assistant) physicians and registered nurses in Haikou, Sanya and Qionghai were all greater than 1, indicating that the equity and accessibility of health technicians in these three regions were better according to geographical distribution, while the agglomeration degrees of other regions were less than 1, indicating that the equity and accessibility were poor.

##### 3.2.2. Analysis of the Agglomeration Degree of Health Technical Personnel Resources from the Perspective of Population

The difference between the aggregation degree of health technical personnel and population in each region of Hainan Province in 2021 shows that there is great room for improvement in the equity of population allocation (Table 3). In terms of health technical personnel, the difference of agglomeration degree and population agglomeration degree in Sanya City, Chengmai County, Qiongzong County, Baoting County, Baisha County and Changjiang County was close to 0, indicating that the equity of health technical personnel allocation according to population was good. In terms of practicing (assistant) physicians, the difference of agglomeration degree and population agglomeration degree in Sanya City, Wuzhishan City, Chengmai County, Dongfang City, Qiongzong County, Baoting County and Baisha County was close to 0, indicating that the fairness of practicing (assistant) physicians allocation according to population was

good. In terms of registered nurses, the difference of agglomeration degree and population agglomeration degree in Sanya City, Qionghai City, Qiongzong County, Baoting County, Baisha County and Changjiang County is close to 0,

indicating that the fairness of the allocation of registered nurses according to population is good. The difference values of the three indicators in Haikou City are far greater than 0, indicating that the health human resources are relatively excess.

**Table 3.** Analysis of the resource agglomeration degree of health technical personnel and population agglomeration degree of each city and county in Hainan Province in 2021.

Area	Health technician		Practicing (assistant) physician		Registered nurse		PAD <sub>i</sub>
	HRAD <sub>i</sub>	Difference value	HRAD <sub>i</sub>	Difference value	HRAD <sub>i</sub>	Difference value	
Haikou City	6.091	1.735	5.856	1.500	6.461	2.104	4.356
Sanya City	1.929	0.037	1.966	0.074	1.926	0.034	1.892
Wuzhishan City	0.503	0.166	0.410	0.073	0.510	0.173	0.337
Wenchang City	0.508	-0.282	0.535	-0.256	0.488	-0.303	0.791
Qionghai City	1.204	0.132	1.212	0.140	1.144	0.072	1.072
Wanning City	0.707	-0.292	0.748	-0.252	0.692	-0.308	0.999
Ding'an County	0.609	-0.219	0.656	-0.173	0.540	-0.288	0.828
Tunchang County	0.518	-0.200	0.581	-0.137	0.450	-0.268	0.718
Chengmai County	0.745	-0.089	0.873	0.040	0.668	-0.165	0.834
Lingao County	0.671	-0.411	0.756	-0.326	0.664	-0.418	1.082
Danzhou City	0.811	-0.169	0.799	-0.182	0.815	-0.166	0.980
Dongfang City	0.511	-0.170	0.606	-0.075	0.438	-0.242	0.680
Ledong County	0.416	-0.168	0.373	-0.211	0.404	-0.179	0.584
Qiongzong County	0.218	-0.012	0.227	-0.003	0.190	-0.041	0.231
Baoting County	0.396	-0.073	0.390	-0.080	0.385	-0.084	0.469
Lingshui County	0.977	-0.191	0.902	-0.267	0.957	-0.212	1.169
Baisha County	0.210	-0.057	0.219	-0.049	0.193	-0.075	0.267
Changjiang County	0.436	-0.061	0.371	-0.126	0.436	-0.060	0.497

### 3.3. GM(1,1) Grey Model Prediction Results

#### 3.3.1. Test Results of GM(1,1) Grey Prediction Model

Taking the number of health technicians, practicing (assistant) physicians, registered nurses, health technicians per thousand permanent residents, practicing (assistant) physicians per thousand permanent residents, registered nurses per thousand permanent residents, and doctor-nurse

ratio in Hainan Province from 2016 to 2021 as raw data, the grey GM(1,1) model is constructed according to formula 3. The development coefficient, posterior difference ratio (C) and small error probability (P) of each index are obtained (Table 4). As can be seen from Table 4, C values are all less than 0.35, P values are all 1, and  $-a < 0.3$ . It can be seen from Table 5 that the relative error values of the models are all less than 0.1.

**Table 4.** Test results of grey GM(1,1) prediction model.

Predictor indicator	Development coefficient a	C	P	Level of accuracy
Health technician (persons)	-0.074	0.009	1.000	Level 1 (Excellent)
Practicing (Assistant) physician (persons)	-0.010	0.010	1.000	Level 1 (Excellent)
Registered Nurse (persons)	-0.077	0.008	1.000	Level 1 (Excellent)
Health technicians per 1,000 resident population (persons)	-0.046	0.013	1.000	Level 1 (Excellent)
Practicing (assistant) physicians per 1,000 resident population (persons)	-0.063	0.006	1.000	Level 1 (Excellent)
Registered nurses per 1,000 resident population (persons)	-0.048	0.0130	1.000	Level 1 (Excellent)
Doctor-nurse ratio	-0.015	0.054	1.000	Level 1 (Excellent)

**Table 5.** Relative error table of grey GM(1,1) model.

indicator	Year	Relative error
Health technician	2016	0.000%
	2017	1.794%
	2018	0.601%
	2019	1.850%
	2020	0.207%
	2021	0.773%
Practicing (Assistant) physician	2016	0.000%
	2017	2.164%
	2018	0.536%
	2019	2.612%
	2020	0.900%
	2021	0.614%
Registered Nurse	2016	0.000%
	2017	1.955%
	2018	0.734%
	2019	1.685%

indicator	Year	Relative error
Health technicians per 1,000 resident population	2020	0.096%
	2021	0.933%
	2016	0.000%
	2017	0.382%
	2018	0.122%
	2019	0.478%
Practicing (assistant) physicians per 1,000 resident population	2020	1.604%
	2021	0.944%
	2016	0.000%
	2017	0.918%
	2018	0.220%
	2019	0.424%
Registered nurses per 1,000 resident population	2020	0.984%
	2021	0.935%
	2016	0.000%
	2017	0.531%
	2018	0.177%
	2019	0.435%
Doctor-nurse ratio	2020	1.803%
	2021	1.102%
	2016	0.000%
	2017	0.025%
	2018	0.125%
	2019	0.243%
	2020	0.924%
	2021	0.534%

### 3.3.2. Predicted Results

According to the fitting model, the health technicians, practicing (assistant) physicians, registered nurses, health technicians per thousand resident population, practicing (assistant) physicians per thousand resident population, registered nurses per thousand resident population and the doctor-nurse ratio in 2022-2030 were predicted respectively. According to the forecast results, the various health manpower in Hainan Province will continue to develop and grow in 2022-2030. By 2030, the total number of health technicians will reach 155,175.78, an increase of 74,648.78 over 2021, an

increase of 92.70%; The total number of practicing (assistant) physicians will reach 67,503.177, an increase of 37,810.177 over 2021, an increase of 127.34%; The total number of registered nurses will reach 76307.446, an increase of 37893.446 over 2021, an increase of 98.64%; The number of health technicians, practicing (assistant) doctors and registered nurses per 1,000 permanent residents will reach 11.77, 5.09 and 5.75, respectively, an increase of 3.88, 2.18 and 1.99 over 2021, an increase of 49%, 75% and 53%. The doctor-nurse ratio will increase from 1:1.30 to 1:1.14. Practicing (assistant) physicians are growing the fastest. (Table 6)

**Table 6.** Prediction results of medical and health technicians in Hainan Province from 2022-2030.

Year	Health technician (persons)	Practicing (Assistant) physician (persons)	Registered Nurse (persons)	Health technicians per 1,000 resident population (persons)	Practicing (assistant) physicians per 1,000 resident population (persons)	Registered nurses per 1,000 resident population (persons)	Doctor-nurse ratio
2022	86,020.23	32,352.39	41,114.15	8.18	3.07	3.90	0.79
2023	92,603.74	35,467.75	44,418.44	8.56	3.27	4.10	0.80
2024	99,691.11	38,883.10	47,988.28	8.96	3.48	4.30	0.81
2025	107,320.91	42,627.32	51,845.04	9.38	3.71	4.51	0.82
2026	115,534.65	46,732.10	56,011.75	9.81	3.95	4.74	0.83
2027	124,377.03	51,232.14	60,513.33	10.27	4.21	4.97	0.85
2028	133,896.15	56,165.52	65,376.70	10.75	4.49	5.22	0.86
2029	144,143.82	61,573.95	70,630.94	11.25	4.78	5.48	0.87
2030	155,175.78	67,503.18	76,307.45	11.77	5.09	5.75	0.88

## 4. Discussion

### 4.1. From 2016 to 2021, the Health Human Resources in Hainan Province Show an Increasing Trend Year by Year

From 2016 to 2021, health human resources in Hainan

Province have developed rapidly with great growth potential. This is related to the implementation of institutional integration innovation in Hainan Province under the background of free trade port. This is also different from other studies, which put Hainan Province in the context of free trade port to discuss the policy orientation of health human resources. Since the construction of the free trade port, Hainan has persisted in reform and innovation, integrated and

optimized resources, and introduced and implemented a number of favorable systems for promoting health talents. In order to strengthen the construction of the team of general practitioners and consolidate the foundation, the Implementation Plan for the Reform and Improvement of the Incentive Mechanism for the Training and Use of General Practitioners in Hainan Province was issued in 2018. In order to meet and adapt to the needs of the construction of free trade ports, it is in line with international standards, and in order to build an international medical tourism pilot zone, the "Hainan Free Trade Port" Foreign Talent Identification Standards (2020-2024 trial) "was issued in 2020. In order to establish and improve the high-level talent identification and service management system, accelerate the introduction and cultivation of high-level outstanding medical talents, and meet the needs of Hainan Free Trade Port construction of high-level complex medical talents, the Measures for the Identification of High-level Talents of Hainan Free Trade Port was issued in 2020, and the Work Plan for introducing "Good Deans" and "Good Doctors" in Hainan Province (2021-2025) was promulgated in 2021. In 2021, the "14th Five-Year Plan for Health and Health of Hainan Province" was issued, and 2021 is the first year of the "14th Five-Year Plan". The province is forging ahead to the goal of high-quality development, and health talents have entered a new growth period, providing the core talent guarantee for health and escorting the construction of free trade ports.

#### ***4.2. The Equity and Accessibility of Health Technicians in Hainan Province Need to Be Improved***

From the concentration degree of health technical personnel resources in 2021, the health technical personnel resources allocated by the population in Hainan Province are better than those allocated by geography. In particular, in areas with relatively backward economy and a large geographical area, the equity and accessibility of health technical personnel allocation are poor. Due to differences in economy, culture, education, treatment, etc., regional distribution is uneven. Most health technicians are concentrated in economically developed cities. Haikou City has good fairness and accessibility of health technicians based on geographical allocation, but Haikou City has an excess of health technicians based on population allocation. The possible reason is that Haikou is a provincial capital city with a relatively developed economy and better policies, and medical colleges and large general hospitals are concentrated in Haikou. More health personnel have been attracted to work and live in Haikou City, so the resources of health technicians are sufficient. But it needs to be further coordinated and optimized to promote the sinking of health resources, improve overall fairness and accessibility, and alleviate the shortage of manpower while avoiding excess.

#### ***4.3. Grey GM(1,1) Model Fitting Effect Evaluation***

Health resource supply and demand forecasts are an important basis for government departments to do health

planning. The grey model is widely used in economic development, consumption level, population, health and other fields, and is often used in the health industry in terms of health resources, health costs, and disease burden [12]. This study uses the GM(1,1) gray model to predict the health technicians, practicing (assistant) physicians, registered nurses, health technicians per thousand permanent residents, practicing (assistant) physicians per thousand permanent residents, registered nurses per thousand permanent residents, and the doctor-nurse ratio in 2022–2030. According to the model test, the C value of all health human resources is less than 0.35, the P-values are 1, the -a of each model is < 0.3, and the relative error between the predicted value and the actual value is less than 0.1, which indicates that the fitting level of each model is 1, and the effect is excellent. It means that the fitting effect of the model meets high requirements. This prediction model is suitable for the prediction of this study. This is consistent with the studies of Xue Wenjing [10] and Sun Jian [13]. However, the GM(1,1) grey model is based on regular and orderly data and ignores the influence of some factors when they change greatly.

#### ***4.4. The Number of Health Technicians in Hainan Continues to Increase, But the Gap Is Still Large, and the Structure Needs to Be Further Optimized and Adjusted***

The forecast results show that the health human resources of Hainan Province will continue to grow rapidly in 2022–2030. According to the "14th Five-Year Plan for Health and Health of Hainan Province", it is predicted that by 2025, the number of practicing (assistant) doctors and the number of registered nurses per thousand permanent residents will reach the goals of the "14th Five-Year Plan" ( $\geq 3.1$  and  $\geq 3.6$  respectively). According to the "Healthy Hainan 2030" planning Outline, it is predicted that by 2030, the number of practicing (assistant) doctors per thousand permanent residents and the number of registered nurses per thousand permanent residents will also be close to the planned value (3.2 and 4.8, respectively). The main reason may be that with the in-depth construction of Hainan Free Trade Port and the continuous optimization of Hainan's policies, a large number of people are attracted to live and work in Hainan, and the rapid increase in population has promoted the great development of medical and health services. However, compared with the whole country, the gap is still large, and it is far from the goal of the "Fourteenth Five-Year Plan for the Development of Health Talents" issued by the National Health and Health Commission. The doctor-nurse ratio is still not up to the national standard, and it is further from developed countries [14]. From the predicted value, the future nurse gap in Hainan Province is very large. The main reasons may be: the first is the large demand. Due to the increasing aging, especially the unique natural scenery and pleasant climate in Hainan Province, which is very suitable for the life of the elderly, a large number of elderly people gather in Hainan. The elderly care industry has developed on a large scale, and the combination of medical care has become the norm. The

second is insufficient supply. The work of nurses is tedious and tiring, and the treatment system is not perfect. Perhaps with the change of people's thinking and the improvement of their living environment, many people will not choose the nursing industry. Different from other places in China, such as Shandong, Sichuan and Guangxi, there are few medical colleges and universities in Hainan Province, which is difficult to cultivate and introduce. The ratio of medical personnel allocation is unreasonable, and the structure should be further optimized and adjusted to promote the sustainable development of health care in Hainan Province.

## 5. Conclusion

In this study, the equity of health technical personnel allocation in Hainan Province was studied under the background of free trade port and its development trend was predicted. It was found that the number of health technical personnel in Hainan Province showed an overall growth trend, but the gap was still large, especially the gap of nurses. And the structure is not excellent, the doctor-nurse ratio has not reached the national standard. The allocation of health technical personnel resources by population in Hainan province is better than that by geography, and the regional differences are large. The fairness of health technical personnel allocation in Hainan Province is mainly affected by policy, economy and environment, and its fairness and accessibility need to be further improved. Therefore, on the one hand, measures should be taken to expand the number and improve the quality of health technicians in Hainan Province; On the other hand, it is necessary to promote the fairness of the allocation of health technicians and the coordinated development of all regions.

## 6. Suggestions

### 6.1. Adhere to the System Integration and Innovation as the "Starting Point" to Stimulate Vitality

First, adhere to deepening reform and put institutional integration and innovation in a prominent position in the construction of Hainan Free Trade Port. Emancipate the mind, make bold innovations, constantly accelerate the reform of scientific and technological systems and mechanisms, and increase scientific and technological innovation and the sharing of achievements. Comprehensively implement the new development concept, accurately grasp the target positioning of "three districts and one center", anchor the strategic framework of "one base, four beams and eight pillars" [15], and accelerate the construction of a free trade port with Chinese characteristics. Second, promote policy implementation, optimization and adjustment, and explore the most suitable development path. Promote innovative policies and systems through the pilot, sum up experience, find problems, put forward targeted improvement measures, optimize and adjust the spread in the province, release vitality. Focusing on building a higher level of health island and

longevity island, the government should accelerate the implementation of the "one health" Hainan demonstration project, promote the process of the Boao Lecheng International Medical Tourism Pilot Zone, and fully tap and develop the unique health industry of each district.

### 6.2. Improve the Health Personnel Policy and Innovate the Talent Governance System

First, improve the recruitment policy and refine the inspection system. Under strengthened supervision, the implementation of autonomous use of human rights, and appropriate reduction of the proportion of examinations, especially for general medicine, psychiatry, gynecology, pediatrics, nursing, and other shortages of professions and positions, do not set the proportion of examinations. Apply for the job with academic qualifications, a resume, a doctor's certificate, training, etc. Conditions such as educational background and age should be appropriately relaxed for grassroots medical staff. Second, innovate the post and staffing systems and promote the reform of the salary system. Optimize the implementation of the policies of "county and township" and "township and village", and further tilt the total establishment toward professional and technical establishment according to the actual situation, further coordinate and allocate the establishment and posts, and promote the sinking of health and technical talents. Deepen the "two permits" policy, further improve the salary level of medical personnel, especially the treatment of nurses, and the incentive mechanism is appropriately oriented to remote areas and grassroots. The government and hospitals should accelerate salary reform in public hospitals. Third, optimize the evaluation system and promote the work to return to reality. Regularly and dynamically develop an evaluation system combining the quality and quantity of talents, and focus on the evaluation of the achievements of transformation and application of scientific and research talents. For clinical operation talents, pay attention to the assessment of practical operation ability, medical technology and level; For the nursing staff, pay attention to the evaluation of service attitude and quality. The latter two can appropriately weaken the conditions of papers, foreign languages, projects, etc., so that they can pay more attention to their own work, improve their post competency, and return to the essence of work. This can promote the optimization and sinking of health human resources, equity and accessibility.

### 6.3. Increase the Cultivation and Introduction of Health Professionals to Escort the Construction of the Free Trade Port

First, increase local cultivation and targeted joint cultivation. Actively publicize the glorious deeds of medical staff, establish a sense of honor, create a good environment, so that more young people love and devote themselves to the cause of health. First-class comprehensive medical colleges and universities should be created, especially nursing colleges, and the government should promote first-class scientific

research bases and medical institutions to settle in Hainan, so as to provide a "cradle" for cultivating health talents. Second, speed up the introduction of high-level composite health personnel. Relying on the favorable talent policy of the Free Trade Port, The talent resources from Shanghai, Beijing and the Guangdong-Hong Kong-Macao Greater Bay Area should be introduced. At the same time, the Hainan government should introduce more favorable policies for international friends, promote the introduction of international medical teams, and strive to build an international medical tourism pilot zone.

#### **6.4. Make Full Use of Big Data Platform to Invigorate Human Resources**

First, consolidate the characteristic grid-compact medical service system of Hainan Province, promote the sinking development of medical service businesses, and rapidly integrate resources, mobilize resources, share experience and technology through a big data platform and modern information technology. Second, accelerate the "5G smart medical lighting up Hainan Health Island" project, with the help of 5G technology and promote intelligent empowerment, which can release the pressure of medical staff, activate human resources, and improve the efficiency of medical services.

The optimal allocation of health technicians is the basis for the high-quality development of the health industry of Hainan Free Trade Port and a strong guarantee for the high-quality construction of Hainan Free Trade Port. It is conducive to promoting the sinking of medical resources, realizing the goal that "small diseases do not enter the city, serious diseases do not leave the island", and comprehensively building a healthy island and a longevity island. It is conducive to the healthy development of medical and health services in regions along the Belt and Road.

### **Author Contribution**

Yanhua Gong analyzed the data and wrote the manuscript. Wen Feng collected the data. Dong Ma designed the study and made revisions to the manuscript.

### **Declaration of Conflicting Interests**

The authors declare no potential conflict of interest.

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### **Consent for Publication**

All authors read the manuscript and approved it for publication.

## **References**

- [1] ZHANG Ruihua, ZHAO Darene, HE Sichang et al. Health human resource prediction based on Grey GM(1,1) model and ARIMA model, Sichuan Provincial [J]. Modern Preventive Medicine, 2017, 44 (07): 1242-1247.
- [2] Chinese government Network. The Outline of Healthy China 2030 Plan was released [EB/OL]. (2016-11-20) [2023-03-01]. [http://www.gov.cn/xinwen/2016-10/25/content\\_5124174.htm](http://www.gov.cn/xinwen/2016-10/25/content_5124174.htm)
- [3] GONG Yanhua, Feng Wen, Ma Dong. Research on the Allocation Status and Equity of Medical and Health Resources in Hainan Province under the Construction of Free Trade Port [J]. Chinese Health Economics, 2022, 41 (09): 46-51.
- [4] Wang Xiangyu, Liu Mengzhu, Wu Jian et al. Equity Evaluation of Health Human Resource Allocation in China from the Perspective of Agglomeration Degree [J]. Chinese Hospital Management, 2022, 42 (12): 60-63.
- [5] Wang Heng, Zhou Dian, Yang Yan et al. Evaluation and prediction of health resource allocation in Yangtze River Delta [J]. Chinese Health Resources, 2022, 25 (04): 434-439+446.
- [6] Liu Yuzhuo, Xu Chao, Wang Xiaoyu et al. Research on equity and prediction of health resources allocation in Shandong Province [J]. Modern Preventive Medicine, 2022, 49 (16): 2986-2991.
- [7] Li Jing, Xu Xiumei, Zhu Yao, Wang Suzhen. Analysis on the evaluation of medical and health resources allocation in China Based on Agglomeration Degree [J]. Soft Science of Health, 2022, 36 (12): 40-45.
- [8] Liu Chunyu, Gong Chao et al. Equity analysis of health resource allocation in Tianjin based on Gini coefficient and aggregation degree [J]. Chinese Hospitals, 2022, 26 (09): 32-35.
- [9] Chen Lijun, Duan Guimin, Li Jiawei et al. Research on the allocation of health resources and demand forecast in ethnic areas, Sichuan [J]. Modern Preventive Medicine, 2022, 49 (17): 3187-3192.
- [10] Xue Wenjing, Liu Zhigang, Yang Yi, Liu Jing. Development of health human resources in China based on the Grey GM (1, 1) Model and its prediction [J]. Chinese Rural Health Service Administration 2022, 42 (06): 400-404.
- [11] Liu Jun, Yang Chuan, Wang Huiqin. Application of grey model GM(1,1) in nurse manpower prediction of Xinjiang Production and Construction Corps [J]. Chinese Journal of Health Statistics, 2014, 31 (03): 461-462.
- [12] Song Chenxiao, Xu Aijun, Wang Dandan. Research on human resource demand forecast of traditional Chinese medicine hospital based on gray GM (1, 1) model [J]. Chinese Research Hospital, 2018, 5 (06): 1-5.
- [13] Sun Jian, Wang Qianqiang. Analysis on health resources demand forecast in Guangxi Zhuang Autonomous Region based on gray system GM(1, 1) Model [J]. Soft Science of Health, 2017, 31 (07): 25-28.
- [14] Liu Lihang, Yan Fengling. A study on status quo and equity of allocation of medical and health resources in Hunan Province [J]. Chinese Journal of Health Policy, 2021, 14 (09): 69-75.



- [15] Kuang Changxun, Wang Jiangshun. Anchor the strategic framework of "One three foundations, four beams and eight pillars" to promote Hainan's comprehensive deepening of reform and opening up and the construction of a free trade port with Chinese characteristics [N]. Hainan Daily, 2022-05-08 (A01).