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Progressive Increase in Scholarly Productivity of New American Board of Anesthesiology Diplomates From 2006 to 2016: A Bibliometric Analysis

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Abstract

Background—Improving research productivity is a common goal in academic anesthesiology. Initiatives to enhance scholarly productivity in anesthesiology were proposed more than a decade ago as a result of emphasis on clinical work. We hypothesized that American Board of Anesthesiology diplomates certified from 2006 to 2016 would be progressively more likely to have published at least once during this time period.

Methods—A complete list of 17,332 new diplomates was obtained from the American Board of Anesthesiology for the years 2006 to 2016. These names were queried using PubMed, and the number of publications up to and including the diplomate's year of primary certification was recorded. Descriptive statistics and logistic regression analysis were used to analyze the association of the year of primary certification and whether a diplomate had published at least once.

Results—The percentage of American Board of Anesthesiology diplomates with at least one publication at the time of primary certification increased from 14.9% to 29.3% from 2006 to 2016. The mean number of publications per diplomate more than doubled from 0.31 to 0.79. Logistic regression analysis revealed the year of primary certification as significantly associated with having at least one publication ($p < 0.001$). Using 2006 as the reference year, odds of having

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Daniel K Ford contributed to the study design, conduct of the study, data collection, data analysis, and wrote the manuscript.

Aaron Richman contributed to the data collection, and helped critically revise the manuscript.

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published at least once were higher in the years 2010 to 2016, with the highest odds ratio of having a paper published occurring in 2016: 2.359 (CI: 1.978-2.812, $p < 0.001$).

Conclusions—Publications by new diplomates of the American Board of Anesthesiology have increased between 2006 and 2016. Whether the observed increase in publications could reflect efforts to stimulate interest in academic objectives during training remains to be proven.

Introduction

Anesthesiologists were responsible for some of the most significant advances in medical care in the 20th century.¹ The 1999 Institute of Medicine report *To Err is Human* specifically praised anesthesiologists for their contributions to patient safety.² Despite these accomplishments, academic anesthesiology drifted away from research toward a more clinical focus in the mid-2000s.^{3–8} For example, National Institutes of Health (NIH) funding awarded to anesthesiology faculty members ranked 24th of 25 specialties in 2005, ahead of only family medicine.⁷ A survey comparing scholarly productivity of chairs of Accreditation Council for Graduate Medical Education (ACGME)-accredited anesthesiology and surgery departments showed that anesthesiology department chairs had less NIH funding, fewer PubMed citations, and fewer publications than their colleagues in general surgery.⁹

A number of suggestions to reinvigorate anesthesia research productivity have been proposed: extension of anesthesiology residency training from four to five years; recruitment of MD-PhD graduates into residency positions; and aggressive advocacy for creation of strong research mentoring relationships within and between departments.^{8,10,11} ACGME requirements (IV.B.4.) for graduate medical education in anesthesiology state that “every resident must complete...an academic assignment”, adding in July 1, 2007 that the outcomes of such assignments should be “suitable for presentation at local, regional, or national scientific meetings, and or result in peer-reviewed abstracts or manuscripts”.¹² Thus, the goal of increasing scholarship by anesthesiology residents has immediate and profound consequences for the integrity of training programs as well.

The scholarly output of academic anesthesiologists has been extensively reported,^{13–17} but the relative productivity of U.S.-based anesthesiology residents is unknown. We examined scholarly productivity of anesthesiology residency graduates that achieved American Board of Anesthesiology (ABA) certification from 2006 to 2016. We hypothesized that the likelihood of diplomates to have published at least once prior and up to their year of primary certification would increase during that time period. Secondary outcomes included the number of publications per diplomate before or during the year of primary certification, the number of publications per diplomate in the year following primary certification, the position of the diplomate in the author list, and the publication type.

Methods

The study was approved by the University of Colorado Institutional Review Board. The requirement for written informed consent was waived. This manuscript adheres to the applicable sections of the STROBE and PRISMA reporting guidelines.¹⁸ The names of new ABA diplomates and each diplomate’s year of primary certification from 2006 to 2016 were

obtained from the ABA database. Using Visual Basic for Applications (VBA) in Microsoft Excel (Version 2016, Microsoft Corporation, Redmond, WA), computer code was written to search for publications authored by each diplomate in the U.S. National Library of Medicine and the NIH MEDLINE database (www.pubmed.gov). The number of publications up to and including the diplomate's year of primary certification, number of publications in the year following primary certification, diplomate position in the author list, and publication type were recorded and used for subsequent analysis. For number of publications up to and including the diplomate's year of primary certification, the exact search phrase “((anesthesia) OR (anesthesiology)) AND Name of Diplomate [Author - Full]” was used, with results limited to publication dates on or before December 31st of the diplomate's year of primary certification as described (Figure 1).¹³ Suffixes (such as Jr. or III) and the type of medical degree for each diplomate were ignored. If any part of the diplomate's name was not found in PubMed, zero publications were assigned to the diplomate.

Diplomates who were listed with a middle name or initial in the ABA database were searched twice (once with and once without the middle initial) to avoid author ambiguity. Only publications from authors with the same middle initial or no middle initial were attributed to the individual diplomate. If a middle name or initial was not listed for a diplomate, only publications for a given author without a middle initial were recorded. A diplomate's middle name was assumed to be the second name listed that was not the last name.

We also recorded the number of publications per diplomate in the year following primary certification and grouped these results by whether or not diplomates had published during or in the year of primary certification. The same method as above was used, but results were limited to those published from January 1st to December 31st of the year after primary certification. To record diplomates in the first author position, we used the same method as above but changed the exact search term to “((anesthesia) OR (anesthesiology)) AND Name of Diplomate [Author - Full] AND Last Name of Diplomate [Author – First]”. For the last author position, the exact search term “((anesthesia) OR (anesthesiology)) AND Name of Diplomate [Author - Full] AND Last Name of Diplomate [Author – Last] NOT Last Name of Diplomate [Author – First]” was used. This method ensured that papers with only one author were recorded only as “first author” publications and not as both “first author” and “last author”. We used the same protocol regarding middle names, and date filters were set to December 31st of the year of primary certification.

For publication type, papers published up to and including the diplomate's primary year of certification were stratified into four separate categories: Case Reports, Reviews, Editorials, and other publications that also included original works. Case Reports were defined as any paper with a publication type tag on PubMed of “Case Reports” or “Clinical Conference”. Reviews contained publications type tags of “Guideline”, “Meta-Analysis”, “Practice Guideline”, “Review”, or “Systematic Reviews”. Editorials included publication type tags of “Comment”, “Editorial”, or “Letter”. The “Other” category contained all publications without one of the publication type tags listed above. Some publications included multiple publication type tags in different categories; therefore, the percentages for any given year may not equal 100%.

To assess overall trends in publications between 2006 and 2016, we searched PubMed for the 31 anesthesiology journals listed in the Web of Science. These journals included British Journal Of Anaesthesia, Anesthesiology, Pain, Anaesthesia, Anesthesia And Analgesia, Journal Of Neurosurgical Anesthesiology, European Journal Of Anaesthesiology, Regional Anesthesia And Pain Medicine, Clinical, Journal Of Pain, European Journal Of Pain, Pain Physician, Minerva Anestesiologica, Pain Practice, Acta Anaesthesiologica Scandinavica, Current Opinion In Anesthesiology, Canadian Journal Of Anesthesia, Pediatric Anesthesia, Anesthesiologie & Intensivmedizin, Journal Of Clinical Monitoring And Computing, International Journal Of Obstetric Anesthesia, Journal Of Cardiothoracic And Vascular Anesthesia, Anaesthesia And Intensive Care, Journal Of Clinical Anesthesia, Anaesthesia Critical Care & Pain Medicine, BMC Anesthesiology, Journal Of Anesthesia, Schmerz, Annales Francaises D Anesthesie Et De Reanimation, Anaesthesist, Revista Brasileira De Anestesiologia, Anesthesiologie Intensivmedizin Notfallmedizin Schmerztherapie.

Statistical Analysis

A 5% random sample (867 diplomate names) manual search was performed by a second investigator (rater B) blinded to the results of rater A to ensure the accuracy of the computer-search algorithm. To measure agreement beyond chance, Cohen's kappa was calculated based on the primary outcome of the study (ABA diplomates who published at least once prior to and including the diplomate's year of primary certification versus not) and the observed agreement was reported separately. Descriptive statistics were used to summarize the data, including mean, median, and percentages of diplomates with one or more publications for each year studied. Logistic regression analysis was performed to assess the relationship between the diplomate's year of primary certification and the chance that he or she had at least one publication listed in PubMed up until that time. Year of graduation was entered as the covariate with 2006 serving as the reference variable in the regression analysis. The null hypothesis was rejected when the two-sided p-value was less than 0.05. All statistical analyses were performed using SPSS Version 24 software (IBM, Armonk, NY, USA).

Results

A complete list of 17,332 new diplomates was obtained from the ABA for the year of primary certification from 2006 to 2016. The mean number of publications per diplomate more than doubled from 0.31 in 2006 to 0.79 in 2016. Among diplomates who had published up to and including their year of primary certification, the mean number of publications increased from 2.09 to 2.70 over the same time period (Table 1). The percentage of diplomates who authored at least one publication increased from 14.9% to 29.3% during this 11-year period (Figure 2). Conversely, the percentage of diplomates who did not publish at all fell from 85.1% in 2006 to 70.7% in 2016 (Table 1). Results for diplomates with publications in the year following primary certification stratified according to whether or not they published before or during their year of primary certification are also shown in Table 1. Results of the logistic regression analysis with the year of primary certification as the covariate and 2006 serving as the reference variable are presented in Table 2. The year of primary certification was significantly associated with the likelihood of

a diplomate having published at least once (degrees of freedom = 10; $p < 0.001$). Significant odds ratios were observed for each year from 2010 to 2016 relative to 2006. Comparison between manual and computational algorithm data demonstrated Cohen's kappa=0.89 (standard error = 0.02, $p < 0.001$), indicating almost perfect agreement beyond chance.¹⁹ Observed agreement was 0.96. Table 3 summarizes data regarding the position of diplomates in the author list as well as publication type for each of the eleven years studied. In order to gauge whether the increase in publications per diplomate mirrored general publication trends, we assessed overall publications in anesthesiology journals. From 2006 to 2016, the overall number of publications in journals in the field of anesthesiology increased by 25.2% (Table 4).

Discussion

The current results indicate that the likelihood of new ABA diplomates to have published at least once prior to or during the year of certification has progressively increased from 2006 to 2016, confirming our hypothesis. The percentage of diplomates who authored at least one publication increased from 14.9% to 29.3%. Using logistic regression analysis, we found that diplomates who obtained primary certifications in the years from 2010 to 2016 were more likely to have published at least once compared to those who were certified in 2006, with the highest odds ratio of 2.359 occurring in 2016, the most recent year in our dataset. The mean number of publications per diplomate more than doubled during the time period of our study. Among those diplomates who did publish, the mean number of publications per diplomate also increased by approximately 29% (2.09 to 2.70). This group also had more publications in the year following primary certification, possibly indicating a higher likelihood of sustained productivity.

Given that the number of aggregate anesthesiology journal publications per year increased by approximately 25%, yet the publications per certification year increased from 479 to 1311 or by 174% (Table 1), the rising number of publications among new ABA diplomates is unlikely only a sequelae of more publications in the field of anesthesiology in general. It may seem intuitive to assume that the observed increase in publications by recent graduates could be due to concerted initiatives by anesthesiologists during their training, e.g. those required by the ACGME guidelines.¹² However, causality cannot be ascertained from our data. The results also show that in 2016 still, 70.7% of new diplomates had no publications when they were first ABA certified, compared to 85.1% in 2006.

Comprehensive publicly available data on publication numbers for trainees and recent residency graduates in other medical specialties are lacking. The neurosurgery residency program at the Mayo Clinic (Rochester, MN campus) reported that 71.6% of applicants have at least one publication.²⁰ A study examining the number of publications among obstetrics and gynecology residents applying for fellowship positions showed that more than 50% had at least one peer-reviewed manuscript.²¹ Although these results could suggest that recent anesthesiology diplomates may not be as academically productive as their colleagues in other specialties, such comparisons need to be made with caution, as requirements for mandatory rotations and dedicated time for research vary substantially between specialties. Comparisons of anesthesiology to hospital-based specialties, such as radiology, would be

desirable in this regard. However, results of a 2016 survey indicated that anesthesiology ranked 12th out of 18 medical specialties in competitiveness (defined as U.S. residency positions filled by graduates from U.S. medical schools).²² Anesthesiology residents applying for certain fellowships may also have less motivation to publish. E.g., only 39% of pediatric anesthesiology fellowship program directors rated research experience as extremely or very important when evaluating candidates.²³

Limitations

The current findings must be interpreted within the constraints of several potential limitations. As previously reported,^{24,25} we encountered difficulty with the definitive identification of each author. We included the qualifiers “anesthesia OR anesthesiology” to our search to exclude authors with the same name but from other specialties. However, this strategy may have eliminated diplomates who published papers unrelated to anesthesiology or an anesthesiology department. Publications not identified using the search criteria for other reasons were also excluded. These limitations may have contributed to an underestimation of recent ABA diplomate scholarly productivity. However, the large number of diplomates included in the current survey made it impractical to pursue a manual search strategy for the entire sample. We did classify publication by type as coded in PubMed. Since accuracy and completeness of this classification may have been incomplete, this represents a further limitation. Nevertheless, the primary outcome of our study was to quantify how many diplomates had any publication and not to assess publication quality or impact. Because PubMed was used as the search platform, we also inevitably excluded publications that do not appear in this database (e.g., those appearing in certain online journals). As we only had access to the names of the diplomates as provided by the ABA, those who published under a different name, including maiden or hyphenated names, may not have been identified. Lastly, limiting to publications to dates on or before December 31st of the diplomate’s year of primary certification would not have identified manuscripts in-press or under review at that time.

Summary

In summary, we found the number of publications by new ABA diplomates increased between 2006 and 2016, and that diplomates gaining their primary certifications in 2010-2016 were significantly more likely to publish at least once before becoming ABA diplomates than those gaining their primary certifications in 2006. Although these findings could have been influenced by initiatives to increase scholarly interest and productivity of anesthesiology residents during training, our data do not permit drawing such a causal conclusion. Lastly, despite these encouraging observations, more than 70% of new ABA diplomates had no publications before obtaining their primary certification. Thus, there remains room for further improvement to enhance publication productivity of our specialty.

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Key Points Summary

Question

Did scholarly productivity of anesthesiology residency graduates that achieved American Board of Anesthesiology (ABA) certification change from 2006 to 2016?

Findings

The percentage of American Board of Anesthesiology diplomates with at least one publication at the time of primary certification increased from 14.9% to 29.3% from 2006 to 2016.

Meaning

Future research should examine whether the observed increase in scholarly productivity of new American Board of Anesthesiology diplomates could reflect efforts to stimulate interest in academic objectives.

Figure 1:
Study flow diagram.

Figure 2:

Percentage of American Board of Anesthesiology diplomates with one or more publications up to and including the year of primary certification.

Publication characteristics of ABA Diplomates by year of primary certification. Percentages of diplomates who published at least once after their year of primary certification (YPC) are based on their publication status before their YPC.

Table 1:

Year	Total # of ABA Diplomates	Total # of Publications	Mean # of Publications per ABA Diplomate	Mean # of Publications Among Diplomates Who Published	% of Diplomates by number of publications				% of Diplomates With Publications Before/ During YPC Who Published in the Year After YPC	% of Diplomates Without Publications Before/ During YPC Who Published in the Year After YPC
					0	1-2	3-4	5+		
2006	1532	479	0.31	2.09	85.05	12.60	1.17	1.17	19.21	2.38
2007	1594	330	0.21	1.49	86.07	12.42	1.25	0.25	19.82	2.99
2008	1491	368	0.25	1.78	86.12	11.67	1.54	0.67	22.71	4.36
2009	1461	563	0.39	2.32	83.37	13.69	1.78	1.16	23.05	2.87
2010	1753	537	0.31	1.74	82.43	15.12	1.48	0.97	20.78	4.36
2011	1534	594	0.39	1.97	80.38	16.88	1.56	1.17	25.58	4.14
2012	1511	765	0.51	2.39	78.82	17.07	1.99	2.12	22.50	3.95
2013	1643	730	0.44	2.27	80.40	15.95	2.56	1.10	28.88	5.07
2014	1587	899	0.57	2.40	76.37	18.90	2.90	1.83	27.47	6.52
2015	1571	1126	0.72	2.71	73.52	20.05	3.69	2.74	31.49	6.41
2016	1655	1311	0.79	2.70	70.69	22.18	3.50	3.63	34.02	7.35

Table 2.

Logistic regression analysis. The odds ratio and 95% confidence limits are reported in reference to the ABA primary certification cohort 2006. The year of primary certification was significantly associated with the likelihood of a diplomate having published at least once (degrees of freedom = 10; $p < 0.001$).

Year	Odds ratio	95% Confidence Interval		p-value
2007	0.921	0.754	1.124	0.417
2008	0.917	0.749	1.124	0.405
2009	1.135	0.932	1.382	0.206
2010	1.213	1.006	1.462	0.043
2011	1.389	1.150	1.677	0.001
2012	1.529	1.268	1.843	<0.001
2013	1.387	1.152	1.670	0.001
2014	1.761	1.468	2.112	<0.001
2015	2.049	1.712	2.453	<0.001
2016	2.359	1.978	2.812	<0.001

Table 3:

Publication classification by author position and publication type in PubMed.

Year	Total Number of Publications	% of Publications w/ Diplomate as First Author	% of Publications w/ Diplomate as Last Author	% of Publications Classified as "Case Reports," ^a	% of Publications Classified as "Reviews," ^a	% of Publications Classified as "Editorials," ^a	% of Publications with other classifications ^a
2006	479	46.76	25.26	30.27	16.28	10.23	48.02
2007	330	36.06	13.64	28.79	16.36	6.97	50.61
2008	368	41.85	10.60	28.26	8.97	9.24	58.70
2009	563	40.85	11.37	24.33	14.03	7.99	57.37
2010	537	37.62	10.06	27.19	12.85	5.21	57.73
2011	594	34.68	10.27	21.55	13.97	8.42	59.76
2012	765	40.00	13.20	21.18	17.91	6.93	55.95
2013	730	38.22	12.88	18.77	13.56	7.67	61.51
2014	899	36.26	12.01	15.24	10.34	7.79	69.41
2015	1126	31.62	11.90	14.30	14.65	7.90	64.48
2016	1311	36.23	8.31	17.70	11.75	7.17	67.05

^aThe total percentage of publication types may exceed 100% as publications may be classified in more than one category.

Table 4.

Number of aggregate publications in 31 journals in the field of anesthesiology per year.

Year	Total number of publications	% change relative to 2006
2006	5995	N/A
2007	5988	-0.1
2008	6097	1.7
2009	6426	7.2
2010	6270	4.6
2011	6330	5.6
2012	6393	6.6
2013	6809	13.6
2014	6703	11.8
2015	6816	13.7
2016	7505	25.2