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# Heterogeneity in Trauma Registry Data Quality: Implications for Regional and National Performance Improvement in Trauma



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- BACKGROUND:** Led by the American College of Surgeons Trauma Quality Improvement Program, performance improvement efforts have expanded to regional and national levels. The American College of Surgeons Trauma Quality Improvement Program recommends 5 audit filters to identify records with erroneous data, and the Georgia Committee on Trauma instituted standardized audit filter analysis in all Level I and II trauma centers in the state.
- STUDY DESIGN:** Audit filter reports were performed from July 2013 to September 2014. Records were reviewed to determine whether there was erroneous data abstraction. Percent yield was defined as number of errors divided by number of charts captured.
- RESULTS:** Twelve centers submitted complete datasets. During 15 months, 21,115 patient records were subjected to analysis. Audit filter captured 2,901 (14%) records and review yielded 549 (2.5%) records with erroneous data. Audit filter 1 had the highest number of records identified and audit filter 3 had the highest percent yield. Individual center error rates ranged from 0.4% to 5.2%. When comparing quarters 1 and 2 with quarters 4 and 5, there were 7 of 12 centers with substantial decreases in error rates. The most common missed complications were pneumonia, urinary tract infection, and acute renal failure. The most common missed comorbidities were hypertension, diabetes, and substance abuse.
- CONCLUSIONS:** In Georgia, the prevalence of erroneous data in trauma registries varies among centers, leading to heterogeneity in data quality, and suggests that targeted educational opportunities exist at the institutional level. Standardized audit filter assessment improved data quality in the majority of participating centers. (J Am Coll Surg 2016;222:288–295. © 2016 by the American College of Surgeons. Published by Elsevier Inc. All rights reserved.)
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The American College of Surgeons (ACS) Committee on Trauma has been one of the principal driving forces behind the rapid maturation of performance improvement (PI) processes in trauma centers. Each subsequent

edition of the *Resources for the Optimal Care of the Trauma Patient* includes more and more extensive requirements for a center's PI process.<sup>1</sup> Quality PI, however, is founded in quality data capture, which, on an institutional level,

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Collaborators in the GRIT Study Group are listed in the [Appendix](#).

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**Abbreviations and Acronyms**

|      |                                      |
|------|--------------------------------------|
| ACS  | = American College of Surgeons       |
| GCOT | = Georgia Committee on Trauma        |
| NTDB | = National Trauma Data Bank          |
| PI   | = performance improvement            |
| TQIP | = Trauma Quality Improvement Program |

relies on standardized and dependable data abstraction. With the advent of the ACS Trauma Quality Improvement Program (TQIP), another step in the evolution of PI has occurred. In fact, ACS TQIP, as a tool for national benchmarking among centers across the country, allows individual institutions to understand the quality of the care they are providing compared with national norms.<sup>2</sup>

In the same way that reliable data abstraction is required for effective institutional-level PI, data homogeneity is required for quality cross-institutional benchmarking. Also, differences in how centers capture and interpret data, as well as enter data points, can strongly affect how each center appears compared with its compatriot institutions.<sup>3-5</sup> As the National Trauma Data Bank (NTDB) grew in size, it was found that different definitions were being used for various data points by both individual centers and various state governments and the National Trauma Data Standard was created in an attempt to standardize a data dictionary.<sup>6</sup> Unfortunately, it is well recognized that many of these data definitions still leave room for interpretation and can be captured differently by different centers.<sup>7</sup>

During the past several years, the trauma centers within the state of Georgia developed a collaborative of the state's trauma medical directors and trauma program managers in an effort to standardize and improve trauma care in the state and to create a foundation for statewide PI. This effort has been led by the Georgia chapter of the Committee on Trauma (GCOT) and the Georgia Committee for Trauma Excellence, a longstanding work group of the state's trauma program managers. As part of the effort to create a statewide PI process, all trauma centers in the state enrolled in ACS TQIP. In the last several years, ACS TQIP provided the state of Georgia with a series of reports amalgamating all the trauma centers in the state into a single report, in addition to each center's individual report. After discussion and analysis, concerns were raised by several centers about data quality and homogeneity. Among other efforts, the state collaborative developed a system for standardized use of a set of audit filters (Table 1), with monthly reporting to the GCOT. The 5 standardized audit filters are recommended by ACS TQIP and designed to identify patient records with potential erroneous data. We hypothesized that

standardized audit filter analysis would uncover variable error rates among registries within the state and would improve data quality during the study time period.

**METHODS**

From July 2013 through September 2014, Level I and II trauma centers in the state of Georgia performed routine audit filter analysis of their trauma registries. Charts flagged by audit filters were individually reviewed within the institution's PI process to determine whether erroneous abstraction had occurred, and the nature of any error was identified. The chart reviews were performed by the individual institution's trauma program manager and trauma medical director and the elements of the reviewed charts varied based on the audit filter. Each directed review was performed specifically to identify whether or not the detail captured by the audit filter was correct or incorrect. For example, if a record was flagged for a potential missed complication, the chart was reviewed for any missed complication. Similarly, if a record was flagged for a missed comorbidity, the record was reviewed for the presence of any and all comorbidities. Finally, the mortality audit prompted a review of the record for the accuracy of the injury data (to determine if the true Injury Severity Score was >16) and to ensure that the mortality end point was correct. The final determinations of whether or not the data were abstracted incorrectly and the nature of the error were made by the trauma program manager and trauma medical director. The deidentified summary data listed in Figure 1 were provided to the GCOT in a standardized format for collation and analysis on a monthly basis. No organized educational activity directed at registry personnel or frontline providers of trauma care was performed by the collaborative during the study time period. For more than a decade, all trauma registries within the state of Georgia have been served by the same vendor (Digital Innovation, Inc), which allowed for the development of a single standardized report that provided a homogenous dataset.

The audit filters used are listed in Table 1. Each is designed to flag charts at high risk for erroneous data abstraction. The audit filter panel was originally described by the Michigan Trauma Quality Improvement Program and is recommended by ACS TQIP as a useful tool for registry data validation.<sup>8</sup> Three audit filters are focused on commonly seen complications, one on a patient population expected to have comorbidities and one on unexpected mortality.

Data were collated by the one author (CJD) and analyzed on a monthly and quarterly level. Data submission began in July 2013 and the study period ended in

**Table 1.** American College of Surgeons Trauma Quality Improvement Program Recommended Audit Filters

| Audit filter panel   |
|--|
| Injury Severity Score >24, no recorded complications                     |
| Hospital length of stay longer than 14 d, no recorded complications      |
| Age older than 64 y, no recorded comorbidities                           |
| Ventilator days more than 7, no recorded ventilator-associated pneumonia |
| Injury Severity Score <16, in hospital mortality                         |

September 2014, yielding 15 months (5 quarters) for analysis. Audit filters were analyzed individually to determine the percentage of charts flagged and percentage yield, defined as the number of errors identified divided by the total number of charts flagged. The 3 audit filters designed to look at missed complications (filters 1, 2, and 4) were also analyzed as a group. The first quarter of data were used to set an individual center's baseline in terms of data error rate and the error rate of each center was analyzed over time to assess for changes in data quality. Differences in error rates among centers were also evaluated over time to assess data homogeneity throughout the state.

Statistical analysis was performed using SPSS software (version 2.0, SPSS, Inc). Continuous variables are presented as mean  $\pm$  SD and categorical variables are presented as frequencies with associated percentages. Univariate analysis was performed using Student's *t*-test for continuous variables and chi-square testing was used for categorical data when appropriate. Statistical significance was set at  $p \leq 0.05$ .

## RESULTS

### Participating centers and overall data

The state of Georgia has designated 5 Level I and 9 Level II trauma centers. During the study period, there were

| Center name  | Total registry cases for month            | No. of cases | Percent of total registry cases | No. of records with error | Percent yield (errors/reviewed) | Nature of error identified |
|--------------|---|--------------|---------------------------------|---------------------------|---------------------------------|----------------------------|
| Audit filter | ISS >24, no complications                 |              |                                 |                           |                                 |                            |
|              | Length of stay >14 days, no complications |              |                                 |                           |                                 |                            |
|              | Age >64 years, no comorbidities           |              |                                 |                           |                                 |                            |
|              | Ventilator >7 days, no pneumonia          |              |                                 |                           |                                 |                            |
|              | ISS <16, mortality                        |              |                                 |                           |                                 |                            |

**Figure 1.** Standardized monthly report. ISS, Injury Severity Score.

no ACS-verified centers in the state. Of the 14 centers, 12 (86%) submitted complete datasets. This included all 5 Level I centers and 7 Level II centers. During the time course of the study, 21,115 patient records were submitted to audit filter analysis. Level I centers subjected a mean of  $2,689 \pm 626$  (range 2,204 to 3,730) records and Level II centers subjected  $1,053 \pm 594$  (range 411 to 1,934) ( $p < 0.001$ ) records to analysis. On a quarterly basis, charts subjected to analysis were relatively constant and ranged from a low of 3,501 (January to March 2014) to a high of 4,631 (July to September 2014).

### Individual audit filter performance

Audit filter performance varied and is presented in Table 2. Overall, 2,901 of 21,115 records were captured for additional review (14%). Individual audit filter capture ranged from a low of 248 records for the filter focused on unexpected mortality (1%) to a high of 865 records for complication filter for patients with Injury Severity Score >24 (4%). Overall percentage of records captured varied by center from a low of 9% to a high of 27%. On average, individual chart review was performed on  $239 \pm 159$  records per center during the entire study period. This amounts to a mean of 47 records individually reviewed by a trauma program's leadership per quarter. Overall error rates among centers varied from 0.4% to 5.2%.

Errors were identified in 549 of 21,115 (2.5%) records overall. Percentage yield ranged from a low of 9.2% (unexpected mortality) to a high of 24.1% (age older than 64 years, no comorbidity). Performance of each audit filter differed markedly among centers, with the audit filter focused on comorbidity yielding the highest percent yield in 5 centers, and the filter focused on unexpected mortality the highest percentage yield in 2 centers. Conversely, the 3 audit filters focused on complications yielded the highest percent yield in 0, 3, and 2 centers, respectively. The most common missed complications and comorbidities are listed in Table 3. Specific detailed information related to the nature of the error was submitted for 228 of the 549 errors (42%). Of note, the collaborative seemed to have specific difficulty with the capture of pneumonia and urinary tract infection, 2 of the most common complications that a trauma patient experiences. In addition, common missed comorbidities included some of the most prevalent afflictions seen in American society (Table 3). Pure data entry errors were also commonly identified. These represented charts that were correctly abstracted but entered incorrectly into the registry and mostly represented typographical errors.

**Table 2.** Individual Audit Filter Performance

| Audit filter (focus)                   | Records captured |    | Errors identified |     | % Yield |
|--|------------------|----|-------------------|-----|---------|
|  | n                | %  | n                 | %   |         |
| ISS >24<br>(complication)              | 865              | 4  | 119               | 0.5 | 13.7    |
| Length of stay >14 d<br>(complication) | 778              | 4  | 165               | 0.6 | 21.2    |
| Age >64 y<br>(comorbidity)             | 573              | 3  | 138               | 0.6 | 24.1    |
| Ventilator >7 d<br>(complication)      | 437              | 2  | 104               | 0.4 | 23.8    |
| ISS <16 (mortality)                    | 243              | 1  | 23                | 0.1 | 9.2     |
| Total                                  | 2,901*           | 14 | 549               | 2.5 | 18.9    |

\*A total of 21,115 records were subjected to audit filter review during the time period of the study.  
ISS, Injury Severity Score.

### Change in error rates over time

Table 4 summarizes the change in audit filter yields over time for both individual centers and for the group as a whole. When comparing quarters 1 and 2 (July 2013 to December 2013) with quarters 4 and 5 (April 2014 to September 2014), 7 of 12 centers had statistically significant decreases in error rates (range 3% to 7% in quarter 1 and 2 vs 0.1% to 1% in quarters 4 and 5;  $p < 0.0001$ ). Of the remaining centers, one noted a minor increase in errors identified from 0.8% to 2%. Of the remaining 4 centers, 3 had very low baseline error rates ( $<0.5\%$ ) and these did not change during the study period. The final center's moderate error rate (4% to 5%) was unchanged. Overall, in quarter 1, error rates ranged from a low of 0.35% to a high of 7.27%, with only 2 centers reporting error rates  $<1\%$  compared with quarter 5, where error rates ranged from 0% to 4.1%, with 7 of 12 centers reporting error rates  $<1\%$ .

## DISCUSSION

Increasing interest in trauma center PI and benchmarking has led to extensive efforts to ensure and improve data quality in trauma registries. The NTDB has its origins in the late 1980s, with the Major Trauma Outcome Study by Champion and colleagues, one of the first large-scale efforts to compare the quality of care provided to patients in a national sample of trauma centers.<sup>9</sup> Unfortunately, because the requirements for data submission by different state governments often varies widely, there have been multiple studies documenting variable degrees of data quality and, most notably, data heterogeneity from different trauma centers. For example, Mann and colleagues<sup>10</sup> documented substantial variations in composition and content among a variety of state trauma registries. Also, multiple studies documenting complex statistical methods designed to improve the statistical

validity of data analyses performed using the NTDB have been published.<sup>11,12</sup>

The advent and maturation of the ACS NSQIP<sup>13</sup> provided an example and a framework for national-level benchmarking, and the National Trauma Data Standard<sup>6</sup> was put forth in 2006 in an attempt to improve data homogeneity in the NTDB. Both of these efforts facilitated the development of ACS TQIP, which now benchmarks  $>200$  trauma centers nationally.<sup>14-16</sup> The state of Georgia was one of the first states to have universal participation in ACS TQIP in its Level I and II centers. In fact, the state of Georgia developed a state collaborative, led by the GCOT, which came together to analyze trauma care at a state level. For the past 4 years, Georgia's TQIP collaborative has worked with ACS TQIP to design state-level benchmarking reports that would allow the collaborative to identify issues in trauma care that affected multiple centers in the state and form the foundation for a statewide PI program. Because of the concerns of data homogeneity among the collaborative members, it was thought that the initial step toward an effective state-level PI program was an organized analysis of the data validity and homogeneity from the state's various trauma centers. The audit filters used in this effort were adopted by all trauma centers in the state after a meeting with members of the ACS TQIP program. As mentioned previously, ACS TQIP currently recommends these filters for institutions looking to improve and validate the data they submit.

Of the 5 filters, 3 are designed to identify patient populations at high risk for complication for which no complication was submitted; 1 filter is similarly designed to capture comorbidity in records for which no comorbidity is listed; and the final is designed to capture unanticipated mortality. As a group, they are designed to improve a center's data quality by identifying and correcting common omissions and mistakes made by abstractors and data entry specialists. In addition, they seem to create a relatively manageable group of patient records to review. Each center's trauma program's leadership was required to review a mean of only 47 records per quarter, or about 15 records per month. In addition, only specific aspects of those records that related to the potential error or omission needed to be analyzed. All centers reported, at worst, a modest additional work burden that improved considerably as data quality improved, and as they became more comfortable with the process. In addition, percent yield was almost 20%, identifying 1 tangible error for every 5 directed reviews. To most centers, this seemed a reasonable yield for the work invested. Anecdotally, several centers reported that their abstractors and data entry specialists were eager to participate in the process and to have feedback provided to them on what they had done

**Table 3.** Common Errors and Omissions

| Missed complications*                                | Data      | Missed comorbidities <sup>†</sup> | Data      |
|--|-----------|-----------------------------------|-----------|
| Pneumonia, ventilator-associated pneumonia, other, n | 60        | Hypertension, n                   | 32        |
| Urinary tract infection, n                           | 15        | Diabetes mellitus, n              | 9         |
| Acute kidney injury/acute renal failure, n           | 9         | Substance/alcohol Abuse, n        | 4         |
| Cardiac arrest/CPR, n                                | 8         | Dementia, n                       | 4         |
| Surgical infection, superficial, deep, n             | 8         | Major depression, n               | 4         |
| Central line-associated bloodstream infection, n     | 7         | Obesity, n                        | 4         |
| Alcohol withdrawal, n                                | 5         | Bleeding disorder, n              | 3         |
| ARDS, n  | 5         | Tobacco use, n                    | 3         |
| Unplanned return to operating room, n                | 3         | Congestive heart failure, n       | 3         |
| Other, n   | 11        | Other, n                          | 6         |
| Total, n (%)   | 131 (6.3) | Total, n (%)                      | 72 (12.6) |
| Data entry errors, <sup>‡</sup> n                    | 25        |                                   |           |
| Total errors, n                                      | 228       |                                   |           |

Only 42% of errors (228 of 549) were further characterized by centers submitting data.

\*Total charts reviewed for missed complications, n = 2,080.

<sup>†</sup>Total charts reviewed for missed comorbidities, n = 573.

<sup>‡</sup>Data entry errors were abstracted correctly but entered into the registry incorrectly.

well and what errors they had made. Having the frontline registry personnel participate in a project where they are provided regular feedback on their effectiveness and are provided some education might be a hidden benefit to an effort such as this one.

Several other interesting conclusions can be made from our collaborative's experience. First, there certainly was evidence of differences in data quality, with reported error rates as low as 0.4% and as high as 5.2%. Although this range does not seem overly wide, it does represent a >10-fold difference in error rates among centers, which could clearly cloud collaborative PI efforts and national benchmarking. Second, simply having an established process to audit data quality seems to have improved it. Many

centers had statistically significant improvements in their error rates and the collaborative's identified error rate fell 3-fold in the course of the study. This improvement was seen even without the benefit of any organized educational activity for frontline data managers, although during this time the collaborative placed increased emphasis on attendance and participation in the various ACS TQIP sponsored educational opportunities. Moving forward, the collaborative will consider tracking a center's participation in these educational activities to improve and homogenize the training and experience of our state's trauma data managers.

It is noted that one center's data quality did seem to worsen considerably during the course of this study.

**Table 4.** Changes in Error Rates over Time

| Trauma center no. | Trauma center level | Quarter 1 and 2 |          | Quarter 4 and 5 |          | p Value           |
|-------------------|---------------------|-----------------|----------|-----------------|----------|-------------------|
|                   |                     | n               | % Yield* | n               | % Yield* |                   |
| 1                 | I                   | 79/1,409        | 5.6      | 33/1,886        | 1.7      | <0.0001           |
| 2                 | I                   | 67/935          | 7.2      | 28/1,212        | 2.3      | <0.0001           |
| 3                 | I                   | 6/1,071         | 0.5      | 7/1,107         | 0.6      | 0.828             |
| 4                 | I                   | 41/861          | 4.8      | 54/959          | 5.6      | 0.40              |
| 5                 | I                   | 8/909           | 0.8      | 18/892          | 2.0      | 0.04 <sup>†</sup> |
| 6                 | II                  | 16/804          | 2.0      | 2/790           | 0.2      | 0.001             |
| 7                 | II                  | 20/654          | 3.1      | 3/691           | 0.4      | 0.0002            |
| 8                 | II                  | 12/446          | 2.7      | 4/643           | 0.6      | 0.005             |
| 9                 | II                  | 15/382          | 3.9      | 3/402           | 0.7      | 0.003             |
| 10                | II                  | 8/169           | 4.7      | 2/185           | 1.1      | 0.04              |
| 11                | II                  | 4/281           | 1.4      | 6/214           | 2.8      | 0.29              |
| 12                | II                  | 1/165           | 0.6      | 0/171           | —        | 0.31              |

\*Number of errors identified per number of records captured.

<sup>†</sup>One center noted increase in identified error rates.



Individual discussion with the trauma program leadership of this center revealed substantial turnover in their registry and abstractor staff during the time period, which certainly might have contributed. Several other centers did not show marked improvement in data quality, but these centers generally had very high-quality data before the effort started, making it difficult to show a true benefit to the audit filter activity. The collaborative's conclusion about the effort, however, is that there is now a much narrower range of error rates than previously, and therefore the data quality within the collaborative seems to be more homogenous.

The collaborative was able to glean some specific information on the types of errors. Although pure data entry errors accounted for a proportion of the characterized errors (approximately 10%), the majority were related to data missed by data abstractors. Many of the complications and comorbidities that were later identified included very common conditions, such as hypertension, diabetes, alcohol dependency, pneumonia, and urinary tract infection. This type of information should allow for institutional- and collaborative-level educational opportunities.

Finally, audit filter performance varied considerably among various centers. Certain centers struggled with the capture of comorbid conditions and others more so with the capture of complications. Less common in most centers were errors in reporting unexpected mortality. It was encouraging that the majority of centers showed improvements in data quality when comparing the early study period to the end of the study period. Of the centers with unchanged error rates, most were already high performers. Only one center with a moderate error rate at the beginning did not improve that rate, and only one center noted an increase in error rates. Taken together, it would seem that this simple exercise raised most centers' data quality to the level of the centers that had achieved high data quality before this effort, likely resulting in improved data homogeneity. However, because every center seems to have its own challenges with data quality, institutional-level educational activities, directed both at frontline clinicians and data managers, are likely to be of benefit not only at the individual center level, but also at a regional or national level.

This study has several weaknesses. First, we did not receive complete datasets from all 14 centers. It is unlikely that the 2 centers who did not participate fully would have submitted enough data to change the conclusions substantially, but that cannot be stated with absolute certainty. Second, this effort was a preliminary and limited assessment of a center's data quality. Although the audit filter set the collaborative used is the set recommended by ACS TQIP and has been used by more

established groups with success (M Hemmila, MD, personal communication, August 2015), it has not been studied extensively. Therefore, the true efficacy of improving data quality in an individual center's registry is not completely known. Clearly, other aspects of a data registry's quality might have been variable between centers. It is believed, however, that this audit filter set is among the best tools a center has to validate its own data quality. Also, not all data errors were fully characterized. Of the available data, as discussed, it would seem we have a considerable statewide problem in identifying pneumonias and urinary tract infections, among other complications. In addition, certain very common comorbidities were missed with some frequency. Although not all the errors were fully elucidated by all centers, preliminary information about the type of errors commonly seen might allow the collaborative to start with targeted educational efforts. Ventilator-associated pneumonia, for example, remains a perplexing and difficult diagnosis to capture consistently. The GCOT's 2015 annual meeting's keynote speaker was a noted expert on the diagnosis and treatment of ventilator-associated pneumonia. Since that keynote address, several centers have begun to collaborate to develop an identical system for diagnosis and treatment of this difficult entity. This will hopefully be the subject of future study. Another effort of the collaborative has been to create specific data capture algorithms for abstractors to use to capture complications in an effort to better standardize their capture. This will also be the subject of future study.

Another important limitation of the study is that the record reabstraction was not standardized among centers and the process was directed by the institution's own leadership. Also, the data reabstraction was not a full revisit of the entire record. It is believed that this preliminary effort should be performed by members of the collaborative in an initial attempt to familiarize participants with the process and also to understand what the time commitments and potential benefits would be to undertaking this ongoing initiative to improve data quality. In the future, a process for more standardized and complete data reabstraction of charts flagged by the filters is being considered.

Finally, it is recognized that this study represents a moment in time along what is a continuum of data collection. There are multiple variables that contribute to maintenance of data quality, especially when personnel and process changes occur. The centers that participated in this exercise continue to perform monthly audit filter analysis and submit their data to the GCOT for ongoing analysis. As all centers have become comfortable and efficient with the process, and as it has become part of these

centers' normal monthly activities, most centers report that it adds little to no additional work for their staff and all continue to profess a desire to participate in the process.

## CONCLUSIONS

Significant data quality and heterogeneity issues remain in trauma registries. As trauma PI continues to mature, more and more interest in regional and national PI projects will occur. For these projects to be successful, increasing attention will need to be paid to improving data homogeneity so that true clinical issues can be identified and rectified. This effort is a smaller part of a larger effort to improve and homogenize one state's data in an effort to create a true statewide PI system. Ultimately, the goal of this effort is to improve the care of the individual patient presenting to a trauma center in Georgia. Although much work remains to be done, this effort gives credence to the fact that improvements in data quality are possible, even in a relatively short period of time, simply with an organized system of data quality monitoring.

## APPENDIX

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