Given the economic constraints of modern health care systems, it is clear that efforts are needed to reduce unnecessary medical costs while providing high-quality patient care to improve the value of health care delivery. Despite tighter regulatory mandates and improved awareness by insurance companies and physicians, there remain significant challenges in minimizing unnecessary diagnostic tests that do not clinically impact the delivery of patient care. Laboratory costs in particular are a significant portion of the overall costs of hospitalization, accounting for up to 25% of a patient’s hospitalization costs for a 2-week inpatient stay in one study. Physician engagement is fundamental in this effort to improve the quality and value of health care systems, and a major hurdle in bringing about significant change is the need to transform the physician culture to make quality, efficiency, and high-value care a focus of everyday practice. To do so, leaders in academic medicine have called for engagement of physician trainees.

As part of these efforts, the Accreditation Council for Graduate Medical Education (ACGME) has identified practice-based medicine, systems-based practice, and quality improvement as core competencies, requiring trainees to identify areas of improvement in their practicing environment. A novel program at the University of California, San Francisco (UCSF), has used financial incentives to further engage and encourage residents to implement their own quality improvement solutions.
and fellows in 80 accredited programs. With collaboration between the medical center and the office of graduate medical education leadership, a program-specific resident incentive quality improvement program was introduced in 2008. Each training program was invited to identify an area in need of improvement specific to its respective clinical practice and to generate a proposal for a program outlining steps toward specific goals. The proposal was evaluated by a committee of the medical center, graduate medical education, and quality improvement leadership in addition to the Resident and Fellow’s Council and residency program directors. At the end of the academic year, if the proposed goal was met, each trainee within the department was awarded $400. The incentive program budgets approximately $1.2 million annually. Previous trainee-led initiatives have focused on improving efficiency (reducing patient wait times and improving on-time operating room starts), documentation and communication (contact with primary care physician and improving sign-out), and patient satisfaction. Here, we describe the results of the UCSF neurosurgery resident–incentivized quality improvement initiative to reduce the utilization of clinically unnecessary laboratory tests.

The residency training program of the Department of Neurological Surgery at UCSF consists of 18 trainees across 6 years of training. The clinical service of the department serves as a large-volume tertiary referral center, providing care for more than 2600 inpatient admissions yearly. Due to frequent use of the ICU and the relatively patient acuity, laboratory tests are used very frequently.

Methods

For the incentive quality improvement initiative for the 2011–2012 year, the neurosurgery residency proposed a 50% reduction in tests for serum calcium (both ionized and total), chloride, magnesium, and phosphorous. These 5 tests were identified as tests that were least likely to yield abnormal results or influence clinical decision making in the neurosurgical inpatient population (Table 1). In conjunction with the co-management hospitalist service,1 a formalized set of guidelines was developed to aid in deciding when to order these specific tests (Table 2). The list was disseminated to residents, and the nurses on the neurosurgical ICUs and wards were notified of the incentive efforts. In addition, the use of bundled chemistry panel laboratory tests (that is, chem-7 panels) was discouraged. The use of these tests per 100 inpatient days was monitored on a monthly basis. To assess the financial impact of any laboratory reduction on the institution, direct laboratory costs and billable charges per test were calculated. The direct laboratory costs represent those expenses incurred to perform the laboratory tests and are inclusive of items such as reagents used in the clinical laboratory, while the billable charges are the costs for the reimbursement agencies, and are designed to cover other hospital expenses incurred, such as facility costs and phlebotomy staff.

Results

Before our intervention, 45,023 total tests of serum calcium, ionized calcium, chloride, magnesium, and phosphorous were ordered on the neurosurgery service during the 2010–2011 fiscal year. Under the resident-incentivized program during 2011–2012, a 47% reduction was achieved, with a new total of 23,660 of the specified laboratory tests. These values translated to a reduction from 253 tests per 100 inpatient days for 2010–2011 to 169 tests per 100 inpatient days for the 2011–2012 fiscal year (Fig. 1). This degree of reduction was similarly distributed in all 5 tests.

Taking into account the direct costs and billable charges attributable to each of these tests, the initiative resulted in a reduction of direct laboratory cost from $137,809 to $63,640, and billable charges from $3.6 million to $1.9 million.

During the same time period, other quality metrics were being closely monitored as part of the Quality Reporting Program to the Governance Advisory Council, to ensure that the quality of care being delivered was not being compromised by the reduction in laboratory test orders. During the 2011–2012 fiscal year, the number of inpatient admissions was 2622. The Medicare case mix index had increased from the year prior from 2.797 to 2.897, the length of stay index had decreased from 1.21 to 1.15, the mean number of ICU days was unchanged at 1.9 days, the average length of stay had decreased from 6.1 to 5.5 days, and the 30-day readmission rates saw a modest increase from 7.8% to 8.3% (Table 3). The difference in the readmission rates was not statistically significant (p = 0.51, chi-square test).

Of the $1.2 million budgeted for the incentive program, 67% of the programs successfully met their goal, and $800,000 was paid as reward to the trainees. Of this amount, a total of $7200 was available as reward for the 18 residents of neurosurgery.

Discussion

Engaging physician trainees with the resident qual-
Cost reduction by reducing unnecessary laboratory tests

### TABLE 2: Guidelines for clinical situations in which each test should be ordered

<table>
<thead>
<tr>
<th>Test</th>
<th>Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>chloride, serum</td>
<td>presence of acidosis on arterial blood gas, bicarbonate &lt;20 mEq/L, to calculate presence of anion gap</td>
</tr>
<tr>
<td>magnesium, serum</td>
<td>clinical evidence of poor nutrition, prolonged NPO status, heavy diuresis</td>
</tr>
<tr>
<td>phosphorus, serum</td>
<td>clinical evidence of poor nutrition, prolonged NPO</td>
</tr>
<tr>
<td>calcium, total</td>
<td>use of blood products outside periop setting, suspicion for multiple endocrinopathies</td>
</tr>
</tbody>
</table>

*NPO = nothing by mouth.

Residen reported that providing moderate financial incentives alone to limit ordering of tests seemed to be of no value. Instead, a rigorous education process including chart review with senior residents and attending physicians discussing the need for specific tests for patients resulted in a 47% reduction in testing. The authors concluded that financial incentives, without any guidance or instructions on test ordering, did not yield any significant changes. Reviews of efforts to influence physician behaviors in ordering laboratory tests found a wide range of interventions including education of cost control, decision support guidelines, and feedback. The authors concluded that a single-pronged intervention resulted mostly in low success rates, while efforts involving multiple interventions had better results. In the same regard, the degree of reduction seen in our program was likely from providing house staff–specific guidelines for ordering laboratory tests, the monthly feedback and reminders regarding the number of tests being ordered on service and the target goal, and the financial incentive.

Identifying the tests that are truly unnecessary can be a complex and challenging task, as many diagnostic tests are essential for screening, diagnosis, and monitoring of diseases. However, there is considerable variation among practitioners and institutions in testing practice, suggesting that a large number of tests may not directly influence patient care. There is an overall lack of any solid evidence supporting a best set of guidelines that are based on improving patient outcomes. A handful of testing guidelines published in the literature have originated from prior efforts to reduce unnecessary tests; however, the authors warn that the guidelines are not based on high-level evidence and are specific to their respective institution's ex-
The frequency of replacement orders were found to be abnormal in only 37%, 7.3%, and 25.5% of tests, respectively. The frequency of replacement orders was even lower, representing approximately half of the abnormal tests. In this study, provider adherence to the testing guidelines was not specifically monitored, and these data would have been of additional value in determining the direct clinical effects as a result of adhering to the recommended testing guidelines.

The 47% reduction in laboratory test orders achieved here was below the target goal of 50% reduction, and thus the financial incentive was not met. In studying sources of laboratory test ordering, it was noted that some tests, such as ionized calcium, are not ordered by neuromuscular residents. Rather, they are often coupled with arterial blood gases ordered by co-managing services, such as the intensive care service or by anesthesiologists in the operating room. Thus, there were intrinsic limitations in offering incentives to neurosurgery residents only. Future incentives programs should incorporate all relevant stakeholders. Some degree of error in order entry also limited laboratory test reduction efforts. For example, the more expensive ionized calcium test was sometimes substituted for the less expensive total calcium test when orders from the patient’s chart were transcribed onto paper laboratory order forms. Implementation of fully electronic order communication should eliminate this type of error.

Although slightly under target, this resident-led effort to decrease clinically unnecessary laboratory testing still led to significant cost savings of approximately $1.7 million of billable laboratory charges to health care payers and insurance companies and direct cost savings of nearly $75,000 to the medical center. Although the direct cost savings to the medical center were modest, this was significantly larger than the incentive prize of $7200 ($400 for each resident) offered, making the return on investment a worthwhile value proposition from the medical center’s perspective. In addition, we thought that the large cost savings of billable charges to be of significant benefit to the ever-growing costs of health care.

There is no evidence of patient care being compromised with reduction in the utilization of these laboratory orders, as measured by metrics such as mean number of ICU days, length of stay index, and readmission rates. A limitation to our analysis is the use of broad quality outcome measures to monitor individual patient care. Thus, an individual patient in whom a preventable morbidity occurred due to limited laboratory testing would not have been detected in our measure, although such a patient’s hospital course would have resulted in additional costs. The costs and morbidity incurred as a result of our project due to an abnormal electrolyte value would have to be in conditions that resulted from the lack of testing when the test would have been of value for the patient’s care. An example of such a situation would be a patient who develops an arrhythmia postoperatively due to unrecognized hypocalcemia, requiring transfer back to the ICU setting, while the morbidity and costs associated with the arrhythmia and prolonged ICU stay could have been avoided by earlier checking of serum calcium levels. However, in these and other similar situations, it is difficult and often impossible to ascertain whether earlier testing would have prevented the morbidity or incurred fewer costs. As in the example above, if the patient had been found to have low calcium levels, there likely would have been earlier correction, but there is no guarantee that arrhythmia would not have occurred and the total number of ICU days would have been shortened. In addition, this type of practice pattern would have extended to other patients in similar situations who would have been tested, with the majority having normal values, and some patients with borderline values may have been monitored in a telemetry-monitored unit for additional days, thus incurring additional costs. Overall, an exact calculation of costs and morbidity for individual patients that are directly referable to limiting testing is very difficult. The broad outcomes measures used to measure the quality of patient care helped ensure that there was no significant negative impact of our intervention.

Lastly, while these initiatives have tangible cost savings, the benefit extends beyond to those of engaging trainees to build skills in quality improvement and project management. The graduate medical education quality improvement incentive program encourages residents to identify areas of improvement directly relevant to their own fields and to propose solutions to address these areas. This ensures that trainees meet the core competencies of systems-based practice, practice-based learning, and quality improvement required by the ACGME. The process of financially incentivizing trainees to participate in quality improvement projects is broadly applicable and will likely be successful in other academic medical settings. However, the specifics of our efforts in reducing laboratory tests are not necessarily applicable to other medical centers, as our study was restricted to neurosurgical patients, and the testing patterns and incidence of abnormal tests are likely to vary depending on the medical center and the patient population studied.

Conclusions

Engaging physician trainees in quality improvement can be achieved by financial incentives. Through the resident-led quality improvement incentive program, neurosurgical trainees achieved a 47% reduction in targeted laboratory tests in 1 year, leading to $1.7 million in cost savings. Similar programs could improve the value of care being provided at other academic medical centers, while providing learning opportunities in quality improvement for residents.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper. Dr. McDermott shared a patent with Integra for the medical device LimiTorr. The patent is now owned by UCSF, and the device is manufactured by Integra.
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Author contributions to the study and manuscript preparation include the following. Conception and design: Han, Saigal, Rolston, Berger. Acquisition of data: Han, Saigal, Rolston, Lau, Mistry. Analysis and interpretation of data: all authors. Drafting the article: Han, Saigal, Rolston, Cheng. Critically revising the article: Han, Saigal, Rolston, Lau, McDermott, Berger. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Han. Statistical analysis: Han.

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