

BMJ Open Trends in the supply of California's emergency departments and inpatient services, 2005–2014: a retrospective analysis

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ABSTRACTS

Objectives Given increasing demand for emergency care, there is growing concern over the availability of emergency department (ED) and inpatient resources. Existing studies of ED bed supply are dated and often overlook hospital capacity beyond ED settings. We described recent statewide trends in the capacity of ED and inpatient hospital services from 2005 to 2014.

Design Retrospective analysis.

Setting Using California hospital data, we examined the absolute and per admission changes in ED beds and inpatient beds in all hospitals from 2005 to 2014.

Participants Our sample consisted of all patients (inpatient and outpatient) from 501 hospital facilities over 10-year period.

Outcome measures We analysed linear trends in the total annual ED visits, ED beds, licensed and staffed inpatient hospital beds and bed types, ED beds per ED visit, and inpatient beds per admission (ED and non-ED).

Results Between 2005 and 2014, ED visits increased from 9.8 million to 13.2 million (an increase of 35.0%, $p < 0.001$). ED beds also increased (by 29.8%, $p < 0.001$), with an average annual increase of 195.4 beds. Despite this growth, ED beds per visit decreased by 3.9%, from 6.0 ED beds per 10 000 ED visits in 2005 to 5.8 beds in 2014 ($p = 0.01$). While overall admission numbers declined by 4.9% ($p = 0.06$), inpatient medical/surgical beds per visit grew by 11.3%, from 11.6 medical/surgical beds per 1000 admissions in 2005 to 12.9 beds in 2014 ($p < 0.001$). However, there were reductions in psychiatric and chemical dependency beds per admission, by $-15.3%$ ($p < 0.001$) and $-22.4%$ ($p = 0.05$), respectively.

Conclusions These trends suggest that, in its current state, inadequate supply of ED and specific inpatient beds cannot keep pace with growing patient demand for acute care. Analysis of ED and inpatient supply should capture dynamic variations in patient demand. Our novel 'beds per visit' metric offers improvements over traditional supply measures.

INTRODUCTION

Emergency departments (EDs) play a critical role in the US health delivery system. EDs provide the only guaranteed around-the-clock healthcare access to all, regardless of financial background.¹ EDs also serve as

Strengths and limitations of this study

- This study evaluates trends in hospital supply using a novel 'beds per visit' metric that reflects dynamic variations in patient demand not captured by traditional absolute or per capita measures.
- Compared with prior inpatient supply research, this study explores trends in medical/surgical, intensive care unit, coronary care unit, psychiatric and chemical dependency bed capacity beyond the emergency department.
- The analyses are limited by availability of data on staffed beds compared with licensed beds.

the main entry for many severely ill patients who require inpatient hospital care.² Despite expansions in outpatient and primary care visits, use of the ED has risen substantially even after accounting for population growth, resulting in greater ED crowding.^{3–6}

In 2007, the Institute of Medicine reported that 91% of EDs were crowded, with close to 40% noting daily crowding.⁷ Nearly a decade later, a 2015 national survey released by the American College of Emergency Physicians revealed that the issue of ED crowding persists despite the implementation of the Affordable Care Act (ACA). 75% of emergency physician respondents said patient volumes have increased since the ACA took effect.⁶

Patients in crowded EDs have a greater likelihood of experiencing long wait times, leaving without being seen by a physician, feeling unsatisfied with their care, and having worse medical outcomes including delays in diagnosing myocardial infarction and increased mortality rates.^{8–15} ED congestion may also eliminate reserve hospital capacity for accommodating critical incidents such as infectious disease epidemics or national disasters.¹⁶

Most of the work on ED crowding focuses on increasing demand, and often overlooks investigating another key aspect of ED



congestion—supply. While experts acknowledge that ED crowding is associated with hospital bed shortages and inpatient boarding,^{9 10 17 18} there exists limited clinical literature that examines bed capacity of hospitals and their EDs. Most of this literature neglects hospital capacity beyond the ED or lacks updated data.^{3 19–21} Given that increasing data show how ED crowding relates to inpatient factors,^{16 22} accessibility to prompt emergency care requires characterisation of ED crowding in the context of the entire delivery system.

Therefore, this study examines recent statewide trends in the capacity of both of California's hospital EDs and inpatient settings from 2005 to 2014. Our analysis of the complete census of California hospitals illustrates how the number of ED beds and inpatient beds has changed over time. Specifically, our study aims to evaluate hospital capacity using traditional (absolute, per capita) and novel (beds per visit) supply measures that may potentially have important implications for resource allocations in appropriately caring for patients originating from any ED.

METHODS

Study design and data sources

We analysed data from California's Office of Statewide Health Planning and Development (OSHPD), which conducts an annual, standardised survey required of all hospitals and health services in the state. We used full census data from OSHPD's Annual Financial Reports of Hospitals and Hospital Annual Utilization Data from 2005 to 2014 to evaluate supply trends in emergency and inpatient care of California's hospitals.^{23 24} To account for changes in population, we used the US Census annual population estimates to calculate annual ED and inpatient rates. This study was exempt from review by the human subjects' protection office of the University of California, San Francisco.

Inclusion criteria and variable definitions

For each year, we included all hospitals operating in the state of California. For analyses restricted to hospitals with EDs, we excluded hospitals if they were reported as closed at the end of the year, were licensed but not in operation, had its licence in suspension or reported the number of ED patient visits as zero. We included all hospitals with an open ED in service at the end of each year and all hospitals without an ED. Our final sample included 5012 hospital years over the 10-year period (across 481–501 hospital facilities) and all patients (inpatient and outpatient) without further sample restrictions.

We determined hospital and ED ownership in a given year as the most recent ownership (government, non-profit or for-profit) reported in the fiscal year. In cases where ownership status was missing, we used the most recent data with a non-missing ownership type. We characterised hospitals as urban or rural by employing the county-based Centers for Disease Control and Prevention urban–rural classification scheme, with rural hospitals as those located

in non-metropolitan counties.²⁵ We classified ED visits as inpatient if the ED visit resulted in a hospital admission, and outpatient if the ED visit resulted in treatment and release without admission.

Statistical analysis

For each year, we analysed the total number of ED visits (total, outpatient, inpatient), hospital admissions, hospitalisation days, ED beds, licensed and staffed inpatient beds (medical/surgical, intensive care unit (ICU), coronary care unit (CCU), psychiatric or chemical dependency recovery), and emergency medical services licensure (standby, basic or comprehensive EDs based on OSHPD facility categorisations) online (supplementary table 1).²⁶ Licensed beds included all health facility inpatient beds licensed by the Department of Health Services, whereas staffed beds included beds that were staffed, equipped and ready for use as needed.²⁷ Hospitals staff beds occupied by inpatients and an increment of beds for unanticipated admissions.²⁷ However, the literature often reports hospital occupancy rates as a ratio of licensed beds, rather than actual staffed bed supply.^{28 29} Therefore, we examined both licensed and staffed bed measures to determine true bed supply.

We calculated the absolute number of beds and the number of beds per capita, and developed two bed supply measures that provide a unique perspective on hospital bed demand: ED beds per ED visit (calculated as the ratio of the number of ED beds divided by the number of ED visits) and inpatient beds per admission (calculated as the ratio of the number of inpatient beds divided by the number of ED and non-ED admissions) online (supplementary table 1). To our knowledge, these two measures have not been used previously in the literature. Existing literature has traditionally denominated ED utilisation with population estimates to show per capita measures of demand, which can provide an important perspective.^{30–33} Our novel supply measures reflect the use of resources relative to actual demand not captured using per capita measures. We also performed a stratified analysis to determine if inpatient bed supply measures were similar across hospitals without EDs.

To assess the statistical significance of changes in ED and hospital characteristics over the study period, we used linear models for continuous outcomes and reported the p value associated with the coefficient on the variable 'year'. No other variables (aside from a constant term) were included in the models as controls. SEs are robust to heteroscedasticity. All analyses were performed using Stata V.13.1 software.

RESULTS

ED and inpatient demand

Table 1 provides a summary of the measures from 2005 to 2014. During this period, the total annual visits to California EDs increased by 35% (p<0.001 for 10-year trend), from an estimated 9.8 million to 13.2 million visits. When

**Table 1** ED visits, hospitalisations, facilities, capacity and ownership in hospitals with an ED, 2005–2014

Variable	2005 N (%)	2014 N (%)	Per cent difference*	p Value for trend
ED visits				
Total ED	9 824 501†	13 261 674†	34.99	<0.001
Outpatient ED	8 357 519 (85.1)	11 436 280 (86.2)	36.84	<0.001
Inpatient ED	1 466 982 (14.9)	1 825 394 (13.8)	24.43	<0.01
Hospitalisations				
Admissions	3 182 583†	3 026 729†	-4.90	0.06
Hospital days	16 623 075†	14 526 322†	-12.61	<0.001
Facilities				
Total EDs	333†	339†	1.80	0.05
Comprehensive EDs	9(2.7)	9(2.7)	0.00	---
Basic EDs	285(85.6)	298(87.9)	4.56	<0.001
Standby EDs	39(11.7)	32(9.4)	-17.95	<0.01
Capacity in hospitals with EDs (number of beds)‡				
ED	5904†	7663†	29.79	<0.001
Medical or surgical	36989†	39147†	5.83	<0.001
Intensive care unit	5145†	6244†	21.36	<0.001
Coronary care unit	940†	922†	-1.91	0.21
Psychiatric	3691†	2975†	-19.40	<0.001
Chemical dependency	321†	237†	-26.17	0.03
Ownership				
<i>Number of hospitals</i>				
Government	71(21.3)	66(19.6)	-7.04	<0.001
Non-profit	203(61.0)	208(61.7)	2.46	0.01
For-profit	59(17.7)	63(18.7)	6.78	0.80
<i>Number of ED beds</i>				
Government	1135(19.2)	1394(18.2)	22.82	<0.001
Non-profit	4006(67.9)	5192(67.8)	29.61	<0.001
For-profit	763(12.9)	1077(14.0)	41.15	<0.001

Percentages might not add up to 100 because of rounding.

*Difference in numbers from 2005 to 2014.

†Not applicable.

‡Licensed beds reported (no staffed beds in this table due to data quality issues).
ED, emergency department.

adjusted for population growth, ED visits climbed steadily over the study period, from 274 visits per thousand persons in 2005 to 342 visits per thousand persons in 2014, for an increase of 24.6% ($p<0.001$) online (supplementary table 2). The proportion of ED visits requiring inpatient admission decreased from 14.9% to 13.8% ($p<0.01$), along with an absolute 4.9% decrease in all hospitalisations (ED and non-ED hospitalisations) ($p=0.06$) and a 12.6% decrease in overall length of hospital stay ($p<0.001$).

ED capacity

The total number of EDs in California increased by 1.8%, from 333 in 2005 to 339 in 2014 ($p=0.05$). Similarly, the total number of ED beds also grew from 5904 beds in 2005 to 7663 beds in 2014 (+29.8%, $p<0.001$), with an average increase of 195.4 beds per year (figure 1A). When examining absolute and per capita measures, growth in total ED visits (absolute rate +35.0%, $p<0.001$; per capita rate +24.6%, $p<0.001$) nearly matched the growth in

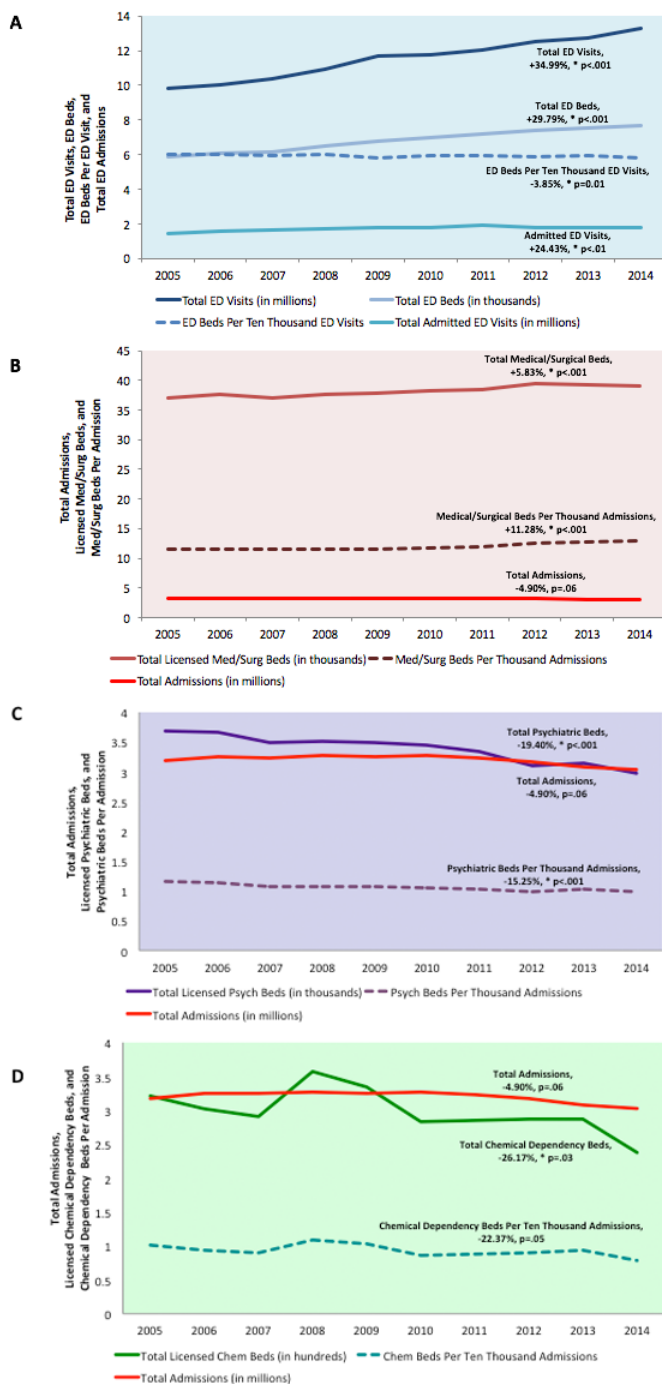


Figure 1 (A) Total emergency department (ED) visits, ED beds, ED beds per ED visit, total ED admissions and per cent change, 2005–2014. (B) Total admissions, licensed medical/surgical beds, licensed beds per admission and per cent change, 2005–2014. (C) Total admissions, licensed psychiatric beds, licensed psychiatric beds per admission and per cent change, 2005–2014. (D) Total admissions, licensed chemical dependency beds, licensed chemical dependency beds per admission and per cent change, 2005–2014. *Denotes changes from 2005 to 2014 that are significant ($p<0.05$).

total ED beds (absolute rate +29.8%, $p<0.001$; per capita rate +19.8%, $p<0.001$). However, when using the new ‘ED beds per ED visit’ measure, we found an overall 3.9%

decrease in ED bed supply, from 6.0 beds per 10 000 ED visits in 2005 to 5.8 beds per 10 000 ED visits in 2014 ($p=0.01$) (figure 1A).

Inpatient capacity

For inpatient hospital supply, the number of licensed medical/surgical beds increased by 5.8% ($p<0.001$) and ICU beds by 21.4% ($p<0.001$), while psychiatric beds decreased by 19.4% ($p<0.001$) and chemical dependency beds by 26.2% ($p=0.03$) from 2005 to 2014. Licensed CCU beds did not change significantly (table 1).

In using the newly proposed supply measure, we found an 11.3% increase in inpatient bed supply in hospitals with EDs, from 11.6 licensed medical/surgical beds per thousand admissions in 2005 to 12.9 beds per thousand admissions in 2014 ($p<0.001$) (figure 1B). Across all hospitals, we found similar growth trends in the supply of all bed types except chemical dependency bed supply (-14.7%, $p=0.74$) (figure 2).

We further stratified our analyses to examine if hospitals with and without EDs had different trends in bed supply (figure 2). In hospitals with EDs, all bed types experienced growth (medical/surgical bed supply, +11.3%, $p<0.001$; ICU bed supply, +27.6%, $p<0.001$; CCU bed supply, 3.1%, $p=0.37$) except for psychiatric bed supply (-15.3%, $p<0.001$) (figure 1C) and chemical dependency bed supply (-22.4%, $p=0.05$) (figure 1D). In hospitals without EDs, we found similar trends in the growth of CCU beds (+70.3%, $p=0.07$) and a decline in chemical dependency beds (-35.4%, $p=0.28$) (figure 2). All other inpatient bed types in hospitals without EDs, however, decreased except for psychiatric bed supply (+45.3%, $p=0.04$).

Staffed and licensed beds

Focusing on the endpoint year of 2014, we examined the total licensed inpatient beds by type and the percentage of staffed inpatient beds. In 2014, hospitals staffed 59% of licensed medical/surgical beds, 73% of CCU beds, 74% of psychiatric beds and 65% of chemical dependency beds (the data set did not report staffed ICU beds) online (supplementary figure 1).

Rural and urban trends in ED and inpatient beds

Our analyses comparing rural and urban hospitals show that from 2005 to 2014, ED visits increased at a faster rate in urban hospitals (35.9% absolute, $p<0.001$; 25.2% per capita, $p<0.001$) compared with rural hospitals (11.4% absolute, $p=0.04$; 12.0% per capita, $p=0.05$) (supplementary table 3). Additionally, the total number of urban EDs increased by 2.3% ($p=0.33$), while rural EDs declined by 3.1% ($p<0.01$). For-profit and non-profit organisations owned most newly built urban EDs (+6.9% and +2.7%, respectively), whereas all rural EDs and most urban EDs that closed were government-owned. No new for-profit or non-profit EDs were built in rural areas.

ED beds increased in both urban and rural settings by +30.2% ($p<0.001$) and +19.8% ($p<0.01$), respectively online (supplementary table 3). ICU beds increased

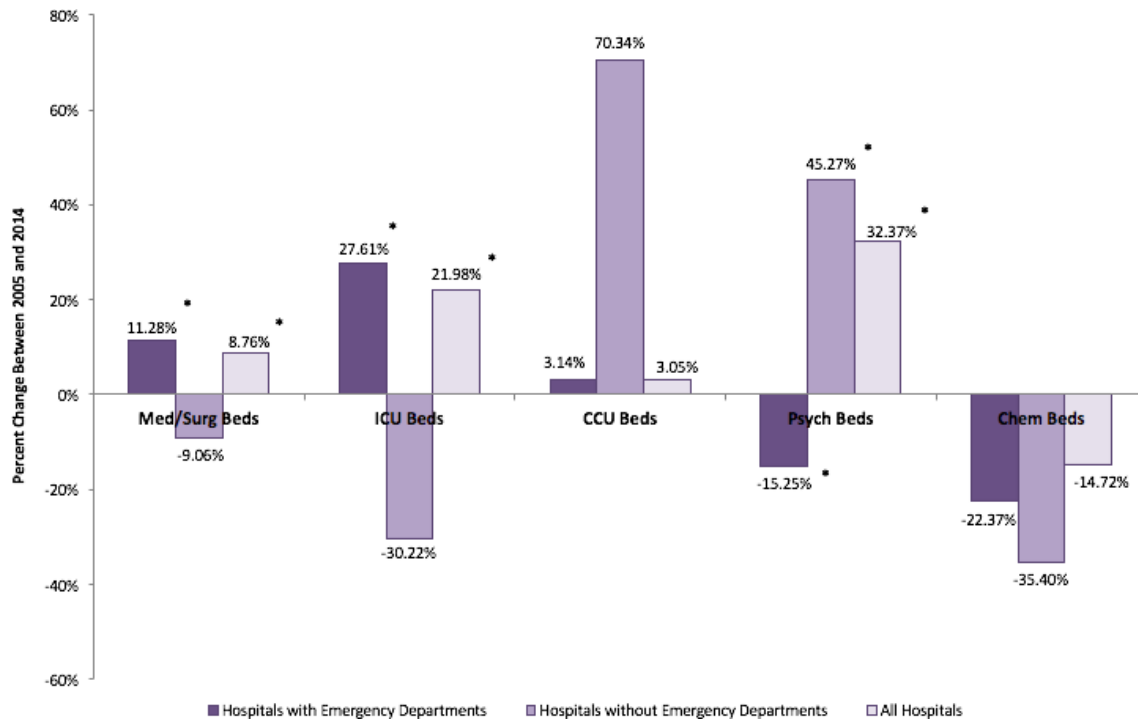


Figure 2 Per cent change in licensed inpatient beds per admission in hospitals with and without emergency departments, 2005–2014. *Denotes changes from 2005 to 2014 that are significant ($p < 0.05$). CCU, coronary care unit; Chem, chemical dependency; ICU, intensive care unit; Med/Surg, medical/surgical; Psych, psychiatric.

in urban settings (+22.1%, $p < 0.001$), but declined in rural settings (-9.2%, $p < 0.001$). Medical/surgical beds increased in urban settings (+6.3%, $p < 0.001$) and declined in rural settings (-9.0%, $p < 0.01$). Other inpatient bed types decreased, with the most pronounced reduction in rural settings where hospitals with EDs eliminated all psychiatric beds (from 16 psychiatric beds in 2005 to 0 starting from 2007 to 2014).

DISCUSSION

According to prior literature, ED supply of beds meets increasing patient demand for acute care.^{19 20 33} Consistent with the literature, our findings revealed sustained growth in ED visits and ED beds from 2005 to 2014.^{19 20 33–36} We also found an increase (1.8%) in the total number of EDs since 2005, in contrast to prior trends of California ED decline.^{3 19} However, our novel measure of beds per visit showed an overall decrease (-3.9%) in ED bed supply per visit, illustrating that traditional capacity metrics conceal shortages in actual ED bed supply relative to demand.

Our work builds on current ED supply studies by using supply and demand in the context of ED beds per ED visit, capturing supply relative to change in patient demand not measured by absolute bed statistics or per capita rates. Through this lens, our study observed fewer ED beds per ED visit over time. These findings possibly indicate that either bed supply may not be keeping up with actual demand, or that ED length of stay may be decreasing over time due to increased efficiency. Improvements in ED

efficiency over the past decade have resulted from process improvement implementation efforts (eg, Lean).³⁷ Recent studies showed hospitals achieved national goals for median ED length of stay and ED treatment times, but consistently continued to perform poorly on the 90th percentile ED length of stay and ED boarding times,^{38–41} suggesting that these trends may be evidence of an overwhelmed hospital system beyond the ED.

Generally, inpatient crowding contributes greatly to ED crowding.⁴² However, in our inpatient analyses, we showed an increasing trend of inpatient beds per admission over time in the setting of declining hospitalisation numbers. The overall growth of inpatient bed supply relative to demand may be explained by numerous factors, including a national trend in what appears to be a higher threshold for admission,^{43–50} well-documented trends in decreased inpatient length of stay,^{51 52} declines in direct hospital admissions due to strict and complex admission policies,^{2 43 51} and reservation of empty beds.^{53 54} For example, one study noted greater than 60% of hospitals board patients in the ED despite having empty beds elsewhere in the hospital reserved for patients who may or may not use these allocated beds (eg, transfer patients, patients having elective admissions, or to maintain hospital layout plans that preallocate and group beds by specialties).⁵³ Our findings of inpatient growth in bed supply may largely be influenced by decreases in admission numbers rather than increased accessibility to inpatient beds. In fact, our analyses illustrated nearly a 25% growth in ED-facilitated admissions despite the decline in total

hospitalisations, and almost a 15% reduction in medical/surgical beds per ED admission online (supplementary figure 2). Our findings suggest that inefficient allocation of inpatient resources for admitted ED patients may exist.

Hospital bed growth has been limited due to historical and operational reasons. In the 1990s, researchers identified excess inpatient capacity and unneeded hospital beds, resulting in policymakers' decision to reduce inpatient bed supply and to close EDs and hospitals.^{19 55 56} In the last two decades, however, increasing population size, demographic changes in insurance coverage and disease complexity, and evolving physician practice patterns due to malpractice concerns have strained already limited supply.^{51 57} Hospitals have been slow to respond to increasing demand due to uncertainties with predicting acute service needs,^{51 58} increased emphasis on cost control^{51 55} and staffing shortages.^{10 21 59 60} In particular, staffing existing beds proves problematic with nursing and personnel shortages, let alone new beds^{60–62}; analyses project national shortages of 300 000 to 1 000 000 nursing jobs by 2020.⁶³ Therefore, the concern for adequate inpatient bed capacity and hospital staffing appears warranted.

Overall, our research showed that inpatient bed supply never functioned at full capacity, despite the influx of patient need for beds. Between 2005 and 2014, a consistent gap existed between licensed and staffed medical/surgical beds (online supplementary figure 3). Most hospitals meet federal benchmarks for surge capacity when measured by annual licensed bed counts.²⁹ However, one study used daily measures of staffed beds and found that hospitals fell below federal surge standards 78% of the time,²⁹ suggesting that our current hospital system is frequently depleted of even emergency bed supply. Maintaining licensed beds holds limited value if hospitals lack the resources to convert them to staffed beds.^{28 29 60} Future research should consistently analyse staffed beds when assessing true hospital supply.

Lastly, we found that the number of medical/surgical, ICU and CCU beds per admission increased over the past 10 years in hospitals with EDs once we examined inpatient bed types at a granular level. However, we observed disturbing trends of reduction in psychiatric and chemical dependency bed supply that suggests an ED's ability to care for urgent psychiatric or substance abuse admitted patients is compromised due to lack of inpatient resources. Existing research points to four decades of deinstitutionalisation of acute psychiatric care, as well as substantial nationwide budget cuts in mental health spending, resulting in dwindling inpatient psychiatric and chemical dependency bed capacity,^{64 65} despite increasing prevalence of psychiatric cases presenting to the ED.⁶⁶ Psychiatric bed shortages exacerbate ED crowding, particularly as psychiatric patients often board in the ED far longer than medical patients.^{38 65 66} Economic reinvestments in mental health, restoration of acute psychiatric reimbursements and reopening of inpatient facilities are a few steps towards addressing mismatches in psychiatric and chemical dependency supply and demand.

This paper shows that traditional bed counts provide insufficient, or even potentially misleading, information about ED and inpatient hospital supply. Using our novel measure, we found concerning trends of decreasing supply over the last decade. Measurement of ED and inpatient supply could be further improved if accurate reporting of licensed and staffed bed types were available to reflect realistic variations in bed supply. Streamlining supply to meet fluctuating demands should integrate capacity management across entire hospital systems,⁵¹ and use evidence-based process improvement interventions within EDs and other inpatient units to improve efficiency and clinical outcomes.^{37 53 67}

This study has several limitations. First, our supply analyses only covered hospitals operating in California, and therefore may not generalise to all of the hospitals in the USA, although the issue of ED crowding continues to be a nationwide phenomenon. Second, the data we used lacked variables that would be useful in further characterising hospital capacity, including ED length of stay, bed occupancy time, other ED treatment spaces (eg, chairs, hallway gurneys) and hospital service disposition of admitted patients (eg, medical/surgical, ICU). Specifically, we note that OSPHD's reporting of staffed inpatient beds, especially prior to 2012, may be biased upwards due to reporting errors; therefore, we limited our analyses of staffed beds to our study endpoint of 2014 and reported a conservative upper bound on the number of staffed beds.⁶⁸ Nevertheless, because the same number for licensed and staffed beds may have been reported in the past, our findings regarding the inadequate supply of resources are conservative, which proves more troubling. Future studies should examine hospital occupancy rates as a ratio of licensed beds and treatment spaces, and as a ratio of staffed beds and treatment spaces in order to adequately gauge true bed supply. Third, we analysed statewide averages of California's hospital systems, but these alone may mask individual hospital supply and patient demand scenarios occurring within specific communities and counties. Future studies should explore trends at the county and patient levels.

CONCLUSION

Strategies to improve patient care and reduce wait times in the ED require a broader understanding of both hospital supply factors and patient utilisation trends. Our novel metrics capturing both supply of beds and visit demand demonstrate that recent trends of hospital supply may be insufficient to keep pace with growing ED patient demand and evolving, complex medical conditions. Analyses with more concise metrics that reflect shifts in patient demand over time such as the measures we have offered in this study may be more beneficial for healthcare policymakers and planners to better respond to growing demands in emergency and hospital care.

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Competing interests None declared.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement The data used in this study are available through the California Office of Statewide Health Planning and Development (OSHPD). To request the data, e-mail HIRCNonPublic@oshpd.ca.gov.

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