RELIABILITY OF A SURGEON-REPORTED MORBIDITY AND MORTALITY DATABASE: A COMPARISON OF SHORT-TERM MORBIDITY BETWEEN THE SCOLIOSIS RESEARCH SOCIETY AND NATIONAL SURGICAL QUALITY IMPROVEMENT PROGRAM DATABASES

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ABSTRACT

Background: There exists a lack of comparison between large national healthcare databases reporting surgical morbidity and mortality. Prior authors have expressed concern that the Scoliosis Research Society (SRS) membership may have underreported complications in spinal surgery. Thus, the purpose of the present study was to compare the incidence of morbidity between the SRS and National Surgical Quality Improvement Program (NSQIP) databases.

Methods: We reviewed patients enrolled between 2012 and 2013, with a total of 96,875 patients identified in the SRS dataset and 15,909 in the combined adult and pediatric NSQIP dataset. Patients were matched based on diagnostic category, and a univariate analysis was used to compare reported complication rates in the categories of perioperative infection, neurologic injury, and mortality. The SRS database only requires detailed demographic data reporting on patients that have had a complication event. We compared the demographics and comorbidities of this subgroup, and used this as a surrogate to assess the potential magnitude of confounders.

Results: Small differences existed between the SRS and NSQIP databases in terms of mortality (0.1% v. 0.2%), infection (1.2% v. 2%), and neurologic injury (0.8% v. 0.1%) ($p<0.001$ for each comparison). Infection rates were consistently lower across multiple diagnostic sub-categories in the SRS database, whereas neurologic injury rates were consistently lower in the NSQIP database. These differences reached statistical significance across several diagnostic subcategories, but the clinical magnitude of the differences was small. Amongst the patients with a complication, modest differences in comorbidities existed between the two cohorts.

Conclusion: Overall, the incidence of short-term morbidity and mortality was similar between the two databases. There were modest differences in comorbidities, which may explain the small differences observed in morbidity. Concerns regarding possible under-reporting of morbidity and mortality data by the SRS membership seem largely unfounded. This study may be useful for future investigators using the NSQIP and SRS datasets.

INTRODUCTION

A key feature of membership in the Scoliosis Research Society (SRS) is the voluntary self-reporting of perioperative morbidity and mortality (M&M) data. Thousands of cases have been registered, and the database is the largest known repository of short-term M&M outcomes for spinal deformity patients. Multiple reports have summarized the data across several diagnoses and complication types.[1-18] These reports have served to benchmark surgeon and institution performance, and have proven useful for surgical planning and patient counseling

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Table I. Definition of Included Morbidities

Patient Death	The SRS defines patient death, as "death that is attributable to a complication of the surgery, or during the surgery." NSQIP defines patient death as, "any mortality within 30-days of the operation."
Wound Complication	NSQIP includes four categories of wound complications, including superficial surgical site infection, deep surgical site infection, organ space infection, and wound dehiscence, each within 30-days of the operation. In contrast, the SRS dataset includes only a single category titled "acute infections that occur at the operative site up to 12 weeks from the date of surgery." The three types of infection from the NSQIP dataset were combined into a single "NSQIP wound complication" category for the purpose of comparison. Wound dehiscence was not included.
Neurologic Deficit	NSQIP contains a category for post-operative neurologic injury, which is defined as an, "injury to the nerve fibers, nerve cell body, or myelin sheath during surgery." This category was compared against the SRS category termed, "new neurologic deficit."
Blindness	NSQIP does not record post-operative blindness, and thus this morbidity was not included in our analysis.

perioperatively. In spite of these strengths, the dataset does have several limitations. In particular, the M&M reporting is voluntary, and relies on the honesty of the membership. External validation of the reported complication rates is limited,[19] and prior authors have speculated that some complications are underreported.[1] Thus, external validation is warranted.

The purpose of the current study is to compare the incidence of complications from the SRS M&M database against the incidence reported to the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP). The ACS NSQIP prospectively collects morbidity and mortality data from adult cases at over 500 hospitals across the United States, and for pediatric cases from 60 hospitals. Data collection is performed by trained on-site personnel, who prospectively review operative notes, postoperative progress and clinic notes while remaining in direct contact with the surgical team for clarification when necessary. Thus, the NSQIP database is a suitable source of independently collected M&M data with which to compare the SRS dataset. The results should serve to help validate the accuracy of voluntary member reporting to the SRS, and may be useful for future researchers using the two databases.

METHODS

Description of Datasets

This study was Health Insurance Probability and Accountability Act (HIPPA) compliant and received an Institutional Review Board (IRB) exemption. The adult NSQIP database is a prospectively collected clinical registry, with over 500 participating hospitals from around the United States, and with a roughly equal mix of private and academic institutions. Each participating hospital employs a surgical clinical reviewer (SCR) who is responsible for collecting patient data for 30-days postoperatively. The SCR reviews operative notes, progress notes, post-operative clinical visits, and if clarification is needed, directly contacts the surgical team. Patients who do not return for clinical follow-up within 30-days are contacted via telephone, and in this way, both inpatient and outpatient complications that occur after discharge are captured. Over 200 data-points are collected, with the detailed description of the methodology available from the ACS.[20] The dataset is routinely audited, with interobserver disagreement rates less than 2%,[21] and its use has been widely accepted in the orthopedic literature.[22-29] The pediatric NSQIP database has similar collection methods, and enrolls patients less than 18 years of age. As of 2013, 60 hospitals participated in pediatric enrollment. There are a small number of variables unique to the pediatric NSQIP, and a full description of the methodology is available from the ACS.[30]

The SRS M&M dataset consists of voluntary data entry from participating surgeon members of the SRS. Each year, the SRS requests that surgeons report their morbidities using an online entry system. The included patients are limited to those with a diagnosis of idiopathic scoliosis, congenital scoliosis, neuromuscular scoliosis, other scoliosis, spondylolisthesis, congenital kyphosis, Scheuermann's kyphosis, or other kyphosis, as diagnosed by the surgeon. Surgeons are asked to retrospectively report their total number of cases for the year, and also the number of each type of case with a complication. For patients that sustained a complication, detailed demographic and comorbidity data is then requested. However, for patients without a complication, no additional information is entered. Thus, demographic and comorbidity information is available only for a small subset of the total cohort.

Since its initial conception, the SRS database has evolved considerably, and current iterations have focused on the collection of data pertaining only to major perioperative events, including blindness, death, neurologic injury, and wound complications. The simplified collection system has been found to have higher member compliance, with similar reported complication rates.[9] Post-operative blindness is not reported in NSQIP, but the other three outcomes are indeed captured. Since blindness is a rare perioperative event, a comparison of the two datasets in terms of mortality, wound complica-

Table II. Un-Adjusted Comparison of The Incidence of Perioperative Morbidity and Mortality

	SRS Dataset			NSQIP Dataset			
Mortality							
Diagnosis	Cases (#)	Deaths (#)	%	Cases (#)	Deaths (#)	%	p value
Idiopathic Scoliosis							
<18 yrs	22980	3	0.01	1618	1	0.06	0.24
≥18yrs	8544	6	0.1	529	4	0.8	**0.002**
Congenital Scoliosis	5238	6	0.1	192	0	0	1
Neuromuscular Scoliosis	7373	11	0.2	58	0	0	1
Other Scoliosis	11442	26	0.2	479	2	0.4	0.31
Spondylolisthesis	31178	13	0.04	11012	23	0.2	**<0.0001**
Kyphosis	10102	33	0.3	192	2	1.0	0.14
Totals	**96875**	**98**	**0.10**	**14080**	**32**	**0.23**	**<0.0001**
Infection							
Diagnosis	Cases (#)	Infections (#)	%	Cases (#)	Infections (#)	%	p value
Idiopathic Scoliosis							
<18 yrs	22980	138	0.6	1618	22	1.4	**0.001**
≥18yrs	8544	83	1.0	529	16	3.0	**0.0002**
Congenital Scoliosis	5238	41	0.8	192	5	2.6	**0.007**
Neuromuscular Scoliosis	7373	256	3.5	58	2	3.5	1
Other Scoliosis	11442	178	1.6	479	11	2.3	0.2
Spondylolisthesis	31178	304	1.0	11012	196	1.8	**<0.0001**
Kyphosis	10102	172	1.7	192	8	4.2	**0.01**
Totals	**96875**	**1172**	**1.2**	**14080**	**260**	**1.9**	**<0.0001**
Neurologic Injury							
Diagnosis	Cases (#)	Neurologic Injuries (#)	%	Cases (#)	Neurologic Injuries (#)	%	p value
Idiopathic Scoliosis							
<18 yrs	22980	73	0.3	1618	6	0.4	0.71
≥18yrs	8544	68	0.8	529	0	0	**0.03**
Congenital Scoliosis	5238	63	1.2	192	0	0	0.17
Neuromuscular Scoliosis	7373	47	0.6	58	0	0	1
Other Scoliosis	11442	140	1.2	479	2	0.4	0.13
Spondylolisthesis	31178	224	0.7	11012	2	0.02	**<0.0001**
Kyphosis	10102	153	1.5	192	1	0.5	0.37
Totals	**96875**	**768**	**0.8**	**14080**	**11**	**0.08**	**<0.0001**

tion, and neurologic injury was felt to provide a reasonable assessment of the accuracy.

The definition and recorded timing of complications between the NSQIP and SRS datasets are not identical. Thus, for the purpose of comparison, some of the NSQIP complications types were combined into a single category (Table I).

All ages are captured in the SRS dataset. However, NSQIP did not begin enrolling pediatric cases until 2012. Thus, we chose to retrospectively query the NSQIP and SRS datasets for the years 2012-2013, which included all of the years with available data for both adult and pediatric cases. The NSQIP dataset was queried using CPT codes to identify cases of thoracolumbar spinal fusion and international classification of disease, 9th edition (ICD-9) codes to verify the patient diagnosis. No ages were excluded, and all cases in the included diagnostic categories were included. A full listing of the included codes and inclusion criteria is available in the appendix (Appendix Table I).

Statistical Analysis

We performed two separate statistical analyses. First, the incidence of each reported complication from the SRS M&M dataset was summarized and then compared against the incidence reported to the ACS NSQIP in a univariate analysis. Where possible, we attempted to compare pediatric and adult cases separately (defined as greater or less than 18 years of age). This was possible for patients with a diagnosis of idiopathic scoliosis because the SRS reporting requires ages for that diagnosis. However, for each of the other categories the SRS reporting does not require age information unless the patient

Table III. Univariate Comparison of Demographics and Comorbidities Amongst Patients Who Sustained a Complication

	SRS Dataset (n=2295)	NSQIP Dataset (n=364)	P Value
Age (mean, sd)	44.49(25.63)	47.39(25.45)	0.0453
Gender (%)			0.0328
Female	63.8	58.0	
Male	36.2	42.0	
ASA Grade (%)			<0.0001
1	34.0	2.5	
2	31.9	39.0	
3	29.9	53.6	
4	4.1	5.0	
5	0.1	0	
BMI (mean, sd)	26.0(7.1)	30.4(10.3)	<0.0001
Diabetic (%)	16.6	7.4	<0.0001
Smoker (%)	8.5	13.2	<0.0001
Hypertension (%)	35.5	43.7	<0.0001
Peripheral Vascular Disease (%)	8.7	0	<0.0001
History of Cancer (%)	5.1	0.3	<0.0001
Operative Time			0.529
<2 hrs	17.8	19.8	
2-6 hrs	54.7	54.4	
6-9 hrs	20.6	18.7	
9-12 hrs	5.6	6.6	
>12 hrs	1.3	0.6	

sustains a complication, and thus the other categories were not divided by patient age. Second, in an attempt to assess the impact of confounders, we compared the demographics of the patients between the SRS and the NSQIP datasets. Demographic information in the SRS dataset is only available for patients that have suffered a complication. This cohort was compared against the cohort of patients from the NSQIP dataset that also had a complication. Categorical comparisons were made with a chi-squared test and continuous variables were compared using the student's t-test. Statistical comparisons for analyses were made using SAS (Version 9.3; SAS Institute, Cary, NC).

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RESULTS

In total, across all diagnostic categories, 96,875 patients were identified from the SRS dataset, of which 2,295 sustained at least one complication (2.4%). There were 15,909 patients identified from the combined adult and pediatric NSQIP dataset, of which 364 sustained at least one complication (2.3%). Small differences existed in the reported M&M incidences between the SRS and NSQIP databases in terms of overall mortality incidence (0.1% v. 0.2%), overall infection incidence (1.2% v. 2.0%), and overall neurologic injury incidence (0.8% v. 0.1%) ($p<0.001$ for each comparison) (Table II).

For mortality, the SRS membership reported a significantly lower incidence as compared to that recorded in the NSQIP database for both the category of idiopathic scoliosis in patients aged ≥18yrs (0.1% SRS v. 0.8% NSQIP, $p=0.0018$), and also for spondylolisthesis (0.04% SRS v. 0.2% NSQIP, $p<0.0001$). Similarly for infection, the SRS membership reported a lower incidence for every diagnostic category, and the difference reached significance for every category except neuromuscular scoliosis and other scoliosis ($p<0.05$ for each). In contrast to the two other categories, the SRS membership consistently reported a higher incidence of neurologic injury across every diagnostic category, and this difference reached significance for patients with idiopathic scoliosis who were aged ≥18yrs (0.8% SRS v. 0% NSQIP, $p=0.032$), and for spondylolisthesis (0.7% SRS v. 0.02% NSQIP, $p<0.0001$) (Table II).

Amongst the patients with a complication, moderate demographic and comorbidity differences existed between the two cohorts across multiple categories (Table III). The patients from the NSQIP database were slightly older (mean of 47.4 yr (sd of 25.5) v. 44.5 yr (sd of 25.6), $p=0.04$), were more likely to be male (42.0% v. 36.2%, $p=0.03$), had a higher mean body mass index (mean of 30.4 kg/m^2 (sd of 10.3) v. 26.0 kg/m^2 (sd of 7.1), $p<0.0001$), and tended to have a higher comorbidity burden as measured by ASA class (58.6% of NSQIP patients were ASA grade 3 or higher, as compared to 34.1% of SRS patients, $p<0.0001$). The range of reported operative times was similar between the two cohorts ($p=0.5$).

DISCUSSION

The SRS database has been widely accepted as a source of morbidity data following spinal deformity surgeries. However, few prior studies have attempted to determine the reliability of the data collection. Thus, the purpose of this study was to compare the reported incidence of short-term morbidity rates between the

NSQIP and SRS data sets. The results should provide an assessment of the validity of the SRS membership's voluntary reporting. Overall, we found that the reported incidence of complications was very similar between the two datasets, across multiple diagnostic categories. Several of our findings merit further discussion.

First, although statistically significant differences in morbidity incidence existed between the SRS and NSQIP datasets across multiple diagnostic subcategories, the magnitude of these differences was small. Specifically, nine comparisons reached statistical significance, but the magnitude of the difference was less than 1% in six of these (Table II). In addition, the composite comparisons of overall mortality incidence (0.1% v. 0.2%), overall infection incidence (1.2% v. 2.0%), and overall neurologic injury incidence (0.8% v. 0.1%) ($p<0.001$ for each) were similar. Although the differences were statistically significant, the similarity of the two data-sets should be viewed as encouraging, providing preliminary evidence that the SRS membership has been validly reporting its complications.

Nonetheless, although the overall rates were similar, there were some notable differences. The SRS membership consistently reported lower rates of wound complications, and these differences reached significance in all except for two diagnostic sub-categories (neuromuscular scoliosis, $p=1.0$, and other scoliosis, $p=0.2$). These results are largely similar to those of Webb et al.,[19] who identified a lower incidence of infection rates in the SRS database as compared the NSQIP dataset. There are several possible reasons for this discrepancy. SRS member surgeons are experts in their field, and it is possible that the SRS membership is less likely to incur an infection, as compared to non-member surgeons. Alternatively, Webb et al. suggested that SRS member surgeons might more accurately report their infections than would the NSQIP clinical reviewers, implying that the NSQIP definitions were overly inclusive, and thus not representative.[19] While possible, this explanation is less likely. In our definitions, we specifically excluded simple wound dehiscence, and only included the more significant superficial and deep infection categories. It is more likely that the SRS membership might have a small bias towards under-reporting of infections. Particularly if a wound complication was minor or treated non-operatively, an SRS surgeon might be inclined not to report the issue, whereas the NSQIP reviewer is likely to document the occurrence regardless of the severity or subsequent needed treatment. Thus, SRS member surgeons might be encouraged to be extra diligent in recording this complication, to ensure the validity of the dataset. However, as noted above, the overall magnitude of difference between the SRS and NSQIP datasets was small (0.8% difference). Thus, if a bias does exist, it is likely small, and we do not think it should detract from the overall generalizability of the SRS data.

In contrast to wound complications, the SRS membership consistently reported higher incidences of neurologic injury, and this difference reached significance for both patients with spondylolisthesis as well as for patients with idiopathic scoliosis who were over 18 years of age. The definition of neurologic injury is different between the SRS and NSQIP datasets. NSQIP defines neurologic injury as, "an injury to the nerve fibers, nerve cell body, or myelin sheath during surgery." In contrast, the SRS asks surgeons to report on any "new neurologic deficit," which is more inclusive terminology. The narrower definition from the NSQIP reviewers may lead to a relative underreporting of neurologic injuries. Furthermore, the NSQIP SCR primarily identifies complications through chart review, whereas the SRS surgical team is directly examining the patient. A significant event such as a neurologic injury might be more likely to stand out on physical exam as opposed to chart review. Indeed, prior studies of spinal surgeries from the NSQIP database have consistently reported remarkably low incidences of neurologic injury, even in complex cases.[29,31,32] Reports from NSQIP are used by some hospitals and insurance payors as a benchmark on surgeon performance. As with each of the complication categories, the absolute magnitude of difference was small (0.7% difference). However, our study implies that NSQIP may under-represent neurologic injury to a small degree, and this finding should caution administrators against applying too low of a benchmark for neurologic complications when relying only on NSQIP data.

The last category compared between the two databases was the incidence of mortality. The overall difference was again small, 0.1%, and the difference in the sub-categories was less than 1% in each comparison. Thus, both datasets reported very similar incidences of mortality. Mortality should be an easily definable event after surgery, and thus it is encouraging that the datasets reported similar incidences. We feel that both datasets support prior studies which have shown low incidences of mortality after spine surgery,[1,32] and this information may be useful for patient counseling and quality benchmarks.

Our study has several important limitations. Most notably, because of the limitations in the data collection methods, it was not possible to robustly adjust for differences in patient characteristics, surgical procedures, or medical comorbidities between the two cohorts. We attempted to match the patient groups based on age and their indication for surgery where possible, and reported individual differences amongst these cohorts. However, this represents a fairly limited set of matched factors, and age matching was only possible for idiopathic sco-

liosis. Thus, in an attempt to determine the magnitude of confounders present, we compared the demographics and comorbidities amongst the patients that had a complication. In this secondary analysis, multiple significant differences were identified, indicating that the two databases likely enrolled modestly different patient cohorts. In particular, the NSQIP dataset tended to capture a slightly older and more comorbid patient population, which likely affected their morbidity risk. These results highlight the need for appropriate risk-adjustment when reporting results from either dataset, and some of the differences in reported morbidity rates may be due to the fact that the patient cohorts are different. In addition, the definition of morbidity varied slightly between the two data-sets, and this also may have contributed to some of the small differences we observed. Furthermore, the SRS data is based on the retrospective recall of the surgeon, and there may be significant recall bias present in this methodology. Lastly, neither database clearly identifies the severity of the surgical intervention (for example types and numbers of three column osteotomies), and thus the cases may not be well matched in terms of surgical complexity. The overall conclusion of our manuscript is that the reported morbidity rates are similar between the two datasets. Thus, particularly in light of the modest demographic differences we identified, we do not think the reader should place too much stock in the small percentage differences we identified in some of the sub-group comparisons. Rather, the results should serve as a broad overview of the two databases.

Overall, the incidence of short-term morbidity was similar between the two databases, across multiple diagnostic patient categories. There were modest differences in the demographics and comorbidities of the patients enrolled in the two databases, likely reflecting differences in collection methods, and this may explain the small differences observed in morbidity. Concerns regarding possible under-reporting of M&M data by the SRS membership seem largely unfounded. Infection rates were consistently lower in the SRS database, and this may be one potential area for improvement. The incidence of neurologic injury was particularly low in the NSQIP dataset, and it is possible that NSQIP coders do not appropriately capture this complication. This study may be useful for future investigators using the NSQIP and SRS datasets.

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