Assessing early unplanned reoperations in neurosurgery: opportunities for quality improvement

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OBJECT Review of morbidities and mortality has been the primary method used to assess surgical quality by physicians, hospitals, and oversight agencies. The incidence of reoperation has been proposed as a candidate quality indicator for surgical care. The authors report a comprehensive assessment of reoperations within a neurosurgical department and discuss how such data can be integrated into quality improvement initiatives to optimize value of care delivery.

METHODS All neurosurgical procedures performed in the main operating room or the outpatient surgery center at the Ronald Reagan UCLA Medical Center and UCLA Santa Monica Medical Center from July 2008 to December 2012 were considered for this study. Interventional radiology and stereotactic radiosurgery procedures were excluded. Early reoperations within 7 days of the index surgery were reviewed and their preventability status was evaluated.

RESULTS The incidence of early unplanned reoperation was 2.6% (occurring after 183 of 6912 procedures). More than half of the patients who underwent early unplanned reoperation initially had surgery for shunt-related conditions (34.4%) or intracranial tumor (23.5%). Shunt failure was the most common indication for early unplanned reoperation (34.4%), followed by postoperative bleeding (20.8%) and postoperative elevated intracranial pressure (9.8%). The average time interval (± SD) between the index surgery and reoperation was 3.0 ± 1.9 days. The average length of stay following re-operation was 12.1 ± 14.4 days.

CONCLUSIONS This study enabled an in-depth assessment of reoperations within an academic neurosurgical practice and identification of strategic opportunities for department-wide quality improvement initiatives. The authors provide a nuanced discussion regarding the use of absolute reoperations as a quality indicator for neurosurgical patient populations.

http://thejns.org/doi/abs/10.3171/2014.9.JNS14666

KEY WORDS reoperation; operating room; neurosurgery; complication; quality indicator; measure; diagnostic and operative techniques

By the nature of the underlying conditions and the corrective procedure, surgical patients are exposed to a variety of risks. Despite oftentimes relatively low complication rates, the median incidence of inpatient adverse events has been estimated at 9%–10%, with operation-related events constituting almost 40% of those events, across all surgical specialties within an institution.3,14 Across surgical specialties, multiple prospective and retrospective studies have reported best-case scenario outcomes and complication rates specific to particular entities and procedures.25 Importantly, neurosurgery has relatively high morbidity and mortality rates in comparison with other surgical specialties.15 Review of morbidities and mortality has been the primary method of assessing surgical quality used by physicians, hospitals, and oversight agencies.10,17,20

In recent years, the reoperation rate, defined as the percentage of patients undergoing a new operation, has been proposed as a quality indicator, a surrogate for surgical adverse events.4,13,19,24 General surgery has been at the forefront of assessing reoperations. Reported rates have varied widely (0.6% to 9.4%) depending on the definition, method of detection, case selection criteria, heterogeneity of practices, and difference in department and hospital practic-
Therefore, the appropriateness of the “absolute” rate of reoperations as a quality indicator enabling quality improvement and comparison between departments and organizations has been questioned.

To date, studies reporting department-wide reoperation rates are scarce in neurosurgery. As departments aim to deliver optimal value of care, understanding the incidence and causes of reoperations, specifically unplanned reoperations, is critical, given their medical impact on the patient and financial impact on health care. Particularities of reoperations occurring within a neurosurgical department may shed light on nuances that are essential to identify so that “reoperation” can effectively serve its function of quality indicator. Most importantly, reviewing reoperation data will help guide strategic deployment of quality improvement efforts.

In this study, we reviewed all returns to the operating room occurring over 5 consecutive years, assessing the incidence, timing, and causes leading to early unplanned reoperations. We discuss elements that should be taken into account when considering “reoperation” as a surgical quality indicator and present how detailed reoperation data can be used by quality improvement programs to raise value of care delivery.

Methods

Patient Population

All neurosurgical procedures performed in the main operating room or the outpatient surgery center at the Ronald Reagan UCLA Medical Center and UCLA Santa Monica Medical Center from July 2008 to December 2012 were considered for this study. Interventional radiology and stereotactic radiosurgery procedures were excluded. Review of the operating room logs and electronic medical database enabled us to identify patients who underwent reoperation within 7 days of the index surgery. The neuroinformatics team developed a query of our databases. The algorithm used enabled us to identify all surgeries performed during the study period where a faculty member of the neurosurgery department was either the primary surgeon or co-surgeon and the number of days between the surgery and the next surgery was less than 7 days. The output also indicated whether the reoperation was during the same hospital visit or a readmission. Surgical data were obtained from tables created in MS SQL Server 2008 R2 (Microsoft Corp.) populated by data from GE Centricity Perioperative Manager (CPM) (GE Healthcare). Patient encounter data were obtained from Allscripts Enterprise Performance Systems, Inc. (EPSI). This study was conducted with UCLA (University of California, Los Angeles) institutional review board approval.

Definitions

In this study, index surgery was defined as the first surgical procedure performed in the operating room (OR) during the patient’s first admission of the episode of surgical care. We defined early return to the OR (early reoperation), as any procedure performed in the operating room within 7 days following the index surgery. The early return to the OR could have occurred either during the same admission or during a readmission, but it had to have been within 7 days of the index surgery. “Planned” or “staged” return to the OR referred to a scheduled second procedure related to the original disease, such as removal of electrodes following electrode implantation in epilepsy surgery, placement of a ventriculoperitoneal (VP) shunt for hydrocephalus following closure of a myelomeningocele, or tumor resection following VP shunt placement for hydrocephalus caused by a pineal region tumor. “Unplanned” return to the OR (reoperation) was defined as an unscheduled second procedure performed after the index operation. For the index surgery and the reoperation surgery, the case status was categorized either “elective” if the operation was scheduled in advance and did not involve a medical emergency or “emergent/urgent” if the operation needed to be performed rapidly or immediately in the setting of a life-threatening state. The indication for reoperation was established by the attending neurosurgeon, based on the patient’s clinical course and investigations.

Data Extraction

Patients’ clinical notes, radiological images, and operative notes were reviewed. Information extracted from the databases and verified and completed by chart review included but was not limited to preoperative diagnoses for the index surgery, title of index surgery and date, indication of reoperations, title of reoperation surgery and date, length of admissions (index hospitalization and readmission if existing), case status (elective vs emergent/urgent), and reoperation status (planned vs unplanned). Two independent reviewers (N.M. and P.J.) reviewed the data.

Results

Patient Demographics and Population Distribution (Planned vs Unplanned)

A total of 6912 neurosurgical operations were performed at UCLA Ronald Reagan Medical Center (n = 5126) and UCLA Santa Monica Medical Center (n = 1786) during the study period. Of these operations, 237 (3.4%) were reoperations performed within 7 days of the index surgery. In 116 of these cases, the patients were male, and in 121, they were female; 156 of the 237 patients were 18 years or older. Of the 237 cases of reoperation, 40 were planned or staged. Figure 1 presents a flowchart of the patient population and summarizes the medical indications for planned or staged return to the OR.

Overview of Unplanned Reoperations

Overall, 197 cases were identified as unplanned returns to the OR. Of these cases, the index surgeries in 12 cases were cancelled by the anesthesiologist after the patient was wheeled into the OR because of unstable medical conditions, such as abnormal blood pressure (uncontrollably high or low), cardiac dysfunction (arrhythmia or supraventricular tachycardia), respiratory dysfunction (desaturation or absence of breath sounds over 1 lung field), or abnormal international normalized ratio (INR) value. One patient underwent an uncomplicated elective C4–5 and C5–6 anterior cervical discectomy and fusion for symptomatic cervical spondylosis. After awakening, the patient was not
moving his right hemibody. An urgent cervical spine MRI confirmed appropriate placement of the hardware without any evidence of cord compression or cord signal changes. The patient was returned to the OR with a laryngeal mask airway to undergo repeat somatosensory and motor evoked potential studies, which showed no change from baseline. One patient with a pituitary adenoma was scheduled for an endonasal endoscopic resection on an elective basis. After intubation, a conflict in scheduling led to the procedure being aborted and rescheduled. These 14 cases were excluded from further analysis because the patients actually underwent only 1 operation despite their 2 trips to the OR.

The remaining 183 cases of unplanned early reoperations were analyzed in greater depth. These cases involved 90 male and 93 female patients, with an average age of 36.8 ± 25.8 years. There were 128 adult cases (patient age ≥ 18 years) and 55 pediatric cases (patient age < 18 years). The overall incidence of unplanned early returns to the OR was 2.6% (183 of 6912 cases). The neurosurgical conditions for which these 183 patients had undergone their index surgery are presented in Fig. 2. Together, shunt-related disease (including but not limited to hydrocephalus, subdural collections, arachnoid cysts, and Dandy-Walker syndrome) (34.4%) and intracranial tumor (23.5%) accounted for more than half of these cases. Of note, intracranial tumors included intraaxial tumors, extraaxial tumors, and skull base tumors, including those of the pituitary region. Table 1 presents the actual categories of the operations performed at the time of the index surgery in these 183 patients. The 3 most frequent surgeries were: 1) CSF diversion–related procedures (31%); 2) craniotomy for resection of intracranial tumoral or nontumoral mass (13%); and 3) laminectomy for spinal pathology (12%). For each category of index surgery, an estimate of the reoperation percentage was also calculated, using the total number of procedures performed during the same time period as denominator.

**Indication for Reoperation**

The indications for early unplanned reoperation are presented according to the underlying neurosurgical condition that the patient’s index surgery was addressing. Shunt failure was the most common indication for early unplanned reoperation (63 [34.4%] of 183 cases). Postoperative bleeding ranked second, with 38 cases (20.8%). Postoperative elevated intracranial pressure (ICP) (18 cases), incomplete resection/procedure (16 cases), postoperative CSF leak (13 cases), and technical issues (13 cases) accounted for 9.8%, 8.7%, 7.1%, and 7.1% of all returns, respectively. Because of the heterogeneity in surgical procedures for a specific neurosurgical condition, the total case numbers according to the underlying neurosurgical condition differ. For example, not all patients with intracranial tumors underwent a craniotomy for tumor resection, some underwent surgery for placement of an Ommaya reservoir.

**Reoperation for Shunt Failures**

Among the 63 cases of reoperation for shunt failure, 36 involved pediatric patients and 27 involved adults. In 14 cases, reoperation was performed for misplacement of a ventricular or peritoneal catheter during the index surgery, in 27 cases for catheter or valve clotting or malfunction, in 9 cases for shunt system infection, in 7 cases for persistent

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**FIG. 1.** Flowchart of the patient population. RR = UCLA Ronald Reagan Medical Center; SM = UCLA Santa Monica Medical Center.
symptomatology after the index surgery, in 3 cases for too long a ventricular catheter affecting the flow of CSF, in 2 cases for wound dehiscence, and in 1 case because a portion of the peritoneal catheter was coming out through an ostomy incision.

Reoperation for Postoperative Bleeding

Among the 38 cases of reoperation for postoperative bleeding, there were 35 in which the bleeding originated from the operative site or between tissue layers (subdural, epidural or subgaleal) in the surgical route. In 2 cases, a subdural hemorrhage occurred at a site remote from the initial surgery. In the last case, the patient developed a depressed skull fracture at the Mayfield pin site and developed an epidural hematoma that required additional surgery. Patients with new postoperative bleeding were returned to the OR if they had deteriorating neurological status in the presence of significant mass effect documented on postoperative imaging.

Reoperation for Postoperative Elevated ICP

Among the 18 cases in which reoperation was performed for elevated ICP, more than half involved patients with intracranial tumors. The factors giving rise to high ICP were brain edema (5 cases, including 1 related to intracranial tumors), arterial infarction (3 cases, including 1 related to intracranial tumors), and postoperative hydrocephalus (persistent or de novo) (10 cases, including 7 related to intracranial tumors).

Reoperation for Incomplete Resection/Procedure

Among the 16 cases in which reoperation was performed for incomplete resection or other procedure, 5 reoperations were performed for incomplete resection of brain tumors and 3 for incomplete resection of functional pituitary adenomas (2 cases of Cushing disease and 1 case of acromegaly). In 4 cases, patients underwent reopera- tion because of an incomplete index procedure related to cerebrovascular conditions (including residual cavernous

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**FIG. 2.** Neurosurgical condition distribution of all unplanned early reoperations.

**TABLE 1. Most common index surgeries for patients having undergone an early unplanned reoperation**

<table>
<thead>
<tr>
<th>Index Surgery Category</th>
<th>No. of Reoperated Cases w/ This Index Surgery Category (%)</th>
<th>Reoperation % for This Index Surgery Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shunt-related procedure</td>
<td>56 (31)</td>
<td>5.5</td>
</tr>
<tr>
<td>Craniotomy for resection of tumor</td>
<td>24 (13)</td>
<td>2.0</td>
</tr>
<tr>
<td>Spinal procedure</td>
<td>22 (12)</td>
<td>1.2</td>
</tr>
<tr>
<td>Endoscopic endonasal approach for pituitary region pathology</td>
<td>16 (9)</td>
<td>4.0</td>
</tr>
<tr>
<td>Decompressive hemicraniectomy w/ or w/o evacuation of hematoma</td>
<td>16 (9)</td>
<td>4.2</td>
</tr>
<tr>
<td>Craniotomy for treatment of cerebrovascular pathology</td>
<td>13 (7)</td>
<td>4.2</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>36 (19)</td>
<td>NA</td>
</tr>
</tbody>
</table>

NA = not applicable.
malformation and residual arteriovenous malformation). There were also 4 cases in which the index procedure was classified in the miscellaneous category.

Reoperation for Postoperative CSF Leak

Among the 13 reoperations for postoperative CSF leak, 4 were performed following an index endoscopic endonasal approach, 3 following an index open skull base approach, 2 following an index frontotemporal craniotomy, and 4 following an index lumbar surgery.

Reoperation for Technical Issues

Among the 13 cases of technical issues, 8 occurred in spinal surgery; 1 involved a stitched drain in the setting of a lumbar procedure, and the other 7 cases were related to misplaced hardware or displaced graft materials needing to be revised given neurological symptoms and signs. The remaining 5 cases included: 1) revision of an Ommaya reservoir in 2 patients; 2) complete resection of a previously partially removed lumbo-peritoneal shunt in a patient with postoperative postural headaches presumed to be related to drainage from the initial lumbar catheter into subcutaneous tissue; 3) disconnection of a right middle cerebral artery/superficial temporal artery bypass with bypass to a separate cortical branch using the superficial temporal artery; and 4) repair of an incisional hernia in a 29-week-old baby who initially underwent surgery for obstructive hydrocephalus following Grade 3 intraventricular hemorrhage.

The top 6 indications mentioned above account for almost 90% of early unplanned reoperations in the present study population.

Timing and Urgency of Reoperation

Time interval, calculated as the numbers of days between the index surgery and early return to the OR, is shown in Fig. 3 for the top 6 indications for reoperation. The average time interval between the index surgery and the reoperation was 3.0 ± 1.9 days. One hundred sixty-seven reoperations were performed during the same hospital admission as the index surgery, and average length of stay (LOS) for these patients was 18.7 ± 16.4 days. Sixteen reoperations were performed during a readmission, but always within 7 days of the index surgery. The average LOS for these readmissions was 10.8 ± 7.8 days. The average LOS from the reoperation to discharge was 12.1 ± 14.4 days. During the same study period, the average LOS for the neurosurgical procedures performed at UCLA Ronald Reagan Medical Center was 7.5 days and for the neurosurgical procedures performed at UCLA Santa Monica Medical Center was 3.18 days.

Among the patient population undergoing unplanned early reoperations, return to the OR was elective in 55.2% of cases (101 of 183) and emergent/urgent in 44.8% (82 of 183).

Discussion

Reoperations: Defining a Significant Event

Across surgical specialties, reoperations have been categorized as an adverse event with significant impact on value-based care delivery. Rate of reoperation has been initially defined as the percentage of patients undergoing a new operation after an index procedure. This definition requires a clear definition of what constitutes an “operation.” In the calculation of the denominator, most studies have excluded interventional radiology and stereotactic radiosurgery procedures. Although most studies include all surgeries performed in an OR, including both the main OR and outpatient surgery centers, some groups have excluded minor surgeries and others have excluded emergent/urgent cases.

Defining the inclusion criteria for the numerator is also critical. As our study documented, not all patients brought to the OR twice (or who returned to the OR) were undergoing reoperation. Medical instability jeopardizing safe surgery was the main reason for aborted surgery and return to the OR for surgery on another day. Although they may also represent opportunities for improvement, the
rate of return to the OR may not be equal to the rate of re-
operations, and these 2 entities should be distinguished.13,18
Among patients who undergo reoperation, some undergo a
planned reoperation, with their physician electing to pro-
cceed in 2 steps for the safety and benefit of the patient.
Most studies recognize that a planned surgery does not
represent an adverse event.13 Therefore, only unplanned
surgeries are generally included in the numerator when
calculating the rate of reoperations. A clear understanding
of the numerator’s and denominator’s definition is essen-
tial for the calculation of reoperation rates and their poten-
tial use as quality indicators.

Preventability of Reoperations

The question arises whether all unplanned reoperations
represent the same type of adverse events. Some groups
have attempted to further qualify reoperations as avoid-
able or unavoidable.14,18,23 Indeed, unplanned reoperations
may not always reflect suboptimal initial surgical treat-
ment; they can also reflect the severity or the complexity
of the underlying condition and the related index pro-
dure. Some authors have proposed using a 6-point scale to
assess the preventability status of adverse events.3,8 More
recently, Halfon and colleagues defined a reoperation as
avoidable when there was strong evidence or significant
consensus in the literature that the probability of the main
cause of reoperation could be reduced by optimal practic-
es, according to the current state of knowledge or technol-
gy.14 Although this represents a promising attempt to bet-
ter assess preventability, ambiguity, uncertainty, and sub-
jectivity in the judgment process contribute to unreliable
and potentially variable determination of preventability
status when using retrospective data. To increase the va-
lidity of the preventability determination, this assessment
should be collected prospectively and determined by the
treating team in real time as the event is occurring. One
might question whether all adverse events present a com-
ponent of preventability following a root-cause analysis.

Reoperation and Return to the OR in Neurosurgery

To date, only 2 published studies report the rate of un-
planned reoperation or the rate of unplanned return to the
OR in neurosurgical practices.18,21 Mukerji and colleagues
noted that the 30-day unplanned reoperation rate was
17% in a pediatric neurosurgical service.21 They defined
an unplanned reoperation as “any unscheduled secondary
procedure required for a complication resulting directly or
indirectly from the index operation or as an unscheduled
return to the OR for the same condition.” In their study,
CSF diversion procedures represented the highest risk
factor for reoperations.21 The number of reoperations was
broken down by 15-day periods, from Day 0 to Day 300
following the index surgery. The authors reported that re-
operation within 1 day of the index surgery was very com-
mon and that 58% of all reoperations occurred within the
first 15-day period after the index surgery (Day 0 to Day
15). Data suggested that the majority of reoperations oc-
curring in neurosurgical patients occurred early after the
index surgery.21 Marini and colleagues assessed the rate
of return to the OR within 30 days of the index surgery.
They further distinguished unplanned returns to the OR
related to the disease’s natural history versus those related
to an unintended injury or complication caused by health
care management rather than by the patient’s underlying
disease process.3,12,26 The overall 30-day unplanned rate
of return to the OR was 9.2% in an adult neurological
service. The time interval between the index surgery and
reoperation was not specified in this study. Preventability
of reoperations was not assessed in either of these studies
in neurosurgical patient populations.

Reoperation as a Quality Indicator

Over the years, reoperation has been suggested as a
screening tool for quality assurance as well as an outcome
measure by the National Surgical Quality Improvement
Program of the Department of Veterans Affairs.2,4,7,20 The
rate of reoperation has also been proposed as a quality in-
dicator, as it seemed to fulfill all proposed criteria: 1) the
event is common; 2) the event is relatively nondiscretion-
ary (patients undergo reoperation or do not); 3) the event is
easy to track with administrative data; and 4) the event rate
may be suitable for comparison between hospitals.5,14,23

Limitations in Use of Reoperation as Quality Indicator

In light of the review of our departmental data and re-
view of the surgical literature, reoperation may not satisfy
these criteria as clearly as initially proposed. Although re-
operation is more common than death following surgery,
the number of unplanned reoperations following a given
procedure may be relatively low. In such circumstances,
the reoperation rate may reflect the severity of a condition
or the complexity of a procedure more than quality of care.
Despite the fact that reoperation may be nondiscretionary,
variation between physicians in their decision-making
processes and their practice styles or variation between
institutions with respect to medical management protocols
and procedures performed at bedside may influence the
calculation of reoperation rates. An example is the possi-
bility of placing an external ventricular drain or a subdural
drain at bedside in the intensive care unit. Some authors
have recognized that reoperation data may not be so easy
to track, whether hospital records or physician-collected
databases are used.21 With both types of databases, docu-
mentation and coding challenges may contribute to under-
reporting of reoperations.13,19 In the absence of a consensus
regarding an operational definition of reoperation (vari-
able inclusion/exclusion criteria), absence of consensus on
what constitutes the most impactful actionable subset of
reoperations to monitor, and in the presence of all of the
above elements, comparison between institutions is cur-
rently impossible.13 Therefore, many arguments have been
raised regarding the true applicability of the absolute reop-
eration rate as a quality indicator for surgical care.

Candidate Nuances for Reoperation as Quality Indicator

Just as mortality is now assessed as observed/expected
with multiple variables taken into consideration, authors
have proposed reporting an adjusted reoperation rate that
could take into account patient-related factors (patient age
(> 60 years old), preoperative ASA (American Society of
Anesthesiologists) state, patient comorbidities), disease-re-
lated factors (trauma case, emergency surgery), physician/
hospital-related factors (case mix). Other authors have introduced the “failure to rescue” metric, which measures the mortality rate among patients who suffer postoperative complications. Importantly, it is unlikely that a single indicator will be sufficient to appropriately estimate surgical quality. A panel of complementary indicators, possibly with a weighted value, may give the best overall surgical care quality assessment.

**Opportunities for Quality Improvement**

This study aimed at gaining a comprehensive understanding of patient populations, causes, and timing of unplanned reoperation to build impactful quality improvement initiatives. Reviewing a surgical unit as a whole instead of by surgeon or by service line enabled commonalities to emerge. In addition, surgeons who perform a procedure rarely may learn from complications and reoperations made by surgeons who perform the procedure often. Although reviewing a department’s reoperation data is an important first step, characterizing reoperations in itself does not result in qualitatively improved outcomes.

Potential subtypes of conditions and procedures were identified where targeted quality improvement initiatives could result in reduction of reoperations. Shunt failure (34.2%) and postoperative bleed (20.7%) represented more than half of the indication for early unplanned reoperation in this series. To have significant impact, quality initiatives should aim to improve processes, which subsequently result in improved outcome. In 2013, a work task was created within the UCLA Department of Neurosurgery to assess in greater detail the etiology of early shunt failure and the current process of shunt implementation (and its variability). This led to the creation in the second half of 2013 of a preoperative CSF shunt checklist, a CSF shunt implementation protocol, and a CSF shunt supplementary time-out. Since the end of 2013, the developed tools have been in use; protocol compliance is being recorded, and data are being collected prospectively. The Clinical Quality Program has planned a strategic agenda to address the other top 5 indications to reduce unplanned reoperations. Importantly, too often quality initiatives in surgical fields target opportunities for improvement in the preoperative or postoperative settings. The OR is often left aside in quality improvement initiatives that span continuum of care. As we develop a plan to improve the most common reasons for reoperation, it is critical to engage the surgeons in assessing what can be modified and improved during the surgery. Table 2 presents initial process improvement ideas that have been proposed by the multidisciplinary workforces mandated to reduce reoperation rates. Although a systematic root-cause analysis is the next step, brainstorming sessions served to get care providers engaged in the improvement initiative.

**Conclusions**

A comprehensive analysis of reoperations within a neurosurgery department allowed for better characterization of the incidence, timing, and causes of early unplanned reoperations. Concise definitions of the numerator and denominator are essential to truly understand what a “reoperation rate” represents. Although use of an “absolute” reoperation rate is appropriate for internal monitoring, development of an adjusted reoperation rate is proposed if comparison with other institutions is projected as an important function of quality indicators. Only once a comprehensive understanding of reoperations is obtained within a department can quality improvement initiatives be strategically launched to successfully reduce the rate of reoperation and improve value of delivered care. As the agenda of neurosurgical clinical quality programs within each institution expands, there is a need for data to strategically attribute resources to the most impactful initiatives.

**Acknowledgments**

We thank Mrs. Nadiya Bhaidani and Mr. Farzad Buxey for assistance with the database queries.
References


Author Contributions

Conception and design: McLaughlin, Jin. Acquisition of data: Jin. Analysis and interpretation of data: all authors. Drafting the article: McLaughlin, Jin. Critically revising the article: all authors. Reviewed submitted version of manuscript: Martin, McLaughlin. Study supervision: Martin, McLaughlin.

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