

Impact of restructuring an inpatient pediatric service on length of stay and patient flow

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ABSTRACT

الأهداف: تحديد تأثير تنفيذ هيكل جديد لرعاية الأطفال المنومين باستخدام وحدة التدريس السريرية (CTU) على طول فترة التنويم وغيرها من النتائج المتعلقة برعاية المرضى.

المنهجية: تم إجراء دراسة بأثر رجعي على الأطفال الذين تم تنويمهم تحت فريق طب الأطفال العام في مستشفى الملك عبد الله التخصصي للأطفال من يوليو 2015م إلى ديسمبر 2018م. كانت مقاييس النتائج الرئيسية تتعلق بحساب الوسيط ومتوسط مدة الإقامة (مدة التنويم) قبل وبعد تنفيذ وحدة التدريس السريرية. كانت النتائج الأخرى التي تم قياسها أيضا هي نسبة المرضى الذين خرجوا من المستشفى في عطلة نهاية الأسبوع و أثناء النهار، ونسبة المرضى الذين خرجوا في غضون 24 ساعة من وقت التنويم، ونسبة المرضى الذين أعيد تنويمهم في غضون 7 أيام منذ خروجهم.

النتائج: انخفض متوسط مدة التنويم من 2.80 إلى 2.63 أيام بعد تطبيق وحدة التدريس السريرية ($p < 0.0001$). زادت نسبة المرضى الذين تم إخراجهم في عطلة نهاية الأسبوع و أثناء النهار بشكل كبير قبل و بعد تنفيذ وحدة التدريس السريري، من 18% إلى 21.5% ($p < 0.0243$) ومن 6.9% إلى 25.6% ($p < 0.0001$) على التوالي. استمر تحسن مدة الإقامة (التنويم) بعد تنفيذ وحدة التدريس السريري في السنوات التالية، حيث انخفض المتوسط والوسيط لمدة الإقامة من 2016 إلى 2018، حيث انخفض المتوسط من 5.03 إلى 3.92 أيام ($p = 0.0031$) وانخفض المتوسط من 2.71 إلى 2.60 أيام ($p < 0.001$). خلال نفس الفترة، ظلت معدلات إعادة تنويم المرضى مستقرة عند 3.5-4%.

الخلاصة: أدى تنفيذ هيكل جديدة لفريق الأطفال العام (باستخدام مفهوم وحدة التدريس السريرية) إلى تحسينات كبيرة في العديد من نتائج رعاية المرضى، بما في ذلك تقصير مدة الإقامة.

Objectives: To determine the impact of implementing a new pediatric inpatient structure - the clinical teaching unit (CTU) - on length of stay (LOS) and other patient care outcomes.

Methods: A retrospective study was carried out on children admitted to the General Pediatric Inpatient Service at King Abdullah Specialized Children's Hospital, Riyadh, Saudi Arabia, between July 2015 and December 2018. The main outcome measures were median and mean LOS before and after CTU implementation. Other outcomes measured were the proportion of patients discharged on weekends, during daytime, and within 24 hours of admission,

and the proportion of patients readmitted within 7 days of discharge.

Results: Median LOS decreased from 2.80 to 2.63 days after CTU implementation ($p < 0.0001$). The proportion of weekend discharges significantly increased after CTU implementation from 18% to 21.5% ($p < 0.0243$) and daytime discharges significantly increased from 6.9% to 25.6% ($p < 0.0001$) after CTU implementation. The improvements in LOS were sustained in the years after CTU implementation, with median LOS decreasing from 2.71 to 2.60 days during 2016-2018 ($p < 0.001$) and mean LOS decreasing from 5.03 to 3.92 days ($p = 0.0031$). During the same period, readmission rates remained stable at 3.5-4%.

Conclusion: The implementation of a new pediatric inpatient team structure led to significant improvements in many patient care outcomes, including decreased LOS.

Keywords: pediatrics, inpatients, length of stay, quality improvement

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Healthcare organizations are under constant pressure to deliver safe and high-quality patient care. This mission has become even more challenging with advancements in medical care. Specifically, in pediatrics, there have been major advancements in neonatal, surgical, and anesthetic care. A significant percentage of pediatric patients suffer from complex medical conditions and are fragile and in need of a high level of clinical coordination.^{1,2} Dimensions of high-quality care extend beyond usual clinical outcomes (related to morbidity and mortality) to embrace additional outcomes that include, but are not limited to, length of stay (LOS), readmission rate, access to outpatient care and diagnostic modalities, reducing cost, and patient family and staff experience.^{3,4}

The LOS is a key performance indicator that can be challenging to assess due to many factors, including complexity of medical conditions, type of inpatient service model, shortage of resources, and psychosocial elements.⁵ Reduction of LOS has several clinical and operational values, such as a drop in nosocomial infections and thromboembolic events, shortening of wait times for medical procedures, and improvements in staff and patient experience.⁶ Although some of the factors contributing to LOS are difficult to control due to the complexity of healthcare organizations, some institutional changes, such as inpatient service restructuring, are attainable. Inpatient service restructuring has been shown to improve patient outcomes, including decreased LOS. Szecket et al⁷ showed that redesigning the admission process of a general internal medicine service by dividing admissions between teams increased daily discharges and decreased median LOS. Another study assessed different interventions for a medical residency teaching service and found that maximizing the number of patients a team shared with a single attending physician improved team efficiency and patient-based teaching. The intervention resulted in improved resident and student experience and a decreased median LOS.⁸ A study in the United Kingdom on the impact of twice-daily consultant (attending) ward rounds on LOS in 2 general medical wards found an almost doubling in number of discharges and halving of the average LOS for patients.⁹ In addition, other studies on various subspecialties examined different attending-lead inpatient service models and concluded a positive impact on the overall hospital LOS.¹⁰⁻¹⁴

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Prior to 2016, the general pediatric inpatient service in our children's hospital was structured as a 4-team model, with one attending physician/team on-call each day. All general pediatric admissions for the day were admitted under the care of the on-call team. The average number of admissions per day over the year was approximately 15, but in the winter it could reach 25-30 daily admissions. Multiple attendings were assigned to each team, and a different attending was on call each day. This type of call structure created the need for extensive cross-coverage, large variations in team admissions, and disparate team workloads.⁷ Following several intra-divisional and intra-department meetings, the general pediatric inpatient service was redesigned to a 4-team clinical teaching unit (CTU) structure in January 2016. In this structure, one attending was assigned to each CTU team for a 1-2 week period. In addition, admissions were divided between the 4 teams daily. With this new inpatient structure, there was increased senior review of patients on a daily basis. We hypothesized that there would be improvements in patient outcomes including decreased LOS and increased weekend and daytime discharges with the implementation of the CTU. The objective of this study was to determine whether changing the inpatient structure to the CTU resulted in a decrease in LOS and other improvements in patient flow.

Methods. Key performance indicators for general pediatric admissions at King Abdullah Specialized Children's Hospital were obtained from electronic medical records supplied by the Information Systems and Informatics Division. The LOS was measured as the time in days from the admission date to the discharge date. The weekend discharge rate was estimated as the proportion of discharges that occurred on weekends (from 00:00 on Friday to 23:59 on Saturday) compared to the total number of discharges during the week (from 00:00 on Sunday to 23:59 on Thursday). Daytime discharges were defined as discharges between 07:00 and 14:00. To account for variations in admissions, we compared data for the same 6-month period (July-December) in 2015 (pre-CTU) and 2016 (post-CTU). Additional data were collected until the end of 2018 to include the first 3 years after CTU implementation.

The study obtained ethics approval from the institutional review board at King Abdullah International Medical Research Center, Ministry of National Guard Health Affairs, Riyadh, Saudi Arabia (research protocol RC17/149/R).

Statistical analysis. The data were analyzed using the statistical program SAS (version 9.4). Data were

presented as the mean \pm standard deviation (SD), or median (interquartile range [IQR]) for continuous variables and as frequencies in the form of percentages for categorical variables. A Chi-square test was used to assess the association between categorical variables, and the Wilcoxon 2-sample test or T-test was used for continuous variables. The chosen level of statistical significance was $p < 0.05$.

Results. In the July-December 2015 (pre-CTU) study period, there were 1167 discharges and in July-December 2016 (post-CTU) study period, there were 1598 discharges. There was no significant difference in the mean LOS between the groups (4.87 and 4.68 days). The median LOS was 2.80 and 2.63 days ($p < 0.0001$). Weekend discharges were 18.0% in the pre-CTU period and 21.5% in the post-CTU period ($p = 0.0243$). In the pre-CTU period, 6.9% of the discharges were daytime discharges versus 25.6% in the post-CTU period ($p < 0.0001$; **Table 1**).

Key performance indicators were also compared post-CTU implementation (2016-2018). The number of discharges increased year by year, but there was a significant decrease in the mean LOS, namely from 5.03 in 2016 to 3.92 in 2018 ($p = 0.0031$; **Figure 1**). The median LOS also decreased from 2.71 in 2016 to 2.60 in 2018 ($p < 0.0001$). The proportion of admissions with LOS less than 24 hours increased from 15.2% in 2016 to 21.9 % in 2018 ($p = 0.0166$). Daytime discharges significantly increased during this period, from 20.84% in 2016 to 30.58% in 2018 ($p < 0.0001$). Weekend discharges did not increase significantly ($p = 0.1171$), and there was also no significant difference in the proportion of unscheduled readmissions ($p = 0.5257$; **Table 2**).

Discussion. In this study, we compared patient outcome measures before and after implementation of a major structural change in our pediatric inpatient

service. Our main findings were that redesigning our service to the CTU structure had a notable positive effect on patient care, with a significant decrease in the LOS as well as improvements in other patient flow outcomes.

There was a significant decrease in the median LOS after CTU implementation. This improvement could be due to several reasons. First, following the implementation of the CTU, the attending physician attended daily rounds for both the new and old patients. This enabled timely and appropriate decisions to be carried out regarding patient care by the most senior physician.¹⁵ Second, by equally dividing the new admissions between the teams, we implemented a “continuous” admission process.⁷ Distributing admissions amongst the teams resulted in less variation in team numbers and smoothening of discharges over the week. The benefit of this daily distribution system in lowering the average LOS has also been noticed in other studies for both acute and chronic patients.^{16,17} Moreover, not only was the improvement in the LOS sustained in the years following CTU implementation but also it significantly decreased further year by year, with the mean LOS in 2018 being more than one day less than in 2016. We postulate multiple reasons for the significant reduction in the LOS, such as further changes that were implemented, namely enhanced weekend coverage (4 attendings rounding on weekends during the winter season) and the development of a post-discharge CTU clinic (an outpatient clinic for rapid follow-up of selected patients). In addition, the significant decrease in mean LOS is likely due to decreased LOS of chronic patients. With the new structure of CTU that includes daily rounds by the most senior physician (attending) and a meticulous handover process, the clinical care of chronic patients is smoother from both clinical and operational perspectives.

After implementation of the CTU, there was a significant increase in the proportion of patients with LOS of 24 hours or less and daytime discharges. We

Table 1 - Length of stay, weekend discharges, and daytime discharges during pre-clinical teaching unit implementation and post-clinical teaching unit implementation.

Variables	July-December 2015 (pre-CTU)	July-December 2016 (post-CTU)	P-values
Number of discharges	1167	1598	-
LOS, mean \pm SD	4.87 \pm 7.91	4.68 \pm 16.61	0.6875
LOS, median (IQR)	2.80 (2.97)	2.63 (2.08)	<0.0001
Weekend discharges (%)	18.0	21.5	0.0243
Daytime discharges (%)	6.9	25.6	<0.0001

CTU: clinical teaching unit, LOS: length of stay, SD: standard deviation, IQR: interquartile range

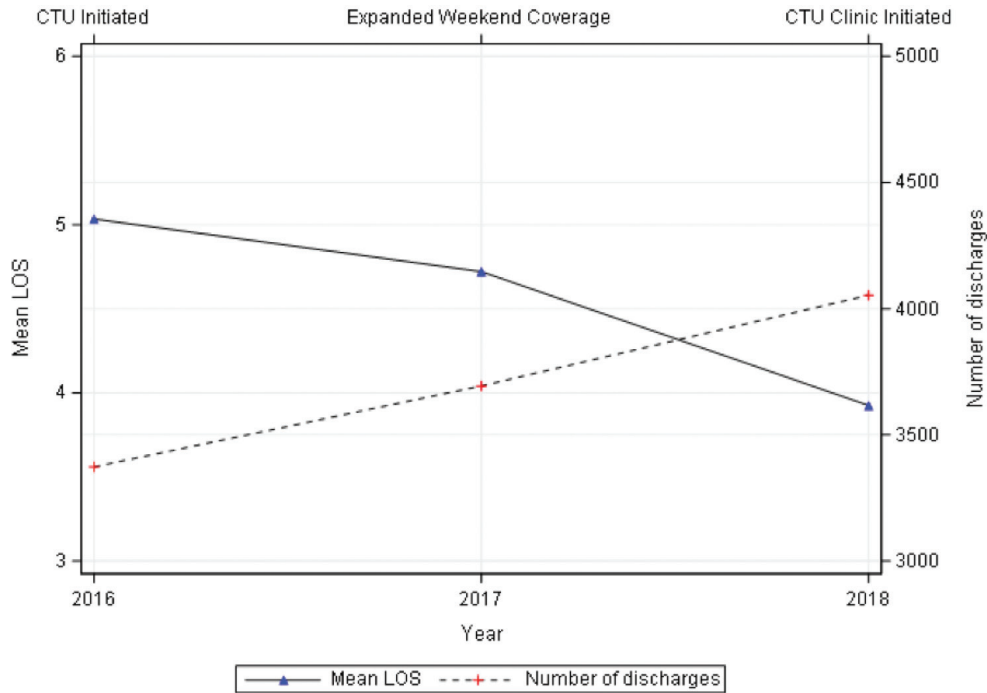


Figure 1 - Annotated run chart of length of stay and number of discharges after clinical teaching unit implementation. LOS: length of stay, CTU: clinical teaching unit

Table 2 - Patient-level outcomes post-clinical teaching unit implementation.

Period	Number of discharges	LOS mean±SD	LOS median (IQR)	Admissions discharged within 24 hours (%)	Daytime discharges (%)	Weekend discharges (%)	Unscheduled readmissions within 7 days (%)
2016	3373	5.03±13.92	2.71 (2.97)	15.17	20.84	19.95	3.50
2017	3694	4.72±20.65	2.68 (2.73)	16.95	25.18	21.36	3.84
2018	4054	3.92±6.29	2.6 (2.1)	21.93	30.58	21.89	4.00

LOS: length of stay, SD: standard deviation, IQR: interquartile range

attribute these improvements to daily rounds by attendings with timely decision-making. Although the proportion of weekend discharges increased slightly between 2016 and 2018, this was not statistically significant. Despite significant reduction in the LOS after CTU implementation and increased daytime discharges, the unscheduled 7-day readmission rate remained stable in the years post-CTU implementation, which was a reassuring outcome. This outcome of reduction in the LOS with an insignificant increase in the readmission rate has been observed in several other studies.^{8,18,19}

Study limitations. One limitation of this study is that it took place in a single tertiary care pediatric center. In addition, the improvement in patient care outcomes, including decreased LOS, could be due to

many factors.²⁰ After the CTU was implemented, a bed management department was introduced in our children’s hospital to improve discharge planning. Although this initiative had an impact on patients with prolonged LOS, we suspect it did not have a major impact on the LOS for the majority of our patients (>80%) with acute illnesses and short hospital stays. Another limitation is that we do not have observed-to-expected LOS ratios. However, the most common admitting diagnoses in the pre-CTU and post-CTU period were the same (namely bronchiolitis, asthma, and gastroenteritis). Moreover, we do not have information regarding medical readiness for discharge. In the future we suggest that our electronic medical record system flags patients that are medically ready for discharge but are not discharged due to other reasons.

In conclusion, restructuring a pediatric inpatient service to be attending-led and dividing admissions between teams resulted in a significant decrease in the LOS and improvement in other patient flow measures. These improvements can indirectly improve overall hospital efficiency and decrease the pressure on emergency departments, operating rooms, and intensive care units. Future studies should focus on the impact of restructuring a pediatric inpatient service on safety incident reports, patient/family experience, and cost savings.

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