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Relationships among gross domestic product per capita, government health expenditure per capita and infant mortality rate in China.

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Abstract

This study aimed to investigate the relationships among Gross Domestic Product (GDP) per capita, Government Health Expenditure (GHE) per capita and Infant Mortality Rate (IMR) in China, and explore the new model to reduce the IMR. A periodic bivariate Pearson's analysis was performed on the data of GDP per capita, GHE per capita and IMR in China from 1952 to 2014. The turning point for the effect of GDP per capita on IMR was sought. Then, the average development levels of these three indicators were compared. Finally, the decline characteristics of IMR were analysed. Results showed that, there was no relationship between GDP per capita and IMR from 1952 to 1970 (r=-0.393, p=0.096). GDP per capita and IMR were negatively correlated from 1970 to 2014 (r=-0.827, p=0.000). The stage from 1970 to 1975 was the initial turning point for the effect of GDP per capita on IMR (r=-0.980, p=0.001). From 1980 to 1995, the growth rate of GHE per capita (12.80%) was slower than that of GDP (17.26%), and the average decline rate of IMR was 2.82%. From 1995 to 2014, the average growth rate of GHE per capita (18.25%) was faster than GDP per capita (12.42%), and the average decline rate of IMR was significantly accelerated (7.15%). The negative correlation of GDP per capita and IMR does not always exist. The effect of GHE per capita on IMR is more obvious than that of GDP per capita. It is suggested to build a "surpass-growth and support" mode to reduce the IMR.

Keywords: Infant mortality rate, Gross domestic product, Government health expenditure, Relationship.

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Introduction

Infant Mortality Rate (IMR) is a comprehensive index reflecting the politics, economic, culture, education and health status of a country or region. In the process of building a well-off society in an all-round way, the IMR is an important index to measure the life-off index [1]. The economy is one of the important factors for IMR. In 2000-2009, the Gross Domestic Product (GDP) per capita and the percentage of Government Health Expenditure (GHE) to GDP significantly affect the IMR in 53 African countries [2]. In 2004-2013, the GDP per capita and GHE per capita have a negative correlation with IMR in members of Organization of Petroleum Exporting Countries (OPEC) [3]. A higher GDP per capita in 73 countries with armed conflict is associated with a reduction in IMR [4].

Researches also show that, there is a significant negative correlation between economic growth and IMR in China [5,6]. Have this negative relationship turned from a previous period of the past? Does this negative correlation exist in the future? These issues are still lack of in-depth study. Previous scholars have studied the relationship between rapid economic growth and IMR, and distinguished two successful types of model in reducing IMR. The first is growth-mediated type, which plays a role by high-speed economic growth. The second is support-led type, which plays a role not by high-speed economic growth, but by a well-planned social assistance program. When using China before the reform as the object of study, it is found that the rapid economic growth has not been achieved but the IMR rate has been reduced effectively. This is a typical example of "support-led" [7]. In the past 30 years of reform and opening up in China, what kind of type is suitable for the decline of IMR? This problem should be paid attention. Understanding the turning point of economic growth to the change of IMR has the guiding significance for the development and implementation of effective investment policies in poor areas and underdeveloped areas. Summarizing the successful types of prevention and control experience and exploration of new operating mechanisms will help to further reduce IMR. Based on the data of historical IMR [8-10] and national surveillance of IMR in China [11], this study investigated the relationships among GDP per capita, GHE per capita and IMR in China, and explored the new model to reduce the IMR. The objective was to provide a decision-making reference for benefiting the health of children's investment and support policies.

Materials and Methods

Sources of data

Data of IMR in China in 1952-1990 was derived from the literature [8-10], and those in 1991-2013 was derived from "the statistical yearbook of China, 2014" [11]. The data of GDP per capita in 1952-1977 were from the "Sixty years of statistical data compiled 1949-2008 in new China" [12], and those in 1978-2013 were from "China statistical yearbook 2014" [11]. In 2014, the data of IMR and GDP per capita were derived from "China's economic and social development statistics database" [13]. "China statistical yearbook 2014" only published the annual total health cost (100 million yuan), absolute number of GHE (100 million yuan) and health cost per capita (yuan). The GHE per capita was calculated as follows: GHE per capita=absolute GHE (100 million yuan)/ (total health cost (100 million yuan)/health cost per capita (yuan)) (Tables 1 and 2).

Staging of data

IMR and GDP per capita of 1952-2014 were grouped by different stages according to the time order. The last year of the previous stage was used as the starting point of the next stage. 1952-1955 was the first stage, with 1955-1960 as the second stage, and so on. 63 years were divided into 13 stages. The GHE data in 1952-1977 were lacked, so the grouping started from 1980-1985, and 35 years were divided into 7 stages. According to the staged grouping, the bivariate Pearson's analysis was performed on IMR with GDP per capita, IMR with GHE per capita, and GDP per capita with GHE per capita in each stage, respectively. According to the results of the correlation analysis, the turning point for effect of GDP per capita to IMR was sought.

IMRs in 1, 2, 3... n-1, n year were set as y_1, y_2, y_3... y_{n-1}, y_n, respectively. The average growth rate was calculated as $(y_n-y_1)/(n-1)$, which reflected the number of average annual growth. The average development speed was calculated as $\sqrt[n-1]{y_n/y_1}$, which represented the average development and annual change in a long period. The average growth rate was calculated by average development rate subtracting 1, which represented the average growth and annual change in a long period. The positive value indicated average rate of rise, and the negative value indicated average rate of decline. The average levels of GDP per capita and GHE per capita were calculated as the same as before.

Statistical analysis

IMR, GDP per capita and GHE per capita were calculated in the Excel worksheet. The bivariate Pearson's correlation analysis was performed using the SPSS 17.0 statistical software. $P<0.05$ was considered as statistically significant. If there was statistical significance, the degree of correlation was judged according to the size of $|r|$. $|r| \geq 0.95$, $0.95>|r| \geq 0.8$, $0.8>|r| \geq 0.5$, $0.5>|r| \geq 0.3$ and $|r|<0.3$ presented significant, high, moderate, low and no correlation, respectively.

Results

Correlation among GDP per capita, GHE per capita and IMR

In the 4 stages from 1952 to 1970, there was no correlation between GDP per capita and IMR (r=-0.393, p=0.096). In the 9 stages of 1970-2014, there was negative correlation between GDP per capita and IMR in the 8 stages (1980-1985 was excepted). In 1970-2014, a high degree of negative correlation between GDP per capita and IMR (r=-0.827, p=0.000). In 1980-1985, there was no correlation between GHE per capita and IMR. In 6 stages in 1985-2014, GHE per capita and IMR were significantly or highly negative correlation. In 1985-2014, there was moderate negative correlation (r=-0.795, p=0.000) between them. In 7 stages in 1980-2014, GDP per capita and GHE per capita were significantly positively correlated. In 1978-2014, they had a significantly positive correlation (r=0.997, p=0.000) (Table 3).

Turning point for effect of GDP per capita to decline of IMR

In 1970-1975, GDP per capita and IMR showed a negative correlation for the first time, which was the initial relevant turning period. In 1970-2014, GDP per capita increased by 46353 yuan, and IMR descended by 73.3%. For GDP per capita increase by 100 yuan, the IMR descended by 0.16%. Although in 1985-1990 the negative correlation firstly appeared between GEH per capita and IMR, due to lack of complete and systematic data of GHE per capita, it was difficult to accurately determine whether there was an "initial relevant turning period" before the 1985-1990 stage. In 1985-2014, GDP per capita increased by 763.4 yuan, and IMR descended by 44.75‰. With GDP per capita increasing by 100 yuan, the IMR descended by 5.86‰. When another turning point appeared, at which the relevant relationship of GDP per capita increase with IMR decrease transferred to no correlation, needed to be further dynamically observed.

Comparison of the staged average development indexes

With different stages, IMR generally presented a downward trend. The average decrease was 2.50%, with the average growth rate of 95.41% and the average decline rate of 4.59%. However, in 1955-1965, the IMR fluctuated significantly. In the first 5 years, the average increase of IMR increased significantly. In the following 5 years, it decreased significantly. In other stages, the absolute amount of the average decrease decreased gradually. The GDP per capita showed an upward trend in general. In 1952-2014, the average growth of GDP per capita was 750.16 yuan, with average rate of 110.11% and average growth rate of 10.11%. In 1960-1965, the average growth of GDP per capita showed a downward trend. In each of the following stages, the average growth of GDP per capita showed a rising year by year. The GHE per capita showed an upward trend in general. In 1978-2014, the

average growth of GHE per capita was 21.38 yuan, with average development rate of 115.60% and average growth rate of 15.60%. In each stage, the average increase amount of GHE per capita increased year by year. In 5 of 7 stages, the average growth rate was higher than the GDP per capita. In 1980-1995, the average growth rate of GDP per capita was 17.26%, the average growth rate of GHE per capita was 12.80%, and the decline rate of IMR was 2.82%. In 1995-2014, the average growth rate of GDP per capita was 12.42%, the average growth rate of GHE per capita was 18.25%, and the decline rate of IMR was 7.15% (Table 4 and Figure 1).

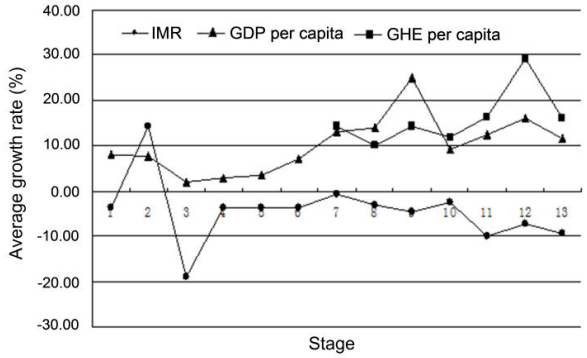

Figure 1. *Change of average growth rate in gross domestic product per capita, government health expenditure per capita and infant mortality rate with different stages.*

Table 1. *Date of IMR (%) and GDP per capita (yuan) in China in 1952-1977.*

Year	IMR	GDP per capita	Year	IMR	GDP per capita
1952	164.1	119	1965	99.6	240
1953	157.9	142	1966	95.8	255
1954	152	144	1967	92.2	236
1955	146.2	150	1968	88.7	223
1956	140.7	166	1969	85.4	244
1957	135.4	168	1970	82.2	276
1958	130.3	200	1971	79.1	290
1959	160	216	1972	76.1	294
1960	284	218	1973	73.2	310
1961	183	185	1974	70.5	311
1962	111.7	173	1975	67.8	329
1963	107.5	181	1976	65.2	318
1964	103.5	208	1977	62.8	341

IMR: Infant Mortality Rate; GDP: Gross Domestic Product.

Table 2. *Date of IMR (%), GDP per capita (yuan) and GHE per capita (yuan) in China in 1978-2014.*

Year	IMR	GDP per capita	GHE per capita	Year	IMR	GDP per capita	GHE per capita
1978	60.4	381	3.7	1997	33.1	6420	42.4
1979	58.1	419	4.2	1998	33.2	6796	47.3
1980	55.9	463	5.3	1999	33.3	7159	51
1981	60.1	492	6	2000	32.2	7858	56
1982	58.5	528	6.8	2001	30	8622	62.7
1983	56.9	583	7.5	2002	29.2	9398	70.7
1984	55.3	695	8.6	2003	25.5	10542	86.4
1985	53.7	858	10.2	2004	21.5	12336	99.5
1986	52.1	963	11.4	2005	19	14185	118.7
1987	50.5	1112	11.6	2006	17.2	16500	135.3
1988	48.9	1366	13.1	2007	15.3	20169	195.4
1989	47.3	1519	14.9	2008	14.9	23708	270.6
1990	45.7	1644	16.4	2009	13.8	25608	360.8
1991	50.2	1893	17.6	2010	13.1	30015	427.5
1992	46.7	2311	19.5	2011	12.1	35198	554
1993	43.6	2998	23	2012	10.3	38459	622.7
1994	39.9	4044	28.5	2013	9.5	41908	701.5
1995	36.4	5046	32	2014	8.9	46629	773.4
1996	36	5846	37.7				

IMR: Infant Mortality Rate; GDP: Gross Domestic Product; GHE: Government Health Expenditure.

Table 3. *Correlation among of IMR, GDP per capita and GHE per capita in China at different stages in 1952-2014.*

Stage	mean value			IMR and GDP per capita		IMR and GHE per capita		GDP per capita and GHE per capita	
	IMR	GDP per capita	GHE per capita	r	p	r	p	r	p
1952-1955	155.05	138.75		-0.908	0.092				
1955-1960	166.1	186.33		0.577	0.231				
1960-1965	148.22	200.83		0.146	0.782				
1965-1970	90.65	245.67		-0.374	0.465				

1970-1975	74.82	301.67		-0.98	0.001*				
1975-1980	61.7	375.17		-0.942	0.005*				
1980-1985	56.73	603.17	7.4	-0.756	0.082	-0.691	0.128	0.986	0.000*
1985-1990	49.7	1243.67	12.93	-0.993	0.000*	-0.98	0.001*	0.977	0.001*
1990-1995	43.75	2989.33	22.83	-0.938	0.006*	-0.936	0.006*	0.998	0.000*
1995-2000	34.03	6520.83	44.4	-0.919	0.010*	-0.907	0.012*	0.996	0.000*
2000-2005	26.23	10490.17	82.33	-0.992	0.000*	-0.993	0.000*	0.997	0.000*
2005-2010	15.55	21697.5	251.38	-0.965	0.002*	-0.928	0.008*	0.984	0.000*
2010-2014	10.78	38441.8	615.82	-0.974	0.005*	-0.98	0.003*	0.996	0.000*

IMR: Infant Mortality Rate; GDP: Gross Domestic Product; GHE: Government Health Expenditure.

Table 4. *Comparison of the average development level in IMR, per capita GDP and per capita GHE in China.*

Stage	IMR			GDP per capita			GHE per capita		
	Average growth	Average development rate	Average growth rate	Average growth	Average development rate	Average growth rate	Average growth	Average development rate	Average growth rate
1952-1955	-5.97	96.22	-3.78	10.33	108.02	8.02			
1955-1960	27.56	114.2	14.2	13.6	107.76	7.76			
1960-1965	-36.88	81.09	-18.91	4.4	101.94	1.94			
1965-1970	-3.48	96.33	-3.77	7.2	102.83	2.83			
1970-1975	-2.88	96.22	-3.78	10.6	103.58	3.58			
1975-1980	-2.38	96.21	-3.79	26.85	107.08	7.08			
1980-1985	-0.44	99.2	-0.8	78.91	113.11	13.11	0.99	114.15	14.15
1985-1990	-1.6	96.82	-3.18	157.33	113.9	13.9	1.24	109.98	9.98
1990-1995	-1.86	95.55	-4.45	680.25	125.14	25.14	3.12	114.3	14.3
1995-2000	-0.84	97.58	-2.42	562.39	109.26	9.26	4.8	111.85	11.85
2000-2005	-2.64	89.99	-10.01	1265.54	112.54	12.54	12.55	116.23	16.23
2005-2010	-1.18	92.83	-7.17	3165.94	116.17	16.17	61.75	129.2	29.2
2010-2014	-1.05	90.79	-9.21	4153.49	111.64	11.64	86.48	115.98	15.98

IMR: Infant Mortality Rate; GDP: Gross Domestic Product; GHE: Government Health Expenditure.

Discussion

Results of this study indicated that, the negative correlation between per capita GDP and IMR did not always exist. During early years of the new nation of China, the IMR was as high as 200%. In 1960-1965, the decline rate of IMR was accelerated after the rebound. The main reason was that, during the three years of natural disasters, the IMR rebounded. After the famine was corrected, the IMR dropped to normal levels. It dropped to 82.2% in 1970. There was no correlation between per capita GDP and IMR in the 4 stages of 1952-1970. This indicated that China had made remarkable achievement in making IMR fallen significantly. Before liberation of China, the people are very destitute. During the early years after liberation, China was still very poor. However, with the gradual stability of the social order, the people's nutrition and health status had been improved after the basic life was gradually guaranteed. The country promoted the popularization of laws on new midwifery, birth control and vaccination, and gradually established a service system of MCH. Particularly, the barefoot doctors were popularized in rural areas, and the IMR decreased rapidly [14]. Foreign research showed that, during the Iraq war, the IMR rebounded [15]. After the end of the war, the IMR rapidly declined. In 1989-2012, the implementation of the peace agreement was linked to the mortality rate of new-borns, infants and children below 5 years old in 73 armed conflict countries in the world. The continued armed conflict led to large-scale migration of population, destruction of the

economic, medical and human infrastructure, which hindered the improvement of children's survival [4].

China's achievements are not only the result of the founding of the new China, but also the implementation of national support policy. In the beginning of the last century, the IMR and economic growth began to show a negative correlation, and the average growth rate of per capita GDP was only 3.58%. The economic growth not only played a role in the decline of infant mortality, but also fully explained the key synergic effect of "support-led" national policy in the same period. With the deepening of reform and opening up and the rapid economic growth, this kind of negative correlation still existed, excepting 1980-1985 years. This was related to the fluctuation of IMR in the late 70s and early 80s, which might be due to the fact that, the children death reporting system had not been established. The IMR after reconstruction and adjustment was still lower than the actual level at that time. Perhaps a decline in IMR was not with a smooth and uniform decline, which was due to an annual fluctuation in the course of the decline in IMR. Whether this role would continue to exist in the future? It is speculated that, when the IMR continued at a low level [16], its cause was a difficult problem to be solved in medical science, and the economic growth would be difficult to play a significant role in the decline of IMR. So this kind of negative relationship would not exist. After entering the initial relevant turning period, the orderly and appropriately increased GHE and timely regulating prevention and control strategies could promote the decline in IMR. Social development, economic growth, material wealth, income growth and improvement of living conditions help to improve the quality of life and health conditions. At the same time, the economic development is the foundation of national health investment. It can promote the progress of medical science, make the health care possible, and create conditions for the prevention and control of the disease and promotion of health. In addition, with the development of the social economy and the popularization of education, the population health and health care awareness have been continuously strengthened. As a result, the economic growth plays an indirect role in the decline of IMR.

Results of this study also showed that, in 1985-2014, the per capita GHE and IMR had a negative correlation. The health investment can be improved the level of health care service and promote the health quality. It also has indirect effect on the IMR. The effect of GDP per capita and GHE per capita on IMR can exist independently, and also can synergistically exist. The results showed that, after entering the initial relevant turning period, when the GHE per capita increased with 100 yuan, the effect of GHE per capita on IMR was significantly higher than that of GDP per capita. When the average growth speed of GHE per capita was faster than the average GDP per capita, the decline of IMR was significantly accelerated. This indicated that, the effect of GHE per capita on IMR was more significant and more direct than that of GDP per capita. 1990-1995 years were the fastest growing stage for GDP per capita growth. At this time, the average growth rate of GHE per capita was lower than the GDP per capita, and the phenomenon of the fastest decline of IMR did not appear in the same period. This showed that, the impact of economic growth on IMR had a certain lag. In 2000-2005, the decline rate of IMR increased once again. This might be caused by the lag of economic growth, and might be related to that the growth rate of GHE per capita was higher than that of GDP per capita. The "growth priming" effect of economic factors can affect the IMR. If the economic growth is not significant, the government should increase investment in health, which can also affect the IMR. In fact, this is also the result of national policy (support-led).

In the early ten years of reform and opening up, the prototype of the framework system of maternal and child health policy in China was established. In 1990s, the policy of maternal and child health was fully improved. Since 21st century, the policy of maternal and child health developed to the equalization of the direction of the people. In following 30 years, this policy transferred from the prevention and treatment of disease to the improvement of the quality of life. The "support-led" is the government's active function. Once the "support-led" effect is lost, and the measure of prevention and control to infant mortality carry out unsuccessfully, the IMR world not decline or even rebound. The "growth-mediated" has the amplification effect on economic growth, and the effect on IMR is indirect and passive. The only way to change the passive to active role is to increase the health investment. Columbia government actualizes the fiscal decentralization, decentralizes the health care spending, and improves the medical insurance system, which has reduced the IMR [17]. Uganda government implements a path of decentralization, and increases the supply of public goods such as health services, which has promoted the decline in infant IMR [18].

Under the situation of social progress and sustainable economic growth, outstripping economic growth results, expanding maternal and child health investment, strengthening the national policy support, implementing the integrated project to reduce the mortality rate, and setting up a the operating mechanism of "surpass-growth and support" will benefit children's health of live and quality of life. In 1952-1970, there was no correlation between per capita GDP and IMR. The decline of IMR was the result of "Support-led". In 1980-1995, the growth rate of per capita GHE was lower than the growth rate of per capita GDP. The decline of IMR was the result of the synergy between "Support-led" and "growth-mediated". In 1995-2014, per capita GDP showed a negative correlation with IMR. Average growth rate of per capita GHE was faster than the average growth rate of per capita GDP. So the decline of IMR was the result of "surpass-growth and support". The main purpose of analysing the successful types of the IMR decline was to summarize the successful experience, establish the active mechanism, construct the new mode of "surpass-growth and support" to reduce the IMR, and shorten the process of the decline in IMR.

The "surpass-growth and support" is the inevitable requirement of the new model. On the one hand, it is required to closely link to the national development strategy, change the mode of economic growth, cultivate new economic growth point, and

explore the sustainable development mode to promote a healthy economic growth. On the other hand, it should be based on the benefit of the people's livelihood, and it is required to increase the health investment, maintain the health investment growth rate. The health work should be vigorously implemented, and the effectiveness of the protection of people's health should be fully developed.

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