Research Article

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Increased Utilization of American Administrative Databases and Large-scale Clinical Registries in Orthopaedic Research, 1996 to 2016

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Abstract

Introduction: Administrative databases and clinical registries provide large sample sizes that characterize specific outcomes and trends over time in orthopaedic surgery.

Methods: A literature review of all English-language orthopaedic surgery journals was conducted. All publications from 1996 to 2016 were reviewed for the utilization of an administrative database or clinical registry. We performed a linear regression with logarithmic transformation to identify trends in database utilization.

Results: Eight hundred forty-nine publications used a database from 1996 to 2016. Each year, 35.3% more database publications are reported than the previous year (95% confidence interval, 30.0 to 40.7), from zero articles in 1996 to 286 in 2016. The ratio of database research publications to overall orthopaedic publications increased from zero in 1996 to 2% in 2016. The most commonly used databases included the National Inpatient Sample and the National Surgical Quality Improvement Program.

Conclusion: Database research in orthopaedics has grown at a faster rate than orthopaedic literature as a whole.

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Recently, there has been an increased usage of health care databases across orthopaedic surgery literature.[1-6] Large-scale databases can broadly be defined as collections of patient data and billable procedures from a single- or multicenter institution at the local, regional, or national level.[3,6] These databases offer large sample sizes that allow researchers and administrators to track hospital metrics, risk factors, and outcomes over a long period at a significantly lower cost than independently run trials.[3-5] Furthermore, databases can be used for epidemiologic study, such as geographic distribution of surgical procedures and identification of health care disparities.[3,6]

Databases used in orthopaedic research include administrative claims and clinical registry databases.[3,5,6] Administrative claims databases collect information from hospital discharges and private insurance claims, including patient demographics, comorbidities, health service records, medical procedures, diagnoses, and costs incurred during hospitalization.[3,4,6] These data are recorded by hospital administrators, insurance billers, or government agency employees and submitted to administrative databases as medical billing codes determined by the *International Classification of Diseases, Tenth Revision, Clinical Modification*.[6,7] These data typically follow clinical outcomes on a short-term basis (30 to 90 days).[4] Examples include the National Inpatient Survey (NIS), National Hospital Discharge Survey, Centers for Medicare and Medicaid Services, MarketScan, and PearlDiver.[3,6]

Unlike administrative claims, clinical registries are smaller in size and require meticulous data collection by highly skilled clinicians and nurses.[3,5,8] Clinical registries follow scrutinized reporting protocols; and these registries offer precise surveillance of long-term trends in specific patient diagnoses or procedures, such as total knee arthroplasty (TKA).[3,5,8] Examples of clinical registries include the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP), Veterans Affairs Surgical Quality Improvement Program, National Trauma Data Bank, Kaiser Permanente (KP), and California Joint Replacement Registry.

The increased utilization of databases in orthopaedic research has coincided with the emergence of value-based medicine and evolution of health care information systems.[5,6] Orthopaedic surgeons are asked to provide evidence supporting the cost and utility of procedures to patients and health care payers. Although randomized, controlled, prospective studies remain the benchmark of quality orthopaedic research, they are more expensive, more time intensive, and limited by smaller sample sizes.[4,6] Furthermore, it may be infeasible, or even unethical in some cases, to use randomization and control groups to answer many of today's research questions. Large-scale administrative and clinical patient data provide answers to questions that are too difficult or costly to address with small cohorts derived from single centers. Consequently, the use of databases in orthopaedic research has increased markedly over the past two decades.[1-6]

Previous research has identified an increased database use across various orthopaedic subspecialties and in specific orthopaedic journals.[2,3,9] However, to our knowledge, no study has comprehensively described the trends in database usage by journal and database names across all orthopaedic surgery literature. This study characterizes trends in database research publications per year by journal and database names in comparison with the overall growth of orthopaedic literature.

Methods

Our search focused on 26 commonly used American administrative databases and clinical registries in the orthopaedic literature.[2-6] These databases and registries include the following: American Board of Orthopaedic Surgery, American Joint Replacement Registry, Blue Cross Blue Shield, Comprehensive Hospital Abstract Reporting System, California Joint Replacement Registry, Centers for Medicare and Medicaid Services, Function and Outcomes Research for Comparative Effectiveness in Total Joint Replacement, Humana, KP orthopaedic registries, Kids' Inpatient Database, MarketScan, Memorial Sloan Kettering Cancer Center orthopaedic registries, Michigan Arthroplasty Registry Collaborative Quality Initiative, National Hospital Discharge Survey, National Inpatient Sample (NIS), National Survey of Ambulatory Surgery, ACS NSQIP, ACS NSQIP-Pediatric, National Trauma Data Bank, PearlDiver, Premier, Surgical Care and Outcomes Assessment Program, Surveillance Epidemiology and End Results Program, State Inpatient Database, UnitedHealthcare, and Veterans Affairs Surgical Quality Improvement Program.

Next, we defined our scope of journals as all English-language orthopaedic surgery journals identified in the 2015 *Thomson Reuters Journal Citation Report*.[10] Using PubMed, we searched all orthopaedic surgery journals for primary research publications that contained the names or abbreviations of our listed databases from January 1, 1996, to December 31, 2016. Two investigators reviewed all resulting publications and confirmed utilization of a database for a primary research study. Secondary research articles such as commentaries and editorials were excluded. The journal name, year of publication, and name of the used database were recorded for each database publication. Studies that used multiple databases were recorded as a single database publication.

To calculate the total number of articles published in orthopaedic surgery literature, we searched PubMed for the total number of publications per year from 1996 to 2016 for each

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orthopaedic surgery journal. If this could not be determined from PubMed alone, we searched the official website of the journal and used the number of articles published in 1 issue as a proxy for the annual publication count, given the number of issues published per year.

We calculated a ratio of the number of database research publications to the total number of orthopaedic surgery publications each year from 1996 to 2016. We performed a linear regression with logarithmic transformation of the number of database research publications using STATA to assess database utilization trends over time, with a two-sided alpha level of 0.05.

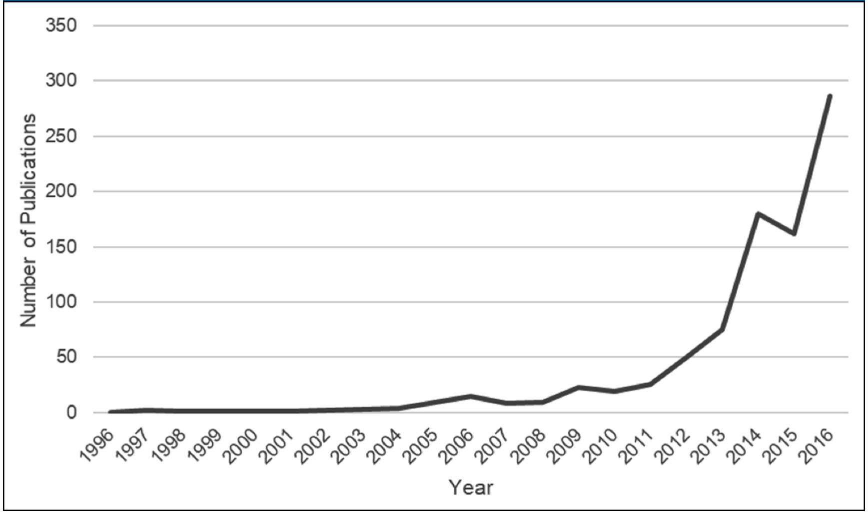
Results

Overall, 174,081 publications were identified across 56 orthopaedic surgery journals from 1996 to 2016. Our search criteria of the names or abbreviations of databases yielded 1,426 publications. Of these, 577 were excluded because they did not use a database for original research in orthopaedic surgery. Eight hundred forty-nine primary research articles published from 1996 to 2016 cited utilization of a database. Twenty-four of these 849 articles cited usage of more than one database.

A positive trend was observed in database research publications over time, from zero articles in 1996 to 286 in 2016 (Figure 1). Each year, 35.3% more publications are reported to use a database than the previous year (95% confidence interval, 30.0 to 40.7). Of the overall orthopaedic surgery publications, 2.07% (286 of 13,813) used a database in 2016, compared with zero (zero of 5,189) in 1996 (Figure 2).

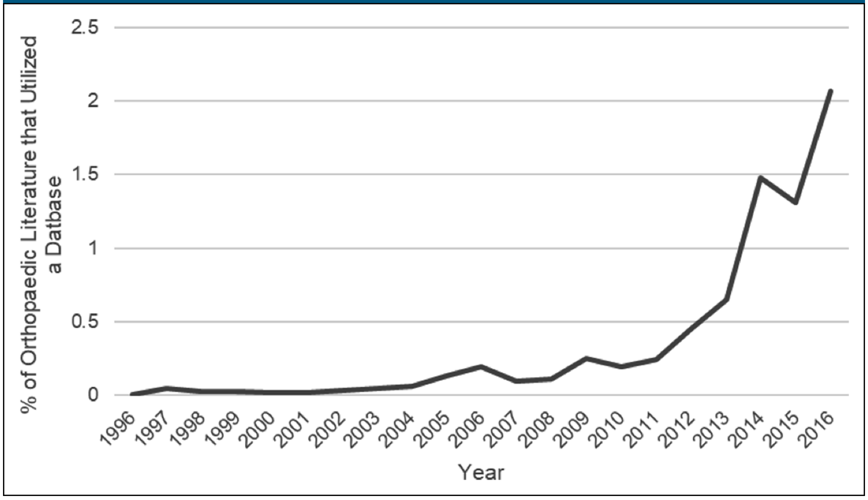
The most commonly cited databases (Figure 3) included the NIS (301 citations), ACS NSQIP (168), and KP orthopaedic registries (71). *Spine (Philadelphia, Pa. 1976)* published the most database research articles (162), followed by the *Journal of Arthroplasty* (161), and the *Journal of Bone and Joint Surgery–American Volume* (92) (Figure 4). We did not identify any database research publications in 23 orthopaedic surgery journals, and we did not find any publications that used the ACS NSQIP-Pediatric or the Surgical Care and Outcomes Assessment

Figure 1



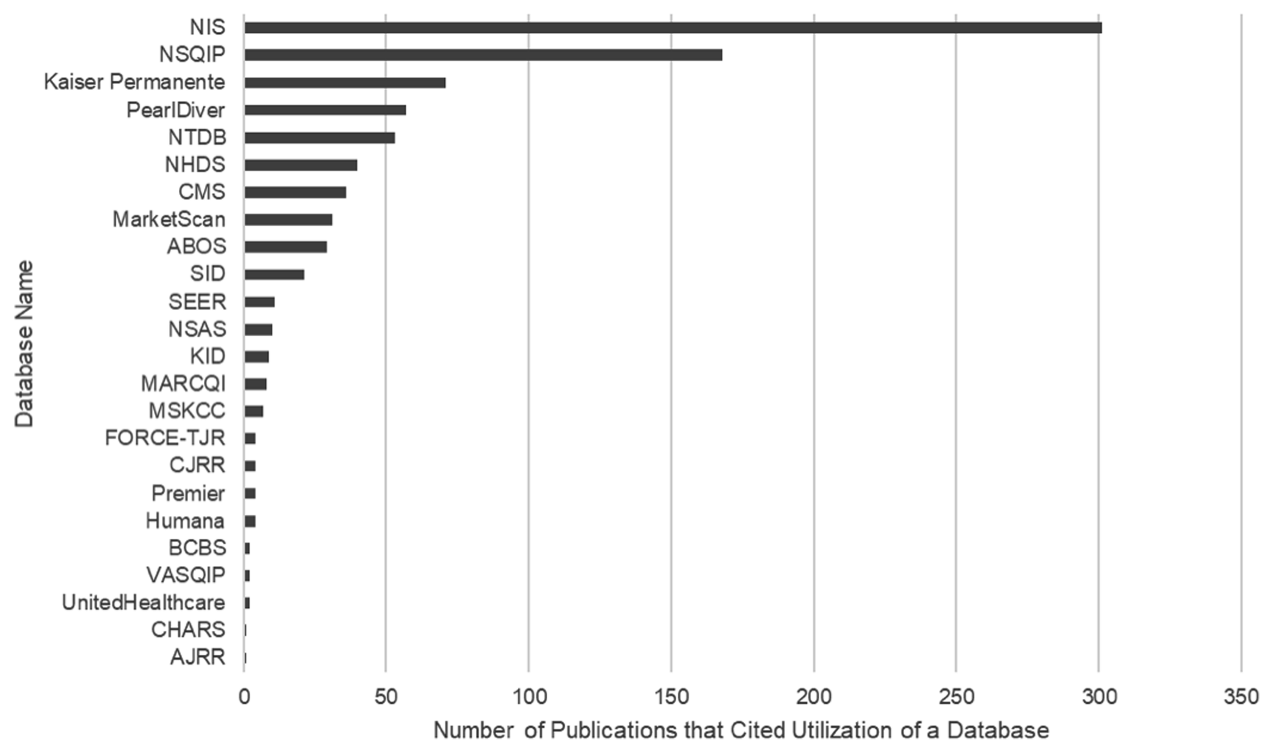
Line graph demonstrating the number of publications per year citing the usage of a database from 1996 to 2016. The graph demonstrates the overall increase in database research publications published in all English-language orthopaedic surgery journals, from zero database research publications in 1996 to 286 in 2016.

Figure 2



Line graph demonstrating the percentage of orthopaedic literature that used a database per year from 1996 to 2016. This proportion was defined as the ratio of publications that cited utilization of a database to the total number of publications in all English-language orthopaedic surgery journals over the same period. This graph demonstrates growth of database research publications from zero of 5,189 (0%) in 1996 to 286 of 13,813 (2%) in 2016.

Figure 3



Graph demonstrating the total number of times each database was used in a publication in an English-language orthopaedic surgery journal by database name from 1996 to 2016. ABOS = American Board of Orthopaedic Surgery, AJRR = American Joint Replacement Registry, BCBS = Blue Cross Blue Shield, CHARS = Comprehensive Hospital Abstract Reporting System, CJRR = California Joint Replacement Registry, CMS = Centers for Medicare and Medicaid Services, FORCE-TJR = Function and Outcomes Research for Comparative Effectiveness in Total Joint Replacement, KID = Kids' Inpatient Database, MARCQI = Michigan Arthroplasty Registry Collaborative Quality Initiative, MSKCC = Memorial Sloan Kettering Cancer Center orthopaedic registries, NHDS = National Hospital Discharge Survey, NIS = National (Nationwide) Inpatient Sample, NSAS = National Survey of Ambulatory Surgery, ACS-NSQIP = American College of Surgeons National Surgical Quality Improvement Program, NTDB = National Trauma Data Bank, SEER = Surveillance Epidemiology and End Results Program, SID = State Inpatient Database, VASQIP = Veterans Affairs Surgical Quality Improvement Program

Program. The distribution of database utilization by individual database name (see Table 1, http://links.lww.com/JG9/A33) and journal name (see Table 2, http://links.lww.com/JG9/A34) can be found in Appendix 1.

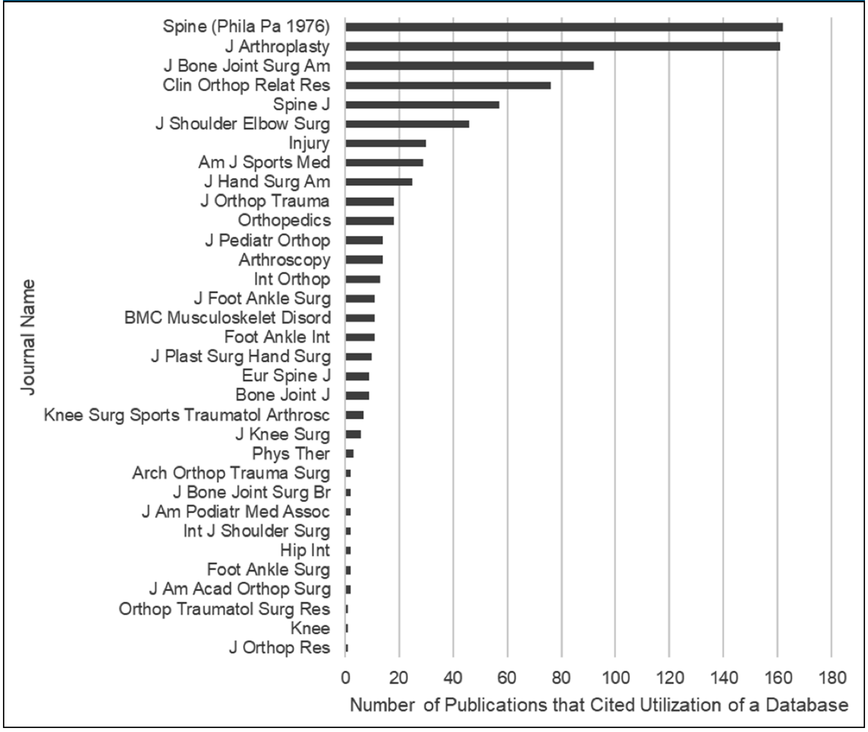
Discussion

In the past two decades, the number of database-driven publications in orthopaedic surgery research has rapidly increased.[1-6] In a review of 9 nationwide databases and 41 orthopaedic surgery journals, Bohl et al (2016) reported a trend of increased administrative and registry database utilization throughout orthopaedic research from 1990 to 2015, with dramatic growth between 2010 and 2015. Similarly, Weinreb et al (2017) charted the growth of large-scale database utilization across a single orthopaedic journal, *Arthroscopy: The Journal of Arthroscopic and Related Surgery*, and reported a proliferation of database publications between 2012 and 2015.

This study presents the most extensive investigation of large-scale database utilization across the most robust range of databases and orthopaedic surgery journals. Furthermore, to our knowledge, this is the first comparison of growth in database utilization across orthopaedic surgery with that of all orthopaedic surgery research over the same period. In agreement with previous findings, our results demonstrated a rapid growth in the number of database research publications in orthopaedic surgery journals per year from 1996 to 2016. The number of database research publications has grown at a faster annual rate than the overall orthopaedic surgery literature in this period.

The increased utilization of large-scale databases can perhaps be explained by their advantages in providing large volumes of patients, accurate information on institutional costs, and clinically relevant predictor variables for adverse events.[1,3,4] These data can be accessed at a low cost and allow researchers to track trends in demographic, procedural, and comorbidity risk factors for a number of hospital metrics, including adverse postoperative outcomes, readmission rates, and length of stay.[3,11-14] Data from these databases have provided major benefits in the reform of hospital metrics and quality improvement programs.[3,15,16] For example, data collected through the NIS have been used to generate improvements in protocols for informed consent, population risk stratification, and preoperative counseling.[3,4,6,17] At the most clinically relevant level, these databases provide large sample sizes that diminish geographic bias across patient populations and permit enough power to detect statistical significance, even for rarely occurring events.[1-4,18]

Figure 4



Graph demonstrating the total number of publications that cited database utilization in each English-language orthopaedic surgery journal by journal name from 1996 to 2016.

Although large-scale databases provide large sample sizes, readers should practice caution when interpreting results of database research. Methodology of data collection varies across independent databases and can provide conflicting results for the same clinical question despite using similar demographic populations. For example, reports of hip fractures and lumbar arthrodesis using the NIS versus the ACS NSQIP yielded up to fourfold differences in comorbidities and adverse events.[15,19] Variation in data across individual databases can arise from differences in metrics used to collect data (eg, billable claims versus patient-reported outcomes), the level of training required by personnel who record data, the duration of care over which data are collected, and sample design used to select populations.[1-6,15,19-21] These parameters are related to the overall goals of each database, which have inherent differences that limit the generalizability and validity of their conclusions.

Furthermore, another limitation of database research concerns the ability of researchers and reviewers to interpret study results. Because of the enormous number of predictor variables included in each study, the use of a skilled analyst is highly recommended through each step of the research and review process to minimize confounding bias.[1,4] To maximize external validity, results from one database study should be compared with retrospective, prospective, or additional database studies that test the same hypothesis using similar populations and sampling methodology. Finally, orthopaedic researchers should publish their methodologies and statistical analyses used in each database study so that they can be evaluated. Given the potential for data misinterpretation, it is important for researchers to have a deep understanding of the individual capabilities and population characteristics of each database before using them for research or clinical recommendations.

Despite these limitations, database research in orthopaedic surgery has continued to grow and influence the way orthopaedic surgeons practice medicine. Large-scale database research in orthopaedics provides valuable, population-based evidence regarding safety and effectiveness that would otherwise be difficult to achieve using prospective, randomized control trials. As an example, using claims data from Premier database, Poeran et al (2014) reported a reduced need for blood transfusion following administration of perioperative tranexamic acid during TKA or total hip arthroplasty

(THA). Outside of smaller randomized control trials, this was the first population-based study to provide incremental evidence supporting the safety and effectiveness of tranexamic acid in patients undergoing TKA or THA.[22] Database studies can direct policy change for a specific orthopaedic procedure by providing projections for demand or risks for adverse outcomes. As an example, using data from the United States Census Bureau and the Nationwide Inpatient Sample, Kurtz et al (2007) projected an increase in THA and TKA demand by 137% and 601%, respectively, through 2030. Moreover, using large-scale data from the 2010 Nationwide Inpatient Survey, Stein[23] reported a low incidence (0.57%) of deep vein thrombosis or pulmonary embolism occurrence among black and non-white patients undergoing TKA and THA. These data can direct decisions regarding how to meet rising demand, and help both doctors and patients make more informed decisions regarding potential risks when considering a specific surgery.

As more researchers continue to use databases for orthopaedic research, the wealth of clinical data available can, and will, shape the delivery of orthopaedic care. However, weaknesses in internal and external validity should always be considered before the adoption of database-driven results to clinical practice. Reviewers and physicians should be aware of the several nuances of orthopaedic database research, and greater emphasis should be placed on transparency in the analytical methodology and clinical relevance of statistical findings.

Limitations

Although every effort was made to include all qualifying databases in our search on PubMed, we acknowledge that not all high-volume and smaller-scale prospective databases used for orthopaedic research were included. The field of databases available to researchers is constantly changing because new databases and registries emerge and make it difficult to include all pertinent databases. In addition, we specifically chose to not include international databases. Thus, our data likely underestimates the true prevalence of database utilization in orthopaedic literature globally. Further research should draw comparisons from international database usage and smaller-scale databases to this study. Finally, our ratio of database research publications to total orthopaedic surgery publications is based on our calculation of publication count and may not be equivalent to the true ratio. However, we would not expect the true number of orthopaedic publications to change the trends presented in this study.

Conclusion

The number of database research publications has grown substantially in orthopaedic surgery, from zero in 1996 to 286 in 2016. Each year, 35% more database research publications are reported than the previous year, which is greater than the overall growth orthopaedic surgery literature. As database research continues to influence the way orthopaedic care is delivered, researchers and practitioners should be aware of inherent limitations across individual databases when conducting research or providing recommendations.

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