In-Hospital Delays Result in Worse Patient Outcomes and Higher Cost After Cardiac Surgery

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Background. **Contemporary reimbursement systems allow hospitals to maintain profitability by offering procedural services. However, increasing procedural volume can be met with structural inefficiencies that in turn cause delays, worse patient outcomes, and increased cost.**

Methods. **A multidisciplinary team assessed operations and outcomes at the Heart and Vascular Center at Yale New Haven Hospital, a tertiary academic medical center. Data were analyzed retrospectively to assess delays in transferring patients between care environments, patient outcomes, and cost. An intervention was implemented over 90 days, with follow-up analysis. Interventions were based off principles of dynamic work design—an emerging management science framework promoting human-centered work design.**

Results. **Before intervention, delay in patient transfer from operating rooms to the intensive care unit (ICU) was associated with statistically significantly longer ICU length of stay (13% increase) and higher blood loss (16% increase). Also increased were the 30-day readmission rate (10%) and 30-day mortality rate (34%). Delays imposed an additional cost of $3,509,621. A tipping point of weekly surgical volume was identified above which delays occurred. After implementing operational changes, 16% fewer patients were delayed, and ICU length of stay decreased by 19%. No significant change occurred in surgical volume, 30-day mortality, 30-day readmission, or readmission to the operating room or ICU. However, costs decreased by 19%.**

Conclusions. **Operational assessment and dynamic work design can be used to help staff manage increasing case volume by improving efficiency while maintaining quality of care at reduced cost to the system.**

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Patients who cannot be moved to the appropriate care environment in the hospital due to lack of available beds are at risk for receiving suboptimal care. Delay in patient transfer within the hospital has been associated with increased cost of care [1], increased length of stay (LOS) [2], and increased mortality in high-acuity populations [2, 3]. Still, health care delivery has been slow to use operations management strategies to optimize patient flow and throughput.

Yale New Haven Hospital (YNHH) is a large academic and safety-net hospital. As with similar hospitals around the country, YNHH has experienced a 33% increase in patient discharges from 2011 to 2016 [4, 5]. Use of highly profitable service lines [6] has been one avenue to growth, and cardiac surgery volume has increased by 31% during the same time period, with 1,314 operations done in 2016. Without matching investment in infrastructure and capacity, however, it is conceivable that inefficiencies of scale can be reached, after which patient outcomes start to deteriorate and costs of care start to increase.

We observed that demand for available beds outstripped supply, resulting in delays in patient transit from the operating rooms (ORs), intensive care units (ICUs), and floors. For example, postoperative cardiac surgery patients waited as long as 6 hours to be transferred from an OR to the ICU, and ICU patients could wait 18 hours for transfer to the floor. To address this issue, we conducted an operational assessment of the YNHH Heart and Vascular Center and hypothesized that design and implementation of a 90-day pilot intervention would reduce delay in patient transfer.

This study details the initial assessment findings, intervention design, and influence on patient outcomes. The case exemplifies process improvement in medicine through application of dynamic work design (DWD) [7], an emerging theory in management science built on studies of organizational psychology and cognitive science.

The Supplemental Tables and Figures can be viewed in the online version of this article [https://doi.org/10.1016/j.athoracsur.2018.05.033] on http://www.annalsthoracicsurgery.org.

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Material and Methods

Setting

YNHH is a tertiary care medical center and the teaching hospital for Yale University School of Medicine in New Haven, Connecticut, with approximately 1,400 licensed beds [5]. The pilot was conducted with approval from the Yale University Human Investigation Committee (Approval# 1611018629).

Assessment of Baseline

Timestamp data of 1,136 patients studied over 1 calendar year were retrospectively analyzed to quantify trends in delay and to identify bottlenecks. A small, representative subset of 78 patients was monitored for 10 days to precisely map patient and information flow. Information from this subset was representative of data collected from the larger retrospective cohort. Faculty and staff were informally interviewed.

Pilot Implementation and Systematic Interventions

To diagnose the root causes of the delays and develop interventions, a multidisciplinary team was sponsored by the director of the Heart and Vascular Center and the cardiac surgeon (A.A.M.) and empowered to enfranchise (and disenfranchise) stakeholders as needed. Membership of this team included representatives from the "rank and file" and also leadership of cardiac surgery faculty, cardiac anesthesia, OR nursing, perfusion, environmental services, transfer teams, cardiac intensivists, ICU nursing, advanced practice providers, floor nursing, house staff, hospital bed management, hospital administration, information technology, and finance.

Subgroups were thoughtfully composed to ensure that no 2 members of one group were in the same subgroup and that no one with a reporting relationship to someone else was in the same group. Several "break the ice" sessions were held to allow people to get to know one another and develop trust. Opinions were solicited from every member, and neither judgment nor criticism was allowed. People were encouraged to question tactics in an area they were wholly unfamiliar with. Appropriate behavior in meetings had to be modeled by the surgeon in charge of the project. The decision to elevate one person to lead a group or to be eliminated from the group was determined by group consensus.

Subgroup meetings were held weekly or more often if needed. The entire team met every 2 weeks to receive feedback, review, and hold accountable the progress of the subgroups. Structured problem solving helped drive group expectations for what needed to be done and on what timeline (Supplemental Fig 1).

The metrics chosen to study included:

- time to transfer from OR to ICU, ICU to step-down, and step-down to floor;
- nonprocedural case volume and cardiac surgery volume;
- percentage of patients transferred from ICU at or before 7:00 AM and ICU and floor LOS;
- percentage of patients discharged from the floor at or before 9:00 AM and between 4:00 PM and 8:00 PM;
- readmission rates to ICU and hospital;
- 30-day mortality, unplanned return to the OR, volume of blood lost, volume of blood products transfused, time on ventilator, and temperature on arrival to ICU; and
- direct cost per case.

Costs were calculated as previously described (Supplemental Material page 8) [6].

Interventions were then implemented over 90 consecutive days. Several changes directly addressed systematic issues:

The existing 9:30 AM meeting to determine bed availability for postoperative patients was moved to 5:30 AM to precede the 7:30 AM procedure start time. A second bed management meeting was implemented at 3:00 PM. These were attended in person or by teleconference by all stakeholders.

Discharge from the ICU was prioritized for 7:00 AM, and the discharge time from the floors was moved from 11:00 AM to 9:00 AM. A second discharge time was established in the evening at 6:00 PM, which created capacity to accept ICU transfers at night.

A "pull throughput" system was put into place, whereby operations were only started if beds were known to be immediately available in the ICU.

"Human Interventions": Interventions Based in DWD

We sought to help the people doing the work function autonomously in diagnosing and resolving issues moving forward. The ability to sustain quality-improvement efforts in health care requires development of a culture interested in change and safety, where key stakeholders and people doing the work are collaboratively engaged in the work [8]. Further interventions were deployed based on principles of DWD.

Like other process improvement methodologies used in health care—Lean Processes [9, 10], Six Sigma [11, 12], Plan-Do-Study-Act [13, 14], and Failure Modes and Effective Analysis [8]—DWD begins with the identification of shortcomings in work flow that produce undesired outcomes. The next steps generally include design of solutions, testing of solutions, and follow-up monitoring. DWD is unique in that it simultaneously focuses on designing solutions that aim to make work more engaging and rewarding for the people doing it. Summarily, DWD has four basic principles [7, 15]: Good work design continuously reconciles activity and intent, connects the human chain, leverages structured problem solving, and manages challenge optimally.

We can "reconcile activity with intent" in the workplace by making it easy for people to know what they are doing, why they are doing it, and to see how their activities affect outcomes in a nearly real-time scale by providing clearly set goals and continuous feedback. For instance, an electronic dashboard (Supplemental Fig 2) provided