INTRODUCTION
Plastic surgery is an attractive specialty to medical students. Residency training programs have the luxury of selecting their trainees from the “cream of the crop” from United States medical schools. Because of the steep competition for PGY-1 integrated program positions, the temptation exists for applicants to falsify parts of their applications, particularly those parts that are difficult to verify.

METHODS
A retrospective analysis of the Integrated Plastic Surgery applications from the years (2010–2013) was done. Two reviewers manually and independently handsearched each of the articles in the databases (Medline, Scopus, Clinical trials, Google scholar) additionally, a specialized medical librarian corroborated. A ghost article was defined as the inability to find the listed applicant in the authorship list of the claimed article/abstract/chapter or the inability to find the submitted article. Misrepresentation was defined as a change in authorship order. Data were summarized and analyzed, generalized estimating equations model was used. SAS software, v9.4.

Results: All 392 applicants were included, 159 (2010–2011), 120 (2011–2012), and 119 (2012–2013). The number of manually reviewed records was 2,124. “Ghost” authorship was found in 234 articles out of 2,124 (11.02%). The overall rate of “Ghost” authorship in applicants to our program was found to be 34.4%, 135 applicants and misrepresentation in 5 cases (1.28%).

Conclusions: Ghost publications are present in Plastic Surgery applications, its trend is similar through the years, “protective” factors are: first authorship and published peer reviewed abstract/article. (Plast Reconstr Surg Glob Open 2020;8:e2617; doi: 10.1097/GOX.0000000000002617; Published online 17 January 2020.)

INTRODUCTION
Plastic surgery is an attractive specialty to medical students. Residency training programs have the luxury of selecting their trainees from the “cream of the crop” from United States medical schools. Using data from the National Resident Matching Program, successful applicants to Plastic surgery tend to have above average USMLE steps 1 and 2 scores. Many applicants are members of AOA and have significant research experience. Extracurricular activities and service to the community are often impressive.

The information gathered through the Electronic Residency Application System (ERAS) is provided by each applicant. Each individual must certify that, “My ERAS application is complete and accurate to the best of my knowledge. I understand that any false or missing information may disqualify me from consideration for a position, or if employed, may constitute cause for termination from the program, and may result in expulsion.”

Because of the steep competition for PGY-1 integrated program positions, we hypothesized that temptation exists for applicants to falsify parts of their applications, particularly those parts that are difficult to verify. To assess the frequency of this phenomenon, our study focuses on not only the frequency in a single group of applications, but also its trend over time and factors associated with it by evaluating the application cycles that each began in 2010, 2011, and 2012.

METHODS
After approval of the Baylor Scott and White Institutional Review Board (IRB approval number: Disclosure: The authors have no financial interest to declare in relation to the content of this article.
“Ghost” status was found for 234 reported publications out of 2,124, which constitutes 11.02% of the articles pool. “Misrepresentation” was found in 21 articles (0.99%).

The overall rate of “ghost” articles at our institution during those 3 years was found to be (34.44%) or in 135 applications out of 392. There were only misrepresentations in 5 applications (1.28%). The trend of “ghost” authorship through the applications years of 2010, 2011, and 2012 did not change over time ($P = 0.27$) (Table 2).

Different publication types were strongly correlated to “ghost” status, with peer reviewed online publications the highest at 43.7%, peer reviewed journal articles/abstracts (other than published) 32.1%, peer reviewed book chapters 22.2%, and peer reviewed journal articles/abstracts 14% ($P = 0.0001$) (Table 3).

Most applications that contained “Ghost” publications had only 1 [61.19%] or 2 articles [22.39%] where this occurred. On the other hand, we found a subset of 5 [1.28%] applicants who had 6 or more “Ghost” publications.

A multivariate linear regression was used to evaluate for each author type, type of publication and year of publication. A total of 2,124 publications were included in the final analysis. This analysis yielded a significant association for first author status and publication type, with $P$ values of 0.0005 and <0.0001, respectively (Table 4).

### RESULTS

All 392 applications from the years 2010, 2011, and 2013 were included, a total of 159 applications from 2010 to 2011, 120 from 2011 to 2012, and 119 from 2012 to 2013. The number of manually reviewed reported publications was 2,124. The greatest number were distributed in peer reviewed journal articles/abstracts 1,187 (55.89%), followed by peer reviewed online publication 805 (37.90%), peer reviewed journal articles/abstracts other than published 70 (3.30%), and lastly, peer reviewed book chapters 62 (2.92%) (Table 1).

| Publication Type                        | Totals | Percent |
|----------------------------------------|--------|---------|
| Peer reviewed journal articles/abstracts| 1,187  | 55.9    |
| Peer reviewed book chapter             | 62     | 2.9     |
| Peer reviewed journal articles/abstracts (other than published) | 70 | 3.3 |
| Peer reviewed online publication       | 805    | 37.9    |

Most of the 2,124 articles were peer-reviewed journal articles/abstracts or online publication >90% (combined), a small minority were book chapters 2.9% and articles other than published 3.3%.
When considering the 2,124 screened publications, only 234 [11.02%] met the “ghost” authorship definition. However, when we look at the percentage of applicants through the 3-year period with at least one ghost publication, a surprising 34.4% value is obtained. This is similar to previously reported values of 18%–33% among surgical specialties.8,13 Nevertheless, this is higher than earlier studies on plastic surgery applications which cited 2%–7%.14,15 These studies were limited to a 1 year cohort, and <240 applicants. When more applicants were added and the length of the cohort was lengthened to 3 years, this percentage increases. Nevertheless, our percentage is still higher than the 28% found by Chung et al16 among plastic surgery residents.

Since our cohort, there has been an increase in the number of claimed publications. There is now an average of 14.2 abstracts, presentations and publications per applicant in 2018.1 With approximately 140 applicants per year, to review a projected 1,960 claimed publications per each year would be impractical. The aim of our study was to characterize the incidence and identify “risk factors” for “ghost” publications to help identify high-risk claims. We found 2 important factors. Not being listed as first author had 2.3 times the chance of being a ghost publication when compared with first authorship. Secondly, any other nontraditional research document (other than peer reviewed articles/abstracts, eg, book chapter or newspaper article) was 8 times more likely to be a ghost citation.

The risk factor of authorship makes intuitive sense. Authorship usually requires a level of involvement that is unlikely to result in not being included in the final publication even if there are bumps in the road and the author list change. One of our other proposed causes of such a high rate of ghost publication is that the role of the medical student during a research project may not be clearly established. During the development of a research plan with their fellow researchers and discussion of working on a paper, there may be a generalized misunderstanding of what constitutes authorship. For instance, a student might gather data for a retrospective study, or run one experiment, eg “western blot,” without participating in the article design, draft and final approval, assuming that 1 task alone constitutes authorship.

Nontraditional research documents such as book chapters and newspapers articles are the second significant risk factor. These are at high risk for not being indexed in google or Medline and have even less clear guidelines for authorship. Book chapters in particular may require a long time between submission and publication.

There are some limitations of our study. Ideally, we would have included all the applicants across the United States to obtain a more accurate estimation of the problem. Consequences of academic dishonesty to someone’s

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**Table 2. Trend of “Ghost” Publication by Years 2010–2013**

| Authorship | 2010–2011 | 2011–2012 | 2012–2013 | Total |
|------------|-----------|-----------|-----------|-------|
| Applicants without “Ghost” (%) | 98 (25) | 85 (21.7) | 74 (18.9) | 257 (65.6) |
| Applicants with “Ghost” (%) | 61 (15.6) | 35 (8.9) | 39 (9.9) | 135 (34.4) |
| Total applicants (%) “Ghost” | 159 (38.4) | 120 (29.2) | 119 (32.8) | 392 |

*aThe trend of “Ghost publications” did not change significantly through the years (*p* > 0.27).*

**Table 3. Distribution of “Ghost Authorship” Publications by Type**

| Publication Type | Verified author (%) | Ghost author (%) | Total (%) |
|------------------|--------------------|------------------|-----------|
| Peer Reviewed Journal articles/abstracts | 79 (20.1) | 13 (3.3) | 92 (23.5) |
| Peer Reviewed Book Chapter | 21 (5.4) | 6 (1.5) | 27 (6.9) |
| Peer Reviewed Journal articles/abstracts (Other than Published) | 19 (4.9) | 9 (2.3) | 28 (7.1) |
| Total applicants | 159 (38.4) | 135 (34.4) | 294 |

The distribution of “Ghost” article is strongly associated by different publication type (*p < 0.0001*).

**Table 4. “Ghost” Publication Characteristics from Applicant Pool Using a GEE Model**

| Publication Type | Estimate | Standard Error | z Value | Pr > | Exponentiated |
|------------------|----------|----------------|---------|-------|---------------|
| Peer reviewed book chapter* | 1.3251 | 0.5257 | 2.52 | 0.011 | 3.76 |
| Peer reviewed journal articles/abstracts | 2.0972 | 0.4421 | 4.74 <0.0001 | 8.14 |
| First author status† | 0.820 | 0.2355 | 3.48 <0.0005 | 2.27 |

*aThe baseline reference for article type was peer reviewed article abstract.*

†When using GEE the first author status was using first author as baseline reference.

First author status and studies published in peer reviewed journals were “protective factors” against Ghost authorship.

GEE, generalized estimating equations.
career could be severe and could result in termination of a resident contract, a generalized bad reputation for the individual and the institution and loss of credibility.\(^\text{17}\)

Plastic surgery as a specialty has been shown to attract strong applicants as evidenced by AOA membership, USMLE step 1 and 2 scores and research articles, but if we want a program to thrive we need men and women whose integrity is not compromised.\(^\text{2}\) At least a partial, possible explanation to the problem could be found in the article by Momenis et al\(^\text{18}\) about opinions on authorship, where 1/3 of plastic surgery residents were not aware of the rules which constitute true authorship, according to the International Committee of Medical Journal Editors guidelines. This should be discussed when helping a prospective applicant to build their application. Applicants should also be encouraged to make clear their level of involvement in studies that they claim on their application and place those where they were not authors instead in the section for research experiences.

As a result of our study, we have started to screen a random sample of research publications from the applicants to which we offer an interview. If there is any discrepancy between what is reported and what is discovered, we ask the applicant about the project and what the circumstances are that could explain the discrepancy.

**CONCLUSIONS**

Ghost publications are present in Plastic Surgery applications and the trend remains similar through the years. Characteristics associated with ghost publications are not being first author and not publishing a standard peer-reviewed article/abstract.

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