Demographics and Outcomes of Spine Surgery in Octogenarians and Nonagenarians: A Comparison of the National Inpatient Sample, MarketScan and National Surgical Quality Improvement Program Databases

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Abstract

Introduction

Despite the increasing use of national databases to conduct spine research, questions remain regarding their study validity and consistency. This study tested for similarity and inter-database reliability in reported measures between two commonly used national databases.

Methods

International Classification of Diseases, 9th edition (ICD-9) codes were used to identify elderly (80-100 years) who underwent spine surgery patients in Truven Health Analytics MarketScan® claims database, National (Nationwide) Inpatient Sample (NIS) discharge database and National Surgical Quality Improvement Program (NSQIP) database (2006-2016). Patient baseline characteristics, comorbid status, insurance enrollment, and outcomes were queried and compared.

Results

We analyzed 15,105 MarketScan, 40,854 NIS, and 7682 NSQIP patients between ages 80 to 100 years (median, 82 years) who underwent spine surgeries during the study period. A majority of patients in both MarketScan and NIS were insured by Medicare (97% vs. 94%). Patients in MarketScan had lower comorbidity scores (comorbidity, 0-2) compared to those in NIS and NSQIP databases. The most common diagnosis was spinal stenosis in MarketScan (54.4%), NIS (54.6%), and NSQIP databases (65.2%). Fusion was the most common procedure performed in MarketScan (48.9%) and NIS databases (46.2%), whereas decompression (laminectomy/laminotomy) was the most common procedure in the NSQIP database (51.8%). In-hospital complications (any) were 6.5% in the MarketScan cohort, 5.3% in the NIS, and 2.02% in the NSQIP cohort. In terms of 30-day complications (any), the MarketScan database reported higher complications rate (12.7%) compared to the NSQIP database (5.98%). In-hospital mortality was slightly higher in the NIS database (0.32%) compared to MarketScan (0.21%) and NSQIP database (0.2%). MarketScan and NIS databases showed an increased risk of complications with increasing age, whereas NIS and NSQIP showed increasing complications with a higher number of comorbidities. Male gender had higher complication at 30-day post-discharge using MarketScan and NSQIP database.

Conclusions

Patients in the NSQIP and NIS database have more comorbidities; patients in the MarketScan database had the highest number of perioperative and 30-day post-discharge complications with the highest number of fusion procedures performed. Patients in the NSQIP database had the lowest number of fusion procedures and complication rates. As databases gain popularity in spine surgery, clinicians and reviewers should be cautious in generalizing results to whole populations and pay close attention to the population being represented by the data from which the statistical significance was derived.

How to cite this article

Bhargava S, Sharma M, Dietz N, et al. (November 19, 2019) Demographics and Outcomes of Spine Surgery in Octogenarians and Nonagenarians: A Comparison of the National Inpatient Sample, MarketScan and National Surgical Quality Improvement Program Databases. Cureus 11(11): e6195. DOI: 10.7759/cureus.6195
solution is to retrospectively extract outcomes from databases to assess the viability of spine surgery in the elderly population. The present study reports the differences in three commonly used databases, MarketScan, National Inpatient Sample (NIS), and National Surgical Quality Improvement Program (NSQIP) in regards to patient demographics, complications, and outcomes following spine surgery in octogenarians and nonagenarians.

**Materials And Methods**

**Data sources**

The Truven Health Analytics MarketScan® claims database collects participant information from Commercial Claims and Encounters, Medicare Supplemental and Coordination of Benefits and Medicaid databases. Insurance enrollment, inpatient and outpatient utility, and claims and costs are provided and organized based on 150 payers in the US from employer-based plans [9]. A neurology/neurosurgery custom-dataset obtained from MarketScan spanning from 2000-2012 was used. Medicare in MarketScan is Medicare Supplemental (also called Medigap). These patients are those on Medicare who can afford to take supplemental insurance to cover some things that Medicare doesn’t cover.

The Healthcare Costs and Utilization Project (HCUP) NIS is the largest all-payer inpatient database that collates discharge patient information on all inpatient admissions in non-federal US hospitals. A stratified random sampling technique of the hospitals and patients produces a representative 20% subsample, which can be generalized to the American medical community [10]. The Elixhauser comorbidity data was implemented to NIS in 1998, which allows for calculating risk adjustments through the database [11]. We extracted a custom dataset spanning from 2000 to 2012 [10]. The NIS data for this study was adapted from Drazin et al. with permission [12].

National Surgical Quality Improvement Program (NSQIP) is a well-recognized nationally validated outcome-based database introduced by the American College of Surgeons (ACS) to improve the quality of surgical care. Data is extracted using the International Classification of Diseases (ICD) 9/10 and Current Procedural Terminology (CPT) codes using this database and include comorbidities and postoperative outcomes.

**Data extraction**

The study population was composed of a retrospective cohort study of patients undergoing spine surgery procedures for spinal stenosis in the Truven Health Analytics MarketScan® database, NIS database, and NSQIP database from 2006-2016. Patient extraction was performed using the International Classification of Diseases, 9th edition (ICD-9) coding system (for all databases), and the Current Procedural Terminology, 4th edition (CPT-4) (for MarketScan only). MarketScan is a longitudinal database. For this study, the first occurring hospitalization, satisfying the extraction conditions, was used for patient characteristics and most outcomes. Patient baseline characteristics included: age, gender, comorbid status, insurance type, and primary procedure. Outcome measures included: in-hospital complication and mortality risks, length of stay (LOS), and stratified in-hospital complication risks. Multivariable analysis assessed the association of baseline and patient characteristics with perioperative complications.

Data was queried to identify patients between the ages of 80-100 years who underwent spinal decompression (ICD-9 codes: 03.0, 03.09), discectomy (ICD-9 codes: 80.30, 80.31), or spinal fusion (ICD-9 codes: 81.0, 81.00, 81.01, 81.02, 81.03, 81.04, 81.05, 81.06, 81.07, 81.08). Primary diagnoses included spinal stenosis (ICD-9 codes: 723.0, 724.0, 724.00, 724.01, 724.02, 724.09), claudication (ICD-9 codes: 724.03), disc herniation (ICD-9 codes: 722.0, 722.10, 722.11), and disc protrusion (ICD-9 codes: 722.30, 722.31, 722.32, 722.51, 722.52, 722.71, 722.72, 722.73). Supplemental tables summarize ICD-9/10 and CPT codes used to extract data from these databases (Appendices). Patients younger than age 80 years, older than 100, and those undergoing vertebroplasty and kyphoplasty (augmentation procedures) were excluded.

**Statistical analysis**

Patient characteristics were summarized using means and standard deviation (for continuous variables) and counts and percentage (for categorical variables). Differences were considered significant if p<0.0001. Each outcome (mortality, complications, and length of stay), within each database, was analyzed in a multivariable analysis including four variables (age at diagnosis, gender, comorbid state, and procedural type). Results were presented in terms of odds ratio (OR) or relative risk (RR) with associated 95% confidence interval.

**Results**

A total of 63,641 octogenarians and nonagenarians who underwent spinal decompression, discectomy, or fusion surgery for spinal stenosis were identified from all the databases. The baseline patient characteristics and procedure outcomes were compared between the 15,105 MarketScan, 40,854 NIS, and 7682 NSQIP patients. Calculated odds-ratio of experiencing a perioperative complication during index hospitalization is presented in Table 1.
### TABLE 1: Adjusted Odds Ratio (OR) of Complications at Index Hospitalization and 30 Days After Admission

| Variable | MarketScan (Index Hospital Complication) | National Inpatient Sample (Index Hospital Complication) | National Surgical Quality Improvement Program (30-day from admission Complication) | MarketScan (30-day from admission Complication) | National Surgical Quality Improvement Program (30-day from admission Complication) |
|----------|------------------------------------------|----------------------------------------------------------|---------------------------------------------------------------------------------|-----------------------------------------------|---------------------------------------------------------------------------------|
| Age, 1 year increase | 1.05 (1.03, 1.08) | 1.05 (1.04, 1.07) | 1.01 (0.94, 1.09) | 1.04 (1.02, 1.06) | 1.02 (0.98, 1.07) |
| Gender (ref: male) | | | | | |
| Female | 0.83 (0.73, 0.95) | 0.73 (0.67, 0.87) | 0.78 (0.63, 1.13) | 0.81 (0.73, 0.89) | 0.75 (0.61, 0.93) |
| Comorbidities group (ref: 0) | | | | | |
| 1 | 0.91 (0.78, 1.06) | 1.07 (0.94, 1.22) | 1.15 (0.49, 2.71) | 0.98 (0.88, 1.1) | 1.06 (0.67, 1.67) |
| 2 | 1.15 (0.96, 1.37) | 1.54 (1.35, 1.76) | 2.16 (0.96, 4.87) | 1.21 (1.06, 1.39) | 1.63 (1.05, 2.52) |
| 3-8 | 1.29 (0.96, 1.74) | 2.52 (2.16, 2.94) | 2.46 (1.07, 5.61) | 1.47 (1.18, 1.83) | 2.69 (1.74, 4.17) |
| Diagnosis (ref: Spinal stenosis) | | | | | |
| Disc herniation | 0.85 (0.68, 1.07) | 0.88 (0.76, 1.03) | 0.57 (0.26, 1.22) | 0.9 (0.76, 1.06) | 0.82 (0.57, 1.18) |
| Disc protrusion | 1.2 (1.01, 1.43) | 1.2 (1.07, 1.35) | 1.4 (0.84, 2.34) | 1.16 (1.02, 1.33) | 0.87 (0.61, 1.23) |
| Degeneration | 0.9 (0.74, 1.11) | 0.86 (0.75, 0.99) | 0.87 (0.49, 1.56) | 1.01 (0.87, 1.17) | 1.06 (0.78, 1.45) |
| Procedure (ref: fusion) | | | | | |
| Decompression | 0.58 (0.5, 0.68) | 0.6 (0.55, 0.67) | 0.48 (0.32, 0.72) | 0.64 (0.57, 0.71) | 0.55 (0.43, 0.69) |
| Discectomy | 0.61 (0.47, 0.81) | 0.69 (0.59, 0.8) | 0.45 (0.25, 0.82) | 0.71 (0.59, 0.87) | 0.54 (0.39, 0.74) |

Demographics and patient characteristics

The median age was 82 years (IQR: 81-85) in all the databases. MarketScan and NIS databases found females to have undergone frequent spine surgeries compared to males (53% vs. 54%, respectively), whereas the NSQIP database showed an equal proportion of males and females undergoing surgeries, Table 2. A majority of patients in both MarketScan and NIS were insured by Medicare (97% vs. 94%). Medicaid was more commonly reported with MarketScan enrollees compared to NIS enrollees (3.1% vs. 0.27%). Because NIS accumulates data on all payers, it has the ability to report commercial/private (4.7%) and other methods of payments (1.08%). Patients in MarketScan had lower comorbidity scores (comorbidity: 0-2) compared to those in NIS and NSQIP databases. Patients with 3+ comorbidities constituted 4% in MarketScan, 9% in NIS and 22% in NSQIP databases. Hypertension was the most common comorbidity, with a median of one comorbidity across the MarketScan and NIS databases (NSQIP: median, 2 comorbidities).
| Variable                  | MarketScan | National Inpatient Sample | National Surgical Quality Improvement Program |
|---------------------------|------------|---------------------------|-----------------------------------------------|
| N                         | 15105      | 40854                     | 7682                                          |
| Age                       |            |                           |                                               |
| Mean (SD)                 | 83.1 (2.8) | 83.1 (2.8)                | 82.9 (2.5)                                   |
| Median (IQR)              | 82 (81, 85)| 82 (81, 85)               | 82 (81, 85)                                  |
| Range (min-max)           | 80-103     | 80-110                    | 80-89                                        |
| Gender, n (%)             |            |                           |                                               |
| Female                    | 7974 (52.79%) | 22224 (54.43%)         | 3835 (49.93%)                                |
| Race, n (%)               |            |                           |                                               |
| White                     | 31396 (76.85%) | 6600 (85.92%)           |                                               |
| Black                     | 1022 (2.5%)  | 236 (3.07%)               |                                               |
| Other/unknown             | 8436 (20.65%) | 846 (11.01%)             |                                               |
| Type of Insurance, n (%)  |            |                           |                                               |
| Commercial/private        | 1933 (4.73%) |                           |                                               |
| Medicaid                  | 468 (3.1%)  | 109 (0.27%)               |                                               |
| Medicare                  | 14637 (96.9%) | 38370 (93.92%)         |                                               |
| Other                     | 442 (1.08%)  |                           |                                               |
| Comorbidities group, n (%)|            |                           |                                               |
| 0                         | 5551 (36.75%) | 7842 (19.2%)             | 788 (10.26%)                                |
| 1                         | 6141 (40.66%) | 18479 (45.23%)          | 2474 (32.21%)                               |
| 2                         | 2764 (18.3%)  | 10838 (26.53%)          | 2668 (34.73%)                               |
| 3-10                      | 649 (4.3%)  | 3696 (9.04%)             | 1752 (22.81%)                               |
| Comorbidities details, n (%)|           |                           |                                               |
| 1 Anemia                  | 2080 (13.77%) | 8018 (19.63%)          | 2683 (34.93%)                               |
| 2 Bleeding disorder       | 222 (1.47%)  | 927 (2.27%)              | 283 (3.68%)                                 |
| 3 COPD                    | 955 (6.32%)  | 3402 (8.33%)             | 448 (5.83%)                                 |
| 4 Diabetes                | 2480 (16.42%) | 9169 (22.44%)          | 1564 (20.36%)                               |
| 5 Hypertension            | 7356 (48.7%) | 26824 (65.66%)          | 6026 (78.44%)                               |
| 6 Morbid obesity          | 118 (0.78%)  | 454 (1.11%)              | 125 (1.63%)                                 |
| 7 Obesity                 | 301 (1.99%)  | 2057 (5.04%)             | 2114 (27.52%)                               |
| 8 Smoking                 | 179 (1.19%)  | 1069 (2.59%)             | 280 (3.64%)                                 |
| Any one of above          | 9554 (63.25%) | 33012 (80.8%)           | 6894 (89.74%)                               |
| Sum of above              |            |                           |                                               |
| Mean (SD)                 | 0.9 (0.9)  | 1.3 (0.9)                 | 1.8 (1)                                     |
| Median (IQR)              | 1 (0, 1)    | 1 (1, 2)                  | 2 (1, 2)                                    |
| Range (min-max)           | 0-5         | 0-6                       | 0-6                                         |

TABLE 2: Patient Characteristics (2006-2016)

The primary diagnoses and procedures performed across the databases are presented in Tables 3, 4. The most common diagnosis was spinal stenosis in MarketScan (54.4%), NIS (54.6%), and NSQIP databases (65.2%). Fusion was the most common procedure performed in MarketScan (48.9%) and NIS databases (46.2%), whereas decompression (laminectomy/laminotomy) was the most common procedure in NSQIP database (51.84%). Discectomy for spinal stenosis was the least common procedure performed across the databases.
| Variable     | MarketScan N=15105 | National Inpatient Sample N=40854 | National Surgical Quality Improvement Program N=7682 |
|--------------|---------------------|-----------------------------------|------------------------------------------------------|
| Diagnosis, n (%) |                     |                                   |                                                      |
| Spinal stenosis | 8216 (54.39%)       | 22328 (54.65%)                   | 5011 (65.23%)                                       |
| Disc herniation | 2474 (16.38%)       | 6967 (17.05%)                     | 970 (12.63%)                                        |
| Disc protrusion  | 2355 (15.59%)       | 6207 (15.19%)                     | 763 (9.93%)                                         |
| Degeneration    | 2060 (13.64%)       | 5352 (13.1%)                      | 938 (12.21%)                                        |
| Procedures, n (%) |                     |                                   |                                                      |
| Fusion         | 7386 (48.9%)        | 18863 (46.17%)                   | 2185 (28.44%)                                       |
| Decompression (Laminectomy/laminotomy) | 6007 (40.17%)    | 15670 (38.36%)                   | 3982 (51.84%)                                       |
| Discectomy     | 1652 (10.94%)       | 6321 (15.47%)                     | 1515 (19.72%)                                       |

**TABLE 3: Primary Diagnoses and Procedures of Cohorts**
### TABLE 4: Diagnosis, Procedures, and Complications

| Procedure                          | MarketScan | National Inpatient Sample | National Surgical Quality Improvement Program |
|------------------------------------|------------|---------------------------|------------------------------------------------|
|                                    | Fusion     | Discectomy                | Diastolic                                          |
|                                    | 717        | 472                       | 1322                                               |
|                                    | 1 (0.01%)  | 6 (0.3%)                  | 18 (0.13%)                                        |
|                                    | 3 (0.42%)  | 4 (0.53%)                 | 10 (0.88%)                                        |
|                                    | 1 (0.14%)  | 4 (0.18%)                 | 12 (1.03%)                                        |
|                                    | 1 (0.14%)  | 4 (0.18%)                 | 12 (1.03%)                                        |
|                                    | 1 (0.14%)  | 4 (0.18%)                 | 12 (1.03%)                                        |

#### In-Hospital Complications, n (%)

| Diagnosis                          | Fusion     | Discectomy                | Diastolic                                          |
|------------------------------------|------------|---------------------------|---------------------------------------------------|
| Any one of the above               | 172 (4.32%)| 107 (2.2%)                | 280 (7.71%)                                       |
| Wound Dehiscence                   | 105 (1.42%)| 62 (1.3%)                 | 135 (8.91%)                                       |
| Stroke                             | 59 (3.89%) | 30 (0.53%)                | 18 (1.19%)                                        |
| Pulmonary Embolism                 | 56 (3.57%) | 30 (0.53%)                | 18 (1.19%)                                        |
| Pneumonia                          | 39 (2.6%)  | 21 (0.36%)                | 12 (0.8%)                                         |
| Deep vein thrombosis               | 280 (4.43%)| 59 (0.96%)                | 18 (1.19%)                                        |
| Cardiac Arrest                     | 61 (4.09%) | 31 (0.52%)                | 12 (0.8%)                                         |
| Deep vein thrombosis               | 280 (4.43%)| 59 (0.96%)                | 18 (1.19%)                                        |
| Pneumonia                          | 39 (2.6%)  | 21 (0.36%)                | 12 (0.8%)                                         |
| Cardiac Arrest                     | 61 (4.09%) | 31 (0.52%)                | 12 (0.8%)                                         |
| Deep vein thrombosis               | 280 (4.43%)| 59 (0.96%)                | 18 (1.19%)                                        |

#### 30-Day Complications, n (%)

| Diagnosis                          | Fusion     | Discectomy                | Diastolic                                          |
|------------------------------------|------------|---------------------------|---------------------------------------------------|
| Acute Kidney Injury                | 207 (3.04%)| 138 (1.78%)               | 38 (0.25%)                                        |
| Any surgical site infection        | 20 (2.9%)  | 13 (2.6%)                 | 20 (0.92%)                                        |
| Cardiac Arrest                     | 17 (0.23%) | 11 (0.24%)                | 12 (0.53%)                                        |
| Deep vein thrombosis               | 59 (3.89%) | 30 (0.53%)                | 18 (1.19%)                                        |
| Myocardial Infarction              | 61 (4.09%) | 31 (0.52%)                | 12 (0.8%)                                         |
| Pneumonia                          | 39 (2.6%)  | 21 (0.36%)                | 12 (0.8%)                                         |
| Pulmonary Embolism                 | 56 (3.57%) | 30 (0.53%)                | 18 (1.19%)                                        |
| Stroke                             | 61 (4.09%) | 31 (0.52%)                | 12 (0.8%)                                         |
| Wound Dehiscence                   | 39 (2.6%)  | 21 (0.36%)                | 12 (0.8%)                                         |

#### Length of hospital stay, complications, and mortality

The median length of hospital stay was similar across the cohorts (3days) with IQR of 2-4 days in MarketScan, 2-5 days in NIS and 1-4 days in NSQIP database. In hospital complications (any), MarketScan reported higher complications rate (12.7%) compared to NSQIP (5.08%) and pneumonia (3.53%) was the most common complication in MarketScan database, whereas surgical site infection (1.58%) was the most common in NSQIP database. In-hospital mortality was slightly higher in the NIS database (0.32%) compared to MarketScan (0.21%) and NSQIP database (0.2%), Table 5.
TABLE 5: Length of Stay, In-hospital Mortality and Complications

| Variable                        | MarketScan | National Inpatient Sample | National Surgical Quality Improvement Program |
|---------------------------------|------------|---------------------------|-----------------------------------------------|
| Length of stay, days            | N=15105    | N=40854                   | N=7682                                        |
| Mean (SD)                       | 3.6 (3.5)  | 3.8 (3.5)                 | 3.5 (3.9)                                     |
| Median (IQR)                    | 3 (2, 4)   | 3 (2, 5)                  | 3 (1, 4)                                      |
| Range (min-max)                 | 1-102      | 0-84                      | 0-67                                          |
| In-hospital mortality, n (%)    | 32 (0.21%) | 132 (0.32%)               | 15 (0.2%)                                     |
| In Hospital Complications, n (%)|            |                           |                                               |
| 1 Acute Kidney Injury           | 351 (2.32%)| 1167 (2.86%)              | 10 (0.13%)                                    |
| 2 Any surgical site infection   | 46 (0.3%)  | 73 (0.18%)                | 13 (0.17%)                                    |
| 3 Cardiac Arrest                | 33 (0.22%) | 79 (0.19%)                | 9 (0.12%)                                     |
| 4 Deep vein thrombosis         | 115 (0.76%)| 237 (0.58%)               | 33 (0.43%)                                    |
| 5 Myocardial Infarction         | 113 (0.75%)| 281 (0.69%)               | 30 (0.39%)                                    |
| 6 Pneumonia                     | 256 (1.69%)| 526 (1.29%)               | 52 (0.68%)                                    |
| 7 Pulmonary Embolism            | 65 (0.43%) | 118 (0.29%)               | 18 (0.23%)                                    |
| 8 Stroke                        | 121 (0.8%) | 158 (0.39%)               | 11 (0.14%)                                    |
| 9 Wound Dehiscence              | 12 (0.08%) | 32 (0.08%)                | 3 (0.04%)                                     |
| Any one of the above            | 989 (6.55%)| 2259 (5.53%)              | 155 (2.02%)                                   |
| 30-day Complications, n (%)     |            |                           |                                               |
| 1 Acute Kidney Injury           | 524 (3.47%)| 27 (0.35%)                |                                               |
| 2 Any surgical site infection   | 345 (2.28%)| 121 (1.58%)               |                                               |
| 3 Cardiac Arrest                | 50 (0.33%) | 17 (0.22%)                |                                               |
| 4 Deep vein thrombosis         | 317 (2.1%) | 82 (1.07%)                |                                               |
| 5 Myocardial Infarction         | 175 (1.16%)| 48 (0.62%)                |                                               |
| 6 Pneumonia                     | 533 (3.53%)| 93 (1.21%)                |                                               |
| 7 Pulmonary Embolism            | 168 (1.11%)| 40 (0.52%)                |                                               |
| 8 Stroke                        | 223 (1.48%)| 22 (0.29%)                |                                               |
| 9 Wound Dehiscence              | 93 (0.62%) | 11 (0.14%)                |                                               |
| Any one of the above            | 1929 (12.77%)| 390 (5.08%)               |                                               |

Both MarketScan and NIS databases showed an increased risk of complication with increasing age, whereas NIS and NSQIP databases showed increased complications with an increasing number of comorbidities. Male gender had higher complication during index hospitalization using MarketScan and NIS database, and 30-day post-discharge using MarketScan and NSQIP database. Using the MarketScan database, patients with 2 and 3+ comorbidities had 1.21 (1.06, 1.39), and 1.47 (1.18, 1.83) higher odds of experiencing a complication compared to those with no comorbidities, respectively at 30 days after hospitalization. In terms of diagnosis, patients with disc protrusion had a higher risk of complications during index hospitalization and 30 days post-discharge compared to those with a diagnosis of spinal stenosis. Compared to fusion, patients undergoing decompression and discectomy had lower odds of developing complications during index hospitalization [MarketScan database: Decompression: 0.58 (0.5-0.68); Discectomy: 0.61 (0.47-0.81)] and [NIS database: Decompression: 0.6 (0.55-0.67); Discectomy: 0.69 (0.59-0.8) discectomy] and 30 days post-discharge, Table 5.

Discussion

Incorporation of national databases into research has substantially increased in the past few years [2,3,6,13,14]. Although these large sample sizes offer researchers opportunities to investigate rare diseases, the statistically significant results are nevertheless susceptible to type I errors, or false-positive results [1]. Therefore, it is essential to understand the observational and retrospective nature of the database and its sample populations prior to generalizing its outcomes to the total population when given statistically significant results. To our knowledge, this study is the first to compare outcomes and demographics of elderly patients undergoing spine surgery in three commonly used databases.
Limitations and strengths

we must be wary of assigning external validity to the total patient population. Retrospective and observational nature of database studies, especially considering changing practices and sampling methods, generalizing this data to the total population may not be accurate due to the database studies. Although they theoretically should represent the population of the country through their results despite differing acquisition methods. Nonetheless, we caution clinicians from generalizing results of study, broadly, the results of these databases are moderately consistent with one another, suggesting precise forgetting to vet the generalizability. Although minor differences are highlighted due to the power of the not be clinically relevant. Additionally, not infrequently, clinicians afford too much attention to p-values, provide a means to obtain statistical significance that highlight minor differences, but these differences may

Differences in the national administrative databases

Non-uniform methodology of these databases can uncover difficulties in generalizing results and thus drawing clinical significance. Crucial differences can arise from each database's sampling methods. Truven Health Analytics MarketScan® database compiles its samples from claims of employees, Medicare-eligible retirees, early retired, Consolidated Omnibus Budget Reconciliation Act (COBRA) participants and their dependents enrolled through large US corporations in the private sector [9,21]. In contrast, HCUP NIS collects a stratified systematic sample from all HCUP hospitals, which is equivalent to 20% of all discharges from community hospitals in the United States [10,14]. Based on the method used to collect the cohort sample, NIS is most likely representative of national means and the US population. However, NIS contains information related to hospital discharges only. MarketScan readily offers outpatient visit information, allowing for better understanding in longitudinal aspects for investigation. Since MarketScan collates participants from those insured by large US corporations, their sample may be limited to specific geographic or socioeconomic groups [21]. It can be argued that because MarketScan databases cover participants who were insured through large US corporations, they may not be as representative or comparable of the general US population. Whereas, NSQIP is a nationally validated program forwarded by the American College of Surgeons (ACS) aimed to improve the quality of surgical care by providing tools to participating hospitals.

Overall, while it is not surprising to report that advanced aged participants are predominantly enrolled in Medicare, discerning discrepant trend allows patients to choose clinically and economically sound providers to anticipate healthcare costs. An arsenal of comprehensive variables is necessary to streamline patients' experiences and outcomes [22]. Due to its limited collection of participant data from only US corporations, MarketScan is theoretically unable to present a cohort that is characteristic of the whole US population. Nonetheless, studies examining the quality of NIS data found discrepancies when comparing results derived from patient charts and administrative data from ICD-9 billing codes [12,23]. Furthermore, billing-codes are variable on the interpretation and accuracy of the operator (trained vs. naïve) as well as external political and economic pressures leading to variability in application of different codes for a similar procedure in different databases [1].

Since these databases have numerous overlapping variables, and no single database contains all variables, multiple database approach may help compensate for their respective weaknesses. Buckland et al. showed that national databases such as NIS and NSQIP did not capture a similar patient population when compared to physician managed database (PMD) in patients undergoing surgery for adult spinal deformity [24]. This difference can be attributed to the referral pattern and selection bias in the PMD cohort. Similarly, Bohl et al. showed that NIS and NSQIP databases gave different results (complications and comorbidities) in patients with hip fractures [25]. In concordance to these studies, we found that 30-day post-discharge complications varied significantly between MarketScan (12.77%) and NSQIP database (5.1%).

According to comorbidity scores alone, NIS and NSQIP patients were less healthy than their MarketScan counterparts. In our study, we used Elixhauser comorbidity index for analysis in all three databases. Nonetheless, it is integral to question the comorbidity indices implemented for the analysis, as not all comorbidities are weighted equally among each index. The algorithm of Elixhauser comorbidity index was developed to predict the inpatient outcomes in hospitalized patients based on their acute and chronic conditions [11,26]. It has been demonstrated to predict the in-hospital mortality with respect to disease burden, especially after 30-days of hospitalization [27]. In contrast, the Charlson comorbidity index was designed to predict one-year mortality based on a patient’s comorbidities [28]. While both calculations are commonly utilized to discriminate for future mortality outcomes, Menendez et al. reported that the Elixhauser comorbidity method outperformed Charlson Index in regards to predicting inpatient outcomes after specifically orthopedic surgery [29]. Thus, inclusion and exclusion criteria for pertinent variables of candidate databases should be deliberated to identify the optimal database fitting study aims.

Differences yet similarity among databases

It is important, however, to note that despite vastly different sample sizes, demographics, and collection methods, the primary and secondary results from the databases are not different. The large cohort sizes provide a means to obtain statistical significance that highlight minor differences, but these differences may not be clinically relevant. Additionally, not infrequently, clinicians afford too much attention to p-values, forgetting to vet the generalizability. Although minor differences are highlighted due to the power of the study, broadly, the results of these databases are moderately consistent with one another, suggesting precise results despite differing acquisition methods. Nonetheless, we caution clinicians from generalizing results of database studies. Although they theoretically should represent the population of the country through their sampling methods, generalizing this data to the total population may not be accurate due to the retrospective and observational nature of database studies, especially considering changing practices and advancing minimally invasive technologies. While the owners of the database may promise internal validity, we must be wary of assigning external validity to the total patient population.

Limitations and strengths

This study has several limitations. First, the accuracy of our results depends largely on the accuracy and
consistency of the reported diagnosis and procedure codes. Secondly, the inability to match patients between these three databases limits our capability to reason several of the discovered outcome discrepancies. Specific patient profiles would allow analysis regarding adherence to evidence-based medicine and hospital guidelines, especially in standards with the geographical location [30]. One such finding includes the differences in stratified post-operative complications between the three databases. Although the most common specific complications were alike in the three databases, it is difficult to ascertain the discrepancies without additional granular clinical details.

Notably, MarketScan and NSQIP can track patient data after the perioperative period. In contrast, NIS was limited to information accumulated during the immediate inpatient stay, thereby disallowing longitudinal comparison to determine superiority in that regard. Moreover, because both NIS and MarketScan were not designed to collect spine- or orthopedic-specific data, this study was limited to available variables. Reported improvements in the quality of life and activities of daily living following procedures would provide integral insight into necessary changes required to expand care delivery outcomes. As all databases offer different groups of patient characteristics and widely differ in their sample collection, we remain cognizant of the limitation in the generalizability of the comparison of results and databases.

Conclusions

Even though the results of the three commonly used databases were not completely different, suggesting some consistency despite differing sampling methods, this study captures the discrepancies in the demographics of spine surgery. The disparities drive the variations observed in preoperative comorbid status and inpatient and long-term adverse events. Overall, it appears that the patients in the NSQIP and NIS database have more comorbidities, patients in the MarketScan database had the highest number of perioperative and 30-day post-discharge complications with the highest number of fusion procedures performed. Patients in the NSQIP database had the lowest number of fusion procedures and complication rates. Thus, researchers should be wary of generalizing results from sample populations onto total populations with retrospective, observational database study designs. Future studies may additionally benefit from different database approaches to supplement any vulnerabilities of the primary database.

Appendices
## TABLE 6: Summary of ICD-9/10 Primary Complication and Comorbidity Codes Utilized to Query Data from MarketScan, National Inpatient Sample and National Surgical Quality Improvement Program Databases

International Classification of Diseases character 1 (i.e. E, J, N) refers to medical or surgical category designation and character 2 refers to body system.

| Procedures | International Classification of Diseases-9 Code | International Classification of Diseases-10 Code | Current Procedural Terminology Code | Description for International Classification of Diseases-9 |
|------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------|----------------------------------------------------------|
| Decompression | 03.09 (this includes all levels) | 0RBxyZZ(X=0,1,4,6,A); 0SBxyZZ(X=0,3); -Excision | 22102, 22114, 22207, 22214, 22224 | Other exploration and decompression of spinal canal |
| | | | | |
| | 00NxyZZ(x=W, X,Y), -Release | 63005, 63012, 63017, 63030, 63035, 63091, 63092, 63093, 63094, 63095 | | |
| | 009xy0Z, 009xyZZ(x=T, W, X,Y); 009U00Z, 009U0ZZ | | | |
| | Drainage | 2019 Bhargava et al. Cureus 11(11): e6195. DOI 10.7759/cureus.6195 | | |
| CPT Code   | Description                                                                 | Medicare Allowable | Notes                                                                 |
|------------|------------------------------------------------------------------------------|--------------------|----------------------------------------------------------------------|
| 80.50      | Excision or destruction of intervertebral disc, unspecified                  | 63042, 63047, 63056, 63087, 63090. |                                                     |
| 80.51      | Excision or destruction of intervertebral disc, unspecified                  | 63042, 63047, 63056, 63087, 63090. |                                                     |
| 80.59      | Other destruction of intervertebral disc                                      | 80.51              | Other destruction of intervertebral disc                             |
| 80.6x      | Disc replacement                                                              |                    |                                                                      |
| 81.01      | Cervical fusion                                                               |                    |                                                                      |
| 81.02      | Thoracic fusion                                                               |                    |                                                                      |
| 81.03      | Lumbar fusion                                                                 |                    |                                                                      |
| 81.04      | Thoracolumbar fusion                                                          |                    |                                                                      |
| 81.05      | Thoracolumbar fusion                                                          |                    |                                                                      |
| 83.06      | Lumbar and lumbosacral fusion                                                 |                    |                                                                      |

### Medicare Allowable Codes

- 63042: Cervical Fusion
- 63047: Thoracic Fusion
- 63056: Lumbar Fusion
- 63087: Thoracolumbar Fusion
- 63090: Lumbar and Lumbosacral Fusion

#### Notes

- Code 80.50: Excision or destruction of intervertebral disc, unspecified
- Code 80.51: Excision or destruction of intervertebral disc, unspecified
- Code 80.59: Other destruction of intervertebral disc
- Code 80.6x: Disc replacement
- Code 81.01: Cervical fusion
- Code 81.02: Thoracic fusion
- Code 81.03: Lumbar fusion
- Code 81.04: Thoracolumbar fusion
- Code 81.05: Thoracolumbar fusion
- Code 83.06: Lumbar and lumbosacral fusion

### Additional Information

- Code 80.6x: Disc replacement
- Codes 81.01-81.06: Various fusion procedures

**References**

- Bhargava et al. Cureus 11(11): e6195. DOI 10.7759/cureus.6195
### TABLE 7: Summary of ICD-9/10 Primary Procedure Codes Utilized to Query Data from MarketScan, National Inpatient Sample and National Surgical Quality Improvement Program Databases

International Classification of Diseases character 1 (i.e. E, J, N) refers to medical or surgical category designation and character 2 refers to body system, character 3 (i.e. OB, RG) refers to root operation.
## Diagnosis

| Diagnosis                                      | International Classification of Diseases-9 Code | International Classification of Diseases-10 Code | International Classification of Diseases-9 Description |
|------------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------------|
| Spinal stenosis                               | 723.0                                         | M48.01, M48.02, M48.03, M99.21-M99.71         | Spinal stenosis in cervical region                   |
|                                                | 724.00                                        | M48.00                                        | Spinal stenosis, unspecified region                 |
|                                                | 724.01                                        | M48.04, M48.05, M99.22-M99.72                 | Spinal stenosis, thoracic region                    |
|                                                | 724.02                                        | M48.06, M48.07, M99.23-M99.73                 | Spinal stenosis, lumbar region, without neurogenic claudication |
|                                                | 724.03 -claudication                           |                                               |                                                     |
|                                                | 724.09                                        | M48.08, M99.24-M99.74                         | Spinal stenosis, other region                       |
| Disk herniation                               | 722.0                                         | M50.2x                                        | Displacement of cervical intervertebral disc without myelopathy |
|                                                | 722.10                                        | M51.26, M51.27                               | Displacement of lumbar intervertebral disc without myelopathy |
|                                                | 722.11                                        | M51.24, M51.25                               | Displacement of thoracic intervertebral disc without myelopathy |
| Disc protrusion                                | 722.30                                        |                                               | Schmorl's nodes, unspecified region                 |
|                                                | 722.31                                        | M51.44, M51.45                               | Schmorl's nodes, thoracic region                    |
|                                                | 722.32                                        | M51.46, M51.47                               | Schmorl's nodes, lumbar region                      |
|                                                | 722.4                                         | M50.3x                                        | Degeneration of cervical intervertebral disc        |
|                                                | 722.51                                        | M51.34, M51.35                               | Degeneration of thoracic or thoracolumbar intervertebral disc |
|                                                | 722.52                                        | M51.36, M51.37                               | Degeneration of lumbar or lumbosacral intervertebral disc |
|                                                | 722.71                                        | M50.0x                                        | Intervertebral disc disorder with myelopathy, cervical region |
|                                                | 722.72                                        | M51.04, M51.05                               | Intervertebral disc disorder with myelopathy, thoracic region |
|                                                | 722.73                                        | M51.06, M51.07                               | Intervertebral disc disorder with myelopathy, lumbar region |
| Degenerative conditions                        | 724.1                                         | M54.6                                         | Pain in thoracic spine                             |
|                                                | 724.3                                         | M54.3x                                        | Sciatica                                          |
|                                                | 724.4                                         | M54.14- M54.17                               | Thoracic or lumbosacral neuritis or radiculitis, unspecified |
|                                                | 724.5                                         | M54.89, M54.9                                | Backache, unspecified                              |
|                                                | 724.9                                         | M43.8x9, M53.80, M53.84, M53.8S, M53.9        | Other unspecified back disorders                    |
|                                                | 738.4                                         | M43.0x, M43.1x                               | Acquired spondylolisthesis                         |
|                                                | 756.11                                        | Q76.2                                         | Spondylosis, lumbosacral region                     |
|                                                | 756.12                                        | Q76.2                                         | Spondylolisthesis                                  |
|                                                | 756.19                                        | Q76.41x, Q76.49                              | Other anomalies of spine                           |

### TABLE 8: Summary of ICD-9/10 Primary Diagnosis Codes Utilized to Query Data from MarketScan, National Inpatient Sample and National Surgical Quality Improvement Program Databases

International Classification of Diseases character 1 (i.e. E, J, N) refers to medical or surgical category designation and character 2 refers to body system, character 3 (i.e. 0B, 0G) refers to root operation.

### Additional Information

**Disclosures**

- **Human subjects**: All authors have confirmed that this study did not involve human participants or tissue.
- **Animal subjects**: All authors have confirmed that this study did not involve animal subjects or tissue.
- **Conflicts of interest**: In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info**: All authors have declared that no financial support was received from...
any organization for the submitted work. Financial relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. Other relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

References

1. Samuel AM, Lukasiewicz AM, Webb MI, et al.: Do we really know our patient population in database research? A comparison of the femoral shaft fracture patient populations in three commonly used national databases. Bone Joint J 2016, 98-B:425-432. 10.1302/0301-620x.98b8.36281
2. Bohd DD, Russo GS, Basques BA, et al.: Variations in data collection methods between national databases affect study results: a comparison of the nationwide inpatient sample and national surgical quality improvement program databases for lumbar spine fusion procedures. J Bone Joint Surg Am. 2014, 96:195. 10.2106/JBJS.M.01490
3. Sharma M, Dietz N, Alhorrani A, Ugilwenne R, Wang D, Drazin D, Boakye M.: Insights into complication rates, reoperation rates, and healthcare utilization associated with use of recombinant human bone morphogenetic protein-2 in patients with spine infections. Neurosurg Focus. 2019, 46:6. 10.3171/2018.10.FOCUS18448
4. Sharma M, Ugilwenne R, Alhorrani Z, Nuno MA, Drazin D, Boakye M: Factors predicting opioid dependence in patients undergoing surgery for degenerative spondylothesis: analysis from the MarketScan databases. J Neurosurg Spine. 2018, 29:271-278. 10.3171/2018.1.SPINE171218
5. Allen MS, Blackmon S, Nichols FC, Casivi SD, Shen RR, Wigle DA: Comparison of two national databases for general thoracic surgery. Ann Thorac Surg. 2015, 100:1153-1161. 10.1016/j.athoracsur.2015.01.051
6. Lin Y, Pan IW, Mayer RR, Lamas G: Complications after craniosynostosis surgery: comparison of the 2012 kids’ inpatient database and pediatric NSQIP database. Neurosurg Focus. 2015, 39:1-6. 10.3171/2015.FOC.SS15383
7. Katz JN, Snack G, Lipsman S, Howell D, Weintraub JS: Predictors of surgical outcome in degenerative lumbar spinal stenosis. Spine. 1994, 22:2225-2235. 10.1097/00007632-199411150-00004
8. Joseph B, Pandit V, Zhang B, et al.: Superiority of frailty over age in predicting outcomes among geriatric trauma patients: a prospective analysis. JAMA surgery. 2014, 149:366-372. 10.1001/jamasurg.2014.296
9. Adams D, Chang S, Hansen LG: Health Research Data for the Real World: The MarketScan Databases. Thomson Healthcare, Connecticut; 2008.
10. Introduction to the HCUP Nationwide Inpatient Sample. (2015). Accessed: December 1, 2016: http://www.hcup-us.ahrq.gov/db/nation/nis/NIS_Introduction_2011.pdf
11. Elixhauser A, Steiner C, Harris DR, Coffey RM: Comorbidity measures for use with administrative data. Med care. 1998, 36:8-27. 10.1097/00005650-199801000-00004
12. Drazin D, Lagman C, Bhargava S, Nuno M, Kim TT, Johnson JP: National trends following discectomy, disectomy, and fusion in octogenarians and nonagenarians. Acta Neurochir. 2017, 159:317-325. 10.1007/s00701-016-3506-1
13. Dietz N, Sharma M, Alhorrani A, et al.: Outcomes of decompression and fusion for treatment of spinal infection. Neurosurg Focus. 2019, 46:1-9. 10.3171/2018.10.FOCUS18440
14. Sharma M, Ugilwenne R, Fortuny EM, et al.: National trends in cerebral bypass for unruptured intracranial aneurysms: a National (Nationwide) Inpatient Sample analysis of 1998-2015. Neurosurg Focus. 2019, 46:15. 10.3171/2018.11.FOCUS18304
15. Boakye M, Patil CG, Santarelli J, Ho C, Tian W, Lad SP: Lamincetomy and fusion after spinal cord injury: national inpatient complications and outcomes. J Neurotrauma. 2008, 25:173-183. 10.1089/neu.2007.0795
16. Patil CG, Santarelli J, Lad SP, Ho C, Tian W, Boakye M: Inpatient complications, mortality, and discharge disposition after surgical correction of idiopathic scoliosis: a national perspective. Spine J. 2008, 8:904-910. 10.1016/j.spmj.2008.02.002
17. Patil CG, Lad EM, Lad SP, Ho C, Boakye M: Visual loss after spine surgery: a population-based study. Spine. 2008, 33:1491-1496. 10.1097/BRS.0b013e3181731634
18. Wang MY, Wdi G, Levi AD: The safety profile of lumbar spinal surgery in elderly patients 85 years and older. Neurosurg Focus. 2015, 39:1-4. 10.3171/2015.7.FOCSSS1830
19. Nie H, Hao J, Peng C, Ou Y, Quan X, An H: Clinical outcomes of discectomy in octogenarian patients with lumbar disc herniation. J Spinal Disord Tech. 2015, 26:74-78. 10.1097/BSD.0000000000000264
20. Raffo CS, Luerman WC: Predicting morbidity and mortality of lumbar spine arthrodesis in patients in their ninth decade. Spine. 2006, 31:99-103. 10.1097/01.BS.0000201788.25586.e5
21. Kong SX, Hatanou HT, Zhao SZ, Agravad NM, Goel SG: Prevalence and cost of hospitalization for gastrointestinal complications related to peptic ulcers with bleeding or perforation: comparison of two national databases. Am J Manag Care. 1998, 4:399-409.
22. Keller DS, Sonavane AJ, Fitch K, Boecher A, Haas EM: A new perspective on the value of minimally invasive colorectal surgery-payer, provider, and patient benefits. Surg Endosc. 2017, 31:2846-2853. 10.1007/s00464-016-5295-x
23. Gollivussar NA, Bohd DD, Basques BA, Fu MC, Gardner EC, Grauer JN: Limitations of administrative databases in spine research: a study in obesity. Spine J. 2014, 14:2925-2928. 10.1016/j.spinee.2014.04.021
24. Buckland AJ, Poorman G, Freitag R, et al.: National administrative databases in adult spinal deformity surgery: a cautionary tale. Spine. 2017, 42:1248-1254. 10.1097/BRS.0000000000002064
25. Bohd DD, Basques BA, Gollivussar NA, Baumgartner MR, Grauer JN: Nationwide Inpatient Sample and National Surgical Quality Improvement Program give different results in hip fracture studies. Clin Orthop Relat Res. 2014, 472:1672-1680. 10.1007/s11999-014-3559-8
26. Van Walraven C, Austin PC, Jennings A, Quan H, Forster AJ: A modification of the Elixhauser comorbidity measures into a point system for hospital death using administrative data. Med care. 2009, 47:626-633. 10.1097/MLR.0b013e3181943265
27. Shabadiani MT, Aylin P, Bottle A: Systematic review of comorbidity indices for administrative data. Med Care. 2012, 50:1099-1118. 10.1093/medcare/ems182.3.640
28. Charnel ME, Pompei P, Atlas KL, Mackenzie CR: A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis. 1987, 40:373-383. 10.1016/0021-9681(87)90117-8
29. Menendez ME, Neuhaus V, van Dijk CN, Ring D: The Elixhauser comorbidity method outperforms a modification of the Charlson index in predicting inpatient death after orthopaedic surgery. Clin Orthop Relat Res. 2014, 472:2878-2886. 10.1007/s11999-014-3546-8
30. Khoukhi S, Miyata H, Ueda I, et al.: An international comparison of patients undergoing percutaneous coronary intervention: A collaborative study of the National Cardiovascular Data Registry (NCDB) and Japan Cardiovascular Database-Reli interhospital Cardiovascular Studies (ICD-KICS). Am Heart J. 2015, 170:1077-1085. 10.1016/j.ahj.2015.09.017

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