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# Evaluation of Citation Inaccuracies in Surgical Literature by Journal Type, Study Design, and Level of Evidence: Towards Safeguarding the Peer-Review Process

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## Abstract

**Background:** Accurate citation practices are key to furthering knowledge in an efficient and valid manner. The aim of this study is to investigate the prevalence of citation inaccuracies in original research from the top-ranked surgical journals and to evaluate the impact level of evidence has on citation inaccuracy.

**Methods:** A retrospective study evaluating the citation accuracy of the top 10 ranked surgical journals using the SJCR indicators. For each year between 2015 and 2020, the top 10 cited studies were selected, totaling 60 studies from each journal. From each individual study, 10 citations were randomly selected and evaluated for accuracy. Categories of inaccuracy included fact not found, study not found, contradictory conclusion, citation of a citation, and inaccurate population.

**Results:** A total of 5973 citations were evaluated for accuracy. Of all the citations analyzed, 15.2% of them had an inaccuracy. There was no statistically significant difference in citations inaccuracy rates among the years studied ($P = .38$) or study level of evidence ($P = .21$). Annals of Surgery, Plastic and Reconstructive Surgery and Annals of Surgical Oncology had significantly more citation inaccuracies than other journals evaluated ($P < .05$). JAMA Surgery, The Journal of Endovascular Therapy and The Journal of Thoracic and Cardiovascular Surgery had significantly fewer citation inaccuracies.

**Conclusions:** Although 84.8% of citations from 2015-2020 were determined to be accurate, citation inaccuracies continue to be prevalent throughout highly-ranked surgical literature. There were no significant differences identified in citation inaccuracy rates between the years evaluated or based on study level of evidence.

## Keywords

citations inaccuracy, surgical literature, evidence-based medicine, peer-review process

## Background

It has been estimated that one out of every eight to nine references in scientific literature are incorrect.[1] Citations provide readers with the source of underlying knowledge that authors are referencing within a study. Referencing previously published work is the foundation of research and serves as a building block for knowledge production. It is therefore critically important that citations be accurate to ensure that the information conveyed is both relevant and correctly portrays the previous work conducted by other researchers. When citations are referenced inappropriately, not only is the legitimacy of the study that incorrectly cited

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the reference brought into question, but there is a high risk of misinformation.[2] This is especially true when the inaccuracy occurs in a prestigious and well-respected journal as there is an expectation that the research published is valid. Moreover, there is a risk that a single citation inaccuracy will lead to the propagation of misinformation if authors do not read the original referenced study.[3] Since academics and physicians rely on research as a source of credible information to improve treatment plans, citation inaccuracies also present significant implications on patient care.

Ideally, citation inaccuracies would be detected and corrected throughout the writing and peer review process, however, research is an ever-evolving process that is subject to human behavior. Researchers may make a mistake and incorrectly cite a fact from another study, or else mistakenly refer to the wrong source when citing a quote. Additionally, researchers may also erroneously cite their own or colleagues' publications to increase recognition of their research. Therefore, not only is the legitimacy of scientific literature at stake, but also the academic integrity of the scientific community. Regardless of the cause of citation inaccuracies, efforts should be made to both identify them and create innovative solutions to prevent future inaccuracies.

Citation accuracy has been evaluated in field-specific journals such as pediatric orthopedics,[4] general surgery,[5] foot and ankle surgery,[6] otolaryngology,[7] psychiatry,[8] biomedical sciences,[9] neurosurgery,[10] spine surgery,[11] and dermatology.[12] These previous studies, though seemingly extensive, have been limited by small sample sizes and focused on specific subspecialties. Additionally, it is unclear how the prevalence of citation inaccuracies has changed over time, especially in the era of Coronavirus Disease 2019 (COVID-19) when misinformation is rampant and dangerous.[13] The objectives of this study are (1) to investigate both the prevalence in citation inaccuracies from 2015-2020 in original research from the top 10 ranked surgical journals as determined by the 2019 Scimago Journal and Country Rank (SJCR) rankings and (2) to identify common citation inaccuracies and evaluate potential solutions to prevent these inaccuracies. It was hypothesized that citation inaccuracies are prevalent, especially across studies with a lower level of evidence.

## Methods

### Selection of Top 10 Surgical Journals and Studies

A retrospective study was conducted utilizing publicly available data to analyze both the rates of citation inaccuracies and trends in citation inaccuracies over time in original research studies in the top 10 ranked surgical journals from 2015-2020. The top 10 ranked surgical journals were selected using the SJCR indicators as previously described.[14,15] The 2019 journal rankings for the "Surgery" subject category were chosen because the 2020 rankings were released several months after the start of this study. Additionally, several journals rose to the top 10 in the 2020 rankings that had not historically been ranked as high or were newer journals with less than six years of published work. The variations in the 2020 ranks were likely due to increased attention and studies on the topic of COVID-19. In order to prevent bias from these short-term shifts, the 2019 ranks were used for this study.

Subsequently, selection of the top 10 most highly cited original research studies per journal for each year from 2015-2020 was conducted using the Web of Science "All Databases" tally as of June 20, 2021.[15] For each study, the total number of references cited was collected, and 10 discrete references were selected for accuracy evaluation using a random number generator. When studies had 10 total discrete citations or less, all citations were evaluated for accuracy. In instances of a discrete reference being cited multiple times throughout a study, the most impactful citation was selected for evaluation.

### Characteristics of Citing Studies

Several demographic and characteristic elements were extracted from the selected top 10 cited original research studies for each year from 2015-2020. The total number of times each study had been cited and total number of references cited in each study was collected from the Web of Science tally. First author's education level (MD, PhD, MS, etc.) and affiliated institution and country of practice at time of publication were extracted. Studies were characterized by their design (retrospective cohort study, prospective cohort study, randomized controlled trial, prospective non-randomized clinical trial, prospective observational study, retrospective descriptive study, case control, cross-sectional study, case study or series, technique study, and basic science study) and subspecialty (orthopedic surgery, surgical oncology, general surgery, neurosurgery, gastrointestinal surgery, hepatobiliary surgery, transplant surgery, vascular/endovascular surgery, plastic surgery, critical care surgery, urologic surgery, gender affirmation surgery, thoracic surgery, and bariatric surgery). The studies were also characterized by level of evidence (1b: Individual randomized controlled trials; 2b: Individual cohort study or low-quality randomized control studies; 3b: Individual case-control studies; 4: Case series, low-quality cohort or case-control studies; and 5: Expert opinions based on non-systematic reviews of results or mechanistic studies).

### Definition of Inaccuracies

The accuracy of the 10 randomly selected references from each of the included studies was assessed according to six

**Table 1.** Definitions and examples of Citation Inaccuracy Categories.

| Citation Inaccuracy Category | Definition | Example |
|---|---|---|
| | **Major Inaccuracy** | |
| (1A) Fact not found | The statement was not supported by the referenced article either directly or implied | Statement: X% of trauma patients were treated at Level 2 trauma centers in 2019<br>Referenced article: No statement about percentage of trauma patients treated by level 2 trauma centers |
| (1B) Fact not found because article could not be accessed | The reference for the statement was not able to be accessed either due to incorrect citation format or because the link was no longer operational | Citation includes link to: www.citationinaccuracy.com/referencedarticle<br>However, link leads to different page or receive a 404 link not found error |
| (2) Contradictory Conclusion | The statement presents a contradictory conclusion or fact to what was reported in the referenced article | Statement: X% of trauma patients were treated at Level 2 trauma centers in 2019<br>Referenced article: Y% of trauma patients were treated at Level 2 trauma centers in 2019 |
| | **Minor Inaccuracy** | |
| (3A) Fact found but reference was not the original article (citation of a citation) | The statement was supported by the referenced article, but the information was originally from a different citation that the referenced article had cited | Statement: X% of trauma patients were treated at Level 2 trauma centers in 2019<br>Referenced article: X% of trauma patients were treated at Level 2 trauma centers in 2019 (link to the original article that stated this fact) |
| (3B) Fact found but was extrapolated from inaccurate population | The statement was found in the referenced article, but the referenced article made the conclusion based on a different population | Statement: X% of all trauma patients were treated at Level 2 trauma centers in 2019<br>Referenced article: X% of pediatric trauma patients were treated at Level 2 trauma centers in 2019 |
| (4) Reference not peer reviewed | Referenced article was no subject to peer review process by others working in the same field | Referenced article was a blog post, news report, ect.that was not peer reviewed |

Note: Citation inaccuracy categories adapted from *Choi et al*[2]

criteria: (1A) Fact not found, (1B) Fact not found because study could not be accessed, (2) Contradictory Conclusion, (3A) Fact found but reference was not the original study, (3B) fact found but was extrapolated from inaccurate population, (4) Reference was not peer reviewed. Detailed explanations of each inaccuracy category along with examples of each are reported in Table 1. Criteria 1A-B and 2 were further categorized as major inaccuracies due to inaccurate information being reported and a high potential for dissemination of misinformation. Criteria 3A-B and 4 were categorized as minor inaccuracies due to reporting of factual information that was improperly/inconsistently cited and has a lower potential for spreading misinformation.

### *Data Collection and Verification*

Five authors (M.S., K.N., I.Z., C.A., and A.E.) conducted the primary study search, screening titles and abstracts to determine if inclusion or exclusion criteria were met and extracted the characteristics of citing studies. All authors then independently evaluated full texts of the 600 studies and 10 of their randomly selected references (5973 referenced studies), for citation inaccuracies. Questions regarding issues related to studies' inclusion and exclusion criteria as well as citations inaccuracies were addressed by all authors and all discrepancies were resolved. Final data verification and review were conducted by all authors.

Descriptive non-parametric statistics such as Chi-square testing were used to evaluate associations between studies with citation inaccuracies and study characteristics. Significance was defined as $P < .05$.

## Results

### *Characteristics of Citing Studies*

These results represent citation inaccuracies identified within the top 10 ranked surgical journals from 2015-2020. A total of 600 studies were evaluated and 5973 citations were assessed for accuracy (number of citations is less than 6000 because some studies referenced less than 10 citations). The studies were cited a mean of 78.5 times and referenced an average of 30.5 citations (supplementary Table 1). The total number of each type of study included 155 retrospective cohorts, 62 prospective cohorts, 71 randomized controlled trials (RCTs), 42

**Table 2.** Trends of Citations Inaccuracies Across all Categories from 2015-2020.

| Citations Inaccuracy Categories | No Inaccuracy | 1A (Fact not found) | 1B (Fact not Found - Lack of access) | 2 (Contradictory conclusion) | 3A (Fact Found - not the Original article) | 3B (Fact Found - Inaccurate population) |
|---|---|---|---|---|---|---|
| Year | | | | | | |
| 2015 | 833 (83.3%) | 107 (10.7%) | 11 (1.1%) | 18 (1.8%) | 25 (2.5%) | 6 (.6%) |
| 2016 | 842 (84.6%) | 87 (8.7%) | 13 (1.3%) | 20 (2.0%) | 30 (3.0%) | 3 (.3%) |
| 2017 | 839 (84.7%) | 86 (8.7%) | 16 (1.6%) | 22 (2.2%) | 23 (2.3%) | 5 (.5%) |
| 2018 | 857 (85.7%) | 75 (7.5%) | 8 (.8%) | 22 (2.2%) | 33 (3.3%) | 5 (.5%) |
| 2019 | 836 (83.9%) | 95 (9.5%) | 16 (1.6%) | 14 (1.4%) | 33 (3.3%) | 2 (.2%) |
| 2020 | 859 (86.9%) | 66 (6.7%) | 14 (1.4%) | 18 (1.8%) | 31 (3.1%) | 3 (.3%) |
| Overall | 5066 (84.8%) | 516 (8.6%) | 78 (1.3%) | 114 (1.9%) | 175 (2.9%) | 24 (.4%) |

non-randomized clinical trials, 58 prospective observational studies, 143 retrospective descriptive studies, 12 case control studies, 17 cross-sectional studies, 11 case studies/series, 6 technique studies, and 23 basic science studies (supplementary Table 1).

These studies consisted of 14 subspecialties with 61 studies associated with orthopedic surgery, 107 with surgical oncology, 34 with general surgery, 61 with neurosurgery, 16 with gastrointestinal surgery, 64 with hepatobiliary surgery, 1 with transplant surgery, 136 with vascular/endovascular surgery, 61 with plastic surgery, 6 with critical care surgery, 1 with urologic surgery, 1 with gender affirmation surgery, 44 with thoracic surgery, and 7 with bariatric surgery (supplementary Table 1).

Among the 600 first authors, 457 had a professional medical degree (eg, MD, MBBS, DDS, PharmD), 21 had a doctoral degree (eg, PhD, ScD), 104 had a combined professional medical and doctoral degree (eg, MD, PhD), 5 had a master's degree (eg, MPH, MSc), 11 had a bachelor's degree (eg, BA, BS), and 2 were unknown (supplementary Table 1). A total of 62.8% of these first authors were affiliated with institutions located in countries where the primary language is English (supplementary Table 1).

### *Prevalence of Citation Inaccuracies Among all Journals*

Overall, 5973 citations were analyzed for accuracy. A total of 5066 (84.8%) citations had no inaccuracies, and 907 (15.2%) had citation inaccuracies. Specifically, 516 (8.6%) stemming from type 1A inaccuracies, 78 (1.3%) from type 1B, 114 (1.9%) from type 2, 175 (2.9%) from type 3A, and 24 (.4%) from type 3B (Table 2). This meant the overall rate for major inaccuracies was 11.8% and the rate for minor inaccuracies was 3.3%. The most common type of inaccuracy was 1A, followed by types 3A, 2, 1B, and 3B. The rate of citation inaccuracies of studies published where the first author was from a primarily English-speaking country compared to a non-English speaking country was 15.3% and 15.0%, respectively. This difference was not statistically significant ($P$=.71).

### *Citation Inaccuracy Trends Over Time*

The year that had the most total citation inaccuracies was 2015, followed by 2019, 2016, 2017, 2018, and 2020 (Table 2). There was no statistically significant difference in inaccuracy rates among the years studied ($P$=.38). The trends in types of inaccuracy rates over time are displayed in Figure 1. There was a downward trend in citation inaccuracy rate over the study period. This general trend was driven in large part due to the downward trend in type 1A citation inaccuracies.

### *Prevalence of Citation Inaccuracies Between Journals*

Annals of Surgery had significantly more citation inaccuracies from 2015-2020 than the average of the other journals evaluated ($P < .001$). The most common inaccuracy identified in Annals of Surgery was 1A (12.75%), followed by 3A (3.19%), 2 (2.85%), 1B (1.34%), and 3B (.34%) Tables 3 and 4. On the other hand, JAMA Surgery had significantly fewer citation inaccuracies from 2015-2020 than the average of other journals evaluated ($P < .001$). The most common inaccuracy seen in JAMA Surgery was 1A (6.00%), followed by 3A (1.50%), 1B (.83%), 2 (.67%), and 3B (.17%) (Tables 2 and 3). A comparison between citation inaccuracy rates in *Annals of Surgery* and JAMA Surgery is reported in Figure 2**.** The average number of references per study for Annals of Surgery and JAMA Surgery during the years evaluated were 33.3 and 34.4, respectively. This difference was not statistically significant ($P = .64$).

Plastic and Reconstructive Surgery ($P < .001$) and Annals of Surgical Oncology ($P = .0016$) had significantly more citation inaccuracies from 2015-2020 than the average of the other journals evaluated. On the other hand, The Journal of Endovascular Therapy ($P < .001$) and The Journal of Thoracic and Cardiovascular Surgery ($P < .001$) had significantly fewer citation inaccuracies from 2015-2020 than the average of the other journals evaluated. The citation inaccuracy rates for the remaining journals are reported in Tables 3 and 4.

### *Prevalence of Citation Inaccuracies Between Surgical Subspecialties*

The rate of citation inaccuracies was significantly less among thoracic surgery and vascular surgery studies at 11.1% ($P = .014$) and 10.9% ($P < .001$), respectively, compared to other subspecialties within this analysis. On the other hand, the rate of citation inaccuracy was significantly higher for plastic surgery studies at 22.0% ($P < .001$) compared to the other subspecialties within this analysis.

### *Impact of Level of Evidence on the Prevalence of Citation Inaccuracies*

There was no significant difference ($P = .21$) between the citation inaccuracy rate and study level of evidence. The data comparing citation inaccuracy and level of evidence are reported in Figure 3**.**

## Discussion

A 15.2% citation inaccuracy rate was identified among the 10 most cited original research studies published in the

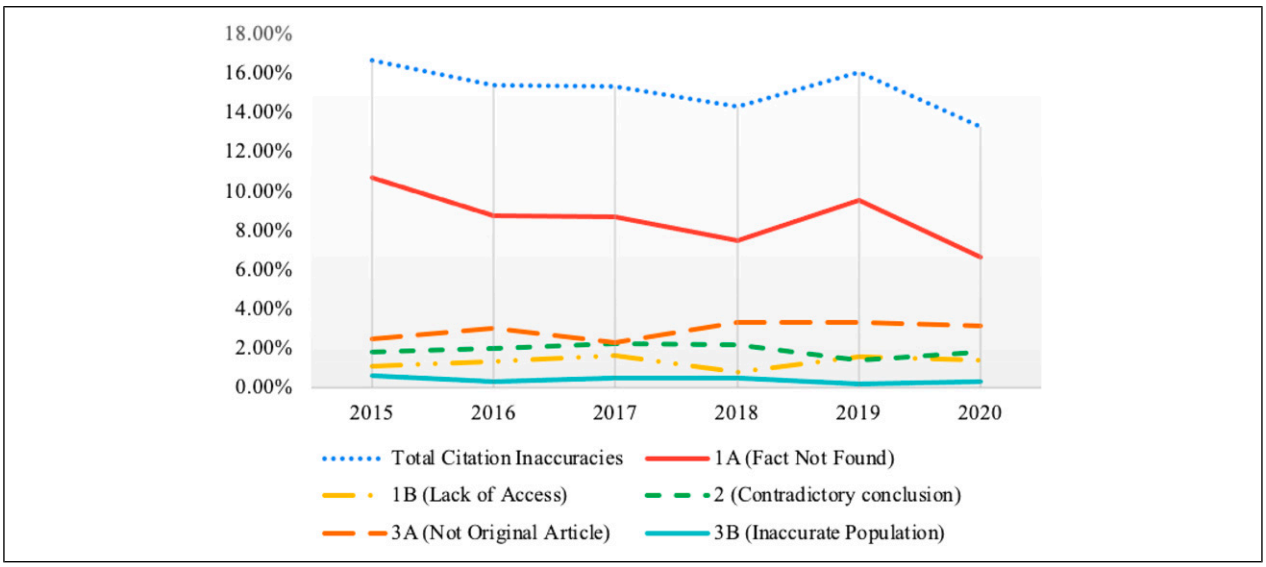


**Figure 1.** Trends in citation inaccuracies overall and by specific inaccuracy categories from 2015-2020.

**Table 3.** Trends of Citation Inaccuracies by Journals Included in this Study.

| Citations Inaccuracies Categories | No Inaccuracy | 1A (Fact not found) | 1B (Fact not Found - Lack of access) | 2 (Contradictory conclusion) | 3A (Fact Found - not the Original article) | 3B (Fact Found - Inaccurate population) |
|---|---|---|---|---|---|---|
| Journal | | | | | | |
| Annals of surgery | 474 (79.5%) | 76 (12.8%) | 8 (1.3%) | 17 (2.9%) | 19 (3.2%) | 2 (.3%) |
| JAMA surgery | 545 (90.9%) | 36 (6.0%) | 5 (.8%) | 4 (.7%) | 9 (1.5%) | 1 (.2%) |
| Journal of bone and joint surgery - series A | 496 (82.7%) | 47 (7.8%) | 18 (3.0%) | 16 (2.7%) | 18 (3.0%) | 5 (.8%) |
| Plastic and reconstructive | 466 (77.7%) | 75 (12.5%) | 15 (2.5%) | 17 (2.8%) | 25 (4.2%) | 2 (.3%) |
| Journal of vascular surgery | 519 (87.2%) | 39 (6.6%) | 4 (.7%) | 6 (1.0%) | 24 (4.0%) | 3 (.5%) |
| Journal of endovascular therapy | 541 (91.9%) | 23 (3.9%) | 4 (.7%) | 14 (2.4%) | 7 (1.2%) | 0 (.0%) |
| Liver transplantation | 495 (83.2%) | 60 (10.1%) | 6 (1.0%) | 7 (1.1%) | 24 (4.0%) | 3 (.5%) |
| Annals of surgical oncology | 481 (80.4%) | 62 (10.4%) | 13 (2.2%) | 20 (3.3%) | 18 (3.2%) | 4 (.7%) |
| Journal of neurosurgery | 518 (86.3% | 57 (9.5%) | 0 (.0%) | 4 (.7%) | 19 (3.2%) | 2 (.3%) |
| Journal of thoracic and cardiovascular surgery | 531 (88.5%) | 41 (6.8%) | 5 (.8%) | 9 (1.5%) | 12 (2.0%) | 2 (.3%) |

top 10 surgical journals from 2015-2020 as defined by the 2019 SJCR indicator rankings. The most common citation inaccuracy was fact not found followed by citation of a citation, constituting 56.9% and 19.3% of citation inaccuracies, respectively. Studies published in the Annals of Surgery had significantly more citation inaccuracies from 2015-2020 than the average of the other journals evaluated, while studies published in JAMA Surgery had significantly fewer citation inaccuracies. There was a slight decrease in citation inaccuracies from 2015 to 2020, however there were no statistically significant changes overall or across each inaccuracy category. There were also no significant differences in rates of citation inaccuracies by level of evidence.

Previous studies have identified a wide range of citation inaccuracies from as low as 9% to as high as

**Table 4.** Trends of Citation Inaccuracies by Study Level of Evidence.

| Study Level of Evidence | | | | | | |
|---|---|---|---|---|---|---|
| 1b | 585 (82.6%) | 82 (11.6%) | 6 (.9%) | 13 (1.8%) | 20 (2.8%) | 2 (.3%) |
| 2b | 2214 (85.8%) | 198 (7.7%) | 27 (1.1%) | 57 (2.2%) | 71 (2.8%) | 13 (.5%) |
| 3b | 159 (83.7%) | 17 (9.0%) | 3 (1.6%) | 3 (1.6%) | 7 (3.7%) | 1 (.5%) |
| 4 | 1880 (84.7%) | 196 (8.8%) | 38 (1.7%) | 34 (1.5%) | 64 (2.9%) | 7 (.3%) |
| 5 | 228 (82.6%) | 23 (8.3%) | 4 (1.5%) | 7 (2.5%) | 13 (4.7%) | 1 (.4%) |

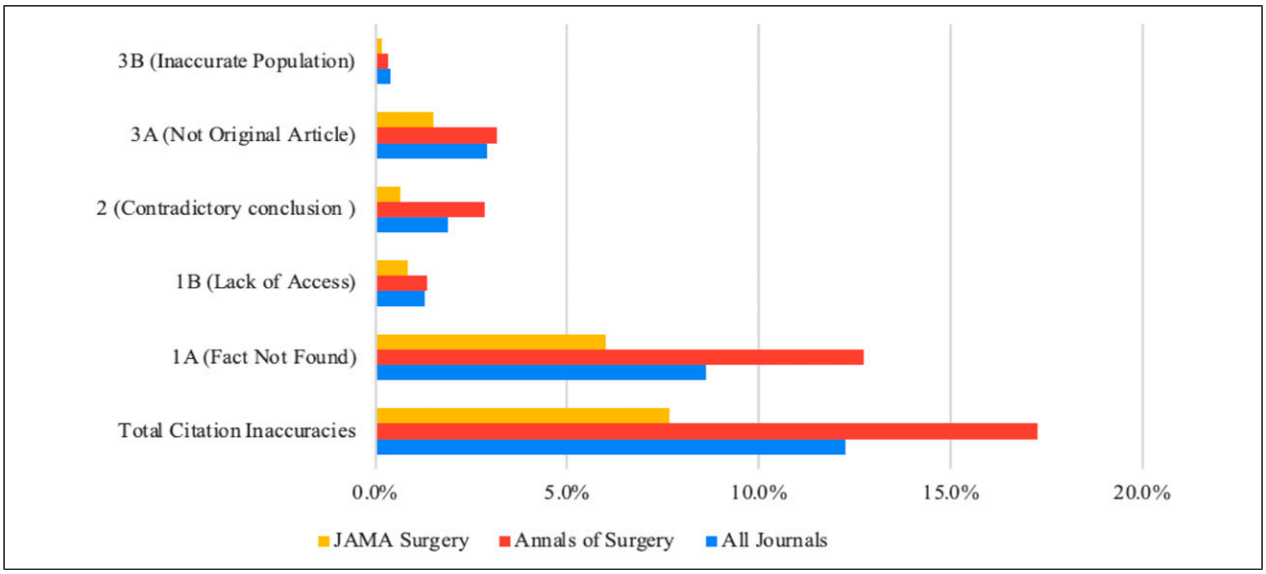


**Figure 2.** Comparison in citation inaccuracies between JAMA Surgery, Annals of Surgery, and other journals included in this study.

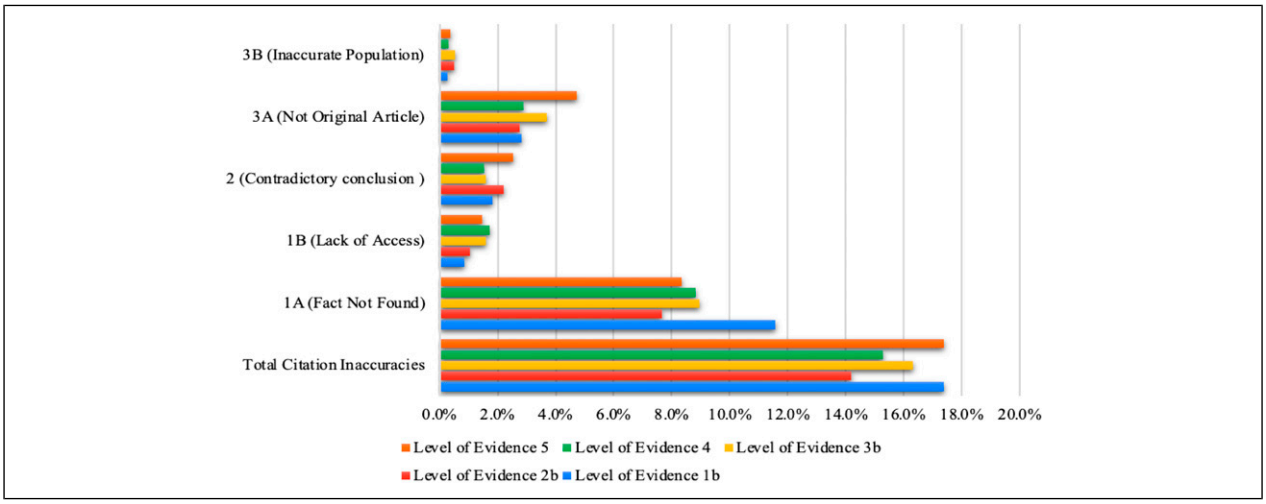


**Figure 3.** Citation inaccuracy assessed according to study level of evidence.

41%.[2,6,7,9] The overall citation inaccuracy rate of 15.2% identified in this study is consistent with these previous findings and demonstrates that the vast majority of references in highly ranked surgical journals are cited accurately, however citation inaccuracies still commonly occur. Studies assessing citation inaccuracies often investigated journals from specific subspecialties, perhaps explaining the wide variation in inaccuracy rates identified previously. A study by Choi et al[9] that assessed citation inaccuracies in 3 different surgical journals

identified a similar inaccuracy rate of 9% to the 15.2% rate in this study, supporting this explanation. The findings from the current study are likely a more accurate representation of overall inaccuracy rates than studies that assessed journals from specific surgical specialties, because this study investigated 10 different journals, encompassing a wide range of 14 different surgical and medical specialties. Interestingly, this study identified that studies published within the fields of thoracic surgery and vascular surgery had significantly less citation inaccuracies, while studies published within the field of plastic surgery had significantly more citation inaccuracies. It is unclear if these variations are a result of differences within the subspecialties or due to differences in the practices of the journals specific to these subspecialties. Further research is needed to investigate the identified disparities in citation accuracy.

Accurate citations provide the background for the dissemination of the newest and most advanced information. Although the majority of evaluated references were cited accurately, a 15.2% inaccuracy rate indicates that a notable number of references used to build this framework are being cited incorrectly. Considering that the studies investigated herein were cited an average of 78.5 times, the potential for the propagation of misinformation is considerable. Especially since highly ranked surgical journals are expected to publish the most impactful and credible surgical research, readers likely assume the information presented is accurate. It is estimated that only about 20% of authors read the studies they cite, posing significant implications on the propagation of inaccurate information.[16]

It is noteworthy that 77.2% of the identified inaccuracies were considered major, predominantly falling into the category of fact not found followed by contradictory conclusion and fact not found due to lack of access. These categories are particularly problematic because information presented in the citing study was either not supported by the reference or presented contradictory information. If readers accept this inaccurate information as fact without verifying the statement with the referenced article, misinformation may spread. Furthermore, when researchers are writing future studies, they may incorporate these unsupported or contradictory claims into their manuscripts, propagating misinformation.

There was no significant association between the level of evidence of citing studies and their citation inaccuracies. RCTs (level 1b) are viewed as a gold standard due to the randomization process balancing patient characteristics[17] and therefore reducing bias in the experimental sample population. It would stand to reason that the references cited within RCT studies would be expected to be more accurate compared to studies of lower level of evidence (eg, case series [level 4]), as they are subject to intense scrutiny and verification. The results from this study do not support this assumption, however. In fact, RCTs had a citation inaccuracy rate of 17.37% compared to case series and low-quality cohort studies which had a citation inaccuracy rate of 15.3%. These findings are considerable, as the results of RCTs are often used in the implementation of clinical practice guidelines[18] and thus have a direct impact on the field of medicine and patient care. Studies with such an impact will likely disseminate their findings rapidly and to a broad audience, reinforcing the importance of accurate citation practices. These findings suggest that special attention should be paid to ensuring the accuracy of citations within all studies, especially RCTs, in order to prevent an inaccurate representation of previous research on a large scale.

When investigating the top 2 ranked surgical journals, Annals of Surgery and JAMA Surgery, Annals of Surgery had significantly more citation inaccuracies from 2015-2020 than the average of the other journals evaluated, while studies published in JAMA Surgery had significantly fewer citation inaccuracies, despite both journals having no significant difference in the average number of references per study. This demonstrates that there is substantial variability in citation inaccuracies even among the top ranked surgical journals, indicating that multiple factors may play a role. As the top ranked surgical journal for the year evaluated in this analysis, the Annals of Surgery receives thousands of annual manuscript submission for consideration of publication.[19] Given there were 524 studies published in the Annals of Surgery in 2020 with a 12% acceptance rate, reviewers evaluated an estimated 4366 manuscripts in that year alone.[19] Comparatively, JAMA Surgery, also a highly-ranked surgical journal, evaluated 3497 submissions in 2020.[20] This in nearly 1000 fewer manuscripts than the Annals of Surgery reviewed in the same year.[20] Given the time a total manuscript review requires, an abundance of submissions can lead to backlogs as well as reviewer fatigue.[21] Recently the Annals of Surgery acknowledged the issue of submission congestion, stating that "Due to the continued high volume of submissions and the resulting backlog of accepted papers, Annals of Surgery will need to initiate steps to address the problem."[22] It is possible that due to the significantly large number of submissions, reviewers are strained to dedicate the time needed to thoroughly investigate manuscripts for citation inaccuracies. One possible solution to this issue is for journals to create a dedicated technical editing team that reviews manuscripts between acceptance and publication. Journals that provide technical editing support have been shown to improve readability and reduce citation inaccuracies.[23] It is also possible that the differences in submission guidelines or peer review processes between journals may contribute to variations in citation inaccuracies. The submission guidelines for JAMA Surgery prompts

authors to verify the accuracy and completeness of their citations,[24] while Annals of Surgery provides no specific statements for authors regarding the accuracy of references,[25] possibly explaining the differences observed. Additional variations in peer review processes or mechanisms for reporting/correcting inaccuracies may also contribute to the variation in citation inaccuracies.

This study identified a slightly downward, but statistically insignificant, trend in citation inaccuracies from 2015-2020. These findings indicate that citation inaccuracies may be slightly improving over time, however, they have remained a prevalent issue during the past 6 years. Despite research inaccuracies becoming a more investigated and published issue recently,[4-12] the problem continues to persist. The strategies to reduce citation inaccuracies proposed by these studies have either failed to elicit a significant improvement in accuracy rates or else have not become widely implemented in surgical journals' practices and procedures. Additionally, it is possible that these changes have not yet had time to take effect and the long-term impact of these interventions were not captured by this study. Regardless, the potential strategies for preventing or reducing citation inaccuracies need to address the issue in both an effective and easily implementable manner. Journal editors and reviewers must read through thousands of manuscripts every year; therefore, interventions must emphasize efficiency and reliability.

Studies submitted for publication are subject to detailed and thorough peer review processes. Despite undergoing intensive scrutiny, it is clear that some mistakes and inaccuracies persist. There are several targets and strategies that have been identified which may help decrease citation inaccuracies in scientific research. The fourth most common citation inaccuracy was fact not found due to lack of access. Commonly, this inaccuracy would occur due to a referenced link leading to a website that no longer exists or has been changed such that the original information is no longer accessible. As websites often change and citing authors have no control over what content is presented or altered from online sources, referencing this information is risky. An additional common mistake that can potentially lead to unintentional and avoidable citation inaccuracies is mislabeling of references. It was noted that several "fact not found" inaccuracies appeared to result from misnumbering of the citations, causing statements to reference an unrelated source. It is impossible to discern if these inaccuracies were intentional or mistakes, however the possibility of accidentally misnumbering citations is reasonable, especially if managing them manually.

Several studies have proposed potential solutions to prevent citation inaccuracies. Choi et al[2] recommended a checklist for authors, posing several practices to consider and avoid when citing. Armstrong et al[7] suggested that widespread recognition and education of the prevalence of citation inaccuracies would lead to decreased inaccuracy rates. Others have suggested improving inaccuracy reporting methods and increasing the incentive for reporting or fixing inaccuracies as potential solutions.[3] Realistically, the ideal solution would incorporate all of these ideas, increasing awareness of the issue among authors and strategies for avoiding them, enhancing the detection of inaccuracies during the peer review process, and improving reporting and correcting of inaccuracy after publication. Additionally, detection and correction of citation inaccuracies should be emphasized at every step of the peer review process from initial manuscript screening to editor appraisal, to reviewer evaluation of manuscripts, and to final review by both the authors and production team following manuscript acceptance.[26] The many steps of the peer review process offer several opportunities for citation inaccuracies to be detected and addressed before publication. All parties must place a strong emphasis on these steps to safeguard the peer review process and emphasize academic integrity within surgical research. This is critical for mitigating the prevalence of citation inaccuracy.

## Recommendations

Several recommendations are offered moving forward. First, all authors should verify their citations for accuracy before submitting for publication. It is easier to correct inaccuracies before a manuscript is published or submitted for review. Second, authors should be cautious when citing websites, preferably referencing government operated websites as there is heightened security for who can edit articles and there is a smaller chance the website will be deleted. Additionally, journals may consider implementing a tool that takes a snapshot of a referenced website so that the information cited is accessible and consistent regardless of whether the website is deleted, similar to how internet archives operate. Third, authors should consider using citation management software to prevent the mislabeling of references and in-text citations which may occur manually. Fourth, journals should consider highlighting common citation inaccuracies such as those reported in Table 1 to their submission guidelines in order to raise awareness of these issues and prompt authors to review their manuscripts for mistakes prior to submission. Fifth, journals may consider involving a dedicated reviewer in the peer review process delegated with verifying citation accuracy to improve the overall quality and credibility of published research.

Future studies should further investigate changes in citation inaccuracies in future years to determine if the downward trend identified in this study persists. Many studies have proposed strategies to prevent citation inaccuracies, however it is unclear if journals are actually

implementing these ideas into their practices. Therefore, future studies should investigate the impact of these interventions on citation inaccuracies to determine their efficiency and effectiveness. Journal editors should also be aware that citation inaccuracies are relatively common and potentially verify references of submitted manuscripts, especially for high impact studies like RCTs, during the peer review process. Finally, future research should investigate citation inaccuracies in studies other than original research to assess the prevalence in editorials or review articles as these articles also have the potential to disseminate misinformation if cited inaccurately.

### *Limitations*

To the best of the knowledge of the authors of this study, this is the largest and most comprehensive investigation on citation inaccuracies in surgical research, assessing 5973 citations from 10 surgical journals. This paper is also the first study to assess changes in citation inaccuracies in surgical journals over time and associations with level of evidence. This study is not without limitations, however. First, due to the nature of the study, causation was unable to be assessed, as is with all retrospective studies. There was also a lack of consistency in regard to the number of selected references from each study, as six studies did not have a minimum of 10 references. Second, the most highly ranked studies from 2019 and 2020 may change over time as limited time has passed for them to accrue citations. Third, there was no validated journal scoring system that cumulatively ranked surgical journals from 2015-2020. As a result, 2019 was used as a representative year for the time period evaluated.

## Conclusion

This study identified a 15.2% citation inaccuracy rate among the most cited original research studies from the top 10 surgical journals from 2015-2020. Although most references are cited accurately, inaccurate citations have proven to be prevalent over time even among prestigious surgical journals. Not all citation inaccuracies are detrimental to science, however, there is a high risk for the dissemination and propagation of misinformation, posing serious implications on research credibility and patient care practices. Several common and avoidable mistakes have been presented as well as potential solutions to mitigate inaccurate citations. Detection and correction of citation inaccuracies should be emphasized at every step of the peer review process. Future research should be conducted to track citation inaccuracies over time and evaluate the adoption and effectiveness of these solutions.

## Author's Note

Study design and conception: AE
Data collection, analysis, and interpretation: MS, KN, IZ, CA, SD, DA, AE
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