

BMJ Open What makes the hospitalisation system more efficient? An application of the decomposition method to Hong Kong morbidity data

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ABSTRACT

Objective: To examine the efficiency of the Hong Kong hospitalisation system based on hospitalisation days.

Design: Retrospective study.

Setting: Hospitalisation data (2000–2010) for all government-funded hospitals in Hong Kong.

Population: Hospitalisation data for the entire Hong Kong population (7.0 million in 2011).

Methods: A decomposition method was used to determine the effects on total hospitalisation days during the period 2000–2010 of the following three factors: (i) hospitalisation rate per person; (ii) the number of visits per patient; and (iii) the mean duration of stay per visit.

Main outcome measures: The decomposition method provides empirical measures of how the three factors contributed to the change in total hospitalisation days during the period 2000–2010 and identifies the most effective way to contain increases in hospitalisation days.

Results: The results of decomposition analysis show that the decrease in mean duration of stay per visit (reducing from 6.83 to 4.58 days) is the most important factor in the reduction in the total number of hospitalisation days, despite increases in total population size (from 6.7 to 7.0 million), the number of individual hospital admissions (from 583 000 to 664 000) and the number of episodes (from 1.2 to 1.4 million) from 2000 to 2010. Hospitalisation days per person decreased from 1.18 in 2000 to 0.93 in 2010. The decline in the mean duration of stay per visit contributed 200.6% to this reduction but was offset by –51.1% due to a slight growth in the number of visits per patient and by –49.4% as a result of changed hospitalisation rates per person.

Conclusions: Better management of the duration of stay of per visit without compromising patient satisfaction levels or the quality of service is the most important factor for controlling increases in health expenditure in Hong Kong.

Strengths and limitations of this study

- This is the first study to examine how the total number of hospitalisation days during the period 2000–2010 were affected by: (i) hospitalisation rate per person; (ii) the number of visits per patient; and (iii) the mean duration of stay per visit.
- The decomposition method results demonstrate the impact of duration of stay on mean duration of stay per visit, the most important factor in the reduction in hospitalisation days in Hong Kong.
- A simple count of the number of hospitalisation days may not accurately reflect the work resulting from the reduction in mean duration of stay per visit as the first few days of each visit might be different from the rest of the stay.
- We have not considered possible variation in the patient case mix in examining hospitalisation days, but any change is expected to be limited as the morbidity and mortality pattern in Hong Kong during the period did not vary significantly.
- Furthermore, a system to monitor the complicated relationship among shortened duration of stay, the capacity of public hospitals and quality of care (in terms of patient safety and satisfaction) in the public hospital system in Hong Kong needs to be formulated carefully.

each episode's cost and enhance efficiency. Studies have confirmed that duration of hospital stay is regarded as an indicator of efficiency.^{1–4} For low dependency inpatients, a long hospital stay may imply ineffective treatment, which increases healthcare expenditure. Theoretically, reducing duration of stay may increase the capacity of available hospital beds and the admissions of new inpatients. However, quick discharge may also generate problems such as additional demands on professionals (doctors and nurses) as well as a heavier workload for follow-up specialist outpatient care, pressure on other healthcare sectors like nursing homes, and a risk of rapid readmission. Thus, the challenges of controlling healthcare expenditure and reducing



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INTRODUCTION

Many healthcare systems seek to reduce the duration of hospital stay in order to reduce

duration of stay must be balanced with providing good quality care and maintaining patient satisfaction. Because disease patterns differ for each age group, the potential reduction in hospitalisation will also differ for each group.⁵

Hospitalisation costs are a major component of health-care expenditure in Hong Kong, which has a population of 7.0 million. Healthcare expenditure has been increasing, accounting for 25% of government expenditure, a relatively high percentage compared with other countries.⁶ About 80% of inpatients attend public hospitals, which are managed by the Hospital Authority.⁷ The public healthcare sector currently accounts for over 90% of total secondary and tertiary care, and receives a government subsidy of 95%. The public pay HK\$100 (US\$13) per day for inpatient services, although the average operating cost per hospital bed is approximately HK\$3300 (US\$350) a day. Furthermore, Hong Kong is facing an acute ageing problem: 14% of older adults were aged 65 or over in 2012, a figure projected to increase to over 33% by 2041, which will have a significant impact on health and medical services.⁸⁻¹¹

In this study we aim to investigate the factors leading to a reduction in total hospitalisation days which has had a direct impact on healthcare costs. According to the latest report from the Hospital Authority, despite a rise in population from 6.7 to 7.0 million and an increase in patient numbers from 583 000 to 664 000 during the period 2000–2010, there has been a significant reduction in the total number of hospitalisation days in Hong Kong. Total hospitalisation days are calculated from the number of inpatients per 1000 population, the number of visits per patient, and the mean duration of stay per visit. The increases in population size, patient population and number of visits per patient in a given year have been offset by improved management of patients, with a reduction in the mean duration of stay per visit, resulting in a 30% decrease in the number of hospitalisation days from 2001 to 2010. In the present study, we use a decomposition method to examine and quantify the impact of the mean duration of stay per visit on the other two factors, hospitalisation rate per 1000 population and the number of visits per patient, in relation to its impact on the total number of hospitalisation days.

DATA AND METHODS

Data

In order to investigate the factors contributing to the changes in the number of hospitalisation days per

person between 2000 and 2010 in Hong Kong, data on the total population and public hospital admissions for this period (table 1) were collected from the Census and Statistics Department and the Hospital Authority, respectively. The census statistics include sex and age for the entire population. The Hospital Authority provides episode-based hospitalisation data which contain information on age, gender, hospital, date of birth, district of residence, dates of admission and discharge, disease code, duration of stay for each visit, and discharge destination. However, as a significant proportion of the patient data have missing disease codes, we will not examine the disease-code specific duration of stay in this analysis. Although the capacity of the Hong Kong hospital system has varied over the years, the overall occupancy rate is about 90% on average. The hospital service model in Hong Kong remained relatively unchanged during the study period. It is also assumed that the range of clinical services and patient case mix in the public hospital system remained constant over the 11-year period.

The decomposition of hospitalisation days per person

Here we define the hospitalisation days per person (HD) as the total number of hospitalisation days in all public hospitals during the examined year (D) divided by the total population in the same year (P). The number of hospitalisation days per person is expressed as:

$$HD = \frac{D}{P} \quad (1)$$

Equation (1) can be decomposed into three components:

$$HD = \frac{D}{P} = \frac{D}{E} \times \frac{E}{I} \times \frac{I}{P} \quad (2)$$

where E and I denote the total number of hospital admission episodes and the distinct number of hospitalised individuals, respectively.

Equation (2) contains three components: (i) D/E, the ratio of the number of hospitalisation days to the number of hospital admission episodes, which is the *mean duration of stay* per visit in hospital; (ii) E/I, the ratio of the number of inpatients in episodes to that in individuals, which is the *number of visits per patient*; and (iii) I/P, the ratio of the number of individuals to the total population, which is the *hospitalisation rate* per person in the community.

Table 1 Total population and public hospital admissions, 2000 and 2010

Year	Total hospitalisation days	Number of admissions (episodes)	Number of admissions (individuals)	Total population
2000	7 865 661	1 152 215	582 695	6 665 000
2010	6 518 924	1 422 807	663 873	7 024 200

In order to measure change in the number of hospitalisation days in the community during this period, we compute the ratio of number of hospitalisation days per person between year a and year b as follows:

$$\frac{HD_a}{HD_b} = \frac{(D_a/E_a) \times (E_a/I_a) \times (I_a/P_a)}{(D_b/E_b) \times (E_b/I_b) \times (I_b/P_b)} \quad (3)$$

$$= \text{Ratio}_{MS} \times \text{Ratio}_F \times \text{Ratio}_{HR}$$

where Ratio_{MS} is the ratio of the mean duration of stay per visit in year a to year b; Ratio_F is the ratio of the number of visits per patient in year a to year b; and Ratio_{HR} is the ratio of hospitalisation rate per person in year a to year b. Thus, the relative change in number of hospitalisation days per person during the periods a and b is calculated as:

$$\frac{HD_a - HD_b}{HD_b} = \frac{HD_a}{HD_b} - 1$$

The decomposition of hospitalisation days per person in year a and year b can be expressed as a product of three factors: the relative difference between mean duration of stay per visit (MS), the relative difference in number of visits per patient (F), and the relative change in hospitalisation rate per person (HR).

The relative contribution of each of the three factors to the discrepancy in number of hospitalisation days per person can be calculated as follows:

$$RC_i = \frac{\text{Ratio}_i - 1}{\sum_{i=1}^3 (\text{Ratio}_i - 1)} \times 100\% \quad (4)$$

where RC_i is the relative contribution of the i -th factor to the difference.^{12 13}

RESULTS

Between 2000 and 2010, more than 515 000 individuals (1 million episodes) were admitted to public hospitals in Hong Kong annually (figure 1). There were 582 695, 605 088 and 597 137 inpatients (1.15, 1.21 and 1.21 million episodes, respectively) in the first 3 years (2000–2002). The next year (2003) had the lowest number of admissions with only 515 408 inpatients as Hong Kong was badly affected by the severe acute respiratory syndrome (SARS) epidemic and public hospitals reduced non-essential services and operations to cope with the epidemic and limited patient admissions.¹⁴ In 2010, public hospitals admitted 664 000 individuals (1.4 million episodes). The population hospitalised in public hospitals increased by 28.8% in terms of individuals and by 41.7% in terms of episodes.

Overall, 31.1–35.0% (37.5–41.9% of episodes) of those admitted to hospital were aged 65 or over, although only 12% of the population are aged 65 or over (figure 2). Nevertheless, the number of elderly inpatients only increased by 28.4% during the entire period, whereas admissions for middle-aged patients (aged 45–54 and 55–64) increased by 30.8% and 54.2%, respectively. Over the 11 years, a 66.4% increase was recorded for women aged 55–64 who were admitted to hospitals, while an increase of 35.4% was recorded for men aged 65 or over.

The hospitalisation rate (figure 3) showed a similar trend to the number of hospital admissions. From 2000 to 2003, the overall hospitalisation rate dropped by 12.4% from 87.43 to 76.57 per 1000 population. Thereafter, the number of admissions increased and reached 94.51 per 1000 population in 2010. The general hospitalisation rate increased by 8.1% during the entire period. The hospitalisation rate for females was about 1.04–1.15 times that for males, but this difference has narrowed in recent years.

Although admission rates increased, the mean duration of stay decreased by 32.9% from 6.83 to 4.58 days

Figure 1 Number of hospitalisation admissions (individuals), 2000–2010.

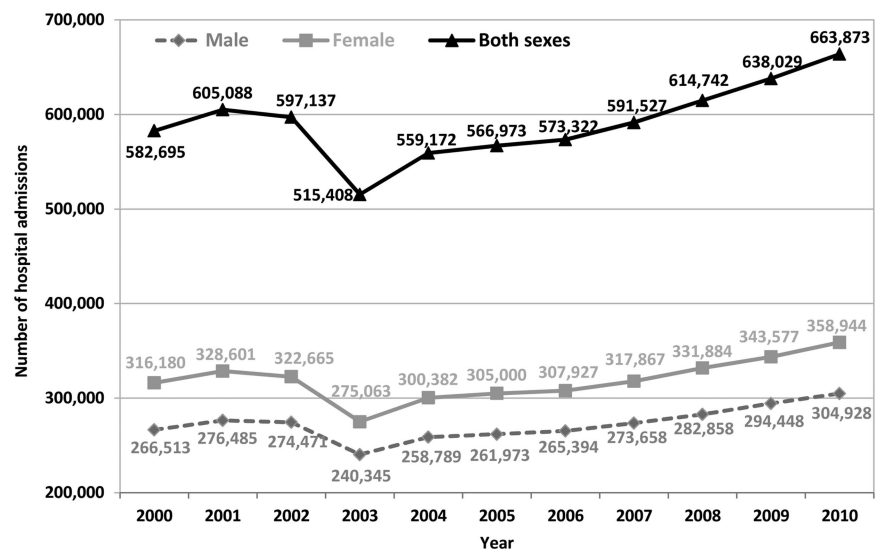
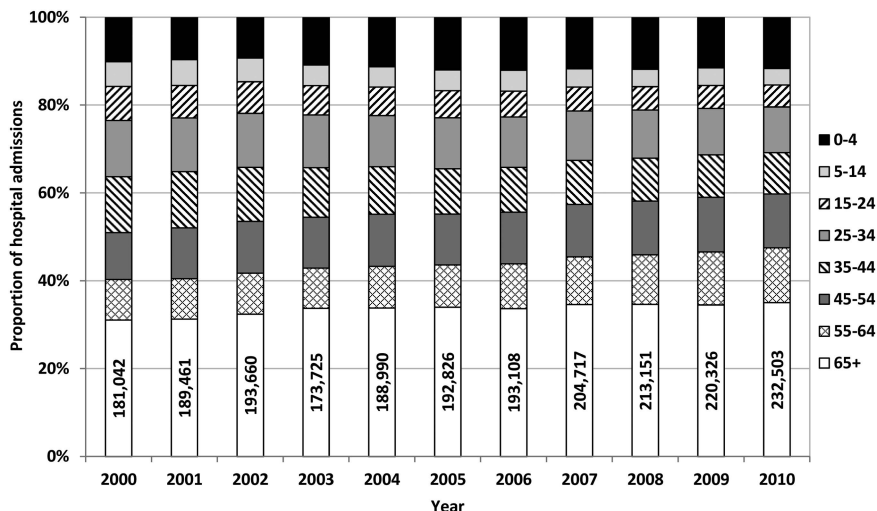




Figure 2 Proportion of hospitalisation admissions in individuals by age group, 2000–2010.



per episode from 2000 to 2010 (figure 4), with a larger reduction in males (35.4%, from 7.38 days to 4.77 days) than in females (30.3%, from 6.33 days to 4.41 days). However, we note that the number of hospital beds in Hospital Authority hospitals during the period declined by 8.1%.¹⁵ Moreover, the total number of hospitalisation days decreased by 17.1% between 2000 and 2010 (table 1).

The decomposition results

Table 2 shows the relative contributions of the differences in mean duration of stay per visit, number of visits per patient and hospitalisation rate per person from 2000 to 2010 as determined by the decomposition method.

In 2000, people were admitted to hospital for 1.18 days on average. By 2010, the number of admission days had fallen by 21% to 0.93 per person. Based on

equation (2), the numbers of hospitalisation days per person in 2010 and 2000 are decomposed as:

$$HD_{2010} = \frac{6518924}{7024200} = 0.93 = \frac{6518924}{1422807} \times \frac{1422807}{663873} \times \frac{663873}{7024200} = 4.58 \times 2.14 \times 0.09451$$

$$HD_{2000} = \frac{7865661}{6665000} = 1.18 = \frac{7865661}{1152215} \times \frac{1152215}{582695} \times \frac{582695}{6665000} = 6.83 \times 1.98 \times 0.08743$$

The ratio of hospitalisation days per person in 2010–2000 can be decomposed into the three factors as follows:

$$\frac{0.93}{1.18} = \frac{4.58}{6.83} \times \frac{2.14}{1.98} \times \frac{0.09451}{0.08743} = 0.67 \times 1.08 \times 1.08$$

Figure 3 Public hospital admission rate per 1000 population, 2000–2010.

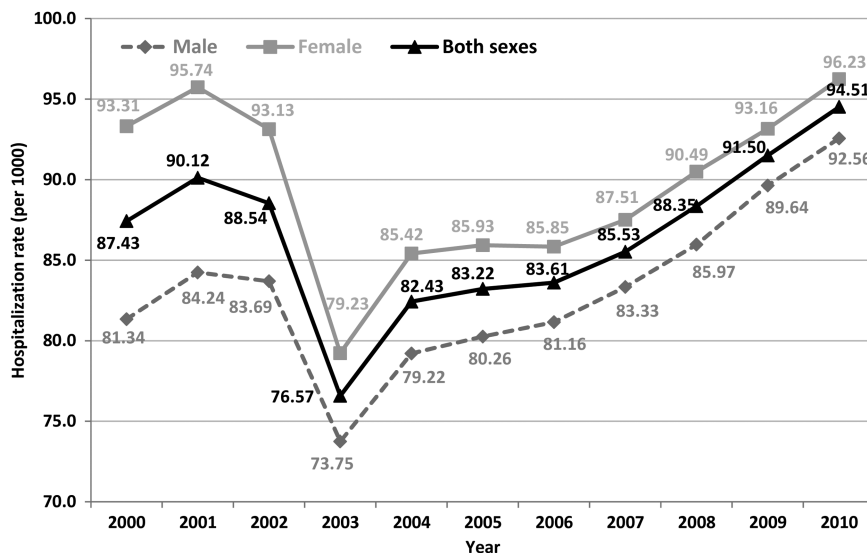
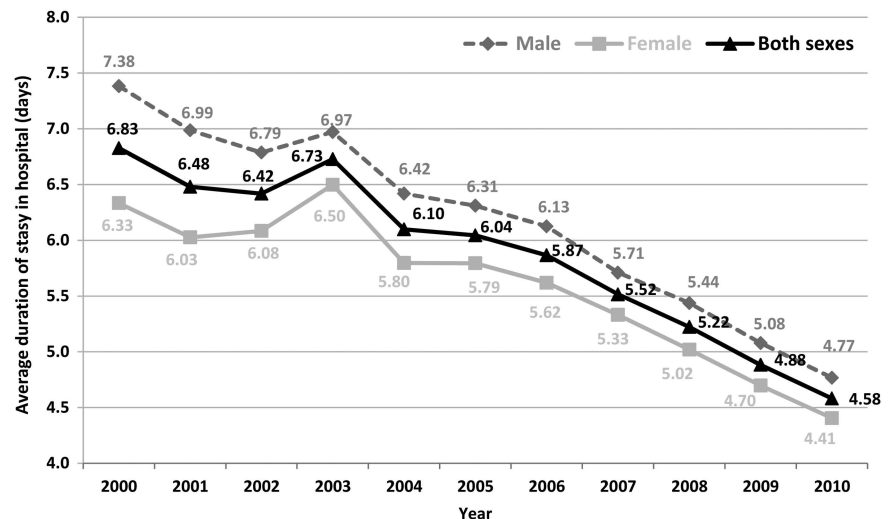


Figure 4 Mean duration of stay in hospital (days) per visit, 2000–2010.



Applying equation (4), the relative contributions of each factor are calculated as follows:

$$\begin{aligned} RC_{MS} &= \frac{0.67 - 1}{(0.67 - 1) + (1.08 - 1) + (1.08 - 1)} \times 100\% \\ &= \frac{-0.33}{-0.16} \times 100\% = 200.6\% \end{aligned}$$

$$\begin{aligned} RC_F &= \frac{1.08 - 1}{(0.67 - 1) + (1.08 - 1) + (1.08 - 1)} \times 100\% \\ &= \frac{0.08}{-0.16} \times 100\% = -51.1\% \end{aligned}$$

$$\begin{aligned} RC_{HR} &= \frac{1.08 - 1}{(0.67 - 1) + (1.08 - 1) + (1.08 - 1)} \times 100\% \\ &= \frac{0.08}{-0.16} \times 100\% = -49.4\% \end{aligned}$$

In short, the 200.6% reduction in the number of hospitalisation days per person from 2000 to 2010 is a result of the decrease in mean duration of stay per visit, and is offset by -51.1% due to the slight growth in the number of visits per patient and by -49.4% as a result of the difference in hospitalisation rates per person (see table 2).

The results of decomposition stratified by age and gender are presented in tables 3 and 4. The mean duration of stay for older adults (65+), those aged 15–64, and those aged under 15 reduced from 8.81 to 5.88 days, from 6.00 to 3.75 days, and from 4.10 to 3.23 days, respectively, from 2000 to 2010. About 95.0% and 74.8% of the reduction in hospitalisation days are due to the decrease in mean duration of stay for inpatients aged 15–64 and the elderly (65 or over), respectively. Stratifying by gender, the mean duration of stay for males and females reduced from 7.38 to 4.77 days, and from 6.33 to 4.41 days, respectively. Approximately 115.5% and 85.1% of the change is due to the reduction in the mean duration of stay of male and female inpatients despite increases in the number of visits per patient and the hospitalisation rate for both genders during this period.

DISCUSSION

The total number of hospitalisation days is the most important factor in determining financial funding and planning for the public hospital system in Hong Kong. Reducing hospital patient days is a major healthcare policy and practice worldwide.^{5 16} From 2002 to 2010, the mean duration of stay for all diagnoses dropped more in Hong Kong hospitals (30.0%) compared with 26 OECD countries, with declines of 23.1%, 15.0%, 18.7% and 2.0% in Australia, New Zealand, the UK and the USA, respectively. The reduction in Hong Kong (6.3 reducing to 4.4) was greater than in Mexico (4.2 reducing to 3.9) and the USA (4.9 reducing to 4.8), but similar to Australia (6.5 reducing to 5.0), Denmark (6.0 reducing to 4.6) and Norway (5.7 reducing to 4.5).

However, does a significant drop in duration of hospital stay indicate improved healthcare services over time? Good quality of care and an efficient healthcare system are both essential. Shortening the duration of hospital stay may be consistent with an orderly and systematic care pathway, but a longer duration of stay may be appropriate for extended treatment. As Clarke states, “The problematic nature of the relationship between LOS [length of stay] and quality needs to be acknowledged”.¹⁷

Our results show that the mean duration of stay plays a significant role in determining the number of hospitalisation days against an overall hospital occupancy of 90%. The number of visits per patient increased from 1.98 to 2.14, and the hospitalisation rate increased from 87.43 to 94.51 (possibly due to the ageing of the population). However, the reduction in the mean duration of stay from 6.83 to 4.58 days contributed to the 21% reduction in the number of hospitalisation days per person. The reduction in duration of hospital stay may also have reduced the risk of cross-infection, especially among older adults and immune-compromised patients. Hence, even a shorter mean duration of stay per visit, which may be associated with an increase in the number of re-visits, still results in a reduction in the total number of hospitalisation days.

Table 2 Summary of the decomposition of hospitalisation days per person from 2000 to 2010

	Number of hospitalisation days per person	Decomposition		
		Mean duration of stay per visit	Number of visits per patient	Hospitalisation rate (per 1000)
2010	0.93	4.58	2.14	94.51
2000	1.18	6.83	1.98	87.43
(2010–2000):2000 ratio	–0.21	–0.33	0.08	0.08
Relative contribution (%)	–	200.6	–51.1	–49.4

The number of people with chronic illness increased by more than 4% each year, which is higher than the anticipated increase in funding for the Hong Kong medical and health services and the growth in GDP.¹⁸ Hong Kong has one of the longest life expectancies in the world (81 years for males and 86 years for females), so people are living longer, but they are not necessarily healthier.^{10–19} The rise in hospitalisation is also driven by the continuing increase in demand for medical and health services, improved medical technologies and enhanced public expectations. A focused management system controlling duration of hospital stay is important for attaining service efficiency and containing the increase in healthcare expenditure. Possible poor patient satisfaction, arising from shorter stays, has not been considered in the current assessment. However, studies in The Netherlands suggest no correlation between shorter duration of stay and patient satisfaction, except in pulmonology.²⁰ Also, the patient satisfaction level in Hong Kong remains high at around 80%, and shorter stays do not seem to be correlated with patient satisfaction.²¹

However, the increased workload for medical and health staff as a result of shorter stays has not been properly measured or reflected in cost considerations.

A recent survey in Hong Kong public hospitals found increasing workload was a major factor contributing to the very high burnout rate.²² Certainly, additional investment in human resources and equipment as well as utilisation of newer technologies can help alleviate the impact of patient volume on the workload of healthcare workers. These are important service quality considerations in assessing the cost-effectiveness of shorter hospital stays.

There are some limitations in applying the decomposition method as described in this study. First, it is a non-parametric method and can be used only as an exploratory technique. Second, we assume the workload for medical and health workers per hospitalisation day is the same for every patient, which is unlikely. It has been reported that the introduction of day surgery, as opposed to admitting the patient the previous day, has resulted in an excessive workload for medical and healthcare workers. Therefore, a simple count of the number of hospitalisation days might not properly reflect the additional work arising from the reduction in the mean duration of stay per visit. Although possible change in the case mix has not been considered in examining the reduction in hospitalisation days, the lack of any significant change in the morbidity and mortality

Table 3 Summary of the decomposition of hospitalisation days per person by age group from 2000 to 2010

	Age group	Number of hospitalisation days per person	Decomposition		
			Mean duration of stay per visit	Number of visits per patient	Hospitalisation rate (per 1000)
2010	0–14	0.60	3.23	1.53	121.03
	15–64	0.48	3.75	2.05	62.55
	65+	3.79	5.88	2.54	253.13
	Overall	0.93	4.58	2.14	94.51
2000	0–14	0.51	4.10	1.53	81.17
	15–64	0.72	6.00	1.87	64.48
	65+	5.22	8.81	2.39	248.27
	Overall	1.18	6.83	1.98	87.43
(2010–2000):2000 ratio	0–14	0.18	–0.21	0.00	0.49
	15–64	–0.34	–0.37	0.09	–0.03
	65+	–0.27	–0.33	0.07	0.02
	Overall	–0.21	–0.33	0.08	0.08
Relative contribution (%)	0–14	–	30.8%	0.0%	–49.2%
	15–64	–	95.0%	–34.1%	–0.2%
	65+	–	74.8%	–17.0%	–0.1%
	Overall	–	200.6%	–51.1%	–49.4%

Table 4 Summary of the decomposition of hospitalisation days per person by gender from 2000 to 2010

	Gender	Number of hospitalisation days per person	Decomposition		
			Mean duration of stay per visit	Number of visits per patient	Hospitalisation rate (per 1000)
2010	Male	1.00	4.77	2.27	92.56
	Female	0.86	4.41	2.04	96.23
	Overall	0.93	4.58	2.14	94.51
2000	Male	1.22	7.38	2.03	81.34
	Female	1.14	6.33	1.93	93.31
	Overall	1.18	6.83	1.98	87.43
(2010–2000):2000 ratio	Male	–0.18	–0.35	0.12	0.14
	Female	–0.24	–0.30	0.06	0.03
	Overall	–0.21	–0.33	0.08	0.08
Relative contribution (%)	Male	–	115.5%	–41.5%	–47.0%
	Female	–	85.1%	–9.7%	–2.4%
	Overall	–	200.6%	–51.1%	–49.4%

pattern in Hong Kong during the period indicates any variation in case mix is expected to be limited. Furthermore, systems monitoring the complicated relationship among shortened duration of stay, the capacity of public hospitals and the quality of care (in terms of patient safety and satisfaction) in the public hospital system in Hong Kong need to be formulated carefully.

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