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Research paper

Comparison of different methods to forecast hospital bed needs

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ABSTRACT

Objectives: This study compares three methods to forecast the number of acute somatic hospital beds needed in a Swiss academic hospital over the period 2010–2030.
Design: Information about inpatient stays is provided through a yearly mandatory reporting of Swiss hospitals, containing anonymized data. Forecast of the numbers of beds needed compares a basic scenario relying on population projections with two other methods in use in our country that integrate additional hypotheses on future trends in admission rates and length of stay (LOS).
Results: The total number of beds in the hospital under study is projected to increase from 960 beds in 2010 to a range of 1188 to 1332 in 2030. This estimated growth equals to 24% to 39% of the hospital size at baseline, and these different figures are largely due to hypotheses about future reduction in LOS. Conversely, as the models' hypotheses regarding future demand have balanced effects on global admission rates, the three methods lead to similar projections for the number of stays, which is estimated to increase by 33% between 2010 and 2030.
Conclusion: In the context of population aging, forecasting the number of hospital beds should not rely on a unique scenario. Using different hypotheses about admission rates and LOS, and comparing projected versus real use are important to avoid shortage of beds.

1. Background

Planning the appropriate number of hospital beds is a challenge that must take into account potential changes both in demand and length of stay (LOS). Population growth and aging is the major factor that has been shown to increase the demand for hospital care, and will continue to do so over the next decades. Indeed, persons aged 65 years and over are high users of hospital stays, showing both higher admission rates and longer stays [1,2]. Therefore, the large number of baby-boomers reaching this age in a near future must be taken into account in forecasting a sufficient number of hospital beds.

Changes in health status and health behaviors also likely influence these projections, as well as technological advances and the continuous search for efficiency in clinical care. An important determinant of future need for inpatient days is the reduction in LOS observed over the past decades, partly linked to the shift from inpatient to outpatient surgery and to the introduction of fixed payment systems with Diagnosis-Related Groups (DRGs) [3,4]. However, uncertainty remains regarding the real impact of these different factors and their evolution over time. Planning a sufficient number of hospital beds in the public sector must, therefore, rely upon reasonable assumptions about their future trends in order to ensure access to appropriate care.

Abbreviations: DRG, Diagnosis-Related Groups; CHOP, Classification Suisse des Interventions chirurgicales; CHUV, Centre Hospitalier Universitaire Vaudois; ICD, International Classification of Diseases; LOS, Length of stay; SHO, Swiss Health Observatory.

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In Switzerland, search for efficient care is one component of the 1996 new Health Insurance Law, and has been reinforced through the progressive introduction of hospital financing based on DRGs. In this context, the Swiss Health Observatory (SHO) proposed a method for hospital planning, which encompasses hypotheses on the evolution of admission rates and LOS [5]. Its main assumption is that, for each DRG, the mean LOS observed in one hospital could shrink over a 10-year period towards a shorter LOS observed in other Swiss hospitals at baseline. This benchmarking method uses the ranking of the hospitals based on their mean DRG-specific LOS. Among other options, the second shortest mean DRG-specific LOS can be chosen as a target. This method was elaborated to help planning the number of beds at the level of a region with several hospitals, and might not be suitable for use at the level of a single hospital. Moreover, the target might be more difficult to reach for university hospitals, because of their particular case-mix. Therefore, an additional variant was proposed, which ranks all stays that occurred in the five Swiss university hospitals based on length and uses the 40th percentile of the distribution as target.

It is to note that a range of different methods to plan the number of hospital beds are used in Switzerland at the time being. Therefore, the objective of this study was to estimate the need for acute somatic hospital beds in a Swiss academic hospital over the period 2010–2030 using three different methods. It compares a basic scenario relying on population projections only with the SHO method modified for the university hospitals and the method used by the Lausanne University Hospital.

2. Methods

2.1. Setting

The Lausanne University Hospital (centre hospitalier universitaire Vaudois, CHUV), with its nearly 1000 beds, serves as the city hospital for Lausanne (250,000 inhabitants), and as a secondary hospital for the population of the Canton de Vaud (750,000 inhabitants). It is one of the five university hospitals in Switzerland.

2.2. Hospital statistics

Information about inpatient stays is based on a yearly mandatory reporting of all cases discharged from Swiss hospitals. This exhaustive and reliable database contains variables pertaining to the hospital itself (infrastructure…), as well as socio-demographic information and medical data related to each patient's stay. Medical data include primary and secondary diagnoses, along with main interventions undertaken during the stay. Medical information is converted into ICD-10 (International Classification of Diseases, 10th edition) and CHOP codes (Classification Suisse des Interventions chirurgicales, based on ICD-9—CM) by trained coders, and then into DRGs using a specific grouper [6,7].

2.3. Baseline data

Baseline data comprised all acute somatic care stays registered among all patients discharged from the CHUV during the year 2010 (n = 33,643 stays, each classified into one of 811 different DRGs), except healthy neonates whose stay is included in the one of their mother. Patients residing outside the Canton of Vaud were also included into the analysis (n = 4183 stays, 12% of the total). Admission rates were computed by age, for each DRG.

2.4. Population projections data

The median scenario of the most recent projections of the number of residents in the Canton of Vaud until 2030, supplied by the Statistical Office of Canton de Vaud, were used [8].

2.5. Hypotheses

The hypotheses included in each model are described in Table 1:

- briefly, the basic scenario assumes that age-, and DRG-specific admission rates will remain constant, as will the mean LOS for each DRG;
- based on the proposed variant of the Swiss Health Observatory (SHO) model, the next scenario postulates that for each DRG, the

Table 1
Hypotheses of the three models for projecting hospital use.

Model	Hypotheses regarding changes in demand	Hypotheses regarding length of stay (LOS)
Basic	Age- and DRG-specific admission rate remains constant	Mean DRG-specific LOS remains constant
Swiss Health Observatory (SHO)	Age- and DRG-specific admission rate remains constant	DRG-specific LOS decreases over the next 10 years to reach the P40 of the stays observed in all 5 Swiss University Hospitals, ranked by length. This target does not apply: - when the stay is an outlier in its DRG - in case the difference exceeds 4 days or 20% of the CHUV-LOS, the method is to select the value closest to the CHUV-LOS (i.e. either the CHUV-LOS minus 4 days or the CHUV-LOS minus 20%) Outliers stays are projected with unchanged LOS
Lausanne University Hospital (CHUV)	Based on past trends in demand, the following hypotheses have been proposed: Medical DRGs: over the next 5 years: - admission rate decreases by 2% in population aged 15-64 years, and by 7% in population aged 65-74 years - admission rate increases by 5% in population aged 75-84 years, and by 7% in population aged 85+ years Then, admission rates remains constant. Surgical DRGs: admission rate increases by 10% over the next 5 years for population aged 75-84 years, then it remains constant	Medical DRGs: mean DRG-specific LOS remains constant Surgical DRGs: mean DRG-specific LOS decreases by 10% over the next 10 years (all age groups), then remain constant

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Table 2a
Projection of the number of hospital stays until 2030.

	Basic model					SHO model					CHUV model				
	2010	2015	2020	2025	2030	2010	2015	2020	2025	2030	2010	2015	2020	2025	2030
Sub-total medical	19'814	21'474	23'223	25'005	26'761	19'814	21'488	23'260	25'031	26'745	19'814	21'293	22'965	24'709	26'543
Sub-total surgical	13'749	14'865	16'040	17'151	18'139	13'749	14'857	16'037	17'146	18'144	13'749	15'021	16'064	17'164	18'227
Sub-total other	80	87	96	105	111	80	87	97	105	112	80	87	94	101	109
Total	33'643	36'427	39'359	42'261	45'011	33'643	36'432	39'393	42'282	45'001	33'643	36'401	39'122	41'974	44'879

LOS will decrease over the next 10 years to reach the 40th percentile of the distribution of the stays observed in the 5 Swiss university hospitals (including the CHUV), ranked on their length. Restricting the analysis to the university hospitals allowed to get a more homogeneous case-mix. Note that this benchmark is not used when:
  - the stay is an outlier in its DRG,
  - the CHUV registered less than 25 inlier stays related to this DRG during year 2010,
  - the difference between the CHUV's 2010 LOS and the 40th percentile of the distribution of all university hospital stays is considered excessive (i.e. higher than 4 days in absolute difference or higher than 20% in relative difference. In this case, the method is to select the value closest to the CHUV-LOS (i.e. either the CHUV-LOS minus 4 days or the CHUV-LOS minus 20%).

  Regarding outliers stays and DRGs with less than 25 inliers stays, projections are based on unchanged baseline LOS.
- the method proposed by the CHUV integrates hypotheses about future trends in admission rates and in LOS. Based on observation from the past 10 years, admission rates for medical stays are expected to continue to decrease over the next 5 years in patients younger than 75 years, and to increase in those aged 75 and over. As for surgical stays, admission rates are expected to increase in the 75-84 years age group over the same period. After this 5-year period, all admission rates remain constant. Based on observation from the past 10 years and assumptions about changes in surgery techniques and management, LOS is assumed to decrease by 10% over the next 5 years in surgical stays, due to changes in the management of surgical patients, and to remain constant when no surgery is performed.

In each model, the proportion of stays (per DRG) pertaining to patients residing outside the Canton of Vaud is supposed to remain constant over time, as there is no strong hypothesis about future changes regarding the flow of patients from and to regions outside the canton.

2.6. Estimation of the number of beds required

The number of beds needed over the study period was estimated using a 3-step process:

- estimation of the annual number of stays using age-, and DRG-specific admission rates and the population projections data;
- forecast of the annual number of inpatient days: for each DRG, the number of days is computed by multiplying the annual number of stays by their projected average LOS;
- computation of the number of beds by dividing the number of inpatient days by 365 (days), and by applying an occupancy rate, set up at 85% in each model.

3. Ethics

This study is based on the use of data routinely collected in all Swiss hospitals, then transmitted to statistical offices for analytical purposes. Both data pertaining to the patients and to the hospitals are anonymized. Therefore, no ethics approval was necessary.

4. Results

Over the next two decades, the population of the Canton will age and grow. Most of this demographic change is driven by population aging, with a projected 50% increase in the number of residents aged 65–79 years, and an even larger, unprecedented 80% growth in the group of persons aged 80 years and over [8]. In addition, the absolute number of persons under 65 years is also expected to rise, due to a high number of immigrants attracted by the local economic context.

Regarding the projections in the number of stays (Table 2a), the three methods lead to very close estimates, rising from 33,643 stays in 2010 to about 45,000 in 2030, corresponding to more than 11,300 additional stays (+33%) in 2030. The CHUV model, assuming a reduction in the medical stays for patients under 75 years of age, leads to a difference of only 131 stays (0.3%) in 2030. Overall, all three methods forecast an annual growth of more than 500 stays.

Projecting the number of stays by Major Diagnostic Categories show no significant difference between the three methods (not shown in table). The 20-year growth ranges from 13% for obstetrical stays to 49% for stays attributable to cardiovascular problems, with or without surgery. As a consequence, about 100 additional stays are expected to be necessary each year to take care of patients with cardiovascular conditions.

Inpatient stays attributable to musculo-skeletal disorders are also expected to increase by about 33% (surgical stays) to 44% (stays without surgery), equivalent to some 90 additional stays each year between 2010 and 2030.

Over the next 20 years, the number of inpatient days is projected to increase by 24% according to the SHO model to 39% if using the basic scenario (Table 2b). The reduction in LOS assumed

Table 2b
Projection of the number of hospital inpatient days until 2030.

	Basic model					SHO model					CHUV model				
	2010	2015	2020	2025	2030	2010	2015	2020	2025	2030	2010	2015	2020	2025	2030
Sub-total medical	145'716	158'995	173'279	188'609	204'691	145'716	149'510	152'733	165'719	179'030	145'716	158'311	172'155	187'131	203'764
Sub-total surgical	149'261	162'770	177'402	191'483	204'749	149'261	155'325	161'202	173'770	185'532	149'261	156'331	159'760	172'497	185'357
Sub-total other	2'791	3'036	3'374	3'632	3'822	2'791	3'052	3'375	3'630	3'861	2'791	3'026	3'242	3'482	3'714
Total	297'768	324'801	354'055	383'724	413'262	297'768	307'887	317'310	343'119	368'423	297'768	317'668	335'158	363'110	392'836

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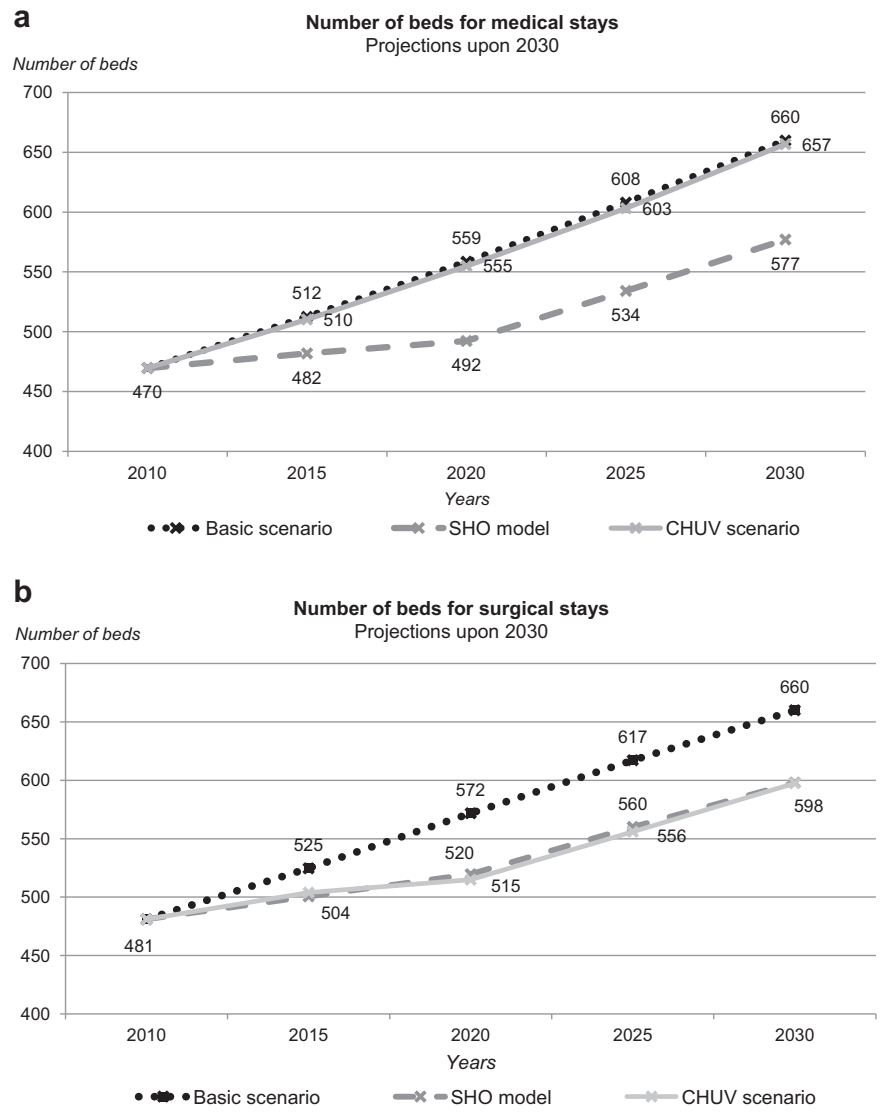

Fig. 1. a: projection of the number of beds for medical stays over the period 2010–2030; b: projection of the number of beds for surgical stays over the period 2010–2030.

in the SHO model involved about one third of the 811 DRGs, while two-thirds were not concerned, because less than 25 inliers stays were registered for these DRGs.

The number of beds needed in the CHUV (Fig. 1a and b, Table 2c) is projected to increase from 960 beds in year 2010 to a range comprised between 1188 (+228 beds) and 1332 (+372 beds) in 2030. Thus, the difference between the three methods of projection amounts 70 to 144 beds that have to be planned to face supplementary admissions. This estimated growth equals 24% to 39% of the size of the hospital at baseline year. As the CHUV model postulates a reduction in LOS for surgical stays only, its projections of the number of beds needed for surgical stays are close to SHO model. Major differences (> 20 beds) are to be anticipated for stays attributable to cardiovascular and orthopedic problems, which constitute a large share of the total number of stays.

5. Discussion

This study illustrates how different models elaborated for hospital planning reach quite different estimations of the number of beds needed after 20 years, although they get similar estimates regarding the projected number of stays.

Overall, all three models converge towards a 33% increase in the number of stays, mainly driven by the aging of the population. As

Table 2c
Projection of the number of hospital beds until 2030.

	Basic model					SHO model					CHUV model				
	2010	2015	2020	2025	2030	2010	2015	2020	2025	2030	2010	2015	2020	2025	2030
Sub-total medical	470	512	559	608	660	470	482	492	534	577	470	510	555	603	657
Sub-total surgical	481	525	572	617	660	481	501	520	560	598	481	504	515	556	597
Sub-total other	9	10	11	12	12	9	10	11	12	12	9	10	10	11	12
Total	960	1'047	1'141	1'237	1'332	960	992	1'023	1'106	1'188	960	1'024	1'080	1'170	1'266

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older persons are hospitalized more often than younger ones, the growth in the projected number of stays exceeds the one of the population. It can be viewed as almost inevitable, unless admission rates can be reduced in older persons. For example, as cardiovascular diseases are responsible for 25% of hospitalizations among patients aged 65 years and over [2], further efforts to prevent and manage these conditions could have a small but significant impact on the number of future hospital admissions. Of note, none of the models compared in this work postulated a decrease in admission rates in persons aged over 65 years, suggesting that such a trend is not viewed as plausible now. In the CHUV model, the hypothesis of reduced admission rates in the population aged under 75 years had a limited effect on the projected number of stays.

This study demonstrates how assumptions about future LOS impact on the number of beds needed in the hospital. Although the SHO benchmarking method applied to only a third of DRGs, those with a sufficient number of inlier cases, it reduced the basic model's projected increase in the number of beds by 10%.

Targeting shorter LOS might appear an appealing solution to reduce the number of extra beds required in the future, but it is not always realistic for one hospital to attain DRG-specific LOS observed in another hospital. In this study, the benchmark was based on LOS of all five Swiss university hospitals, selected as they have a more similar case-mix than other non-academic hospitals. Nevertheless, each university hospital also serves as local primary care hospital, and, therefore, admits a certain proportion of non-complex cases. A hospital might also operate strong patients' selection (i.e. not too severe cases) for some specific DRGs. As a consequence, targeting the 40th percentile of LOS observed in the Swiss university hospitals might convey an important challenge and perhaps be out of reach for some DRGs while trying to maintain quality of care. On the other hand, it has been shown that physicians tend to adapt their length of stay decisions to what is usual in the hospital where they work [9]. This tendency might explain why some hospitals show longer LOS for specific DRGs, with room for improvement.

One can postulate that the case-mix of inpatients will become heavier over time, as the shift to day surgery for elective interventions will involve fit patients more often than complex ones, as well as the shift towards home and ambulatory care for some medical treatments (e.g. oncology, etc.) [3]. This evolution of the inpatient population might preclude significant shortening of LOS in acute wards, all the more as a significant proportion of these patients are likely to need post-acute care, whose availability might also be limited. Finally, even when facing strong pressure towards cost-effectiveness, a sufficient margin has to be secured to prevent bed shortage, which might have serious consequences on the quality of care that can be provided to the population, especially the elderly [13,14].

This study, of course, has some limitations. Notably, none of the three methods specifically quantified the impact of other potential factors, such as technological progress, changes in health status and expectations of the population, epidemiological changes regarding the most frequent reasons for hospital admission, and transfer from inpatient to outpatient care. However, previous studies concluded that population's aging was the major drive of increasing hospital use and that the effects related to these numerous other factors could be considered as marginal, as they are quite often opposite [11]. Another limitation regards the limited proportion of DRGs really impacted by the SHO model (30%) when applied to one single hospital, even with a large annual number of admissions. This indicates that a large number of DRGs are relatively uncommon or are related to very heterogeneous LOS,

As a major strength of this work, the quality of the data cannot be disputed, as the hospital database has been shown to be exhaustive and the reliability of coding, which is controlled since 1999, has been rated as good over the years 2008–2009 in the CHUV [10]. The use of observed data distributed by DRG accounts for effective bed use and clinical needs.

6. Conclusion

Globally, by quantifying how the results of three models differ over the long term, this study illustrates that planning hospital beds using a unique formula is not possible [12]. Each method has advantages and disadvantages, depending on whether the forecast targets a region or a single hospital, a primary or tertiary hospital. As a consequence, it might be better to provide alternative projections based on different hypotheses as a basis for policy decisions. Finally, real use of hospital, in terms of admissions and inpatient days, should be monitored and confronted to past projections, in order to assess the appropriateness of underlying hypotheses and revise them accordingly.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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