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RESEARCH ARTICLE

An Iterative Quality Improvement Process Improves Pediatric Ward Discharge Efficiency

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ABSTRACT

OBJECTIVES: Discharge of hospitalized pediatric patients may be delayed for various "nonmedical" reasons. Such delays impact hospital flow and contribute to hospital crowding. We aimed to improve discharge efficiency for our hospitalized pediatric patients by using an iterative quality improvement (QI) process.

METHODS: Opportunities for improved efficiency were identified using value stream mapping, root cause, and benefit-effort analyses. QI interventions were focused on altered physician workflow, standardized discharge checklists, and physician workshops by using multiple plan-do-study-act cycles. The primary outcome of percentage of discharges before noon, process measure of percentage of discharges with orders before 10 AM, and balancing measures of readmission rate, emergency department revisit rate, and parent experience survey scores were analyzed by using statistical process control. The secondary outcome of mean length of stay was analyzed using *t* tests and linear regression.

RESULTS: Implementation of our interventions was associated with special cause variation, with an upward shift in mean percentage of discharges before noon from 13.2% to 18.5%. Mean percentage of patients with discharge orders before 10 AM also increased from 13.6% to 23.6% and met rules for special cause. No change was detected in a control group. Adjusted mean length of stay index, 30-day readmissions, and parent experience survey scores remained unchanged. Special cause variation indicated a decreased 48-hour emergency department revisit rate associated with our interventions.

CONCLUSIONS: An iterative QI process improved discharge efficiency without negatively affecting subsequent hospital use or parent experience. With this study, we support investment of resources into improving pediatric discharge efficiency through value stream mapping and rapid cycle QI.

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Hospital crowding is a critical patient safety issue associated with adverse outcomes. Patients admitted during times of high hospital occupancy tend to have increased length of stay (LOS),[1] higher readmission and emergency department (ED) revisit rates,[2,3] and increased mortality.[2,4] Inpatient crowding also impacts patient flow in other areas of the hospital, including the ED and postanesthesia care unit (PACU),[5] leading to additional problems, such as ambulance diversion, denial of patient transfers, or cancelled elective surgical cases.[6,7] Therefore, efforts to reduce hospital crowding are critical to improving patient safety.

Pediatric populations are prone to hospital crowding during key times of year, such as the winter viral respiratory season.[8] Pediatric hospital discharge represents an opportunity for improved efficiency of care that may reduce hospital crowding. In 1 single-center study, researchers found, over 1 month, nearly one-quarter of hospitalized pediatric patients experienced a discharge delay of at least 24 hours for "nonmedical" reasons, such as delays in discharge planning, establishing follow-up, or obtaining test results.[9] Such delays are not only costly and inconvenient to patients and families, but they also contribute to the hospital flow issues noted above, potentially delaying care for other patients.

There is limited evidence for effectiveness of specific interventions to improve pediatric discharge efficiency. Many interventions have been studied in limited contexts, such as implementation of a discharge risk assessment,[10] a "medications-in-hand" policy on hospital discharge,[11] or a ward discharge coordinator to schedule outpatient follow-up. In several studies, researchers have shown that quality improvement (QI) methods can leverage existing resources and account for local needs to improve discharge efficiency without compromising care quality or family satisfaction.[10,12,13] However, many of these studies were performed in specific subpopulations (eg, patients with asthma or children with medical complexity), and only in 1 of the above studies did researchers use a control comparison group to support that discharge improvements truly resulted from the study interventions, as opposed to broader institutional or other factors.

Our primary aim was to use QI processes to improve percentage of patients discharged before noon from a mean baseline of 13% to a goal of 18% on the pediatric hospitalist service. To more fully evaluate the impact of our interventions, we used a comparison control group as well as monitored LOS, readmissions, ED revisits, and parent experience scores throughout the study.

METHODS

Context

The study took place on a 36-bed pediatric inpatient unit within a tertiary care academic children's hospital. All children admitted to the pediatric hospitalist service on the general pediatric inpatient ward were included. Patient care is provided by pediatric and family medicine residents and medical students, supervised by pediatric hospitalists. At least 1 hospitalist is present in the hospital 24-7; the hospitalist at night is referred to as the nocturnist. Nurses are typically assigned to patients at a 1:4 ratio. Two pediatric case managers and 2 pediatric social workers provide support to all services on the pediatric ward. Teams conduct daily family-centered rounds involving the patient, family, nurse, students, residents, and attending physician. Daily "discharge rounds" are conducted in a separate late-morning meeting after rounds, involving the attending physician, charge nurse, case manager, and social worker. The baseline study period was July 2015 through November 2016. The intervention period began in December 2016 and continued through June 2018.

Control Group

As a control, the primary outcome was monitored for pediatric patients hospitalized on the same inpatient ward during the same time period but cared for by nonhospitalist services, which did not participate in the improvement process. This included patients on pediatric surgical and subspecialty services.

Intervention Planning

A multidisciplinary pediatric team, including a QI specialist, 3 hospitalists, 1 resident, 2 nurse managers, 1 social worker, and 1 case manager, was assembled. Value stream mapping of the baseline pediatric hospital discharge process was used to identify areas for improved efficiency (Supplemental Fig 5). Root cause analysis of the 2 primary failure reasons (lack of transportation and outpatient prescriptions unavailable for pickup) revealed many improvement opportunities. A benefit-effort analysis was conducted to identify interventions with highest potential benefit and lowest projected effort. The top 3 interventions were then moved forward to the implementation phase.

Intervention 1: Altered Physician Workflow

The first intervention was an altered physician workflow. Before the intervention, patients were discharged by the daytime hospitalist and residents between 8 AM and 9 PM. Although a nocturnist existed before initiation of this intervention, the nocturnist's primary roles were staffing new admissions and handling emergent issues. Patients meeting discharge criteria after 9 PM were typically discharged on the following day during daily rounds. In the study intervention, eligible families were approached the evening before anticipated discharge to discuss optimal discharge timing. Families who desired "early discharge" were evaluated for discharge early the following morning by the nocturnist. Specific discharge timing was based on the family's expressed needs but could range from midnight to 7 AM. Early discharges allowed families with limited transportation to be discharged before family or friends left for work. Patients eligible for early discharge were typically not medically complex and had all nonmedical discharge needs met by the evening before discharge.

Intervention 2: Discharge Checklist

The second intervention was a standardized checklist used by nurses, case managers, social workers, and physicians to evaluate patients' discharge needs. This checklist was used to guide the assessment of each patient's transportation, medication, equipment, supply, and social needs that must be addressed before discharge. The checklist was incorporated as a Smartphrase into resident admission and progress note templates as well as the nurse and case manager standard assessments. Although the information in each individual's checklist did not autopopulate for other team members, the information was shared in the electronic medical record through each individual's daily notes. The checklist was reassessed during daily discharge rounds to identify, share, and work toward meeting each patient's discharge needs.

Intervention 3: Discharge Workshops

The final intervention involved resident and hospitalist discharge workshops. The residents' 2-hour workshop was led by the case manager, with input by the hospitalists, and was held during required weekly residency-wide didactic sessions. The workshop covered the use of the discharge checklist, discharge workflow, and hospital discharge resources, including availability and contact information for case managers and social workers. Hospitalist workshops, which occurred during twice-monthly divisional meetings, were focused on encouraging prioritizing discharges, offering potential solutions for delayed discharges, and educating hospitalists on accessing their individual discharge metrics, which included each hospitalist's discharge orders placed by 10 AM, discharges by noon, and average LOS.

Measures

The primary outcome measure was monthly percentage of discharges occurring before noon. This measure was calculated by dividing the monthly number of patients on the hospitalist service who were discharged before noon by the total number of hospitalist service patients discharged monthly. Time of discharge was assessed as the time when the patient actually left the ward. The process measure was monthly percentage of discharge orders placed before 10 AM. This measure was calculated by dividing the monthly number of patients on the hospitalist service with discharge orders placed before 10 AM by the total number of hospitalist service patients discharged monthly. These measures were chosen because our hospital was experiencing midday hospital crowding, which delayed interfacility transfers and prolonged ED and PACU wait times. In addition, these data were already being collected by hospital administration; these measures were relevant to local stakeholders and allowed us to leverage existing resources for real-time data tracking. Alternative outcomes, such as time to discharge after meeting medical discharge goals, could not be feasibly measured within our electronic medical record. Baseline data analysis revealed that 13% of patients were discharged before noon; we therefore set an achievable a priori goal of 18% of patients discharged before noon, creating a goal 5% absolute increase from baseline to target.

The secondary outcome measures were mean LOS in days and mean monthly LOS index. LOS index, calculated through Vizient, compares the observed LOS to expected LOS on the basis of diagnosis, disease severity, and complexity in a similar population nationally.[14] Therefore, LOS index accounts for patient characteristics that can impact LOS. To present the unadjusted LOS data, we also measured and analyzed mean LOS. Balancing measures included same-hospital 30-day readmission rates, 48-hour ED revisit rates, and parent experience measured by the Child Hospital Consumer Assessment of Healthcare Providers and Systems (CHCAHPS) survey discharge domain top box scores. Both the secondary outcome and balancing measures were selected to evaluate for unintended adverse consequences of the interventions. For example, monitoring LOS index ensured that earlier discharges were not simply improving at the expense of LOS.

Analysis

The primary outcome, process measure, readmission rate, ED revisit rate, and CHCAHPS scores were analyzed by using statistical process control in Excel.[15] P-charts were selected to monitor the variation in proportion of nonconforming items in subgroups of variable size. Upper and lower control limits were defined as $> 3\,\sigma$ above or below the mean. Special cause variation was identified by a single point outside of the upper or lower control limit or by 8 consecutive points above or below average.[16] Participant demographics were compared in the pre- and postintervention periods by using χ^2 tests. Pre- and postintervention periods for LOS index and mean LOS were compared by using *t* tests. A Bonferroni correction for multiple simultaneous comparisons was used to set the threshold *P* value for significance at .01. A sensitivity analysis was used to assess whether LOS differed in the pre- and postintervention periods after adjusting for expected LOS and temporal trends. The units of analyses were monthly mean LOS, which was natural log transformed and used as

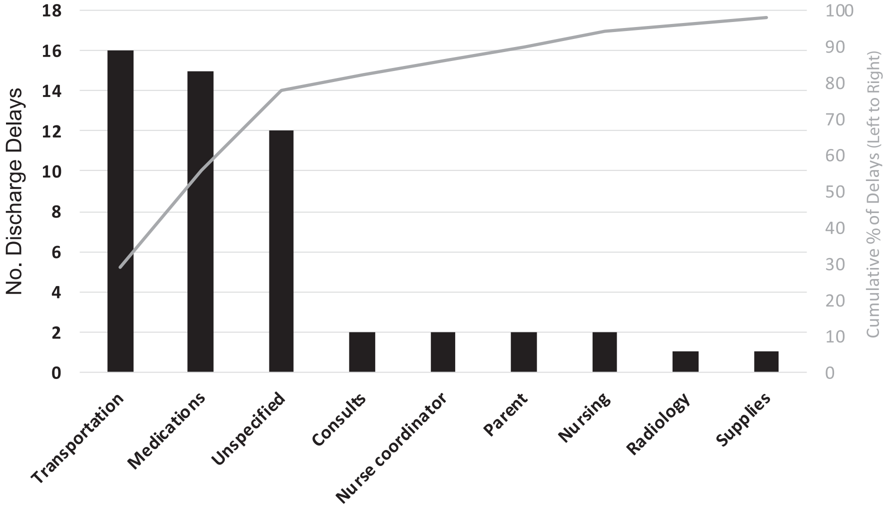

FIGURE 1 Reasons for patient discharge delays.

the dependent variable in a SAS linear regression model that included a binary indicator for postintervention, study month (as a continuous variable), and natural log of the expected mean LOS, according to Vizient. Monthly variation in patient counts was accounted for by including patient count in the error variance specification. The regression coefficient for the postintervention variable was back-transformed via exponentiation, so that it represents the relative change in LOS index (as a mean ratio) from pre- to postintervention.

Ethical Considerations

This protocol was approved by the University of California, Davis Institutional Review Board.

RESULTS

Participant demographic characteristics are shown in Supplemental Table 2. No significant difference was noted in the distribution of patients by sex, race, or insurance status in the pre- versus postintervention periods. Participant age distribution differed, with a higher percentage of children $<$6 years of age and lower percentage of children in the 6- to 12-year age range in the postintervention period ($P < .001$).

Figure 1 shows a Pareto chart depicting the most-common reasons for discharge delays in the study population over a 1-month period. The leading reported cause of discharge delays was lack of transportation (29%, $n = 16$), followed by medication delays (27%, $n = 15$). The full value stream map is included in Supplemental Fig 5.

The primary outcome measure of percentage of patients discharged by noon increased from the baseline mean of 13.2% to 18.5% in the postintervention period (Fig 2). A statistical process control chart for the primary outcome showed a stable process in the baseline period with special cause variation in the postintervention period. Interventions are denoted by markers 1, 2, and 3. We saw significant improvement in patients discharged by noon after the first intervention but soon declined below our goal. The additional interventions allowed us to maintain our 18% goal. The process measure of percentage of patients with discharge

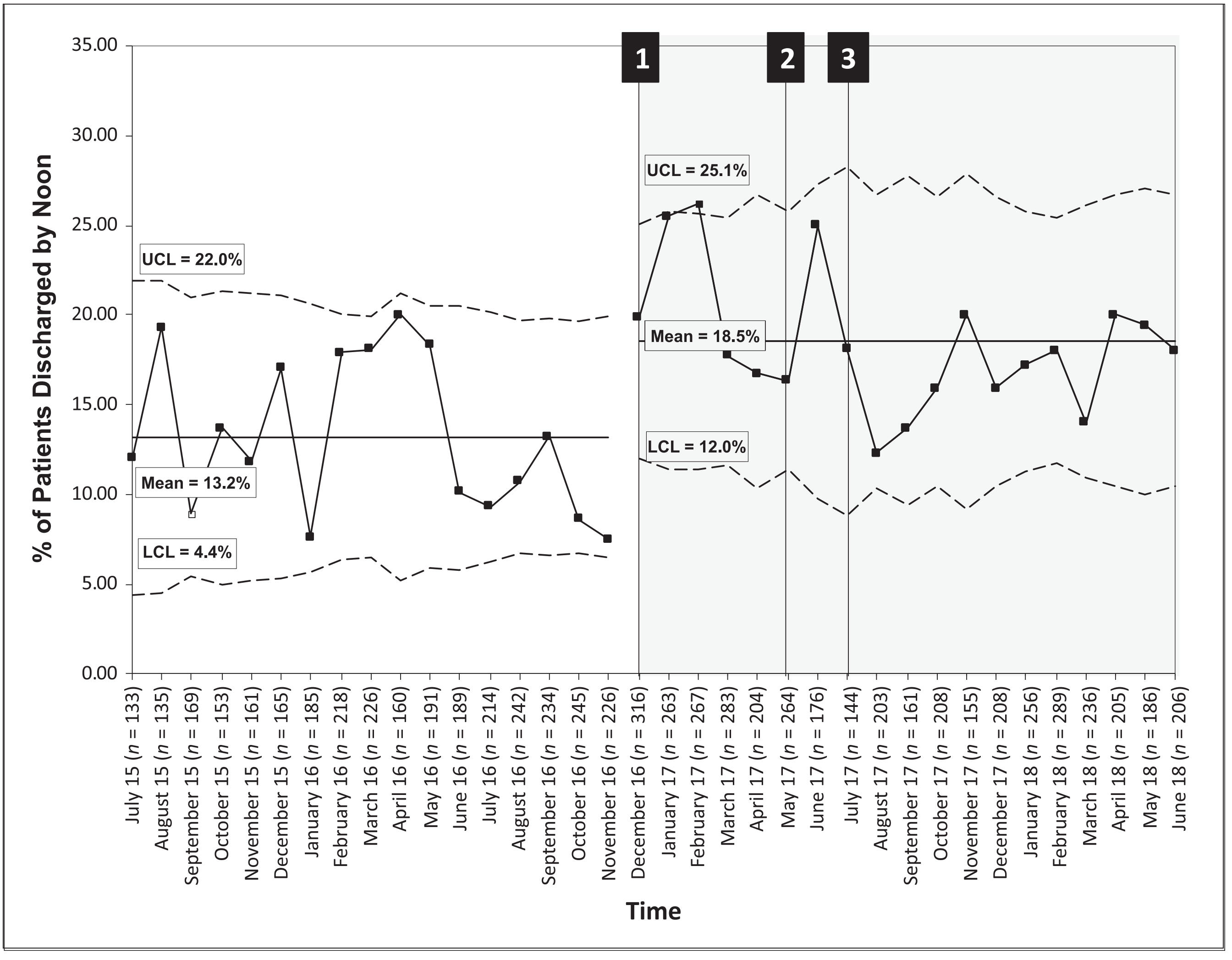

FIGURE 2 P chart of percentage of patients discharged by noon. Interventions are denoted by markers 1, 2, and 3. LCL, lower control limit; UCL, upper control limit.

orders written by 10 AM increased from the baseline mean of 13.6% to 23.6% with special cause variation in the postintervention period (Fig 3). The primary outcome and process measures were also tracked for our comparison control group of pediatric patients, and there was no sustained change over the baseline and intervention periods for this control group (Fig 4).

Secondary outcome and balancing measure data are shown in Table 1. Between the pre- and postintervention periods, mean LOS decreased from 3.7 to 3.5 days (−0.2 days, $P = .045$). Mean LOS index declined from 1.07 to 1.03 (−0.040, $P = .0042$). When accounting for expected LOS and temporal trends through sensitivity analysis, the relative change in LOS index (as a mean ratio) from pre- to postintervention was 0.996 (95% confidence interval: 0.89 to 1.11), indicating that mean LOS index was unchanged.

Statistical process control showed no significant variation in balancing measures of same-hospital 30-day readmission rates (preintervention 6.3% versus postintervention 6.8%, Supplemental Fig 6) and CHCAHPS discharge domain top box scores (preintervention 80.8% versus postintervention 80.0%, Supplemental Fig 7). Same-hospital 48-hour ED revisit rates were 1.0% preintervention and 0.9% postintervention with statistical process control showing special cause variation indicating decreased ED revisit rate coinciding with the interventions (Supplemental Fig 8).

DISCUSSION

In this study, it was shown that a multidisciplinary QI process improved discharge efficiency on our general pediatric ward, improving percentage of patients discharged by noon from the baseline mean of 13.2% to 18.5% in the postintervention period. Our interventions incorporated an altered physician workflow, discharge checklist, and physician discharge workshops to sustain improvement over a 12-month period. Major strengths of this initiative included evaluation of several balancing measures to monitor for adverse consequences of our interventions as well as use of a comparison control group to ensure that our improvements did not result from factors external to our study.

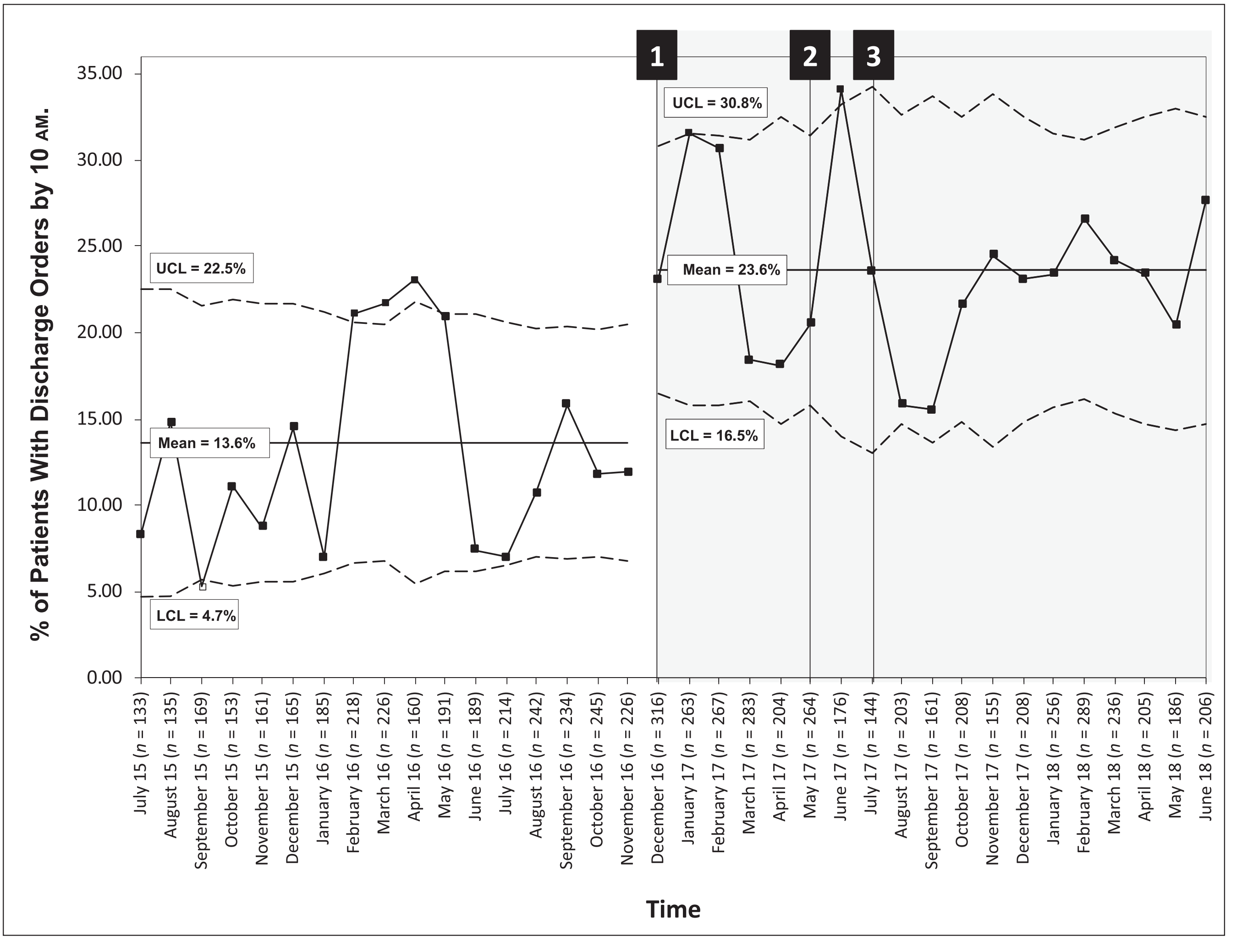

FIGURE 3 P chart of percentage of patients with discharge orders by 10 AM. Interventions are denoted by markers 1, 2, and 3. LCL, lower control limit; UCL, upper control limit.

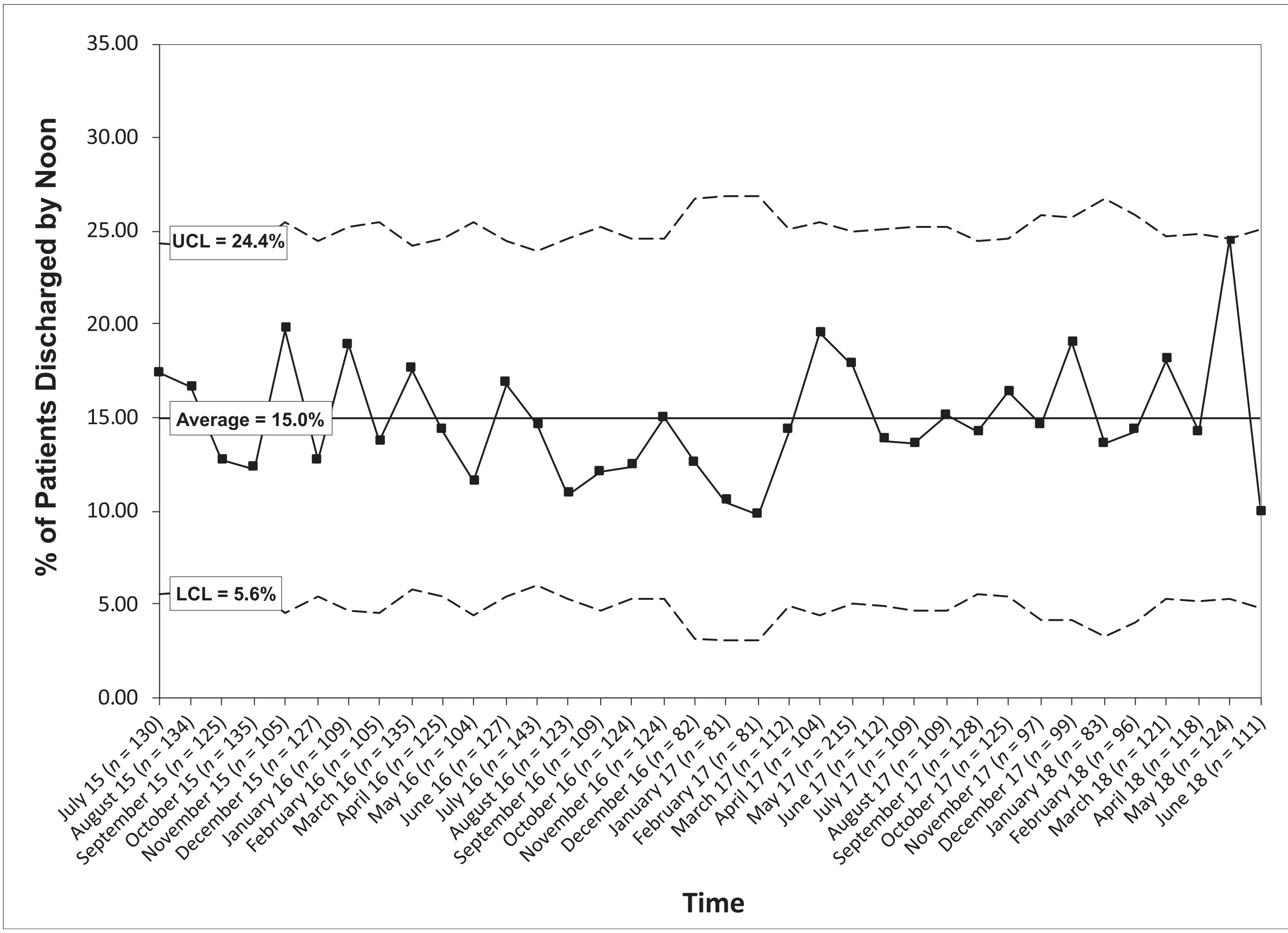

FIGURE 4 P chart of percentage of patients discharged by noon in the control group. LCL, lower control limit; UCL, upper control limit.

In this project, we leveraged a change in physician staffing to alter physician rounding processes, allowing for improved efficiency. Before the project's initiation, our ward transitioned to 24-7 in-house hospitalist coverage. This provided a unique opportunity to implement an intervention using our nocturnist to assist with early morning discharges for patients meeting medical criteria for discharge overnight. Potentially eligible patients were prepared for discharge on the previous evening and were required to complete discharge education, pick up prescription medications from the pharmacy, confirm receipt of discharge equipment and supplies, and determine a transportation plan.

Implementation of a discharge checklist and physician educational workshops were essential to sustaining the improvement in discharge efficiency. Checklists have been used in a variety of settings to standardize care and improve patient safety. Such checklists help reduce reliance on memory, improve team communication, and standardize care processes.[17,18] In adults, hospital discharge checklists have been shown to reduce errors, decrease hospital readmissions and ED revisits, and improve patient satisfaction.[19–23] However, in relatively few studies have researchers evaluated the effect of pediatric discharge checklists. Statile et al[10] found that use of a discharge needs assessment tool, among other interventions, to evaluate discharge needs in medically complex pediatric patients helped improve the percentage of patients who were discharged within 2 hours of meeting medical goals. With our study, we suggest that discharge checklists may also be effective in improving discharge efficiency in a general pediatric population.

Although our secondary outcome measure of LOS and balancing measures of readmissions and CHCAHPs scores showed no significant change over the study period, we found special cause variation indicating a decreased ED revisit rate associated with our interventions. We speculate that this unintended decline in ED revisit rate may have resulted from improved discharge care coordination associated with our interventions. For example, our altered physician workflow of discharging patients before morning rounds required that patients' nonmedical discharge needs be met on the evening before discharge. In several previous studies, researchers have shown that advance discharge planning and care coordination efforts can reduce ED revisit rates in pediatric populations.[24–26]

Measuring and improving pediatric discharge efficiency has presented a

TABLE 1 Comparison of Secondary Outcome and Balancing Measures Before and After Implementation

Measure	Before (SD)	After (SD)	Change (95% Confidence Interval)	*P*
Mean LOS, d	3.7 (5.4)	3.5 (4.7)	−0.2 (−0.5 to −0.005)	.045
Mean LOS monthly index	1.07 (0.10)	1.03 (0.08)	−0.04 (−0.07 to −0.01)	.0042*
% 30-d readmission rate	6.3 (2.0)	6.8 (1.8)	0.5 (−0.7 to 1.7)	—
% 48-h ED revisit rate	1.0 (0.8)	0.9 (0.6)	−0.1 (−0.3 to 0.6)	—
% CHCAHPS discharge domain top box score	80.8 (9.7)	80.0 (7.0)	−0.8 (−6.7 to 7.4)	—

—, not applicable.
* denotes significance at $P < .01$.

challenge for clinicians and administrators alike. Hospitals often reach their peak pediatric census between 10 AM and 12 PM,[8] resulting in prolonged ED and PACU wait times and delayed transfers from the ICU or outlying hospitals. As a result, many improvement efforts, including our own, are focused on a set discharge time (often 11 AM or noon) as a key indicator of efficiency. However, others have warned against setting discharge deadlines, suggesting that hospitalized patients are too complex to set a uniform expected time of discharge.[27] Although a set discharge time may not be the best indicator for all patients, in our study, it is shown that early discharge is feasible for a subset of patients who have met medical criteria for discharge. Integrating discharge time with balancing measures, such as revisit rates and patient satisfaction, can help to ensure that interventions do not have unintended adverse consequences.

Notably, our interventions produced a more-significant change in our process measure (13.6%–23.6%) than in the primary outcome (13.2%–18.5%). Therefore, many patients for whom discharge orders were written by 10 AM were unable to leave the hospital by noon. Although we did not investigate the causes for this discrepancy, we speculate that the increased emphasis on this measure may have inspired physicians to write discharge orders even before patients met all discharge criteria (ie, "contingent" discharge orders). In addition to elucidating the causes for such delays, future studies could help mitigate such discrepancies by seeking alternative methods of tracking discharge readiness, with an emphasis on discharging patients as soon as possible after meeting medical discharge criteria, an approach that has been taken by similar initiatives previously.[10,13]

This study was limited to a single inpatient general pediatric service in an academic medical center. Although results may not be generalizable to other care settings, the multidisciplinary QI process and the interventions that were implemented could be used in other settings to identify and implement opportunities for improvement. Because this was a nonrandomized study, differences in patient age distribution or other unknown differences in patient population in the pre- versus postintervention periods may have contributed to the observed improvement. In addition, in our study, we may have failed to detect changes to balancing measures of LOS, readmission rates, ED revisit rates, and family satisfaction because of inadequate power.

CONCLUSIONS

This iterative QI process involving staggered implementation of discharge interventions is effective in improving pediatric discharge efficiency without evidence of negative impact to subsequent hospital use or patient experience. Although contextual factors and resources may vary across institutions, with this study, we support the use of value stream mapping and rapid cycle QI to identify and implement high-impact, low-resource interventions to improve pediatric discharge efficiency. Future studies will continue this work through ongoing rapid cycle process improvement to maintain sustainability as well as the dissemination of this process to other pediatric inpatient services and units.

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Dr Hamline participated on the University of California (UC), Davis Children's Hospital Discharge Quality Improvement Working Group and also performed the data analysis, drafted the manuscript, and reviewed and revised the manuscript; Drs Rutman and Tancredi assisted with the data analysis and also critically reviewed the manuscript and assisted with revisions; Dr Rosenthal participated on the UC Davis Children's Hospital Discharge Quality Improvement Working Group and also critically reviewed the manuscript and assisted with revisions; the UC Davis Children's Hospital Discharge Quality Improvement Working Group collaboratively conceptualized and designed the study, implemented the interventions, collected the data, and evaluated the impact on the study measures; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

This trial has been registered at www.clinicaltrials.gov (identifier NCT03153722).

Deidentified individual participant data will not be made available.

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