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Infant mortality and life expectancy in China

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Background: It is reported that the infant mortality (IM) rate decreased rapidly in China and the life expectancy (LE) also had a high increase. Our objective was to determine the health status of the Chinese population by investigating IM and LE and their inter-relationship.

Material/Methods: Based on a literature review on the history and current status of IM and LE in China and other major countries, the relationship between IM, LE, and per capita gross national income (GNI) was investigated in 2013.

Results: The decline in IM from 30% to 15% took China only 7 years, which was faster than in developed countries. The leading causes of infant death in China were perinatal diseases, infectious and parasitic diseases, congenital anomalies, accidents, and signs, symptoms, and ill-defined conditions. Most under-5 mortality occurred during infancy (80%), particularly during the neonatal period (55%). LE was negatively correlated with IM ($r=-0.921$, $P<0.001$) and per capita GNI ($r=0.778$, $P<0.001$), while IM was negatively correlated with per capita GNI ($r=-0.735$, $P<0.001$). However, healthcare capabilities and per capita GNI in China are still below the level of developing countries. Some countries have a comparable IM and healthcare capabilities, but they have a much higher per capita GNI than China.

Conclusions: In China, IM has decreased and IE increased rapidly. However, they were not in parallel with the current economic development. Deviation of these data might be attributed to many factors. In-house surveys and hospital-based follow-ups should be carried out to better understand infant death.

MeSH Keywords: **Life Expectancy • Infant Mortality • Social Class • Gross Domestic Product**

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Background

Infant mortality (IM), an internationally recognized indicator for assessing socioeconomic status and population health, reflects the overall conditions of health care, education, and economic development in a specific region. Life expectancy (LE) provides an estimate of the average expected life-span under certain conditions based on the current mortality [1]. LE is useful in assessing health status, socioeconomic development, and quality of life in a specific population. Many studies have shown that IM is an independent and significant determinant of LE, although many other factors, such as accuracy of the data, life habits and customs, religion, and infectious disease, may affect the actual situation.

China is a developing country with a dramatic socioeconomic development since the reforms in 1980s. Much effort has been made to monitor and reduce the mortality of mothers, neonates, and children younger than 5 years in the whole country. The Chinese government was actively involved in the MDGs project [2]. Meanwhile, a series of laws and regulations aiming to improve maternal and child health were legislated, including the *Maternal and Infant Health Care Law of the PRC* in 1994 [3]. However, there have been rare reports about the accuracy of LE, and the relationship between IM and LE in China. Therefore, the current study aimed to investigate the relationship between IM and LE, and to evaluate the health status of the Chinese population.

Material and Methods

Data sources

LE, IM, and per capita gross national income (GNI) in major regions/countries were based on the World Health Statistics 2013 released by the World Health Organization (WHO). Data concerning per capita GNI were obtained from *The World Economy: A Millennial Perspective* [4] and the Center for China Study of Tsinghua University [5]. Data concerning IM in China were based on the *Data & Statistics of Maternal and Child Health Service in China* [6], and those concerning LE were from the *China Statistical Yearbook* in the past decades [7].

Methods and statistical analysis

All the data were analyzed using the SPSS-13 database program. Correlations among IM, LE, and per capita GNI were calculated using bivariate correlation analysis. Two-tailed significance tests were reported, with statistical significance set at $P < 0.05$.

Table 1. IM and LE in different regions of the world.

	IM (‰)	LE (years)
African Region	68	56
Eastern Mediterranean Region	44	68
South-East Asia Region	42	67
Western Pacific Region	13	76
Region of the Americas	13	76
European Region	11	76
China	13	76
Global	37	70

* Data taken from the World Health Statistics, 2013 [1].
IM – infant mortality; LE – life expectancy.

Figure 1. The time spent in different countries for the infant mortality to decrease from 30‰ to 15‰. (Data taken from the website of the World Health Organization [8]).

Results

IM and LE in China and other countries

The IM continuously decreased and LE steadily escalated in China in the past decades [4]. IM and LE were closely correlated worldwide. For example, the IM was relatively higher and the LE was lower in the African and South-East Asian regions than in the other regions. In contrast, a low IM and relatively high LE were observed in the developed European countries (Table 1).

IM and leading causes of infant death

The decline in IM from 30‰ to 15‰ took China only 7 years, but it took the United States 24 years, the United Kingdom 26 years, and France 15 years (Figure 1) [8]. Brazil has a similar LE and IM to China. It also took Brazil 11 years to achieve a

Table 2. The main causes of infant death in major countries.

	First	Second	Third	Fourth	Fifth
China	Certain conditions originating in the perinatal period	Infectious and parasitic diseases	Congenital anomalies	Accidents	Signs, symptoms and ill-defined conditions
U.S.	Certain conditions originating in the perinatal period	Congenital anomalies	Signs, symptoms and ill-defined conditions	Accidents	Diseases of the respiratory system
Germany	Certain conditions originating in the perinatal period	Congenital anomalies	Signs, symptoms and ill-defined conditions	Diseases of the nervous system	Accidents
France	Certain conditions originating in the perinatal period	Congenital anomalies	Signs, symptoms and ill-defined conditions	Diseases of the nervous system	Infectious and parasitic diseases
Britain	Certain conditions originating in the perinatal period	Congenital anomalies	Signs, symptoms and ill-defined conditions	Diseases of the nervous system	Diseases of the respiratory system
Japan	Congenital anomalies	Certain conditions originating in the perinatal period	Signs, symptoms and ill-defined conditions	Accidents	Diseases of the respiratory system
Brazil	Certain conditions originating in the perinatal period	Congenital anomalies	Infectious and parasitic diseases	Signs, symptoms and ill-defined conditions	Diseases of the respiratory system
South Africa	Certain conditions originating in the perinatal period	Infectious and parasitic diseases	Congenital anomalies	Nutritional deficiencies	Signs, symptoms and ill-defined conditions

* Data taken from the website of the World Health Organization [9].

decline in IM from 30% to 17%, although Brazil has a per capita GNI that is 3030 USD higher than that of China.

The leading causes of infant death in different countries were similar, although the order varied slightly, including certain conditions originating in the perinatal period, congenital anomalies, and signs, symptoms and ill-defined conditions. Accidents and infectious and parasitic diseases were also major causes in several countries. The primary cause of infant death in China was perinatal diseases, including birth asphyxia, birth trauma, and sudden infant death syndrome. The second cause was infectious and parasitic diseases, followed by congenital anomalies, accidents, and signs, symptoms, and ill-defined conditions (Table 2) [9].

Health care use prior to death among Chinese children

In China, most under-5 mortality (U5M) occurred during infancy (80%), particularly during the neonatal period (55%) [3]. From 2000 to 2012, nearly 40% of U5M occurred at home or on the way to hospital. Although the diagnosis rate and inpatient treatment rate increased during the last 10 years, 7.4% of the deaths were undiagnosed, and 13.4% had never been treated in a healthcare setting in 2012, as shown in Table 3.

Correlations of IM/LE with economy and health in major countries

By analyzing the LE with economy and health in major countries, we found that developed countries (e.g., the United States, Germany, and Japan) with a mature healthcare system usually had a higher LE than the developing countries with relatively poor healthcare services. Moreover, LE was negatively correlated with IM ($r=-0.921$, $P<0.001$) and per capita GNI ($r=0.778$, $P<0.001$), while IM was negatively correlated with per capita GNI ($r=-0.735$, $P<0.001$). It was notable that Brazil had comparable IM and healthcare capabilities to China, whereas its per capita GNI was 1.5 times that in China, as shown in Table 4.

It took the United States and Germany 150 years, the United Kingdom and France 140 years, Japan 70 years, and China 50 years to achieve an increase in LE from 40 years to 70 years (Table 5). In 2011, the LE in China reached 76 years, although the economic level of China was still far behind that in developed countries. According to World Health Statistics (2013), the GNI per capita based on purchasing power parity (PPP) was 48820 USD in the United States (LE: 79 years), 36010 USD in the United Kingdom (LE: 80 years), and 11420 USD in Brazil

Table 3. Characteristics of children who died under 5 years in China (%).

		2000	2002	2004	2006	2008	2010	2012
Death place	In hospital	52.1	53.9	56.9	61.2	64.1	63.7	59.1
	On the way to hospital	3.3	3.8	4.8	5.0	6.2	6.4	9.3
	At home	44.6	42.3	38.3	33.8	29.7	29.9	31.6
Diagnosis level	Provincial	31.7	33.5	37.9	41.5	51.1	41.3	48.3
	County	23.9	28.6	29.3	32.6	30.3	38.7	34.5
	Township	12.2	11.0	11.5	10.5	7.5	9.8	7.6
	Village	19.2	14.9	12.8	6.8	4.4	3.1	2.2
	Undiagnosed	13.0	12.0	8.5	8.6	6.7	7.1	7.4
Treatment	Inpatient	56.4	59.4	64.6	69.1	73.4	75.4	73.8
	Outpatient	26.7	24.4	19.3	16.4	13.3	13.0	12.8
	Untreated	16.9	16.2	16.1	14.5	13.3	11.6	13.4

* Data taken from the Data & Statistics of Maternal and Child Health Service in China, 2000–2012 [3].

Table 4. LE, IM, per capita GNI and health service capacity in different countries.

	LE (year)			IM (‰)			GNI per capita (PPP int. \$)			Physician (/10000)	Nursing and midwifery (/10000)	Hospital beds (/10000)
	1990	2000	2011	1990	2000	2011	1990	2000	2011			
U.S.	75	77	79	10	7	6	22850	35690	48820	24.2	98.2	30
Germany	75	78	81	7	4	3	18590	25700	40230	36.9	113.8	82
France	77	79	82	7	4	3	17320	25680	35910	33.8	93.0	66
Britain	76	78	80	8	6	4	16040	26020	36010	27.7	94.7	30
Japan	79	81	83	5	3	2	19160	25950	35330	21.4	41.4	137
Korea	72	76	81	8	6	4	8180	17130	30370	20.2	52.9	103
Brazil	67	70	74	46	28	14	5050	6830	11420	17.6	64.2	23
South Africa	63	56	58	48	54	35	5540	6610	10710	7.6	40.8	28
India	57	61	65	84	68	47	890	1560	3590	6.5	10.0	9
China	68	71	76	37	30	13	800	2340	8390	14.6	15.1	39

* Data taken from the World Health Statistics, 2013 [1]. IM – infant mortality; LE – life expectancy; GNI – gross national income.

(LE: 74 years). China had a PPP GNI of only 8390 USD, but the LE reached 76 years. The per capita GNI was only one-fifth to half of that in the other countries when China increased its LE of 70 years (Figure 2).

Discussion

It took a long time for LE to reach the current level. Historically, the average LE was only approximately 20 years in Europe before Christ. After slow and continuous growth, the average LE was only 46.5 years in the early 1950s worldwide [10]. Thus, it took nearly 2 millennia for the global LE to double. Such an

extremely slow growth is related to the slow development of productivity in the ancient world. The 19th century is a hinge point. It witnessed the Industrial Revolution, the liberation of social productive forces, and a rapid increase in average LE. The global LE reached 59.8 years at the end of the 1970s and then 65.4 years in the early years of this century. One of the greatest achievements in the 20th century was the remarkable improvement in population health worldwide, especially the dramatic increase in LE and the substantial decrease in IM. It has been accepted that IM has a major effect on LE. LE at 0 years old has the closest relationship with IM. Many studies have shown the association of LE with healthcare and economic development and consistently concluded that IM directly affects

Table 5. Development of LE in major countries.

	1820	1900	1950	1960	1970	1980	1999	2009
China	–	24	41	36.32	61.74	66.84	71	73.47
U.S.	39	47	68	69.77	70.81	73.66	77	78.11
Germany	41	47	67	69.54	70.46	72.63	77	79.26
France	37	47	65	70.24	72.01	74.18	78	80.98
Britain	40	50	–	70.76	71.67	73.78	77	79.01
Japan	34	44	61	67.67	71.95	76.09	81	82.12
India	21	24	32	44.33	49.37	54.18	60	69.89

* Data taken from the *World Economy: A Millennial Perspective* [2] and the Center for China study of Tsinghua University [5].

Figure 2. The per capita GNI (International dollar 1990) at LE of 40 and 70 in different countries. (Data taken from the *World Economy: A Millennial Perspective* [2] and the Center for China study of Tsinghua University [5]).

LE [11–15], and that LE is closely associated with economic development [16–18]. It has also been reported that LE was affected by various factors, including socioeconomic status, education, and even maternal mortality rate [19–21]. Similarly, the current study found that, globally, the increase in LE from 1990 to 2011 was inversely correlated with the decline in IM and positively correlated with the increase in per capita GNI.

Our study found that LE increased much faster in China than in Western countries. It took only 50 years for China to raise its LE from 40 years to 70 years, in comparison to a century in Western countries. Besides, when the LE reached 76 years in 2011, China had a PPP GNI of only 8390 USD, which was significantly lower than that in other countries. It seems surprising that a country with a less advanced economy and health-care system achieved such an LE. The rapid progress of LE in China might be attributed to the fact that the Chinese government has always promoted maternal and children health-care by the active implementation of policies including family

planning, immunization, and nutritional support. However, the LE in China may be disproportionately high due to the following reasons.

First, the definition of IM in China is not exactly the same as the internationally recognized definition. In China, “live birth” involves gestational age at least 28 weeks, with at least 1 of 4 vital signs (breathing, heartbeat, umbilical pulse, and voluntary muscle contraction). Therefore, all infants born before 28 weeks of gestation are not included in counting IM. In contrast, the United Nations (UN) definition of live birth has no gestational age-specific thresholds. All fetuses with 4 vital signs are included in counting IM. In addition, during the quality control monitoring of infant mortality, we found that some preterm infants who died after birth, but had 1 of the 4 vital signs, were often categorized as “fetal death” or “still birth”.

Second, under-reporting of infant death cases in health care facilities results from limited willingness or capacity to trace high-risk infants, critically ill infants, and/or self-discharged patients, especially among the “floating” or nonresident populations. The lack of data on final outcomes will ultimately cause under-reporting of infant death. According to the China Statistical Yearbook 2013, the hospital delivery rate in China was 99.2%, and the number of non-hospitalized births reached 130000 among the 16 million infants born. The ultimate outcome of infants born outside of a hospital is extremely difficult to trace, and the deaths of infants born at home are often not recorded. Moreover, China also has a large floating population, making infant death statistics even more complicated and difficult to obtain. The death of babies born in floating populations often lacks proper supervision or administration, and is therefore rarely included. China is also frequently affected by natural disasters. For example, more than 80000 people were killed or reported missing during the 2008 Sichuan earthquake. According to the percentage (5.13%) of children under age 5 years among the total population in China in 2008,

approximately 4000 children died or went missed during this disaster. However, even after such a major natural disaster, the IM and U5M rate were reported to be 12.6% and 20.1%,⁶ respectively, which were even lower than those in 2007.

Third, the “abandoned baby” remains a public concern in China. According to statistics, there are 570000 abandoned babies in China, among whom 470000 are in rural areas. The abandonment of baby girls, who account for 99% of the abandoned babies, is a particularly pressing issue [22]. The deaths of these abandoned babies are usually difficult to determine by monitoring systems.

Fourth, the gap between China and developed countries in healthcare delivery can indirectly reflect the level of healthcare for infants in China. China differs from developed countries in terms of the number of physicians, nursing and midwifery personnel, and hospital beds per 10000 people. On the other hand, some developing countries (e.g., Brazil) have higher economic levels and comparable IM and healthcare capabilities, but they have a lower LE compared with China. Etiological studies have also shown that infectious and parasitic diseases are the leading causes of infant death in China. It was similar to that in Brazil and South Africa, but the infectious diseases were less common as the leading cause of death in developed countries (except in France). Essential healthcare services are still provided at low levels to Chinese children. The current study found that approximately one-third of IM occurred at home or on the way to hospital, whereas 7.4% and 13.4% of these dead children had never been diagnosed and treated, respectively.

Fifth, governments at all levels have adopted IM and U5M rates as key performance indicators for maternal and child healthcare. As a result, similar to economic growth, many local officials always hope that IM will decrease and LE will increase annually. In such an environment, LE is not only an indicator for population health, but also a target of government operations.

References:

1. World Health Statistics 2011. Geneva. World Health Organization, 2013
2. Bhutta ZA, Chopra M, Axelson H et al: Countdown to 2015 decade report (2000–10): taking stock of maternal, newborn, and child survival. *Lancet*, 2010; 375(9730): 2032–44
3. Maternal and Infant Health Care Law of the PRC. www.moh.gov.cn/public-files/business/htmlfiles/mohzcfgs/s3576/200804/17584.htm
4. Maddison A: The world economy: A millennial perspective. Paris: OECD, 2001
5. Hu AG: From the sick man to the giant of the East: The road of healthy development in China (1949–2020). Beijing: Center for China study, Tsinghua University, 2010
6. Data & Statistics of Maternal and Child Health Service in China. The Minister of Health of the PRC, 2000–2012
7. China Statistical Yearbook. The National Bureau of Statistics of the PRC, 1981–2013

Many government authorities have goals to raise LE, which causes great stress among primary staff. Intentionally or unintentionally, they lower the age-specific mortality rates and neglect the under-reporting and even concealment of infant deaths, in an attempt to achieve the continuous growth of LE.

Finally, access to information on infant death in China is mainly based on a manual search. There is no nationwide information reporting system that connects the birth registration systems as well as all the obstetric departments, hospitals, and communities. Therefore, a more sophisticated effort including in-house surveys and hospital-based follow-ups should be carried out to understand infant death in China, during which a good partnership with the related institutions is critical. However, the majority of Chinese hospitals spend most of their time in seeking profit via their daily business. Usually these hospitals lack sufficient interest in the above-mentioned activities because they are not profitable. Therefore, it is even more difficult to obtain accurate infant mortality statistics.

Conclusions

With the socioeconomic development in China, IM has decreased and LE increased rapidly. However, they are not in parallel with the current economic development and the deviation of these data might be attributed to many factors. In-house surveys and hospital-based follow-ups should be carried out to better understand infant death in China.

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8. World Health Organization. www.childmortality.org
9. World Health Organization. apps.who.int/whosis/database/mort/table2.cfm
10. Ren Q: Trajectory of changes in human life expectancy in the world since 1950s. *Population Research*, 2007; 31(5): 75–81 [in Chinese]
11. Ye Y, Dong SF: An analysis on the life expectancy and mortality levels in Wuhan, China. *Chin J Health Stat*, 2003; 20(6): 363–65 [in Chinese]
12. Research Group for the Demography Characters. Life Expectancy and its Influence Factors of Henan Province. *J Henan Institute. Edu (Philoso Soc Sci)*, 2007; 26(2): 30–36 [in Chinese]
13. Qiu H, Zhou JJ, Zhang JH, Wu Y: An analysis on the average life expectancy of residents in the recent 50 years Huangpu district, Shanghai. *Shanghai JP Med*, 2008; 20(6): 269–71 [in Chinese]
14. Yang S, Khang YH, Harper S et al: Understanding the rapid increase in life expectancy in South Korea. *Am J Public Health*, 2010; 100(5): 896–903

15. Harper S, Lynch J, Burris S, Smith GD: Trends in the black-white life expectancy gap in the United States, 1983–2003. *JAMA*, 2007; 297(11): 1224–32
16. Suhrcke M, McKee M, Stuckier D et al: The contribution of health to the economy in the European Union. *Public Health*, 2006; 120(11): 994–1001
17. Tang Z, Kaneda T, Xiang MJ et al: Life and active life expectancy of elderly people with different socioeconomic status in Beijing. *Chin J Clin Rehabil*, 2004; 8(30): 6569–71 [in Chinese]
18. Castelló-Climent A, Doménech R: Human capital inequality, life expectancy and economic growth. *J Econ*, 2008; 118(528): 653–77
19. Cherkas LF, Aviv A, Valdes AM: The effects of social status on biological aging as measured by white-blood -cell telomere length. *Aging Cell*, 2006; 5(5): 361–65
20. Meara ER, Richards S, Cutler DM: The gap gets bigger: Changes in mortality and life expectancy, by education, 1981–2000. *Health Aff (Millwood)*, 2008; 27(2): 350–60
21. Jayachandran S, Lleras-Muney A: Life expectancy and human capital investments: Evidence from maternal mortality declines. *QJ Econ*, 2009; 124(1): 349–97
22. Qu WY, Wu HH: An analysis on the reason of abandoning infants and the countermeasure. *J Chongqing Univ Sci Technol (Soc Sci Edition)*, 2010; 19: 76–78 [in Chinese]