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What is the major driver of China's hospital medical expenditure growth? A decomposing analysis

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ABSTRACT

Objectives: To quantify increases in the medical expenditures of public hospitals associated with changes in service use and prices, which could inform policy efforts to curb the future growth of hospital medical expenditures.

Design: Nationwide and provincial data on service volume, service price and intensity of public hospitals' outpatient and inpatient services from 2008 to 2018 were extracted from the China Health Statistical Yearbooks, and population size data were obtained from the 2019 China Statistical Yearbook.

Methods: Decomposition analysis was performed to measure the relative effects of changes in service use (volume or utilization rate) and service price and intensity on the increase in the inpatient and outpatient total and average (per capita) medical expenditures of public hospitals from 2008 through 2018.

Results: After adjustments for price inflation, the total and average medical expenditure of public hospitals increased approximately 3-fold from 2008 to 2018. Over this period, the increase in service volume was associated with 67.4% of the observed increase in total medical expenditures in the inpatient sector and with 57.2% of the observed increase in total medical expenditures in the outpatient sector; the growth in utilization rate was associated with 66.3% of the observed

growth in average medical expenditures in the inpatient sector and with 55.2% of the observed growth in average medical expenditures in the outpatient sector.

Conclusion: Service use, rather than price, appears to be the major driver of increases in medical expenditures in Chinese hospital. These results will inform medical cost containment policies in both China and other countries.

Strengths and limitations of this study

- This is the first paper using the decomposing method to explore the associations of service use, service price and intensity with increases in public hospitals' total and average medical expenditures in the first decade of the new round of health system reform in China.
- This study traced sources of the growth in medical costs for outpatient and inpatient care in public hospitals.
- Nationwide and provincial data were used, which could provide crucial evidence for local decision makers.
- Due to the lack of a price index specific to the health sector in China, this study cannot distinguish between the contributions of service price and service intensity.
- This study did not consider changes in types of conditions prompting people to visit the hospitals and the aging of the population.

INTRODUCTION

Medical cost escalation is a major problem in both developed and developing countries, including China.[1],[2] What is the major driver of medical cost growth? Some existing literature directly explores US health spending drivers by decomposing growth in health spending into its constituent parts, which focus on 2 or more factors, including population growth, population ageing, disease prevalence, utilization, cost of care, and technology. No consensus has been reached on the factors driving increased US healthcare spending. [3],[4],[5]

Studies decomposing growth in China's health expenditure since the 1990s have also obtained different results. Zhai et al.'s study, using data from China's National Health Accounts studies and Global Burden of Disease 2013 studies, decomposed the changes in health expenditures by disease into population growth, population ageing, disease prevalence rate, expenditure per case of disease, and excess health price inflation. It found that 72.6% of the increases in China's health expenditure between 1993 and 2012 was caused by the growth in health expenditure per prevalent case.[6] A recent study by Yip et al., using the China National Health Accounts data, decomposed the growth in health spending by healthcare type into increase in visit volume and increase in charges per visit or admission. The study showed that the increase in visit volume accounted for approximately 70% of the increase in total health spending in China

between 2008 and 2017, and increases in charges per visit or admission accounted for approximately 30% of the increase.[7] These studies examined drivers of health expenditure growth from different perspectives (cost of disease and healthcare) in different periods of time since the 1990s.

As the main body of China's health service delivery system, public hospitals accounted for 93.2% of hospital inpatient admissions and 92.6% of hospital ambulatory visits in 2008; the corresponding values dropped to 81.8% and 85.3% in 2018.[8] Public hospital medical expenditures accounted for approximately half of the total health expenditures in 2018.[8, 9] Cost containment in public hospitals is a key focus of China's new round of health system reform since 2009. [7],[10] Public hospital reforms were launched in 2012, including altering provider payment, eliminating drug mark-up, and adjusting fee schedules. Previous studies took an indirect approach, using regression methods to examine the respective impacts of these reforms on drug expenditures and total or per visit medical expenditures.[11-17] These studies found that such reforms reduced drug expenditures, but not overall medical expenditures.[17]

Our study focuses on growth in total and average medical expenditure of public hospitals. We take a direct approach to decompose growth into its constituent factors, including changes in service use and changes in service price and intensity. To our knowledge, this is the first paper

to use the decomposing method to explore the associations of service use, service price and intensity with increases in total and average medical expenditures for public hospitals based on nationwide and provincial data during the first decade of the new round of health system reform in China. These results will inform cost containment policies in China and other countries that experience soaring health expenditures.

STUDY DATA AND METHODS

Data source and variable definitions

We extracted eleven years of nationwide data and eight years of provincial data from the China Health Statistical Yearbooks in 2009-2019 published by the National Health Commission. We obtained aggregative information on medical expenditures per visit or per admission discharged, and service volumes of public hospital outpatient and inpatient care for each year.[8] In this paper, we use public hospital medical revenue variables as expenditure indicators. According to the interpretation of the indicators in the China Health Statistics Yearbook and previous studies[17], hospital medical expenditures in this study fall into three categories: medical services, drugs, and diagnostic examinations/medical consumables. All expenditure variables in this study were adjusted for inflation using the economy-wide consumer price index of China from the International Monetary Fund and were reported

in Chinese yuan in 2018 prices.[18] Nationwide and provincial population size data were obtained from the 2019 China Statistical Yearbook.

Table 1 provides definitions of variables used in this study. For outpatient care, service volume was the annual volume of visits to public hospitals, and utilization was the portion of population that received public hospital outpatient care, while price and intensity were the mean expenditure per visit. For inpatient care, service volume was the annual volume of admissions discharged from public hospitals, and utilization was the portion of population that received public hospital inpatient care, while price and intensity were the mean expenditure per admission discharged.

Table 1 Definitions for service volume, utilization, price and intensity, by type of care

Care type	Service volume (A)	Service utilization (B)	Price and intensity (C)
Outpatient	Annual volume of visits to public hospitals in outpatient and emergency departments	Annual visits per capita; that is the portion of the population that received public hospital outpatient and emergency care	Medical expenditure per visit
Inpatient	Annual volume of admissions discharged from public hospitals	Annual admissions per capita, that is, the portion of the population that received public hospital inpatient care	Medical expenditure per admission discharged

Decomposition methods

The total medical expenditure of public hospitals is the product of two factors: (1) service volume and (2) price and intensity, as shown in the following equation:

$$TME_y = V_y \times P_y,$$

where y indicates year; TME_y is total medical expenditure; V_y is service volume; and P_y is service price and intensity.

To measure the relative effect of each factor, we used the decomposition method described by Das Gupta[19]. This decomposition was based on the equation above to calculate standardized rates for each factor and then calculate their additive contributions to annual changes in hospital outpatient or inpatient total medical expenditures from 2008 to 2018. (For a more detailed description of the decomposing method, see online appendix exhibit 1).

Given that service volume is the number of people that receive inpatient or outpatient care in public hospitals, its effect on growth in real total medical expenditures reflects both the effects of population growth and the changing portion of people using care. After adjusting for population growth, we used the decomposition method to measure the relative effect of service utilization (portion of population using care) and price and cost per case on the growth in average real medical expenditure (per capita).

RESULTS

Both the inpatient and outpatient real total medical expenditures of public hospitals increased annually from 2008 to 2018 (Table 2).In 2018, the inpatient real total medical expenditure increased 3.6 fold, and the outpatient real total medical expenditure increased 2.9 fold compared with 2008 costs. The growth rates of inpatient and outpatient real total medical expenditures showed downward trends. Inpatient and outpatient real total medical expenditure increased at average annual rates of 18.2% and 14.4%, respectively, between 2008 and 2013, and dropped to 9.1% and 8.3% between 2013 and 2018. The average annual growth rates of hospital service volume and service price and intensity also displayed downward trends, while the average annual growth rate of hospital service volume outpaced that of service price and intensity in the same period. Similar trends occurred after adjusting for population growth. (For more detailed data on average medical expenditures and service utilization for inpatient and outpatient care, see online appendix exhibit 2).

Table 2 Medical expenditures and service volumes for public hospital inpatient and outpatient care in China (2008-18)

	Inpatient			Outpatient		
	Real total medical exp. (billion yuan)	Exp. per admission (yuan)	Admissions[1] (million)	Real total medical exp. (billion yuan)	Exp. per visit (yuan)	Visits (million)
2008	456.8	6678.7	68.4	285.0	172.8	1649.1
2009	571.2	7344.5	77.8	338.3	191.3	1768.9
2010	676.2	7789.8	86.8	380.6	203.1	1873.8
2011	770.4	7960.4	96.8	426.1	207.6	2052.5
2012	930.6	8224.8	113.1	497.0	217.2	2288.7
2013	1054.3	8600.1	122.6	558.6	227.5	2455.1
2014	1190.1	8894.5	133.8	629.4	237.7	2647.4
2015	1278.5	9345.6	136.8	675.0	248.8	2712.4
2016	1406.1	9573.9	146.9	728.1	255.7	2847.7
2017	1517.6	9764.2	155.4	774.9	262.5	2952.0
2018	1629.1	9976.4	163.3	830.5	272.2	3051.2
Annual growth rates (%)						
2008-13	18.2	5.2	12.4	14.4	5.6	8.3
2013-18	9.1	3.0	5.9	8.3	3.7	4.4

NOTES Expenditures per admission discharged or per visit, admission or visit volume data were extracted from the China Health Statistical Yearbooks in 2009-2019. Total medical expenditure represents the authors' analysis of data based on the above equation. [1]Numbers of inpatients who were discharged from public hospitals.

Figure 1 tracks a 1172.3 billion yuan and a 545.5 billion yuan increase in inpatient and outpatient real total medical expenditures, respectively, for public hospitals from 2008 through 2018. (The exchange rate in 2018 was 6.6 Chinese yuan to one US dollar.) From 2008 to 2018, the increase in admission volume was associated with a 67.4 % (790.3

billion yuan) of the observed increase in inpatient real total medical expenditure, while the change in price and intensity was associated with the remaining 32.6% (382.0 billion yuan). The increase in visit volume was associated with a 57.2% (312.0 billion yuan) of the observed increase in outpatient real total medical expenditure, while the change in service price and intensity was associated with the remaining 42.8% (233.5 billion yuan).

Figure 2 shows that the real average medical expenditure (per capita) on inpatient care rose by 823.5 yuan from 2008 to 2018, from 343.9 yuan in 2008 to 1167.5 yuan in 2018. The contribution of growth in service utilization (more admissions discharged per capita) to the growth in real average medical expenditure on inpatient care was 66.3% (545.7 yuan of the 823.5 yuan increase), while the increase in price and intensity was associated with the remaining 33.7% (277.9 yuan of the 823.5 yuan) increase. The real average medical expenditure on outpatient care increased by 380.6 yuan between 2008 and 2018, from 214.6 yuan in 2008 to 595.2 yuan in 2018. Rising service utilization contributed to 55.2% of the growth in real average medical expenditure on outpatient care, compared to rising price and intensity, which contributed 44.8%.

For public hospitals' inpatient and outpatient care in 31 provinces, autonomous regions and municipalities of mainland China, growth in service volume contributed more than growth in service price and

intensity to the growth in real total medical expenditures in public hospital inpatient and outpatient care for most provinces from 2011 to 2018 (Table 3a). For inpatient care, the growth in service volume contributed more than the growth in service price and intensity to the growth in real total medical expenditures for all provinces except Tibet. For example, growth in service volume was associated with 87.3% of the observed growth in real total medical expenditure in the inpatient sector in Zhejiang province (38.2 billion yuan of the 43.8 billion yuan increase). For outpatient care, growth in service volume contributed more to growth in public hospital outpatient real total medical expenditures for most provinces (23 of the 31 provinces). Trends were similar in the decompositions of real average medical expenditures for public hospitals' inpatient and outpatient care in 31 provinces, autonomous regions and municipalities (Table 3b).

Table 3a Decompositions of total medical expenditures for public hospitals' inpatient and outpatient care in 31 provinces, autonomous regions and municipalities of mainland China during 2011-2018

Province	Inpatient		Outpatient	
	service volume	Price and intensity	service volume	price and intensity
All	69.5	30.5	59.2	40.8
Beijing	77.7	22.3	51.5	48.5
Tianjin	70.0	30.0	*47.7*	*52.3*
Hebei	56.7	43.3	67.2	32.8
Shanxi	62.4	37.6	60.8	39.2
Inner Mongolia	78.5	21.5	66.5	33.5
Liaoning	65.9	34.1	*48.3*	*51.7*
Jilin	54.8	45.2	*45.2*	*54.8*
Heilongjiang	72.2	27.8	54.7	45.3
Shanghai	74.5	25.5	58.2	41.8
Jiangsu	77.7	22.3	60.5	39.5
Zhejiang	87.3	12.7	70.6	29.4
Anhui	76.1	23.9	65.3	34.7
Fujian	56.9	43.1	*45.0*	*55.0*
Jiangxi	59.6	40.4	*46.1*	*53.9*
Shandong	62.6	37.4	68.1	31.9
Henan	59.8	40.2	59.0	41.0
Hubei	67.4	32.6	70.4	29.6
Hunan	66.2	33.8	61.5	38.5
Guangdong	65.1	34.9	36.0	64.0
Guangxi	63.8	36.2	58.1	41.9
Hainan	68.9	31.1	55.7	44.3
Chongqing	76.1	23.9	59.1	40.9
Sichuan	68.9	31.1	59.8	40.2
Guizhou	82.3	17.7	76.0	24.0
Yunnan	79.6	20.4	58.1	41.9
Tibet	*49.3*	*50.7*	*34.7*	*65.3*
Shaanxi	75.1	24.9	63.4	36.6
Gansu	83.4	16.6	65.1	34.9
Qinghai	66.7	33.3	*37.5*	*62.5*
Ningxia	75.9	24.1	58.7	41.3
Xinjiang	69.0	31.0	63.7	36.3

Table 3b Decompositions of average medical expenditures for public hospitals' inpatient and outpatient care in 31 provinces, autonomous regions and municipalities of mainland China during 2011-2018

Province	Inpatient		Outpatient	
	service utilization	price and intensity	service utilization	price and intensity
All	68.0	32.0	57.0	43.0
Beijing	75.6	24.4	*45.3*	*54.7*
Tianjin	60.6	39.4	*18.6*	*81.4*
Hebei	54.3	45.7	65.3	34.7
Shanxi	60.6	39.4	58.8	41.2
Inner Mongolia	77.9	22.1	65.6	34.4
Liaoning	66.2	33.8	*48.8*	*51.2*
Jilin	55.9	44.1	*46.5*	*53.5*
Heilongjiang	73.0	27.0	56.3	43.7
Shanghai	73.3	26.7	55.6	44.4
Jiangsu	77.1	22.9	59.3	40.7
Zhejiang	86.3	13.7	67.8	32.2
Anhui	74.0	26.0	63.0	37.0
Fujian	52.6	47.4	*40.2*	*59.8*
Jiangxi	58.1	41.9	*43.7*	*56.3*
Shandong	60.4	39.6	66.1	33.9
Henan	58.8	41.2	57.8	42.2
Hubei	66.4	33.6	69.3	30.7
Hunan	64.2	35.8	59.1	40.9
Guangdong	61.3	38.7	*27.0*	*73.0*
Guangxi	61.3	38.7	54.7	45.3
Hainan	65.7	34.3	51.6	48.4
Chongqing	74.3	25.7	56.3	43.7
Sichuan	67.6	32.4	58.2	41.8
Guizhou	81.7	18.3	75.2	24.8
Yunnan	78.5	21.5	56.1	43.9
Tibet	*43.9*	*56.1*	*26.1*	*73.9*
Shaanxi	74.5	25.5	61.9	38.1
Gansu	83.0	17.0	64.1	35.9
Qinghai	64.8	35.2	*32.2*	*67.8*
Ningxia	73.9	26.1	54.8	45.2
Xinjiang	62.6	37.4	56.5	43.5

NOTES: Provincial expenditures per admission discharged or per visit,

admission or visit volume data were only available since 2011 from the China Health Statistical Yearbooks in 2012-2019. Numbers in italics are outliers where the contribution of service volume or service utilization is less than that of price and intensity.

Discussion

This study measured the increases of inpatient and outpatient real total and average medical expenditures of public hospitals as well as how service use and price were collectively associated with these increases from 2008 to 2018. Our results showed that the inpatient and outpatient real total medical expenditures of public hospitals increased annually, but the growth rate decreased. The growth in service volume explains more of the growth in the real total medical expenditures of public hospitals in China than growth in service price and intensity, especially for inpatient care. After adjusting for population growth, our study found a similar pattern.

The average annual growth rate of inpatient and outpatient real total medical expenditures of public hospitals decreased by nearly half from 2013 to 2018 compared to the period from 2008 to 2013. This finding is consistent with the goal of containing the unreasonable growth of medical expenditures in public hospital reform since 2012.[20] Empirical studies in Beijing[16, 21] and Guangdong[22] showed the same trend. Payment method

reforms since 2011 also played a role in containing the unreasonable growth of public hospital expenses.[23]

Our findings of the major driver of hospital medical expenditures differ from those of Zhai et al., who, using data for the period 1993-2012, reported that the contribution of increasing health expenditure per prevalent case to the growth in health expenditures was more than 70%.[6] This study contradicts our finding that approximately 70% of the increase in the inpatient real total medical expenditure of public hospitals was associated with service volume, based on data for the period 2008-2018. A number of differences can contribute to varying results across studies, such as a different perspective (e.g., cost of disease vs. hospital care) and component factors. A key source of differences may be varying time periods. Yip et al.'s results closely parallel ours. Using data for the period 2008-2017, Yip et al. found that the increase in service volume accounted for approximately 70% of the increase in total health spending in China. [7] Addressing drivers of the increase in service volume, Moses et al.'s decomposition of change in volume of outpatient visits and inpatient admissions by countries from 1990-2016 showed that more than 80% of the increase in volume of outpatient visits and inpatient admissions was due to an increase in age-sex utilization rates, and less than 20% could be attributed to changes in the other 3 factors (population growth, population ageing, and sex composition).[24]

One study indicated that the need factor (i.e., whether one had a chronic disease or not) was a dominant determining factor for health service utilization among rural residents in China.[25] According to the China National Health Services Survey, the prevalence of chronic diseases increased from 15.7% in 2008 to 34.3% 2018. Coupled with the soaring real gross domestic product and declining share of out-of-pocket spending on health services, the affordability of health services has improved[7],[26]. An extensive body of literature highlights the impact that expanding China's basic medical insurance has had on increasing health service use, especially inpatient services.[27-31] It is plausible that rising health service utilization is related to the increase in the underlying need for and improvements in affordability of public hospital service. However, the increase in health service utilization may also be supply-induced.

This study has several limitations. First, the analysis relies on government administrative data, which may be subject to reporting errors. Second, due to the lack of a price index specific to the health sector in China, this study cannot distinguish between the contributions of service price and service intensity. Third, further research is needed to identify the sources of the increase in public hospital medical expenditures by types of conditions and by controlling for ageing, which could provide crucial evidence for decision makers.

Conclusions

We concluded that service use, rather than price, appears to be the major driver of China's hospital medical expenditure increase. In the coming years, health service utilization is likely to accelerate due to the ageing population and the increased burden of noncommunicable diseases. A study of China's health expenditure projections showed that the increase in services per case of disease and unit cost would contribute 4.3 and 2.4 percentage points, respectively, of the 8.4% annual average growth rate in health expenditure during 2015–2035.[32] Controlling price growth is crucial, but its effect on containing medical costs would be limited. Controlling service utilization would be essential through a nationwide effort for a healthy population, which would include disease prevention, healthy ageing, ensuring quality care and improving unreasonable healthcare demands.[33],[34] Positive incentive mechanisms should be established to enhance an integrated medical and long-term care delivery system, which would be expected to increase growth in outpatient and long-term care in primary facilities and prevent unnecessary hospitalization.

Author Contributions

YX and LY designed and conceptualized the study. YX conducted the acquisition, analysis and interpretation of data, and drafted the manuscript. LY reviewed the manuscript. LJ and RK reviewed and edited

the manuscript. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

Date availability statement

All data generated or analyzed during this study are included in this published article.

Patient and public involvement

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

Patient consent for publication

Not required.

Ethics approval

This study did not require the participation of human subjects. The information was anonymous, and no data related to individuals were

collected or were accessible. As a secondary analysis of existing data, ethics approval was, therefore, unnecessary.

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Figure List

Figure 1 Contributions of growth in service volume and price and intensity to growth in real total medical expenditure of public hospitals, 2008-2018

Figure 2 Contributions of growth in service utilization and price and intensity to growth in real average medical expenditure of public hospitals, 2008-2018

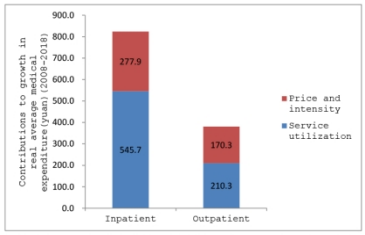

Figure 2 Contributions of growth in service utilization and price and intensity to growth in real average medical expenditure of public hospitals, 2008-2018

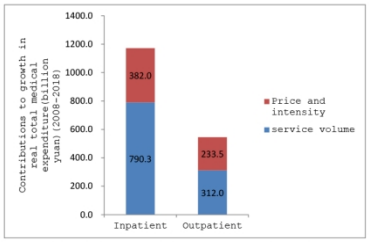

Figure 1 Contributions of growth in service volume and price and intensity to growth in real total medical expenditure of public hospitals, 2008-2018

Appendix exhibit 1.

Decomposing Methods

To measure the relative effect of each of the two factors, we used the decomposition method described by Das Gupta[1]. This decomposition was based on the equation above to calculate standardized rates for each factor and then calculate the addictive contributions of each factor to annual changes in hospital outpatient or inpatient total expenditure from 2009-2018 (below equations).

$$\Delta TE = TE_{y1} - TE_{y0}$$

$$V_a = \frac{P_{y1} + P_{y0}}{2}(V_{y1} - V_{y0})$$

$$P_a = \frac{V_{y1} + V_{y0}}{2}(P_{y1} - P_{y0})$$

$$V_r = {}^{V_a}/_{\Delta TE} * 100\%$$

$$P_r = {}^{p_a}/_{\Delta TE} * 100\%$$

where ΔTE is the change in total expenditures between y_1 and y_0 (e.g., 2008 and 2018). V_a is the change in total expenditures associated with the change in service volumes; P_a is the change in total expenditures associated with the change in service price and intensity; V_r is the relative contribution rate of change in total expenditure due to change in service volume; and P_r is the relative contribution rate of change in total expenditure due to change in service price and intensity.

Appendix exhibit 2.

Table 1 After adjustment for population growth, the average medical expenditures and service utilization for public hospital inpatient and outpatient care in China (2008-18)

	Inpatient			Outpatient		
	Real average medical exp.(yuan)	Exp. per admission (yuan)	Service utilization(%)	Real average medical exp.(yuan)	Exp. per visit (yuan)	Service utilization
2008	343.9	6678.7	5.1	214.6	172.8	1.2
2009	428.0	7344.5	5.8	253.5	191.3	1.3
2010	504.3	7789.8	6.5	283.9	203.1	1.4
2011	571.8	7960.4	7.2	316.3	207.6	1.5
2012	687.2	8224.8	8.4	367.0	217.2	1.7
2013	774.8	8600.1	9.0	410.5	227.5	1.8
2014	870.1	8894.5	9.8	460.2	237.7	1.9
2015	930.0	9345.6	10.0	491.0	248.8	2.0
2016	1016.9	9573.9	10.6	526.6	255.7	2.1
2017	1091.7	9764.2	11.2	557.5	262.5	2.1
2018	1167.5	9976.4	11.7	595.2	272.2	2.2
Annual growth rates (%)						
2008-13	17.6	5.2	11.8	13.8	5.6	7.8
2013-18	8.5	3	5.4	7.7	3.7	3.9

NOTES Expenditures per admission discharged or per visit, admission or visit volume data were extracted from the China Health Statistical Yearbooks in 2009-2019. All expenditure variables in this study were adjusted for inflation using the economy-wide consumer price index of China from the International Monetary Fund and were reported in Chinese yuan in 2018 prices. We expresses service utilization as the admission or visit volume divided by the population size in a given year, which was obtained from the China Statistical Yearbook in 2019. The real average medical expenditures in a given year was medical expenditures per admission or per visit multiplied by service utilization.

Note

1. Das Gupta P. Decomposition of the difference between two rates and its consistency when more than two populations are involved. Mathematical Population Studies:: An International Journal of Mathematical Demography. 1991;3(2):105-25.

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What is the major driver of China's hospital medical expenditure growth? A decomposing analysis

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What is the major driver of China's hospital medical expenditure growth? A decomposing analysis

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ABSTRACT

Objectives: This study aimed to quantify increases in the medical expenditures of public hospitals associated with changes in service use and prices, which could inform policy efforts to curb the future growth of hospital medical expenditures.

Design: Nationwide and provincial data regarding service volume, service price and intensity of public hospitals' outpatient and inpatient care from 2008 to 2018 were extracted from the China Health Statistical Yearbooks, and population size data were obtained from the 2019 China Statistical Yearbook.

Methods: A decomposition analysis was performed to measure the relative effects of changes in service use (volume or its subcomponent factors) and service price and intensity on the increase in the inpatient and outpatient total medical expenditures of public hospitals from 2008 to 2018.

Results: After adjusting for price inflation, the total medical expenditure of public hospitals increased by approximately 3-fold from 2008 to 2018. During this period, the increase in service volume was associated with 67.4% of the observed increase in the total medical expenditures in the inpatient sector and 57.2% of the observed increase in the total medical expenditures in the outpatient sector. Most of the service volume effect is due to an increase in the hospital utilization

rate. The growth in the utilization rate was associated with 73.7% of the observed growth in the total medical expenditures in the inpatient sector and 60.3% of the observed growth in the total medical expenditures in the outpatient sector.

Conclusion: Service use, rather than price, appears to be the major driver of increases in medical expenditures in Chinese hospitals. An important policy implication for China and other countries with similar drivers is that the effect of controlling price and intensity growth on containing medical costs could be limited and controlling service utilization growth could be essential.

Strengths and limitations of this study

- This study extends the existing literature by focusing on the drivers of growth in public hospitals' medical expenditure during the first decade of the new round of health system reform in China.
- This study decomposed growth in medical expenditure into changes in its primary policy-relevant constituent factors, i.e., service volume and price, and subcomponent factors of service volume.
- This study provides region-specific decomposition rates of the sources of the growth in public hospitals' medical expenditure in 31 provinces, autonomous regions and municipalities in mainland China.
- Due to the lack of a price index specific to the health sector in

China, this study cannot distinguish between the contributions of the service price and service intensity.

- This study did not consider changes in the types of conditions prompting people to visit hospitals and the ageing of the population.

INTRODUCTION

Medical cost escalation is a major problem in both developed and developing countries, including China.[1,2] Efforts to contain medical expenditure growth may benefit from a better understanding of the underlying drivers of increasing medical costs.

Studies decomposing growth in China's health expenditure into its constituent parts since the 1990s have revealed different results. Zhai et al.'s study used data from China's National Health Accounts studies and Global Burden of Disease 2013 studies and decomposed the changes in health expenditures by disease into population growth, population ageing, disease prevalence rate, expenditure per case of disease, and excess health price inflation. These authors found that 72.6% of the increases in China's health expenditure between 1993 and 2012 was caused by growth in health expenditure per prevalent case.[3] A recent study by Yip et al. using China National Health Accounts data decomposed the growth in health spending by healthcare type into an increase in visit volume and an increase in charges per visit or admission. The study showed that

the increase in visit volume accounted for approximately 70% of the increase in the total health spending in China between 2008 and 2017, while increases in charges per visit or admission accounted for approximately 30% of the increase.[4] These studies examined the drivers of health expenditure growth in China from different perspectives (cost of disease or healthcare) during different periods since the 1990s.

Some existing studies explored spending drivers in the US,[5,6,7] Switzerland[8] and Brazil[9] by decomposing growth in spending into its constituent parts while focusing on two or more factors, including population growth, population ageing, disease prevalence, utilization/quantity, and cost/price. Among all these factors in the decomposing models in the existing literature, the two primary factors are quantity and price, and the other factors can be considered the further decomposition of these two factors.

As the main body of China's health service delivery system, public hospitals accounted for 92.8% of hospital inpatient admissions and 92.6% of hospital ambulatory visits in 2008; the corresponding values decreased to 81.8% and 85.3% in 2018.[10] Public hospital medical expenditures accounted for approximately half of the total health expenditures in 2018.[10 11] Cost containment in public hospitals has been a key focus of China's new round of health system reform since 2009. [4,12] Public hospital reforms were launched in 2012, including altering provider payment,

eliminating drug mark-up, and adjusting fee schedules.[11] A guidance document to contain excess public hospital medical expenditure growth issued by the central government in 2015 listed 21 monitoring indicators of medical cost control for public hospitals.[13] Of these indicators, seven indicators monitor charges per unit of service (charges per visit, admission, or case), three indicators monitor service utilization, and the remaining indicators mainly monitor the share of the cost of drugs, diagnostic examinations or medical consumables in medical expenditures. Based on these monitoring indicators, it seems that the assumption underlying policy decisions was that price and intensity were the primary drivers of medical costs. However, these reforms did not reduce the overall medical expenditures.[14 15]

Our study extends the existing literature by focusing on the drivers of the growth of national and provincial total medical expenditures of public hospitals during the first decade of the new round of health system reform in China. We focused on the growth in medical expenditure of public hospitals because most of medical spending is by public hospitals and because cost containment in public hospitals is the focus of health-care delivery reform across China. We decompose growth in medical expenditure into its primary policy-relevant constituent factors to quantify how much of the growth in real total medical expenditure was attributable to changes in service volume versus service price and intensity. We also

explored the impact of changes in the subcomponent factors of the service volume, i.e., the population size, hospital utilization rates, and the share of public hospital utilization, on the growth of public hospitals' real total medical expenditures. One of the main contributions of this study is the provision of the region-specific decomposition rates of 31 provinces, autonomous regions and municipalities in mainland China. The results of this study could inform cost containment policies in China and other countries that experience soaring medical expenditures.

STUDY DATA AND METHODS

Data sources

We extracted eleven years of nationwide data and eight years of provincial data from the China Health Statistical Yearbooks in 2009-2019 published by the National Health Commission (originally called the Ministry of Health).[4 16] We obtained aggregative information of public hospital medical expenditures per visit or per admission discharged and outpatient and inpatient service volumes of public and private hospitals per year.[10] The nationwide and provincial population size data in specific years between 2008 and 2018 were obtained from the 2019 China Statistical Yearbook, which provides nationwide and provincial population size data from 2008 to 2018.[17]

We chose 2008 as the base year for the nationwide analysis and 2011 as the base year for the provincial analysis because the earliest available years of nationwide and provincial public hospitals' service volume and price and intensity data were 2008 and 2011, respectively. Additionally, there were significant policy changes in 2009 and 2012 as mentioned above, rendering 2008 and 2011 appropriate as base years. The year 2018 was selected as the end date for both the nationwide and provincial analyses because the latest data we could obtain during our study period was 2018, which was also the period of the first decade of new round health system reform.

Patient and public involvement

The data used for this study were directly harvested from China Health Statistical Yearbooks and China Statistical Yearbook. Therefore there was no direct patient and public involvement.

Variable definition

In this paper, we use public hospital medical revenue variables as expenditure indicators. According to the interpretation of the indicators in the China Health Statistics Yearbook and previous studies, hospital medical expenditures in this study fall into the following three categories: medical services, drugs, and diagnostic

examinations/medical consumables. [14] All expenditure variables in this study were adjusted for inflation using the economy-wide consumer price index of China from the International Monetary Fund and were reported in Chinese yuan in 2018 prices.[18]

Table 1 provides the definitions of the variables used in this study. For outpatient care, the service volume was defined as the annual volume of visits to public hospitals; the utilization rate was defined as annual hospital visits per capita, including public and private hospital visits; the share of public hospitals' utilization was defined as the fraction of public hospitals in the number of hospital visits; and price and intensity was defined as the mean expenditure per visit for public hospitals. For inpatient care, the service volume was defined as the annual volume of admissions discharged from public hospitals; the utilization rate was defined as annual hospital admissions per capita, including public and private hospital admissions; the share of public hospitals' utilization was defined as the fraction of public hospitals in the number of hospital admissions; and price and intensity was defined as the mean expenditure per admission discharged from public hospitals.

Table 1 Definitions of service volume, utilization rate, share of public

hospitals' utilization, price and intensity, by type of care

Care type	Service volume	Utilization rate	Share of public hospitals' utilization	Price and intensity
Outpatient	Annual volume of visits to public hospitals in outpatient and emergency departments	Annual hospital (including public and private hospitals) visits per capita	The share of public hospitals in the number of hospital visits.	Public hospitals' medical expenditure per visit
Inpatient	Annual volume of admissions discharged from public hospitals	Annual hospital (including public and private hospitals) admissions per capita	The share of public hospitals in the number of hospital admissions.	Public hospitals' medical expenditure per admission discharged

Decomposition methods

The total medical expenditure of public hospitals is the product of two factors: (1) service volume and (2) price and intensity, as shown in the following equation:

$$TME_y = V_y \times P_y,$$

where y indicates the year; TME_y is the total medical expenditure; V_y is the service volume; and P_y is the service price and intensity.

To measure the relative effect of each factor, we used the decomposition method described by Das Gupta.[19 20] This decomposition was based on the equation above to calculate standardized expenditures for each factor and then calculate their additive contributions to the changes in hospital outpatient or inpatient total medical expenditures from 2008

to 2018. (for a more detailed description of the decomposition method, see online appendix exhibit 1.1).

Given that the public hospitals' service volume can be expressed as the product of the population size, hospital utilization rate, and share of public hospital utilization (the share of public hospitals in the number of admissions or visits), its effect on the growth of real total medical expenditures reflects the subcomponent effects of population growth, changes in the utilization rate and changes in the share of public hospital utilization. We further explored the impact of changes in the population size, utilization rate, and share of public hospital utilization on the growth of total medical expenditure of public hospitals by developing a four-factor decomposition model as follows:

$$\mathrm{TME_y} = Pop_y \times \frac{V_{th,y}}{Pop_y} \times \frac{V_{ph,y}}{V_{th,y}} \times \mathrm{P}_y,$$

where y indicates the year; $\mathrm{TME_y}$ is the total medical expenditure of public hospitals; Pop_y is the population size; $\mathrm{V_{th,y}}$ is the service volume of all hospitals (including public and private hospitals); $V_{ph,y}$ is the service volume of public hospitals; and $\mathrm{P_y}$ is the service price and intensity of public hospital care.

Then, we calculated their additive contributions to the growth of public hospital outpatient or inpatient total medical expenditures from 2008 to 2018. The sum of the contributions of the changes in the population size, utilization rate, and share of public hospitals' utilization was

equal to the contribution of the changes in the service volume in the above two-factor decomposition. (for a more detailed description of the four-factor decomposition method, see online appendix exhibit 1.2).

RESULTS

Both the inpatient and outpatient real total medical expenditures of public hospitals increased annually from 2008 to 2018 (Table 2).In 2018, the inpatient real total medical expenditure increased by 3.6-fold, and the outpatient real total medical expenditure increased 2.9-fold compared with the costs in 2008. The growth rates of inpatient and outpatient real total medical expenditures showed downward trends. Inpatient and outpatient real total medical expenditures increased at average annual rates of 18.2% and 14.4%, respectively, between 2008 and 2013 and decreased to 9.1% and 8.3% between 2013 and 2018. The average annual growth rates of public hospitals' service volume and service price and intensity also displayed downward trends, while the average annual growth rate of public hospitals' service volume outpaced that of service price and intensity during the same period.

Table 2 Medical expenditures and service volumes of public hospital

inpatient and outpatient care in China (2008-18)

	Inpatient			Outpatient		
	Real total medical exp. (billion yuan)	Exp. per admission (yuan)	Admissions[1] (million)	Real total medical exp. (billion yuan)	Exp. per visit (yuan)	Visits (million)
2008	456.8	6678.7	68.4	285.0	172.8	1649.1
2009	571.2	7344.5	77.8	338.3	191.3	1768.9
2010	676.2	7789.8	86.8	380.6	203.1	1873.8
2011	770.4	7960.4	96.8	426.1	207.6	2052.5
2012	930.6	8224.8	113.1	497.0	217.2	2288.7
2013	1054.3	8600.1	122.6	558.6	227.5	2455.1
2014	1190.1	8894.5	133.8	629.4	237.7	2647.4
2015	1278.5	9345.6	136.8	675.0	248.8	2712.4
2016	1406.1	9573.9	146.9	728.1	255.7	2847.7
2017	1517.6	9764.2	155.4	774.9	262.5	2952.0
2018	1629.1	9976.4	163.3	830.5	272.2	3051.2
Annual growth rates (%)						
2008-13	18.2	5.2	12.4	14.4	5.6	8.3
2013-18	9.1	3.0	5.9	8.3	3.7	4.4

NOTES Expenditures per admission discharged or per visit, admission and visit volume data were extracted from the China Health Statistical Yearbooks in 2009-2019. Total medical expenditure represents the authors' analysis of data based on the above equation. [1]Numbers of inpatients who were discharged from public hospitals.

Figure 1 reveals a 1172.3 billion yuan and a 545.5 billion yuan increase in inpatient and outpatient real total medical expenditures, respectively, for public hospitals from 2008 through 2018. (the exchange rate in 2018 was 6.6 Chinese yuan to one US dollar.) From 2008 to 2018, the increase in admission volume was associated with 67.4 % (790.3 billion yuan) of the observed increase in inpatient real total medical expenditure, while the change in price and intensity was associated with the remaining 32.6% (382.0 billion yuan). The increase in visit volume

was associated with 57.2% (312.0 billion yuan) of the observed increase in outpatient real total medical expenditure, while the change in the service price and intensity was associated with the remaining 42.8% (233.5 billion yuan).

Figure 2 shows growth in the real total medical expenditure associated with changes in each factor in the four-factor decomposition from 2008 to 2018. The increase in utilization rate contributed 73.7% (863.8 billion yuan of the 1172.0 billion yuan increase) of the growth in the real total medical expenditure on inpatient care, and 60.3% (328.8 billion yuan of the 545.5 billion yuan increase) of the growth in the real total medical expenditure on outpatient care. Population growth was associated with a slight increase in inpatient (4.2%) and outpatient (4.8%) total medical expenditures, while a lower share of public hospitals' utilization was associated with a slight reduction in inpatient (10.9%) and outpatient (8.1%) total medical expenditures.

Regarding public hospitals' inpatient and outpatient care in 31 provinces, autonomous regions and municipalities in mainland China, growth in the service volume contributed more than growth in the service price and intensity to the growth in the real total medical expenditures in public hospital inpatient and outpatient care in most provinces from 2011 to 2018 (Table 3a). Regarding inpatient care, the growth in service volume contributed more than the growth in service price and intensity

to the growth in the real total medical expenditures in all provinces except for Tibet. For example, the growth in service volume was associated with 87.3% of the observed growth in the real total medical expenditure in the inpatient sector in Zhejiang Province (38.2 billion yuan of the 43.8 billion yuan increase) . Regarding outpatient care, the growth in service volume contributed more to growth in public hospital outpatient real total medical expenditures in most provinces (23 of the 31 provinces).

Increases in hospital utilization rates accounted for most increases in real total medical expenditures on inpatient and outpatient care in public hospitals in 31 provinces, autonomous regions and municipalities in mainland China from 2011 to 2018 (Table 3b). Regarding inpatient care, increases in hospital utilization rates accounted for the largest increases in real total medical expenditures of public hospitals in all 31 provinces, autonomous regions and municipalities. Regarding outpatient care, increases in hospital utilization rates accounted for the largest increases in real total medical expenditures of public hospitals in 25 provinces, autonomous regions and municipalities, except for 6 provinces, autonomous regions and municipalities, where increases in price and intensity accounted for the largest increases in the real total medical expenditures of public hospitals. Changes in the share of public hospital service utilization were associated with reductions

in both inpatient and outpatient real total medical expenditures of public hospitals in 30 provinces, autonomous regions and municipalities, except for Xinjiang. Changes in the population size were associated with increases in both inpatient and outpatient real total medical expenditures of public hospitals in 28 provinces, autonomous regions and municipalities, except for 3 provinces (Liaoning, Jilin and Heilong).

Table 3a Contributions of growths in the service volume and price and intensity to the growths of public hospital real total medical

expenditures on inpatient and outpatient care in 31 provinces, autonomous regions and municipalities in mainland China, 2011-2018

Province	Inpatient		Outpatient	
	Service volume	Price and intensity	Service volume	Price and intensity
Beijing	77.7	22.3	51.5	48.5
Tianjin	70.0	30.0	47.7	52.3*
Hebei	56.7	43.3	67.2	32.8
Shanxi	62.4	37.6	60.8	39.2
IM	78.5	21.5	66.5	33.5
Liaoning	65.9	34.1	48.3	51.7*
Jilin	54.8	45.2	45.2	54.8*
HLJ	72.2	27.8	54.7	45.3
Shanghai	74.5	25.5	58.2	41.8
Jiangsu	77.7	22.3	60.5	39.5
Zhejiang	87.3	12.7	70.6	29.4
Anhui	76.1	23.9	65.3	34.7
Fujian	56.9	43.1	45.0	55.0*
Jiangxi	59.6	40.4	46.1	53.9*
Shandong	62.6	37.4	68.1	31.9
Henan	59.8	40.2	59.0	41.0
Hubei	67.4	32.6	70.4	29.6
Hunan	66.2	33.8	61.5	38.5
Guangdong	65.1	34.9	36.0	64.0*
Guangxi	63.8	36.2	58.1	41.9
Hainan	68.9	31.1	55.7	44.3
Chongqing	76.1	23.9	59.1	40.9
Sichuan	68.9	31.1	59.8	40.2
Guizhou	82.3	17.7	76.0	24.0
Yunnan	79.6	20.4	58.1	41.9
Tibet	49.3	50.7*	34.7	65.3*
Shaanxi	69.5	30.5	63.4	36.6
Gansu	81.2	18.8	65.1	34.9
Qinghai	60.9	39.1	37.5	62.5*
Ningxia	68.8	31.2	58.7	41.3
Xinjiang	63.6	36.4	63.7	36.3

Table 3b Contributions of changes in each factor in the 4-factor decomposition to the growth in real total medical expenditure on public

hospital inpatient and outpatient care in 31 provinces, autonomous regions and municipalities in mainland China, 2011-2018

Province	Inpatient				Outpatient			
	Pop. size	Utilization rate	Share of PHU	Price and intensity	Pop. size	Utilization rate	Share of PHU	Price and intensity
Beijing	9.5	75.2	-7.0	22.2	11.5	50.8	-10.8	48.6
Tianjin	24.4	44.6	1.2	29.8	35.8	37.2	-25.4	52.4*
Hebei	5.6	65.2	-14.3	43.6	5.9	75.1	-13.9	33.0
Shanxi	4.7	74.3	-17.0	38.0	5.0	65.1	-9.5	39.3
IM	3.0	82.6	-7.2	21.6	3.0	69.5	-6.0	33.5
Liaoning	-1.0	92.3	-25.8	34.6	-1.1	71.0	-22.0	52.1
Jilin	-2.6	79.1	-22.2	45.8	-2.6	58.5	-11.0	55.1
HLJ	-2.9	98.3	-23.6	28.1	-3.9	78.0	-19.7	45.6
Shanghai	4.6	72.0	-2.0	25.5	6.0	55.1	-2.9	41.8
Jiangsu	2.9	85.4	-10.7	22.5	3.1	69.6	-12.3	39.7
Zhejiang	7.6	88.8	-9.1	12.7	9.1	72.1	-10.7	29.4
Anhui	8.5	82.0	-14.5	24.0	7.0	65.6	-7.3	34.7
Fujian	9.4	57.5	-9.9	43.1	8.3	40.1	-3.3	54.9*
Jiangxi	4.0	65.2	-9.8	40.6	4.4	48.8	-7.2	54.0*
Shandong	5.9	70.4	-13.9	37.6	6.2	73.3	-11.5	32.0
Henan	2.6	76.5	-20.0	40.9	3.0	72.2	-16.7	41.5
Hubei	3.3	73.6	-9.7	32.8	4.0	71.7	-8.7	32.9
Hunan	6.0	79.4	-19.5	34.2	6.3	68.1	-13.1	38.7
Guangdong	10.3	60.6	-5.8	34.8	12.5	26.9	-3.3	63.9*
Guangxi	6.9	63.8	-7.0	36.3	7.9	52.8	-2.5	41.8
Hainan	9.8	70.1	-11.0	31.1	8.8	52.9	-5.9	44.3
Chongqing	7.8	92.9	-25.1	24.4	6.9	60.4	-8.3	40.9
Sichuan	4.6	80.4	-16.4	31.4	4.2	63.3	-7.8	40.3
Guizhou	4.0	92.8	-14.8	18.0	3.9	84.7	-12.9	24.3
Yunnan	5.5	83.0	-9.0	20.5	5.0	59.5	-6.5	41.9
Tibet	10.8	55.5	-17.5	51.3	12.1	36.6	-14.3	65.6*
Shaanxi	3.8	80.0	-14.6	30.8	4.2	65.1	-6.0	36.6
Gansu	3.3	86.9	-9.0	18.9	3.3	67.9	-6.2	34.9
Qinghai	7.2	65.4	-11.8	39.3	8.0	42.0	-12.7	62.7*
Ningxia	11.2	77.7	-20.3	31.5	9.2	57.8	-8.3	41.3
Xinjiang	20.9	42.7	0.1	36.2	17.2	43.2	3.6	36.0

NOTES: IM is Inner Mongolia, HLJ is Heilongjiang, Pop size is population size, Share of PHU is the share of public hospitals' utilization. Provincial expenditures per admission discharged or per visit, admission and visit volume data have only been available since 2011 from the China Health Statistical Yearbooks in 2012-2019. * The exception of provinces where increases in price and intensity accounted for the largest increases in the real total medical expenditures of

public hospitals.

Discussion

This study measured the increases in inpatient and outpatient real total medical expenditures of public hospitals and how service use and price were collectively associated with these increases from 2008 to 2018. Our results show that the inpatient and outpatient real total medical expenditures of public hospitals increased annually, but the growth rate decreased. The growth in service use explains more of the growth in the real total medical expenditures of public hospitals in China than the growth in service price and intensity, especially for inpatient care.

The annual growth rate of inpatient and outpatient real total medical expenditures of public hospitals decreased by nearly half from 2013 to 2018 compared to that during the period from 2008 to 2013. This finding is consistent with the goal of containing the excess growth of medical expenditures of public hospital reform since 2012.[13] Empirical studies in Beijing[21 22] and Guangdong[23] showed the same trend. Payment method reforms since 2011 have played a role in containing the excess growth of public hospital expenses.[24]

Our findings of the major drivers of public hospitals' medical expenditures differ from those reported by Zhai et al., who used data from the 1993-2012 period and reported that the contribution of increasing health expenditure per prevalent case to the growth in health

expenditures was more than 70%.[3] This study contradicts our finding that approximately 70% of the increase in the inpatient real total medical expenditure of public hospitals was associated with the service volume based on data from the 2008-2018 period. Several differences can contribute to the varying results across the studies, such as different perspectives (e.g., cost of disease vs. hospital care) and component factors. A key source of the differences may be the varying time periods. Yip et al.'s results closely parallel ours. Using data from the 2008-2017 period, Yip et al. found that the increase in service volume accounted for approximately 70% of the increase in total health spending in China.[4]

Our findings also suggest that most of the service volume effect is due to an increase in the hospital utilization rate. Our findings closely parallel Moses et al.'s[25] results. Moses et al.'s decomposition of change in the volume of outpatient visits and inpatient admissions by countries from 1990-2016 showed that in China, more than 80% of the increase in volume of outpatient visits and inpatient admissions was due to an increase in age-sex utilization rates, and less than 20% could be attributed to changes in the other three factors (population growth, population ageing, and sex composition).[25]

Is the increase in service use acceptable? One study indicated that the need factor (i.e., whether one had a chronic disease) was a dominant factor determining health service utilization among rural residents in

China.[26] According to the China National Health Services Survey, the prevalence of chronic diseases among respondents aged 65 and above increased from 46.8% in 2008 to 62.3% in 2018.[27 28] The share of population aged 65 and above increased from 8.3% in 2008 to 11.9% in 2018.[17] Coupled with the soaring real gross domestic product and declining share of out-of-pocket spending on health services, the affordability of health services has improved.[4,29] An extensive body of literature highlights the impact of expanding China's basic medical insurance on increasing health service use, especially inpatient services.[30-34] It is plausible that rising hospital service utilization is related to the increase in the underlying need for and improvements in access to hospital services. However, the increase in health service utilization may also be supply-induced.[35] However, because underutilization was a concern before the health system reform initiated in 2009, the increase in hospital service utilization currently represents as improvements in access. Therefore, the increase in service use is acceptable.

These findings inform health policy makers, whose current cost contains tools mainly to control the cost per visit or per admission,[13] that controlling price and intensity growth are crucial, but their effect on containing medical costs could be limited. In the coming years, health service utilization is likely to increase due to the ageing population and the increased burden of noncommunicable diseases. A study of China's

health expenditure projections showed that the increase in services per case of disease and unit cost would contribute 4.3 and 2.4 percentage points, respectively, of the 8.4% annual average growth rate in health expenditure during the 2015–2035 period.[36] Controlling service utilization growth could be essential through a nationwide effort for a healthy population, which could include disease prevention, healthy ageing, ensuring quality care and minimizing unreasonable healthcare demands.[37,38] Positive incentive mechanisms should be established to enhance an integrated medical and long-term care delivery system, which would be expected to increase growth in outpatient and long-term care in primary facilities and prevent unnecessary hospitalization.

However, this study has several limitations. First, the analysis relies on government administrative data, which may be subject to reporting errors. Second, due to the lack of a price index specific to the health sector in China, this study cannot distinguish between the contributions of service price and service intensity. Third, further research is needed to identify the sources of the increase in public hospital medical expenditures by type of condition and by controlling for ageing, which could provide crucial evidence for decision makers.

Conclusions

We conclude that service use, rather than price, appears to be the major

driver of the increases in China's hospital medical expenditures. An important policy implication for China and other countries with similar drivers is that the effect of controlling price and intensity growth on containing medical costs could be limited and controlling service utilization growth could be essential.

Author Contributions

YX and LY designed and conceptualized the study. YX conducted the acquisition, analysis and interpretation of the data and drafted the manuscript. LY reviewed the manuscript. LJ and RK reviewed and edited the manuscript. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

Date availability statement

Raw data used in our study are publicly available, and all data sources have been cited in the methods section. The data used to support the findings of this study are available from the corresponding author upon request.

Patient consent for publication

Not required.

Ethics statement

No human participants included.

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Figure legends

Figure 1 Contributions of growth in service volume and price and intensity to growth in the real total medical expenditure of public hospitals, 2008-2018

Figure 2 Growth in the real total medical expenditure of public hospitals

associated with changes in each factor in the 4-factor decomposition by type of care, 2008-2018

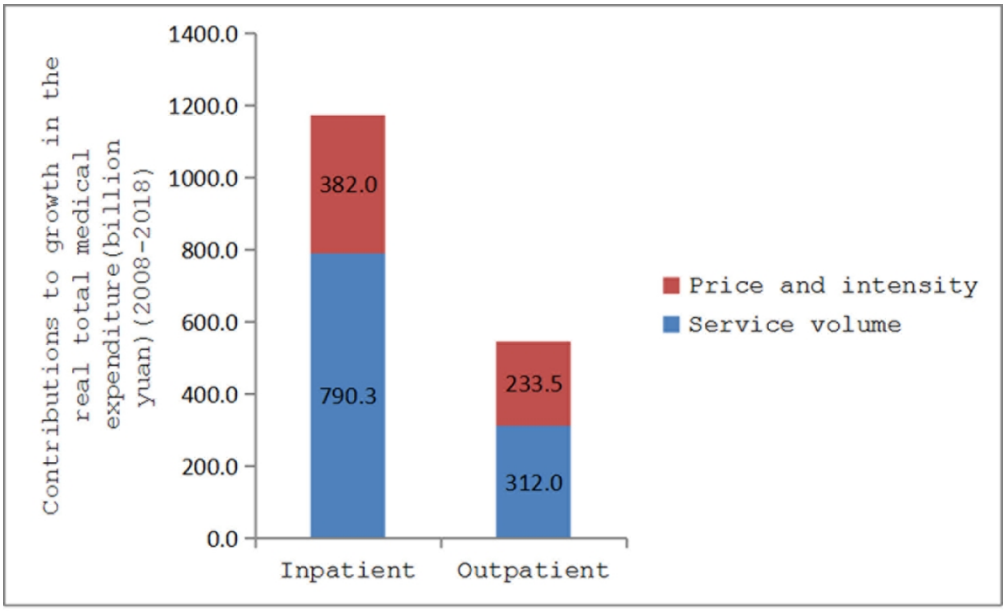

Figure 1 Contributions of growth in service volume and price and intensity to growth in the real total medical expenditure of public hospitals, 2008-2018

397x311mm (96 x 96 DPI)

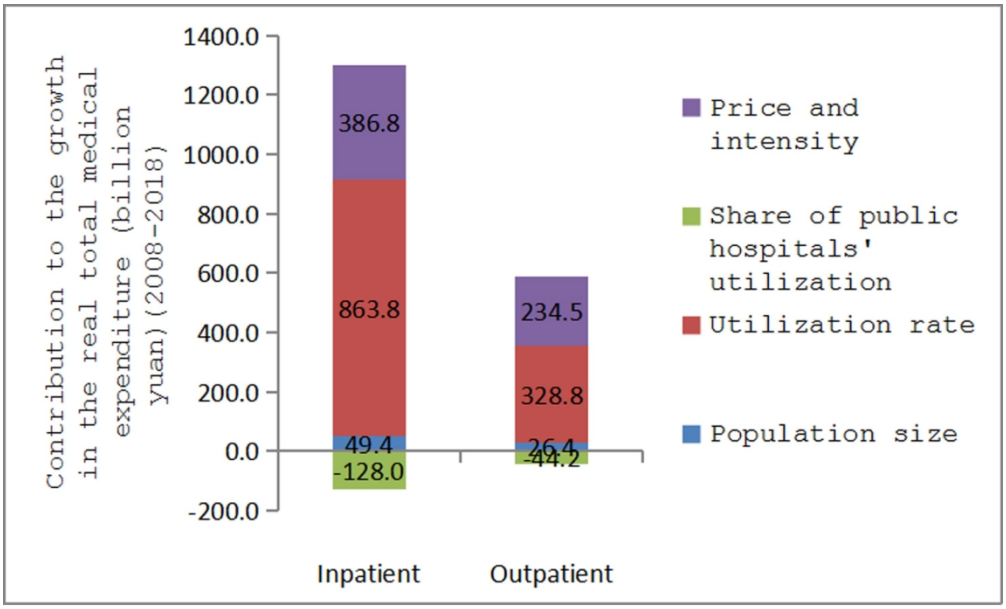

Figure 2 Growth in the real total medical expenditure of public hospitals associated with changes in each factor in the 4-factor decomposition by type of care, 2008–2018

Growth in the real total medical expenditure of public hospitals from 2008 to 2018 were decomposed into changes in four factors: population size, utilization rate, share of public hospitals' utilization, and price and intensity. Colours represent the contribution of each fator to the overall growth in real total medical expenditure. Bars below zero show that the factor contributed to a decrease and bars above zero show an increase.

397x429mm (96 x 96 DPI)

Appendix exhibit 1.

Decomposition-standardization methods

1.1 The case of two factors

To measure the relative effect of each of the two factors, we used the decomposition method described by Das Gupta[1,2]. This decomposition was based on the calculation of the standardized rates of each factor, and then, we calculated the addictive contributions of each factor to the changes in hospital outpatient or inpatient total expenditure in different years from 2008 to 2018 using the following equations:

Price and intensity standardized medical expenditure: $y_{0:}\frac{P_{y1}+P_{y0}}{2}V_{y0}$

Price and intensity standardized medical expenditure: $y_{1:}\frac{P_{y1}+P_{y0}}{2}V_{y1}$.

The difference between the y_0 price and intensity standardized medical expenditure and the y_1 price and intensity standardized medical expenditure is the effect of the difference in the service volume, or the contribution of the difference in the service volume to the difference in the medical expenditure between y_0 and y_1 based on the following equation:

$$V_a = \frac{P_{y1}+P_{y0}}{2}(V_{y1} - V_{y0}).$$

Similarly, the difference between the y_0 service volume standardized medical expenditure and the y_1 service volume standardized medical expenditure is the effect of the difference in the price and intensity, or the contribution of the difference in the price and intensity to the difference in the medical expenditure between y_0 and y_1 based on the following equation:

$$P_a = \frac{V_{y1}+V_{y0}}{2}(P_{y1} - P_{y0}).$$

Then, we obtain the following identity:

$$\Delta \mathrm{TME} = \mathrm{TME}_{y1} - \mathrm{TME}_{y0} = \mathrm{V_a} + \mathrm{P_a}.$$

The relative contributions of the two factors can be expressed as follows:

$$V_r = {}^{\mathrm{V_a}}/_{\Delta \mathrm{TME}} * 100\%,$$

$$P_r = {}^{\mathrm{p_a}}/_{\Delta \mathrm{TME}} * 100\%,$$

where $\Delta \mathrm{TME}$ is the change in the total medical expenditures between y_1 and y_0 (e.g., 2008 and 2018).$\mathrm{V_a}$ is the difference in the total medical expenditures associated with the difference in the service volume in counterfactual scenarios if the price and intensities were identical in the two years; $\mathrm{P_a}$ is the difference in the total medical expenditures associated with the difference in the service price and intensity in counterfactual scenarios if the service volumes were identical in the two years; V_r is the relative contribution rate of the difference in the total medical expenditure attributed to the in the service volume by expressed as a percentage; and P_r is the relative contribution rate of the difference in the total medical expenditure attributed to the difference in the service price and intensity by expressed as a percentage.

1.2 The case of four factors

The following four factors were constructed: (1)the total Chinese population, (2) the utilization rate (hospital visits per capita), (3) the share of public hospital service utilization, (4) the service price and intensity; then, the total medical expenditure of public hospitals can be written as follows:

$$\mathrm{TME_y} = Pop_{\,y} \times \frac{V_{th,y}}{Pop_{\,y}} \times \frac{V_{ph,y}}{V_{th,y}} \times \mathrm{P}_y,$$

where y indicates the year; $\mathrm{TME_y}$ is the total medical expenditure of public hospitals; $Pop_{\,y}$ is the population size; $\mathrm{V_{th,y}}$ is the service volume of all hospitals (including public and private hospitals); $V_{ph,y}$ is the service volume of public hospitals; and $\mathrm{P_y}$ is the service price and intensity of public hospital care.

To make it easier to write the above equation, the total medical expenditure can be written as follows:

$$\mathrm{TME_y} = \alpha\ \beta\ \gamma\ \delta\ .$$

Then, we can express the total medical expenditure in y_0 and y_1 as follows:

$$\mathrm{TME_{y0}} = ABCD,\ \mathrm{TME_{y1}} = abcd$$

From the decomposition method described by Das Gupta[1,2], we obtain $\beta\ \gamma\ \delta$-standardized expenditure as follows:

$$\text{in } y_0 = Q(A),$$

$$\text{in } y_1 = Q(a),$$

such that

$$\alpha\_\text{effect} = Q(a-A),$$

where Q is a function of b,c,d,B,C,D given by the following:

$$Q = Q(b,c,d,B,C,D) = \frac{bcd+BCD}{4} + \frac{bcD+bCd+Bcd+BCd+BcD+bCD}{12}.$$

Other standardized total medical expenditure and factor effects can be easily derived by interchanging the letters in the above equations. For example, the $\alpha\ \gamma\ \delta$ standardized total medical expenditure and effect are obtained by substituting b,a,B,A for a,b,A,B, respectively.

Then, we obtain the following identity:

$$\Delta\mathrm{TME} = \mathrm{TME_{y1}} - \mathrm{TME_{y0}} = \alpha\_\text{effect} + \beta\_\text{effect} + \gamma\_\text{effect} + \delta\_\text{effect}$$

Note

1. Das Gupta P. Decomposition of the difference between two rates and its consistency when more than two populations are involved. *Mathematical Population Studies:: An International Journal of Mathematical Demography* 1991;3(2):105-25.
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The RECORD statement – checklist of items, extended from the STROBE statement, that should be reported in observational studies using routinely collected health data.

	Item No.	STROBE items	Location in manuscript where items are reported	RECORD items	Location in manuscript where items are reported
Title and abstract					
	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found		RECORD 1.1: The type of data used should be specified in the title or abstract. When possible, the name of the databases used should be included. RECORD 1.2: If applicable, the geographic region and timeframe within which the study took place should be reported in the title or abstract. RECORD 1.3: If linkage between databases was conducted for the study, this should be clearly stated in the title or abstract.	RECORD 1.1, 1.2 and 1.3 were reported in the Design section of the abstract in page 2.
Introduction					
Background rationale	2	Explain the scientific background and rationale for the investigation being reported			Page 4, 5 and 6.
Objectives	3	State specific objectives, including any prespecified hypotheses			Page 6 and 7.
Methods					
Study Design	4	Present key elements of study design early in the paper			Page 10, 11 and 12.
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection			Page 7 and 8.
Participants	6	*(a) Cohort study* - Give the eligibility criteria, and the		RECORD 6.1: The methods of study population selection (such as codes or	Not applicable.

		sources and methods of selection of participants. Describe methods of follow-up *Case-control study* - Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study* - Give the eligibility criteria, and the sources and methods of selection of participants *(b) Cohort study* - For matched studies, give matching criteria and number of exposed and unexposed *Case-control study* - For matched studies, give matching criteria and the number of controls per case		algorithms used to identify subjects) should be listed in detail. If this is not possible, an explanation should be provided. RECORD 6.2: Any validation studies of the codes or algorithms used to select the population should be referenced. If validation was conducted for this study and not published elsewhere, detailed methods and results should be provided. RECORD 6.3: If the study involved linkage of databases, consider use of a flow diagram or other graphical display to demonstrate the data linkage process, including the number of individuals with linked data at each stage.	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable.		RECORD 7.1: A complete list of codes and algorithms used to classify exposures, outcomes, confounders, and effect modifiers should be provided. If these cannot be reported, an explanation should be provided.	Page 8 and 9 and 10.
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group			Page 7 and 8.
Bias	9	Describe any efforts to address potential sources of bias			Not applicable.
Study size	10	Explain how the study size was			Not applicable.

		arrived at			
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why			Page 8, 9 and 10.
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) *Cohort study* - If applicable, explain how loss to follow-up was addressed *Case-control study* - If applicable, explain how matching of cases and controls was addressed *Cross-sectional study* - If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses			Page 10, 11 and 12.
Data access and cleaning methods		..		RECORD 12.1: Authors should describe the extent to which the investigators had access to the database population used to create the study population. RECORD 12.2: Authors should provide information on the data cleaning methods used in the study.	Page 7
Linkage		..		RECORD 12.3: State whether the study included person-level, institutional-	Page 7 and 8.

				level, or other data linkage across two or more databases. The methods of linkage and methods of linkage quality evaluation should be provided.	
Results					
Participants	13	(a) Report the numbers of individuals at each stage of the study (*e.g.*, numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed) (b) Give reasons for non-participation at each stage. (c) Consider use of a flow diagram		RECORD 13.1: Describe in detail the selection of the persons included in the study (*i.e.,* study population selection) including filtering based on data quality, data availability and linkage. The selection of included persons can be described in the text and/or by means of the study flow diagram.	Not applicable.
Descriptive data	14	(a) Give characteristics of study participants (*e.g.*, demographic, clinical, social) and information on exposures and potential confounders (b) Indicate the number of participants with missing data for each variable of interest (c) *Cohort study* - summarise follow-up time (*e.g.*, average and total amount)			Page 12 and 13.
Outcome data	15	*Cohort study* - Report numbers of outcome events or summary measures over time *Case-control study* - Report numbers in each exposure category, or summary measures of exposure *Cross-sectional study* - Report numbers of outcome events or summary measures			Page 13
Main results	16	(a) Give unadjusted estimates			Page 13 and 14

		and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period			
Other analyses	17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses			Page 15, 16,17, and 18.
Discussion					
Key results	18	Summarise key results with reference to study objectives			Page 19
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias		RECORD 19.1: Discuss the implications of using data that were not created or collected to answer the specific research question(s). Include discussion of misclassification bias, unmeasured confounding, missing data, and changing eligibility over time, as they pertain to the study being reported.	Page 22
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence			Page 19, 20 and 21.
Generalisability	21	Discuss the generalisability (external validity) of the study results			Page 21 and 22.

Other Information					
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based			Page 23
Accessibility of protocol, raw data, and programming code		..		RECORD 22.1: Authors should provide information on how to access any supplemental information such as the study protocol, raw data, or programming code.	Page 23

*Reference: Benchimol EI, Smeeth L, Guttmann A, Harron K, Moher D, Petersen I, Sørensen HT, von Elm E, Langan SM, the RECORD Working Committee. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement. *PLoS Medicine* 2015; in press.

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What is the major driver of China's hospital medical expenditure growth? A decomposing analysis

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What is the major driver of China's hospital medical expenditure growth? A decomposing analysis

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ABSTRACT

Objectives: This study aimed to quantify increases in the medical expenditures of public hospitals associated with changes in service use and prices, which could inform policy efforts to curb the future growth of hospital medical expenditures.

Design: Nationwide and provincial data regarding service volume, service price and intensity of public hospitals' outpatient and inpatient care from 2008 to 2018 were extracted from the China Health Statistical Yearbooks, and population size data were obtained from the 2019 China Statistical Yearbook.

Methods: A decomposition analysis was performed to measure the relative effects of changes in service use (volume or its subcomponent factors) and service price and intensity on the increase in the inpatient and outpatient total medical expenditures of public hospitals from 2008 to 2018.

Results: After adjusting for price inflation, the total medical expenditure of public hospitals increased by approximately 3-fold from 2008 to 2018. During this period, the increase in service volume was associated with 67.4% of the observed increase in the total medical expenditures in the inpatient sector and 57.2% of the observed increase in the total medical expenditures in the outpatient sector. Most of the service volume effect is due to an increase in the hospital utilization

rate. The growth in the utilization rate was associated with 73.7% of the observed growth in the total medical expenditures in the inpatient sector and 60.3% of the observed growth in the total medical expenditures in the outpatient sector.

Conclusion: Service use, rather than price, appears to be the major driver of increases in medical expenditures in Chinese hospitals. An important policy implication for China and other countries with similar drivers is that the effect of controlling price and intensity growth on containing medical costs could be limited and controlling service utilization growth could be essential.

Strengths and limitations of this study

- This study extends the existing literature by focusing on the drivers of growth in public hospitals' medical expenditure during the first decade of the new round of health system reform in China.
- This study decomposed growth in medical expenditure into changes in its primary policy-relevant constituent factors, i.e., service volume and price, and subcomponent factors of service volume.
- This study provides region-specific decomposition rates of the sources of the growth in public hospitals' medical expenditure in 31 provinces, autonomous regions and municipalities in mainland China.
- Due to the lack of a price index specific to the health sector in

China, this study cannot distinguish between the contributions of the service price and service intensity.

- This study did not consider changes in the types of conditions prompting people to visit hospitals and the ageing of the population.

INTRODUCTION

Medical cost escalation is a major problem in both developed and developing countries, including China.[1,2] Efforts to contain medical expenditure growth may benefit from a better understanding of the underlying drivers of increasing medical costs.

Studies decomposing growth in China's health expenditure into its constituent parts since the 1990s have revealed different results. Zhai et al.'s study used data from China's National Health Accounts studies and Global Burden of Disease 2013 studies and decomposed the changes in health expenditures by disease into population growth, population ageing, disease prevalence rate, expenditure per case of disease, and excess health price inflation. These authors found that 72.6% of the increases in China's health expenditure between 1993 and 2012 was caused by growth in health expenditure per prevalent case.[3] A recent study by Yip et al. using China National Health Accounts data decomposed the growth in health spending by healthcare type into an increase in visit volume and an increase in charges per visit or admission. The study showed that

the increase in visit volume accounted for approximately 70% of the increase in the total health spending in China between 2008 and 2017, while increases in charges per visit or admission accounted for approximately 30% of the increase.[4] These studies examined the drivers of health expenditure growth in China from different perspectives (cost of disease or healthcare) during different periods since the 1990s.

Some existing studies explored spending drivers in the US,[5,6,7] Switzerland[8] and Brazil[9] by decomposing growth in spending into its constituent parts while focusing on two or more factors, including population growth, population ageing, disease prevalence, utilization/quantity, and cost/price. Among all these factors in the decomposing models in the existing literature, the two primary factors are quantity and price, and the other factors can be considered the further decomposition of these two factors.

As the main body of China's health service delivery system, public hospitals accounted for 92.8% of hospital inpatient admissions and 92.6% of hospital ambulatory visits in 2008; the corresponding values decreased to 81.8% and 85.3% in 2018.[10] Public hospital medical expenditures accounted for approximately half of the total health expenditures in 2018.[10 11] Cost containment in public hospitals has been a key focus of China's new round of health system reform since 2009. [4,12] Public hospital reforms were launched in 2012, including altering provider payment,

eliminating drug mark-up, and adjusting fee schedules.[11] A guidance document to contain excess public hospital medical expenditure growth issued by the central government in 2015 listed 21 monitoring indicators of medical cost control for public hospitals.[13] Of these indicators, seven indicators monitor charges per unit of service (charges per visit, admission, or case), three indicators monitor service utilization, and the remaining indicators mainly monitor the share of the cost of drugs, diagnostic examinations or medical consumables in medical expenditures. Based on these monitoring indicators, it seems that the assumption underlying policy decisions was that price and intensity were the primary drivers of medical costs. However, these reforms did not reduce the overall medical expenditures.[14 15]

Our study extends the existing literature by focusing on the drivers of the growth of national and provincial total medical expenditures of public hospitals during the first decade of the new round of health system reform in China. We focused on the growth in medical expenditure of public hospitals because most of medical spending is by public hospitals and because cost containment in public hospitals is the focus of health-care delivery reform across China. We decompose growth in medical expenditure into its primary policy-relevant constituent factors to quantify how much of the growth in real total medical expenditure was attributable to changes in service volume versus service price and intensity. We also

explored the impact of changes in the subcomponent factors of the service volume, i.e., the population size, hospital utilization rates, and the share of service utilization in public hospitals, on the growth of public hospitals' real total medical expenditures. One of the main contributions of this study is the provision of the region-specific decomposition rates of 31 provinces, autonomous regions and municipalities in mainland China. The results of this study could inform cost containment policies in China and other countries that experience soaring medical expenditures.

STUDY DATA AND METHODS

Data sources

We extracted eleven years of nationwide data and eight years of provincial data from the China Health Statistical Yearbooks in 2009-2019 published by the National Health Commission (originally called the Ministry of Health).[4 16] We obtained aggregative information of public hospital medical expenditures per visit or per admission discharged and outpatient and inpatient service volumes of public and private hospitals per year.[10] The nationwide and provincial population size data in specific years between 2008 and 2018 were obtained from the 2019 China Statistical Yearbook, which provides nationwide and provincial population size data from 2008 to 2018.[17]

We chose 2008 as the base year for the nationwide analysis and 2011 as the base year for the provincial analysis because the earliest available years of nationwide and provincial public hospitals' service volume and price and intensity data were 2008 and 2011, respectively. Additionally, there were significant policy changes in 2009 and 2012 as mentioned above, rendering 2008 and 2011 appropriate as base years. The year 2018 was selected as the end date for both the nationwide and provincial analyses because the latest data we could obtain during our study period was 2018, which was also the period of the first decade of new round health system reform.

Patient and public involvement

The data used for this study were directly harvested from China Health Statistical Yearbooks and China Statistical Yearbook. Therefore there was no direct patient and public involvement.

Variable definition

In this paper, we use public hospital medical revenue variables as expenditure indicators. According to the interpretation of the indicators in the China Health Statistics Yearbook and previous studies, hospital medical expenditures in this study fall into the following three categories: medical services, drugs, and diagnostic

examinations/medical consumables. [14] All expenditure variables in this study were adjusted for inflation using the economy-wide consumer price index of China from the International Monetary Fund and were reported in Chinese yuan in 2018 prices.[18]

Table 1 provides the definitions of the variables used in this study. For outpatient care, the service volume was defined as the annual volume of visits to public hospitals; the utilization rate was defined as annual hospital visits per capita, including public and private hospital visits; the share of public hospitals' utilization was defined as the fraction of public hospitals in the number of hospital visits; and price and intensity was defined as the mean expenditure per visit for public hospitals. For inpatient care, the service volume was defined as the annual volume of admissions discharged from public hospitals; the utilization rate was defined as annual hospital admissions per capita, including public and private hospital admissions; the share of public hospitals' utilization was defined as the fraction of public hospitals in the number of hospital admissions; and price and intensity was defined as the mean expenditure per admission discharged from public hospitals.

Table 1 Definitions of service volume, utilization rate, share of public hospitals' utilization, price and intensity, by type of care

Care type	Service volume	Utilization rate	Share of public hospitals' utilization	Price and intensity
Outpatient	Annual volume of visits to public hospitals in outpatient and emergency departments	Annual hospital (including public and private hospitals) visits per capita	The share of public hospitals in the number of hospital visits.	Public hospitals' medical expenditure per visit
Inpatient	Annual volume of admissions discharged from public hospitals	Annual hospital (including public and private hospitals) admissions per capita	The share of public hospitals in the number of hospital admissions.	Public hospitals' medical expenditure per admission discharged

Decomposition methods

The total medical expenditure of public hospitals is the product of two factors: (1) service volume and (2) price and intensity, as shown in the following equation:

$$TME_y = V_y \times P_y,$$

where y indicates the year; TME_y is the total medical expenditure; V_y is the service volume; and P_y is the service price and intensity.

To measure the relative effect of each factor, we used the decomposition method described by Das Gupta.[19 20] This decomposition was based on the equation above to calculate standardized expenditures for each factor and then calculate their additive contributions to the changes in

hospital outpatient or inpatient total medical expenditures from 2008 to 2018. (for a more detailed description of the decomposition method, see online appendix exhibit 1.1).

Given that the public hospitals' service volume can be expressed as the product of the population size, hospital utilization rate, and share of service utilization in public hospitals (the share of public hospitals in the number of admissions or visits), its effect on the growth of real total medical expenditures reflects the subcomponent effects of population growth, changes in the utilization rate and changes in the share of service utilization in public hospitals. We further explored the impact of changes in the population size, utilization rate, and share of service utilization in public hospitals on the growth of total medical expenditure of public hospitals by developing a four-factor decomposition model as follows:

$$\mathrm{TME_y} = Pop_y \times \frac{V_{th,y}}{Pop_y} \times \frac{V_{ph,y}}{V_{th,y}} \times \mathrm{P}_y,$$

where y indicates the year; $\mathrm{TME_y}$ is the total medical expenditure of public hospitals; Pop_y is the population size; $\mathrm{V_{th,y}}$ is the service volume of all hospitals (including public and private hospitals); $V_{ph,y}$ is the service volume of public hospitals; and $\mathrm{P_y}$ is the service price and intensity of public hospital care.

Then, we calculated their additive contributions to the growth of public hospital outpatient or inpatient total medical expenditures from

2008 to 2018. The sum of the contributions of the changes in the population size, utilization rate, and share of public hospitals' utilization was approximately the same as the contribution of the changes in the service volume in the above two-factor decomposition. (for a more detailed description of the four-factor decomposition method, see online appendix exhibit 1.2).

RESULTS

Both the inpatient and outpatient real total medical expenditures of public hospitals increased annually from 2008 to 2018 (Table 2).In 2018, the inpatient real total medical expenditure increased by 3.6-fold, and the outpatient real total medical expenditure increased 2.9-fold compared with the costs in 2008. The growth rates of inpatient and outpatient real total medical expenditures showed downward trends. Inpatient and outpatient real total medical expenditures increased at average annual rates of 18.2% and 14.4%, respectively, between 2008 and 2013 and decreased to 9.1% and 8.3% between 2013 and 2018. The average annual growth rates of public hospitals' service volume and service price and intensity also displayed downward trends, while the average annual growth rate of public hospitals' service volume outpaced that of service price and intensity during the same period.

Table 2 Medical expenditures and service volumes of public hospital inpatient and outpatient care in China (2008-18)

	Inpatient			Outpatient		
	Real total medical exp. (billion yuan)	Exp. per admission (yuan)	Admissions[1] (million)	Real total medical exp. (billion yuan)	Exp. per visit (yuan)	Visits (million)
2008	456.8	6678.7	68.4	285.0	172.8	1649.1
2009	571.2	7344.5	77.8	338.3	191.3	1768.9
2010	676.2	7789.8	86.8	380.6	203.1	1873.8
2011	770.4	7960.4	96.8	426.1	207.6	2052.5
2012	930.6	8224.8	113.1	497.0	217.2	2288.7
2013	1054.3	8600.1	122.6	558.6	227.5	2455.1
2014	1190.1	8894.5	133.8	629.4	237.7	2647.4
2015	1278.5	9345.6	136.8	675.0	248.8	2712.4
2016	1406.1	9573.9	146.9	728.1	255.7	2847.7
2017	1517.6	9764.2	155.4	774.9	262.5	2952.0
2018	1629.1	9976.4	163.3	830.5	272.2	3051.2
Annual growth rates (%)						
2008-13	18.2	5.2	12.4	14.4	5.6	8.3
2013-18	9.1	3.0	5.9	8.3	3.7	4.4

NOTES Expenditures per admission discharged or per visit, admission and visit volume data were extracted from the China Health Statistical Yearbooks in 2009-2019. Total medical expenditure represents the authors' analysis of data based on the above equation. [1]Numbers of inpatients who were discharged from public hospitals.

Figure 1 reveals a 1172.3 billion yuan and a 545.5 billion yuan increase in inpatient and outpatient real total medical expenditures, respectively, for public hospitals from 2008 through 2018. (the exchange rate in 2018 was 6.6 Chinese yuan to one US dollar.) From 2008 to 2018, the increase in admission volume was associated with 67.4 % (790.3 billion yuan) of the observed increase in inpatient real total medical expenditure, while the change in price and intensity was associated with

the remaining 32.6% (382.0 billion yuan). The increase in visit volume was associated with 57.2% (312.0 billion yuan) of the observed increase in outpatient real total medical expenditure, while the change in the service price and intensity was associated with the remaining 42.8% (233.5 billion yuan).

Figure 2 shows growth in the real total medical expenditure associated with changes in each factor in the four-factor decomposition from 2008 to 2018. The increase in utilization rate contributed 73.7% (863.8 billion yuan of the 1172.0 billion yuan increase) of the growth in the real total medical expenditure on inpatient care, and 60.3% (328.8 billion yuan of the 545.5 billion yuan increase) of the growth in the real total medical expenditure on outpatient care. Population growth was associated with a slight increase in inpatient (4.2%) and outpatient (4.8%) total medical expenditures, while a lower share of public hospitals' utilization was associated with a slight reduction in inpatient (10.9%) and outpatient (8.1%) total medical expenditures.

Regarding public hospitals' inpatient and outpatient care in 31 provinces, autonomous regions and municipalities in mainland China, growth in the service volume contributed more than growth in the service price and intensity to the growth in the real total medical expenditures in public hospital inpatient and outpatient care in most provinces from 2011 to 2018 (Table 3a). Regarding inpatient care, the growth in service

volume contributed more than the growth in service price and intensity to the growth in the real total medical expenditures in all provinces except for Tibet. For example, the growth in service volume was associated with 87.3% of the observed growth in the real total medical expenditure in the inpatient sector in Zhejiang Province (38.2 billion yuan of the 43.8 billion yuan increase) . Regarding outpatient care, the growth in service volume contributed more to growth in public hospital outpatient real total medical expenditures in most provinces (23 of the 31 provinces).

Increases in hospital utilization rates accounted for most increases in real total medical expenditures on inpatient and outpatient care in public hospitals in 31 provinces, autonomous regions and municipalities in mainland China from 2011 to 2018 (Table 3b). Regarding inpatient care, increases in hospital utilization rates accounted for the largest increases in real total medical expenditures of public hospitals in all 31 provinces, autonomous regions and municipalities. Regarding outpatient care, increases in hospital utilization rates accounted for the largest increases in real total medical expenditures of public hospitals in 25 provinces, autonomous regions and municipalities, except for 6 provinces, autonomous regions and municipalities, where increases in price and intensity accounted for the largest increases in the real total medical expenditures of public hospitals. Changes in the share

of public hospital service utilization were associated with reductions in both inpatient and outpatient real total medical expenditures of public hospitals in 30 provinces, autonomous regions and municipalities, except for Xinjiang. Changes in the population size were associated with increases in both inpatient and outpatient real total medical expenditures of public hospitals in 28 provinces, autonomous regions and municipalities, except for 3 provinces (Liaoning, Jilin and Heilong).

Table 3a Contributions of growths in the service volume and price and intensity to the growths of public hospital real total medical expenditures on inpatient and outpatient care in 31 provinces, autonomous regions and municipalities in mainland China, 2011-2018

Province	Inpatient		Outpatient	
	Service volume	Price and intensity	Service volume	Price and intensity
Beijing	77.7	22.3	51.5	48.5
Tianjin	70.0	30.0	47.7	52.3*
Hebei	56.7	43.3	67.2	32.8
Shanxi	62.4	37.6	60.8	39.2
IM	78.5	21.5	66.5	33.5
Liaoning	65.9	34.1	48.3	51.7*
Jilin	54.8	45.2	45.2	54.8*
HLJ	72.2	27.8	54.7	45.3
Shanghai	74.5	25.5	58.2	41.8
Jiangsu	77.7	22.3	60.5	39.5
Zhejiang	87.3	12.7	70.6	29.4
Anhui	76.1	23.9	65.3	34.7
Fujian	56.9	43.1	45.0	55.0*
Jiangxi	59.6	40.4	46.1	53.9*
Shandong	62.6	37.4	68.1	31.9
Henan	59.8	40.2	59.0	41.0
Hubei	67.4	32.6	70.4	29.6
Hunan	66.2	33.8	61.5	38.5
Guangdong	65.1	34.9	36.0	64.0*
Guangxi	63.8	36.2	58.1	41.9
Hainan	68.9	31.1	55.7	44.3
Chongqing	76.1	23.9	59.1	40.9
Sichuan	68.9	31.1	59.8	40.2
Guizhou	82.3	17.7	76.0	24.0
Yunnan	79.6	20.4	58.1	41.9
Tibet	49.3	50.7*	34.7	65.3*
Shaanxi	69.5	30.5	63.4	36.6
Gansu	81.2	18.8	65.1	34.9
Qinghai	60.9	39.1	37.5	62.5*
Ningxia	68.8	31.2	58.7	41.3
Xinjiang	63.6	36.4	63.7	36.3

Table 3b Contributions of changes in each factor in the 4-factor decomposition to the growth in real total medical expenditure on public hospital inpatient and outpatient care in 31 provinces, autonomous regions and municipalities in mainland China, 2011-2018

Province	Inpatient				Outpatient			
	Pop. size	Utilization rate	Share of PHU	Price and intensity	Pop. size	Utilization rate	Share of PHU	Price and intensity
Beijing	9.5	75.2	-7.0	22.2	11.5	50.8	-10.8	48.6
Tianjin	24.4	44.6	1.2	29.8	35.8	37.2	-25.4	52.4*
Hebei	5.6	65.2	-14.3	43.6	5.9	75.1	-13.9	33.0
Shanxi	4.7	74.3	-17.0	38.0	5.0	65.1	-9.5	39.3
IM	3.0	82.6	-7.2	21.6	3.0	69.5	-6.0	33.5
Liaoning	-1.0	92.3	-25.8	34.6	-1.1	71.0	-22.0	52.1
Jilin	-2.6	79.1	-22.2	45.8	-2.6	58.5	-11.0	55.1
HLJ	-2.9	98.3	-23.6	28.1	-3.9	78.0	-19.7	45.6
Shanghai	4.6	72.0	-2.0	25.5	6.0	55.1	-2.9	41.8
Jiangsu	2.9	85.4	-10.7	22.5	3.1	69.6	-12.3	39.7
Zhejiang	7.6	88.8	-9.1	12.7	9.1	72.1	-10.7	29.4
Anhui	8.5	82.0	-14.5	24.0	7.0	65.6	-7.3	34.7
Fujian	9.4	57.5	-9.9	43.1	8.3	40.1	-3.3	54.9*
Jiangxi	4.0	65.2	-9.8	40.6	4.4	48.8	-7.2	54.0*
Shandong	5.9	70.4	-13.9	37.6	6.2	73.3	-11.5	32.0
Henan	2.6	76.5	-20.0	40.9	3.0	72.2	-16.7	41.5
Hubei	3.3	73.6	-9.7	32.8	4.0	71.7	-8.7	32.9
Hunan	6.0	79.4	-19.5	34.2	6.3	68.1	-13.1	38.7
Guangdong	10.3	60.6	-5.8	34.8	12.5	26.9	-3.3	63.9*
Guangxi	6.9	63.8	-7.0	36.3	7.9	52.8	-2.5	41.8
Hainan	9.8	70.1	-11.0	31.1	8.8	52.9	-5.9	44.3
Chongqing	7.8	92.9	-25.1	24.4	6.9	60.4	-8.3	40.9
Sichuan	4.6	80.4	-16.4	31.4	4.2	63.3	-7.8	40.3
Guizhou	4.0	92.8	-14.8	18.0	3.9	84.7	-12.9	24.3
Yunnan	5.5	83.0	-9.0	20.5	5.0	59.5	-6.5	41.9
Tibet	10.8	55.5	-17.5	51.3	12.1	36.6	-14.3	65.6*
Shaanxi	3.8	80.0	-14.6	30.8	4.2	65.1	-6.0	36.6
Gansu	3.3	86.9	-9.0	18.9	3.3	67.9	-6.2	34.9
Qinghai	7.2	65.4	-11.8	39.3	8.0	42.0	-12.7	62.7*
Ningxia	11.2	77.7	-20.3	31.5	9.2	57.8	-8.3	41.3
Xinjiang	20.9	42.7	0.1	36.2	17.2	43.2	3.6	36.0

NOTES: IM is Inner Mongolia, HLJ is Heilongjiang, Pop size is population size, Share of PHU

is the share of public hospitals' utilization. Provincial expenditures per admission discharged or per visit, admission and visit volume data have only been available since 2011 from the China Health Statistical Yearbooks in 2012-2019. * The exception of provinces where increases in price and intensity accounted for the largest increases in the real total medical expenditures of public hospitals.

Discussion

This study measured the increases in inpatient and outpatient real total medical expenditures of public hospitals and how service use and price were collectively associated with these increases from 2008 to 2018. Our results show that the inpatient and outpatient real total medical expenditures of public hospitals increased annually, but the growth rate decreased. The growth in service use explains more of the growth in the real total medical expenditures of public hospitals in China than the growth in service price and intensity, especially for inpatient care.

The annual growth rate of inpatient and outpatient real total medical expenditures of public hospitals decreased by nearly half from 2013 to 2018 compared to that during the period from 2008 to 2013. This finding is consistent with the goal of containing the excess growth of medical expenditures of public hospital reform since 2012.[13] Empirical studies in Beijing[21 22] and Guangdong[23] showed the same trend. Payment method reforms since 2011 have played a role in containing the excess growth of public hospital expenses.[24]

Our findings of the major drivers of public hospitals' medical expenditures differ from those reported by Zhai et al., who used data

from the 1993-2012 period and reported that the contribution of increasing health expenditure per prevalent case to the growth in health expenditures was more than 70%.[3] This study contradicts our finding that approximately 70% of the increase in the inpatient real total medical expenditure of public hospitals was associated with the service volume based on data from the 2008-2018 period. Several differences can contribute to the varying results across the studies, such as different perspectives (e.g., cost of disease vs. hospital care) and component factors. A key source of the differences may be the varying time periods. Yip et al.'s results closely parallel ours. Using data from the 2008-2017 period, Yip et al. found that the increase in service volume accounted for approximately 70% of the increase in total health spending in China.[4]

Our findings also suggest that most of the service volume effect is due to an increase in the hospital utilization rate. Our findings closely parallel Moses et al.'s[25] results. Moses et al.'s decomposition of change in the volume of outpatient visits and inpatient admissions by countries from 1990-2016 showed that in China, more than 80% of the increase in volume of outpatient visits and inpatient admissions was due to an increase in age-sex utilization rates, and less than 20% could be attributed to changes in the other three factors (population growth, population ageing, and sex composition).[25]

Is the increase in service use acceptable? One study indicated that

the need factor (i.e., whether one had a chronic disease) was a dominant factor determining health service utilization among rural residents in China.[26] According to the China National Health Services Survey, the prevalence of chronic diseases among respondents aged 65 and above increased from 46.8% in 2008 to 62.3% in 2018.[27 28] The share of population aged 65 and above increased from 8.3% in 2008 to 11.9% in 2018.[17] Coupled with the soaring real gross domestic product and declining share of out-of-pocket spending on health services, the affordability of health services has improved.[4,29] An extensive body of literature highlights the impact of expanding China's basic medical insurance on increasing health service use, especially inpatient services.[30-34] It is plausible that rising hospital service utilization is related to the increase in the underlying need for and improvements in access to hospital services. However, the increase in health service utilization may also be supply-induced.[35] However, because underutilization was a concern before the health system reform initiated in 2009, the increase in hospital service utilization currently represents as improvements in access.

These findings may inform health policy makers, whose current cost contains policy instruments mainly to control the cost per visit or per admission,[13] that controlling price and intensity growth are crucial, but their effect on containing medical costs could be limited. In the coming years, health service utilization is likely to increase due to

the ageing population and the increased burden of noncommunicable diseases. A study of China's health expenditure projections showed that the increase in services per case of disease and unit cost would contribute 4.3 and 2.4 percentage points, respectively, of the 8.4% annual average growth rate in health expenditure during the 2015–2035 period.[36] Controlling service utilization growth can be essential through a nationwide effort for a healthier population, which could include disease prevention, healthy ageing, ensuring quality care and minimizing unreasonable healthcare demands.[37,38] Positive incentive mechanisms should be established to enhance an integrated medical and long-term care delivery system, which would be expected to increase outpatient and long-term care in primary facilities and prevent unnecessary hospitalization.

However, this study has several limitations. First, the analysis relies on government administrative data, which may be subject to reporting errors. Second, due to the lack of a price index specific to the health sector in China, this study cannot distinguish between the contributions of service price and service intensity. Third, due to the lack of age-specific price and intensity of public hospitals' inpatient and outpatient care for disease conditions in both base year and end year, this study did not consider changes in types of conditions prompting people to visit the hospitals and the aging of the population. Further

research is needed to identify the sources of the increase in public hospital medical expenditures by type of condition and by controlling for ageing, which could provide crucial evidence for decision makers.

Conclusions

We conclude that service use, rather than price, appears to be the major driver of the increases in China's hospital medical expenditures. An important policy implication for China and other countries with similar drivers is that the effect of controlling price and intensity growth on containing medical costs could be limited and controlling service utilization growth could be essential.

Author Contributions

YX and LY designed and conceptualized the study. YX conducted the acquisition, analysis and interpretation of the data and drafted the manuscript. LY reviewed the manuscript. LJ and RK reviewed and edited the manuscript. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

Date availability statement

Raw data used in our study are publicly available, and all data sources have been cited in the methods section. The data used to support the findings of this study are available from the corresponding author upon request.

Patient consent for publication

Not required.

Ethics statement

No human participants included.

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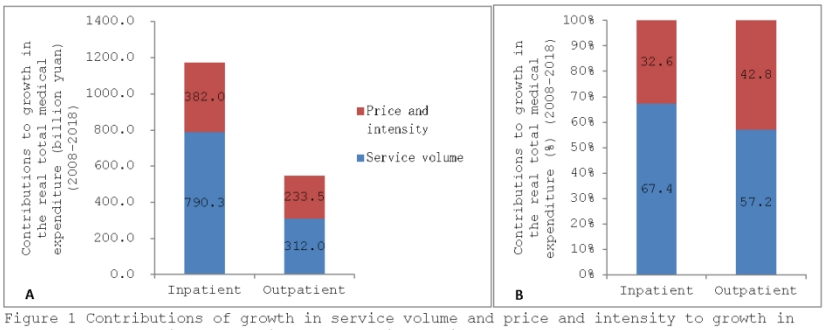
Figure legends

Figure 1 Contributions of growth in service volume and price and intensity to growth in the real total medical expenditure of public hospitals, 2008-2018

(A) The first panel shows the absolute contribution (billion yuan) of each factor; (B) The second panel shows the relative contribution (%) of each factor. Colours represent the contribution of each factor to the overall growth in real total medical expenditure.

Figure 2 Growth in the real total medical expenditure of public hospitals associated with changes in each factor in the 4-factor decomposition by type of care, 2008-2018

Growth in the real total medical expenditure of public hospitals from 2008 to 2018 were decomposed into changes in four factors: population size, utilization rate, share of service utilization in public hospitals, and price and intensity.(A) The first panel shows the absolute contribution (billion yuan) of each factor; (B) The second panel shows the relative contribution (%) of each factor. Colours represent the contribution of each factor to the overall growth in real total medical expenditure. Bars below zero show that the factor contributed to a decrease and bars above zero show an increase.



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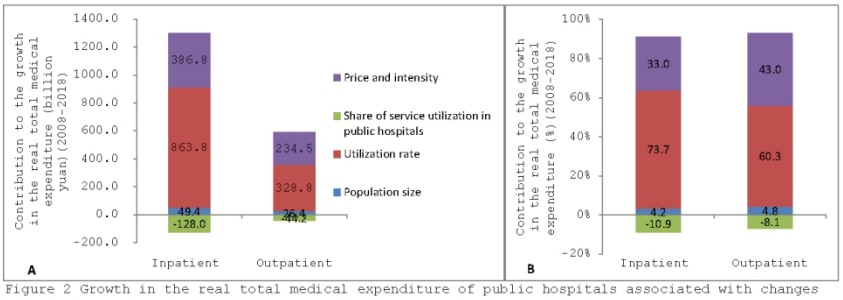
209x113mm (200 x 200 DPI)



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206x117mm (200 x 200 DPI)

Appendix exhibit 1.

Decomposition-standardization methods

1.1 The case of two factors

To measure the relative effect of each of the two factors, we used the decomposition method described by Das Gupta[1,2]. This decomposition was based on the calculation of the standardized rates of each factor, and then, we calculated the addictive contributions of each factor to the changes in hospital outpatient or inpatient total expenditure in different years from 2008 to 2018 using the following equations:

Price and intensity standardized medical expenditure: $y_{0:}\frac{P_{y1}+P_{y0}}{2}V_{y0}$

Price and intensity standardized medical expenditure: $y_{1:}\frac{P_{y1}+P_{y0}}{2}V_{y1}$.

The difference between the y_0 price and intensity standardized medical expenditure and the y_1 price and intensity standardized medical expenditure is the effect of the difference in the service volume, or the contribution of the difference in the service volume to the difference in the medical expenditure between y_0 and y_1 based on the following equation:

$$V_a = \frac{P_{y1}+P_{y0}}{2}(V_{y1} - V_{y0}).$$

Similarly, the difference between the y_0 service volume standardized medical expenditure and the y_1 service volume standardized medical expenditure is the effect of the difference in the price and intensity, or the contribution of the difference in the price and intensity to the difference in the medical expenditure between y_0 and y_1 based on the following equation:

$$P_a = \frac{V_{y1}+V_{y0}}{2}(P_{y1} - P_{y0}).$$

Then, we obtain the following identity:

$$\Delta \mathrm{TME} = \mathrm{TME}_{y1} - \mathrm{TME}_{y0} = \mathrm{V_a} + \mathrm{P_a}.$$

The relative contributions of the two factors can be expressed as follows:

$$V_r = {}^{\mathrm{V_a}}/_{\Delta \mathrm{TME}} * 100\%,$$

$$P_r = {}^{\mathrm{p_a}}/_{\Delta \mathrm{TME}} * 100\%,$$

where $\Delta \mathrm{TME}$ is the change in the total medical expenditures between y_1 and y_0 (e.g., 2008 and 2018).$\mathrm{V_a}$ is the difference in the total medical expenditures associated with the difference in the service volume in counterfactual scenarios if the price and intensities were identical in the two years; $\mathrm{P_a}$ is the difference in the total medical expenditures associated with the difference in the service price and intensity in counterfactual scenarios if the service volumes were identical in the two years; V_r is the relative contribution rate of the difference in the total medical expenditure attributed to the in the service volume by expressed as a percentage; and P_r is the relative contribution rate of the difference in the total medical expenditure attributed to the difference in the service price and intensity by expressed as a percentage.

1.2 The case of four factors

The following four factors were constructed: (1)the total Chinese population, (2) the utilization rate (hospital visits per capita), (3) the share of public hospital service utilization, (4) the service price and intensity; then, the total medical expenditure of public hospitals can be written as follows:

$$\mathrm{TME_y} = Pop_{\,y} \times \frac{V_{th,y}}{Pop_{\,y}} \times \frac{V_{ph,y}}{V_{th,y}} \times \mathrm{P}_y,$$

where y indicates the year; $\mathrm{TME_y}$ is the total medical expenditure of public hospitals; $Pop_{\,y}$ is the population size; $\mathrm{V_{th,y}}$ is the service volume of all hospitals (including public and private hospitals); $V_{ph,y}$ is the service volume of public hospitals; and $\mathrm{P_y}$ is the service price and intensity of public hospital care.

To make it easier to write the above equation, the total medical expenditure can be written as follows:

$$\mathrm{TME_y} = \alpha\ \beta\ \gamma\ \delta\ .$$

Then, we can express the total medical expenditure in y_0 and y_1 as follows:

$$\mathrm{TME_{y0}} = ABCD,\ \mathrm{TME_{y1}} = abcd$$

From the decomposition method described by Das Gupta[1,2], we obtain $\beta\ \gamma\ \delta$-standardized expenditure as follows:

$$\text{in } y_0 = Q(A),$$

$$\text{in } y_1 = Q(a),$$

such that

$$\alpha\_\text{effect} = Q(a-A),$$

where Q is a function of b,c,d,B,C,D given by the following:

$$Q = Q(b,c,d,B,C,D) = \frac{bcd+BCD}{4} + \frac{bcD+bCd+Bcd+BCd+BcD+bCD}{12}.$$

Other standardized total medical expenditure and factor effects can be easily derived by interchanging the letters in the above equations. For example, the $\alpha\ \gamma\ \delta$ standardized total medical expenditure and effect are obtained by substituting b,a,B,A for a,b,A,B, respectively.

Then, we obtain the following identity:

$$\Delta\mathrm{TME} = \mathrm{TME_{y1}} - \mathrm{TME_{y0}} = \alpha\_\text{effect} + \beta\_\text{effect} + \gamma\_\text{effect} + \delta\_\text{effect}$$

Note

1. Das Gupta P. Decomposition of the difference between two rates and its consistency when more than two populations are involved. *Mathematical Population Studies:: An International Journal of Mathematical Demography* 1991;3(2):105-25.

2. Das Gupta P. Standardization and decomposition of rates: a users's manual: US Department of Commerce, Economics and Statistics Administration, Bureau of the Census 1993.

The RECORD statement – checklist of items, extended from the STROBE statement, that should be reported in observational studies using routinely collected health data.

	Item No.	STROBE items	Location in manuscript where items are reported	RECORD items	Location in manuscript where items are reported
Title and abstract					
	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found		RECORD 1.1: The type of data used should be specified in the title or abstract. When possible, the name of the databases used should be included. RECORD 1.2: If applicable, the geographic region and timeframe within which the study took place should be reported in the title or abstract. RECORD 1.3: If linkage between databases was conducted for the study, this should be clearly stated in the title or abstract.	RECORD 1.1 and 1.2 were reported in the Design section of the abstract in page 2.
Introduction					
Background rationale	2	Explain the scientific background and rationale for the investigation being reported			Page 4, 5 and 6.
Objectives	3	State specific objectives, including any prespecified hypotheses			Page 6 and 7.
Methods					
Study Design	4	Present key elements of study design early in the paper			Page 10, 11 and 12.
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection			Page 7 and 8.
Participants	6	*(a) Cohort study* - Give the eligibility criteria, and the		RECORD 6.1: The methods of study population selection (such as codes or	Not applicable.

		sources and methods of selection of participants. Describe methods of follow-up *Case-control study* - Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study* - Give the eligibility criteria, and the sources and methods of selection of participants *(b) Cohort study* - For matched studies, give matching criteria and number of exposed and unexposed *Case-control study* - For matched studies, give matching criteria and the number of controls per case		algorithms used to identify subjects) should be listed in detail. If this is not possible, an explanation should be provided. RECORD 6.2: Any validation studies of the codes or algorithms used to select the population should be referenced. If validation was conducted for this study and not published elsewhere, detailed methods and results should be provided. RECORD 6.3: If the study involved linkage of databases, consider use of a flow diagram or other graphical display to demonstrate the data linkage process, including the number of individuals with linked data at each stage.	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable.		RECORD 7.1: A complete list of codes and algorithms used to classify exposures, outcomes, confounders, and effect modifiers should be provided. If these cannot be reported, an explanation should be provided.	Page 8 and 9 and 10.
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group			Page 7 and 8.
Bias	9	Describe any efforts to address potential sources of bias			Not applicable.
Study size	10	Explain how the study size was			Not applicable.

		arrived at			
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why			Page 8, 9 and 10.
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) *Cohort study* - If applicable, explain how loss to follow-up was addressed *Case-control study* - If applicable, explain how matching of cases and controls was addressed *Cross-sectional study* - If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses			Page 10, 11 and 12.
Data access and cleaning methods		..		RECORD 12.1: Authors should describe the extent to which the investigators had access to the database population used to create the study population. RECORD 12.2: Authors should provide information on the data cleaning methods used in the study.	Page 7 and 8.
Linkage		..		RECORD 12.3: State whether the study included person-level, institutional-	Page 7 and 8.

				level, or other data linkage across two or more databases. The methods of linkage and methods of linkage quality evaluation should be provided.	
Results					
Participants	13	(a) Report the numbers of individuals at each stage of the study (*e.g.*, numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed) (b) Give reasons for non-participation at each stage. (c) Consider use of a flow diagram		RECORD 13.1: Describe in detail the selection of the persons included in the study (*i.e.,* study population selection) including filtering based on data quality, data availability and linkage. The selection of included persons can be described in the text and/or by means of the study flow diagram.	Not applicable.
Descriptive data	14	(a) Give characteristics of study participants (*e.g.*, demographic, clinical, social) and information on exposures and potential confounders (b) Indicate the number of participants with missing data for each variable of interest (c) *Cohort study* - summarise follow-up time (*e.g.*, average and total amount)			Not applicable.
Outcome data	15	*Cohort study* - Report numbers of outcome events or summary measures over time *Case-control study* - Report numbers in each exposure category, or summary measures of exposure *Cross-sectional study* - Report numbers of outcome events or summary measures			Not applicable.
Main results	16	(a) Give unadjusted estimates			Page 13 and 14

		and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period			
Other analyses	17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses			Page 14-19.
Discussion					
Key results	18	Summarise key results with reference to study objectives			Page 19
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias		RECORD 19.1: Discuss the implications of using data that were not created or collected to answer the specific research question(s). Include discussion of misclassification bias, unmeasured confounding, missing data, and changing eligibility over time, as they pertain to the study being reported.	Page 22
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence			Page 19, 20 and 21.
Generalisability	21	Discuss the generalisability (external validity) of the study results			Page 21 and 22.

Other Information					
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based			Page 23
Accessibility of protocol, raw data, and programming code		..		RECORD 22.1: Authors should provide information on how to access any supplemental information such as the study protocol, raw data, or programming code.	Page 24

*Reference: Benchimol EI, Smeeth L, Guttmann A, Harron K, Moher D, Petersen I, Sørensen HT, von Elm E, Langan SM, the RECORD Working Committee. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement. *PLoS Medicine* 2015; in press.