

BRIEF REPORT

Longitudinal Trends in Costs for Hospitalizations at Children's Hospitals

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ABSTRACT

OBJECTIVES: Children's hospitals are increasingly focused on value-based improvement efforts to improve outcomes and lower costs. Such efforts are generally focused on improving outcomes in specific conditions. Examination of cost drivers across all admissions may facilitate strategic prioritization of efforts.

METHODS: Pediatric Health Information System data set discharges from 2010 to 2017 were aggregated into services lines and billing categories. The mean annual growth per discharge as a percentage of 2010 total costs was calculated for aggregated medical and surgical service lines and 6 individual service lines with highest rates of growth. The mean annual growth per discharge for each billing category and changes in length of stay was further assessed.

RESULTS: The mean annual growth in total costs was similar for aggregated medical (2.6%) and surgical (2.7%) service lines. Individual medical service lines with highest mean annual growth were oncology (3.5%), reproductive services (2.9%), and nonsurgical orthopedics (2.8%); surgical service lines with highest rate of growth were solid organ transplant (3.7%), ophthalmology (3.3%), and otolaryngology (2.9%).

CONCLUSIONS: Room costs contributed most consistently to cost increases without concomitant increases in length of stay. Value-based health care initiatives must focus on room cost increases and their impacts on patient outcomes.



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Children's hospitals, like other segments of the US health care system, are increasingly focused on providing value-based care. Value-based care requires demonstrable delivery of either or both components of better value: improved outcomes and lower costs.^{1,2} In 2013, the United States spent ~\$70.9 billion on pediatric inpatient care, 30% of all US pediatric health care spending.³ As a general trend, administrators and clinicians at children's hospitals have pursued better value by improving outcomes for specific conditions⁴⁻⁸ rather than decreasing costs. Relatively little is known about which activities and services drive inpatient cost increases.

Health care costs and outcomes continuously change under the influence of new technologies, provider and patient choices, payment structures, competitive pressures, and other influences. Children's hospitals must balance the challenges presented by these changes against the substantial investment required by hospitals to improve and maintain outcomes.^{9,10} Understanding drivers of changes in costs will add an important dimension to children's hospitals' abilities to prioritize and scale value-based care improvements.

With this analysis, we support strategic prioritization of value-based initiatives by defining cost categories that drive increases in inpatient total costs over time. Focusing on areas of greatest cost growth over time may identify targets for future value improvement in hospital care for children. To better understand these drivers across children's hospitals, we performed a retrospective analysis of hospital costs from January 2010 to December 2017. Our objectives were to (1) characterize changes in cost over time across common medical and surgical service lines and (2) identify which cost categories were driving these changes. We only measured cost, the denominator of the value equation, and did not include quality of care or patient outcomes.

METHODS

In this retrospective cohort study, we used data from hospitals contributing adequate

data to the Pediatric Health Information System (PHIS) data set.¹¹ PHIS is a comprehensive database containing clinical and financial details of hospital-based encounters. We included all inpatient and observational status discharges during 2010 to 2017. We excluded transfers out, deaths, obstetrical and normal newborn hospitalizations, and visits from hospitals that did not provide complete data during the study period.

Deidentified patient demographics included age, sex, race, medical condition, and primary payer. For each patient encounter, daily billing data are categorized into 1 of 7 cost categories: laboratory, radiology, pharmacy, clinical, supplies, room, and other (IBM Watson, Armonk, NY). The clinical category includes such costs as ventilatory and respiratory support, transfusions, and rehabilitation, whereas the other category includes operative and perioperative services. All Patient Refined Diagnosis Related Groups (APR-DRGs) (3M Corporation, St Paul, MN) were aggregated into service lines by The Children Hospital Association and PHIS.¹¹ The service line other medicine was excluded because the APR-DRGs within this service line were extremely heterogeneous (Supplemental Table 1).

For each discharge, we estimated costs from charges using hospital- and year-specific ratios of cost to charges.¹² We then inflated all costs to 2017 US dollars using the Consumer Price Index.¹³

The change in the mean adjusted annual cost per discharge was calculated by service line and cost category by using generalized linear mixed effects models with random hospital intercepts to account for clustering of patients within hospitals. Models were case-mix adjusted by using relative resource-use weights¹⁴ and age. Exponential distributions were used due to the non-normal behavior of costs. Inclusion of a year covariate allowed us to determine a mean change per year. This numeric value was reported in dollars and as a percentage of the 2010 mean cost per discharge.

We identified the 3 medical and surgical service lines with the greatest mean annual change as a percentage of 2010 cost. To

determine drivers of the increases for these service lines, we modeled change in costs within the 7 cost categories using models similar to those described above.

Finally, we modeled length of stay (LOS) (days) similarly. We included LOS to determine if cost increases were related to longer stays or to higher costs per day. All statistical analyses were performed by using SAS version 9.4 (SAS Institute, Inc, Cary, NC), and *P* values <.001 were considered statistically significant because of large sample sizes. This research was exempt from review by the Baylor College of Medicine Institutional Review Board.

RESULTS

There were 3 485 181 discharges during 2010–2017 from 37 children's hospitals in 23 states (Supplemental Table 2). The majority (75.6%) were medical rather than surgical, and 45.9% were associated with ≥1 complex chronic conditions. Over half (56.7%) were publicly insured and/or male (53.8%). Non-Hispanic white individuals composed the largest racial or ethnic group (48%). The median age was 5 years (interquartile range: 0–12 years).

The mean annual change in total costs was similar for medical (2.6%) and surgical (2.7%) service lines overall, although 2010 mean adjusted cost per discharge differed (\$7710 and \$17 921, respectively). Increases in the mean adjusted annual cost per discharge were observed in all service lines except for infectious disease–surgical, which decreased (*P* = .002) (Fig 1). The 3 medical service lines with the highest rate of annual change in adjusted cost per discharge were oncology (3.5%), reproductive services (2.9%), and orthopedics–medical (2.8%). The 3 surgical service lines with the highest rate of annual change in adjusted cost per discharge were solid organ transplant (3.7%), ophthalmology (3.3%), and otolaryngology (2.9%). APR-DRGs included in each service line are presented in Supplemental Table 1.

The room category was the most consistent driver of cost growth of all service lines examined. Mean annual increases in this category were \$136 for medical and

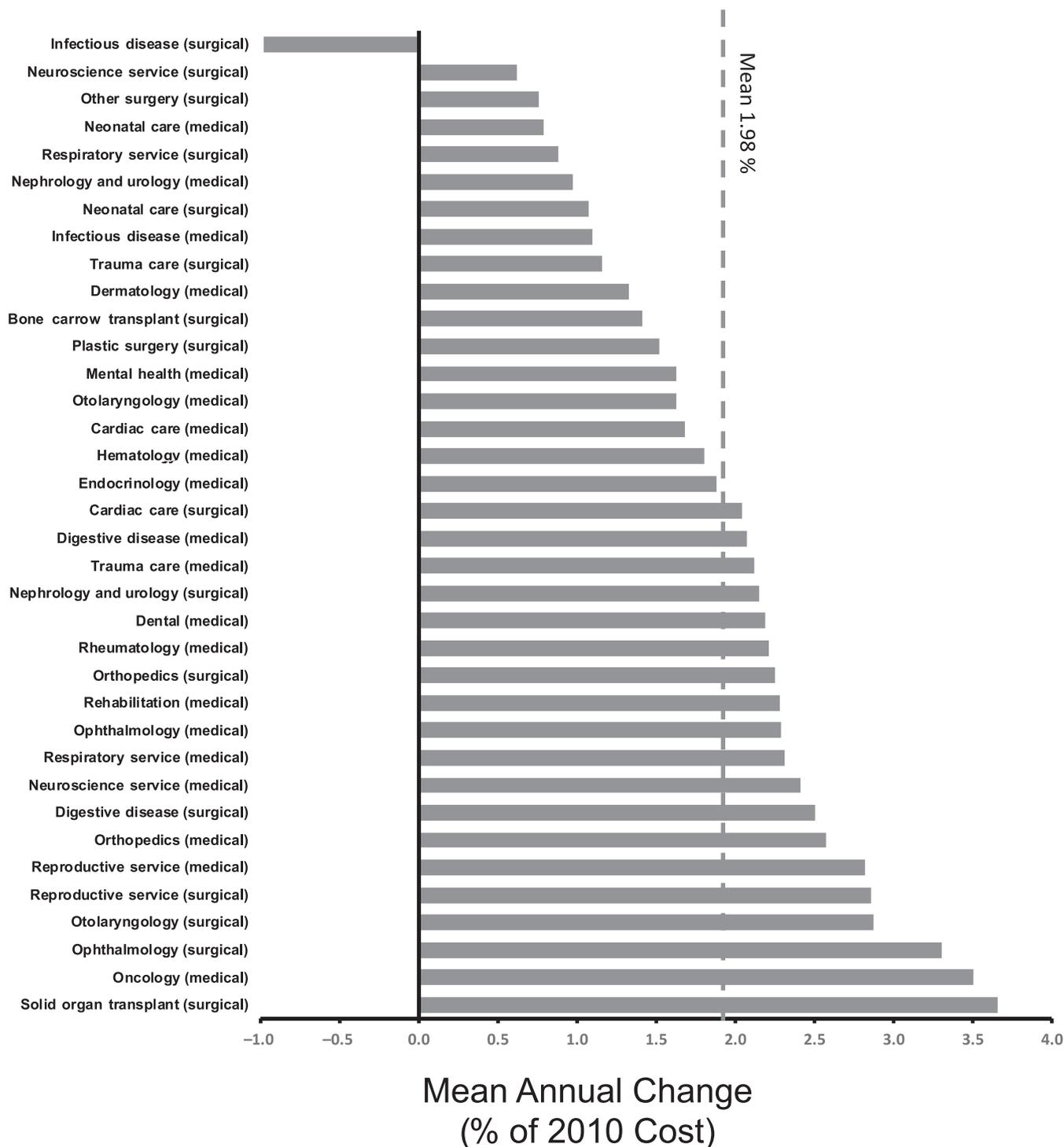


FIGURE 1 Rate of change from 2010 to 2017 by individual service lines.

\$160 for surgical aggregated service lines and ranged from \$51 to \$282 across the top 6 individual service lines (Fig 2, details in Supplemental Table 3). This category represented 55.8% and 32.5% of total costs

of medical and surgical aggregated services lines (respectively) in 2010. LOS was unchanged or decreased over time in all service lines. The clinical category was the predominant driver of growth in solid organ

transplant, accounting for 35% of total 2010 solid organ transplant costs, and had a mean annual growth of \$4517. Pharmacy costs as drivers of total growth were most evident in the oncology and solid organ

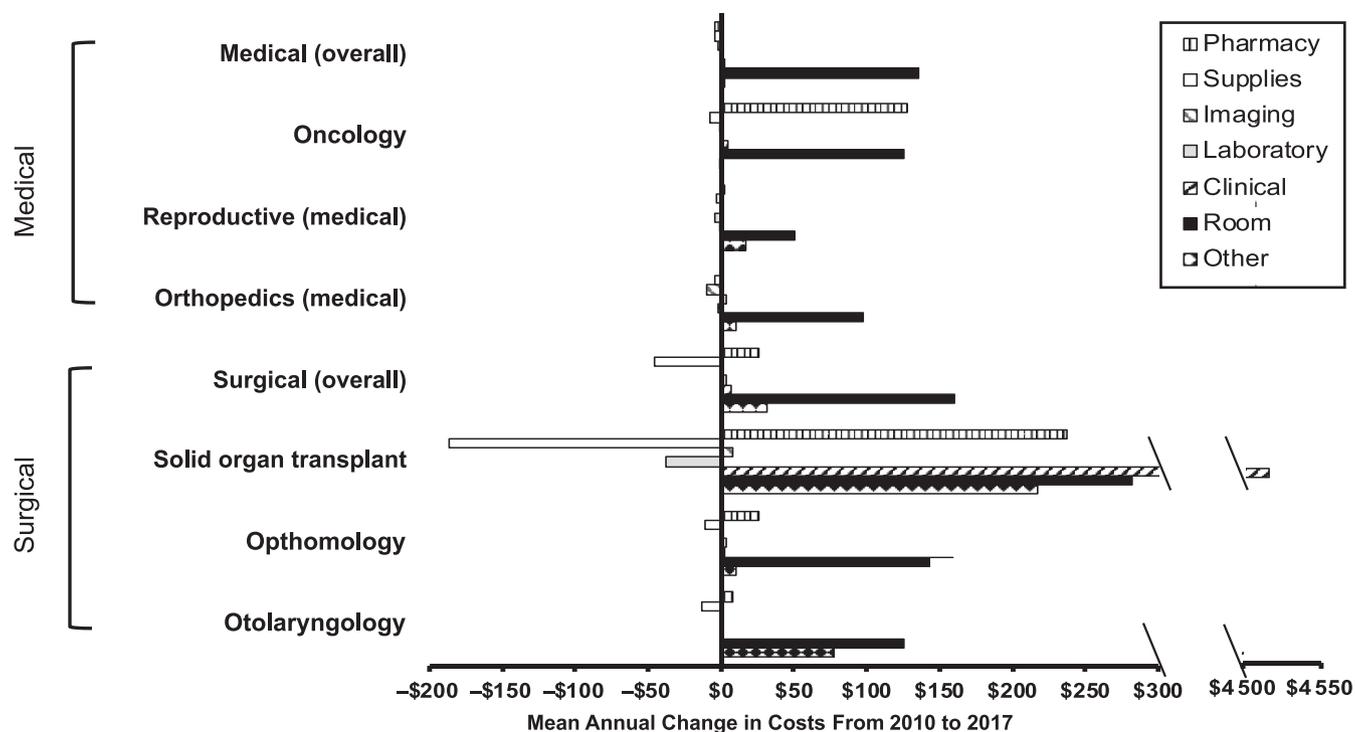


FIGURE 2 Mean annual change in cost categories from 2010 to 2017 by service lines.

transplant service lines, with mean annual growth of \$128 and \$237 respectively.

DISCUSSION

Between 2010 and 2017, we observed similar rates of growth in adjusted cost per discharge for medical and surgical service lines. Growth occurred in all individual service lines except one. We adjusted costs to 2017 US dollars, indicating that our observed growth exceeded inflation. The cost category most consistently contributing to growth was room costs; this category also represented a dominant proportion of the total hospitalization costs in all service lines. Room costs did not result from longer LOS because LOS did not increase during this period.

The cost categories are not further subcategorized in PHIS, which is a limitation of understanding the implications of this study. A critical next step in addressing the value of rising room, clinical, and other categories is to discover what components of these category are driving the increase and how each of these components is associated with patient outcomes. Our models included case-mix indexes using

APR-DRG severity scores,¹⁴ but increases in patient complexity that are not captured by severity scores¹⁵ may have resulted in higher room costs. Room costs attributable to health care administration across all hospital types, not just children's hospitals, have risen over the last decade, as the numbers of nonclinical personnel and salaries of higher level administrators have increased faster than for clinical personnel.¹⁶ Significant investment in information technology occurred during this time, with mixed evidence of system improvement.^{17–19} Overall administrative costs in the US between 2013 and 2016 were ~8% of total health care expenditures compared with 1% to 5% in other high income countries.²⁰ Because room costs account for the dominant proportion of total costs, decreases in this category have potential for significant impacts on slowing overall growth.

Increases in pharmaceutical costs are described in the peer-reviewed literature and lay media. In our review, growth related to the pharmacy category was most prominent in the solid organ transplant and

oncology service lines. Increasing costs of pharmaceutical agents for cancer management is an identified concern in the United States.²¹ The clinical costs category for solid organ transplant represented the greatest growth, and further connection between this growth and outcomes is also warranted.

One limitation of this analysis is that reported costs represent an estimate of resource use within each category. Hospitals participating in PHIS may have different methods for allocating resource use among cost categories; however, hospital-level allocation was unlikely to change over the time of this analysis. We focused on freestanding children's hospitals. Our data set represents ~12% of all pediatric admission during this time²² and may overrepresent higher intensity patient populations compared with other hospitals.²³ This may limit generalizability of our findings. A third limitation is that we only examined the cost half of the value equation. Estimating value will require a comparison of these resources to a change in outcome, a task outside the scope of this initial study.

This work was performed to support strategic approaches to value improvement. Although service lines varied in secondary drivers of total cost, the common factor across all discharges was a rise in room costs independent of LOS. Key future directions are breaking down the components of room cost and ongoing evaluations of how these components impact patient outcomes. An understanding of the individual drivers of growth on outcomes for all service lines is vital before expending resources on improvements.

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