The Pennsylvania State University

The Graduate School

PUBLICATION PRODUCTIVITY AND ACADEMIC RANKING IN MEDICINE:

A SYSTEMATIC REVIEW AND META-ANALYSIS

A Thesis in

Clinical Research

by

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ABSTRACT

Objective: The purpose of the current work is to systematically review, synthesize, and analyze the available literature on publication productivity and academic ranking across specialties.

Summary Background Data: Publication performance of academic medical faculty members is used for hiring, promotion, grants, and awards.

Methods: A PICOS/PRISMA/MOOSE selection protocol was used to find studies that reported on h-indices and m-indices across academic ranks. Data from 19 studies were pooled using weighted random effects meta-analyses via the DerSimonian and Laird method.

Results: Data on 14,567 physicians were analyzed and summary effect sizes for mean h-indices were determined at each academic level. The random effects estimate for mean h-index of assistant professors was 5.22 (95% CI, 4.21-6.23, I^2=98.76%, n=6,609), 11.22 (95% CI, 9.65-12.78, I^2=97.08%, n=3,508) for associate professors, 20.77 (95% CI, 17.94-23.60, I^2=97.63%, n=3,626) for full professors, and 22.08 (95% CI, 17.73-26.44, I^2 =95.88%, n=816) for department chairs. Similar trends were seen for the m-index, across the 3 included studies. Our study is limited due to the variation in h-index calculation depending on database used, reporting differences, limited studies published about internal medical fields, and an inherent time bias, where studies published more recently had higher h-indices due to its natural growth over time.

Conclusions: H-indices are associated with successive academic rank. The results of this study may be used as an additional metric for benchmarking research productivity in hiring, promotion, grant, and award assessments based on publication productivity across academic medical specialties.

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These forest plots depict mean h-indices for various academic medical specialties at successive levels of academic rank. The four panes are arranged in order of successive academic rank: assistant professor, associate professor, full professor and chair. Based on summary effect size under random effects model, the mean h-index for each medical specialty at each rank is listed, with 95% confidence intervals in brackets. The square represents the individual studies effect. The size of the square varies to reflect the weight a particular study has in the overall analysis. The black line represents the confidence interval of a study. The diamond represents the overall or summary effect with 95% confidence interval.

Legend:

These forest plots depict mean m-indices for various academic medical specialties at successive levels of academic rank. The four panes are arranged in order of successive academic rank: assistant professor, associate professor, full professor and chair. Based on summary effect size under random effects model, the mean m-index for each medical specialty at each rank is listed, with 95% confidence intervals in brackets. The square represents the individual studies effect. The size of the square varies to reflect the weight a particular study has in the overall analysis. The black line represents the confidence interval of a study. The diamond represents the overall or summary effect with 95% confidence interval.

Legend:

“H-index” was searched on PubMed with a result of 786 studies. Of these, 440 humans-only studies were assessed for eligibility and 406 were excluded if they were retracted, not available online, did not include h-indices AND/OR total n values, and those that were review articles. The remaining 36 studies were analyzed and where multiple studies existed for the same department, the most recent publication was used. If studies provided means, SEMs or SDs, they were converted to 95% confidence intervals and used in the meta-analysis. Studies that provided medians and interquartile ranges were included in data tables but not in the meta-analysis.

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I would like to thank my colleagues Ms. Emily O'Brien, Ms. Jennifer Mardini, Dr. Eric J. Lehrer, Dr. Emma Holliday, and Dr. Carol S. Weisman for their assistance in this research project.

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Nicholas G. Zaorsky

INTRODUCTION

In academic medicine, faculty members are assessed on their research performance for the purposes of hiring, promotion, grants, and awards [1,2]. There is bias in assessment of productivity that prevents women and underrepresented minorities from promotions as compared to their peers [3]. Objective metrics for scholarly output are necessary for this comparison, so that faculty members may be juxtaposed institutionally, nationally, and internationally. Several metrics, including total publication number and citation count, have been studied but are limited in that they do not evaluate publication quality, quantity, or citation trajectory.

The h-index is a bibliometric index proposed by Jorge Hirsh in 2005 in order to assess academic productivity across all fields of academia and represents both quantity and quality of an author's work. An individual has index h, if h of his or her total publications (Np) have at least h citations each and the other (Np - h) papers have ≤h citations each [4]. The h-index therefore helps to report the quantity and quality of one's publications. Additionally, the m-index is calculated as the h-index divided by the number of years since the author's first published paper, thus providing h-index trajectory. Several specialty-specific studies reveal that as the h- and m-index are positively correlated with academic rank. However, no study has compared these metrics across all fields and specialties in medicine.

The purpose of the current work is to systematically review, synthesize, and analyze the available literature on publication productivity and academic ranking across specialties. We hypothesized that academic medical fields have unique h- and m- indices among academic ranks. The results of this study have the potential to help academic institutions standardize their guidelines for hiring, promotion, grants and awards.

METHODS

This systematic review of the published literature was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA; Appendix Figure 1) [5] and the Reporting Checklist for Meta-analyses of Observational Studies (MOOSE; Appendix Table 1) [6].

DATA SOURCES AND SEARCHES

Medical literature including observational studies published in English from 2005 to 2018 was searched in PubMed, with the term “h-index.” Initially, 786 studies were screened for eligibility; subsequently, 440 abstracts of studies which passed the initial screen were reviewed. Review articles, studies that were not available online and studies not evaluating h-indices and/or total n were excluded; however, their references and related articles were evaluated for inclusion. Further, to ensure the most up-to-date data for all physicians, all 120 medical specialties from the Association of American Medical Colleges (AAMC) website were part of the inclusion criteria [7]. Ultimately, 36 full-text articles met all inclusion criteria, encompassing 21 different medical specialties. Relatively few studies pertaining to internal medicine subspecialties were published, and most of the studies pertained to surgical specialties.

STUDY SELECTION

The inclusion criteria for the literature search was defined using the Population, Intervention, Control, Outcome, and Study Design (PICOS) approach (Appendix Table 2) [8]. All studies included were scrutinized for inclusion in the review. Observational studies were identified from PubMed. The population comprised of faculty in academic medicine with reported mean and/or median h-indices. The studies must have reported h-indices and other publication metrics if available, including number of citations, number of publications and m-indices.

The primary outcome was the h-index, and this was stratified by academic rank: instructor, assistant professor, associate professor, full professor, and chair. The secondary outcome measure was the m-index, defined as (h-index)/(number of years since the author’s first published paper), which characterizes the rise in the h-index over time.

DATA EXTRACTION AND QUALITY ASSESSMENT

The results of the PubMed searches were exported into EndNote (Clarivate Analytics). Data in these articles were initially independently extracted by 2 authors (EO, JM) who were not involved in any of the specified studies. Any discrepancies in values were resolved by discussion with two other investigators (NZ, EL). When multiple studies existed for the same specialty, the most recent study was chosen in order to avoid potentially double counting faculty members. This eliminated 15 of the 36 studies.

DATA SYNTHESIS AND ANALYSIS

Of the remaining 21 studies, 19 studies reported both mean h-index and provided the data needed to calculate standard deviation (SD), standard error of mean (SEM), and 95% confidence interval (95% CI). These 19 studies were included in the meta-analysis. The two additional studies reported only median h-indices and interquartile ranges (IQRs); the authors of these studies were contacted to supply means, SDs, SEMs, and 95% CIs. These two studies that reported only median h-indices were included in the subsequent systematic review; however, were not included in the meta-analysis (PRISMA; Appendix Figure 1).

STATISTICAL ANALYSIS

R studio version 1.1.383 [9] (Boston, MA) and The Meta-Analysis Package for R (metafor)[10] version 2.0-0 were used to conduct the meta-analyses and heterogeneity tests. The DerSimonian and Laird method was utilized to perform meta-analyses for each of the primary and secondary outcomes measures [11,12]. Heterogeneity was assessed using the I^2 statistic [13], Significant heterogeneity was considered present if the I^2 statistic was > 50%. Forest plots were generated for each of the primary and secondary outcome measures.

RESULTS

STUDY CHARACTERISTICS

The meta-analysis included a total of 14,567 North American academic physicians across 19 separate studies from the years 2009-2018. Publication productivity metrics were analyzed for general pediatrics and 4 pediatric subspecialties (n = 445 faculty members) [14-16], general surgery and 7 surgical subspecialties (n = 7,260) [17-24], anesthesia and subspecialist cardiothoracic anesthesiologists (n = 904) [25,26], and 6 other specialties including sports medicine (n = 313) [27], radiation oncology (n = 986) [28], dermatology (n = 1,061) [29], psychiatry (n = 1,601) [30], ophthalmology (n = 1,459)[31] and radiology (n = 538) [1]. Overall, the meta-analysis included 8 (<1%) instructors, 6,609 (45%) assistant professors, 3,508 (24%) associate professors, 3,626 (25%) full professors and 816 (5.6%) departmental chairs. Additional data on gynecological oncology [32] and gastroenterology [33] were found, though these data were reported in medians and therefore not included in our meta-analysis. Median h-indices at each academic rank in gynecological oncology and gastroenterology are indicated by asterisks and can be found in Table 1. The h-indices are dependent on the number of publications and number of citations; for reference, these are included in Appendix Table 3 and Appendix Table 4**.**

Table 1. Mean and Median H-indices by Academic Rank and Subspecialty

			Instructor		Assistant		Associate		Full		Chair			
		N total faculty	Mean h-index	n	Mean h-index	n	Mean h-index	n	Mean h-index	n	Mean h-index	n	References	Year published
Anesthesia	General	645			0.8	367	3.2	151	7.9	102	10.3	25	[25]	2013
	Cardiothoracic	259	1	8	3	123	7	56	12	63	18	9	[26]	2011
Dermatology		1,061			5.2	466	10.2	233	22.5	268	23.6	94	[29]	2016
Gastroenterology*		2,043	1.5*	136	3.5*	817	10.5*	470	20.5*	620			[33]	2016
Gynecological oncology*		507			6*	208	14.5*	120	23*	179			[32]	2015
Ophthalmology		1,459			3.7	619	8.2	321	16.4	411	15.8	108	[31]	2014
Otolaryngology		1,054			4.3	456	8.7	248	14.9	258	15.5	92	[17]	2013
Pediatrics	Gastroenterology	80			1.8	28	9.6	25	21.5	27			[14]	2016
	General	116			1.8	29	7.8	29	19.4	28	26.5	30	[14]	2016
	Nephrology	80			3.2	28	11.1	25	21.8	27			[14]	2016
	Neurosurgery	72			7.8	25	13	24	27.9	23			[15]	2013
	Surgery	97			9.0	16	16.5	20	18	28	25	33	[16]	2015
Psychiatry		1,601			4.4	911	9.4	387	21.7	303			[30]	2017
Radiology		538			5	212	11	128	27	198			[1]	2016
Radiation oncology		986			6.8	465	14.0	251	31.3	195	34.8	75	[28]	2017
Sports medicine		313			7	134	14	88	28	91			[27]	2016
Surgical oncology		476			7.9	186	18	128	32	142	48	20	[18]	2018
Surgery	General	129			7.9	74	14.3	55					[19]	2017
	Hand surgery	2,055			4.4	894	8.8	484	15.1	585	15.5	92	[20]	2015
	Neurosurgery	20			5.1	5	10.7	5	16	5	24.7	5	[21]	2009
	Orthopedic surgery	2,061			3.6	976	8.4	504	15.1	461	17.8	120	[22]	2017
	Plastic surgery	614			4.6	268	9.1	141	15.3	183	15.4	22	[23]	2016
Urology		851			7.5	327	12.5	205	20.5	228	24.5	91	[24]	2014
Totals included in the meta-analysis		14,567		8		6,609		3,508		3,626		816		
Totals (with mean and median values)		17,117		144		7,634		4,098		4,425		816		

*Asterisk denotes median values instead of mean values.

PUBLICATION PRODUCTIVITY AND RANK

Table 1 lists the mean h-indices by both academic rank and subspecialty. Consistent with previously published literature on academic medicine and h-index, mean h-index increased with successive academic rank for all specialties. Figure 1 presents mean h-indices as Forest plots by academic rank and subspecialty. The summary effect sizes under weighted random effects models revealed: mean h-indices for assistant professors, associate professors, full professors and department chairs of 5.22 (95% CI, 4.21-6.23, I^2=98.76%, n=6,609), 11.22 (95% CI, 9.65-12.78, I^2=97.08%, n=3,508), 20.77 (95% CI, 17.94-23.60, I^2=97.63%, n=3,626), and 22.08 (95% CI, 17.73-26.44, I^2=95.88%, n=816), respectively.

Figure 1. Forest plots by academic rank and subspecialty for h-index

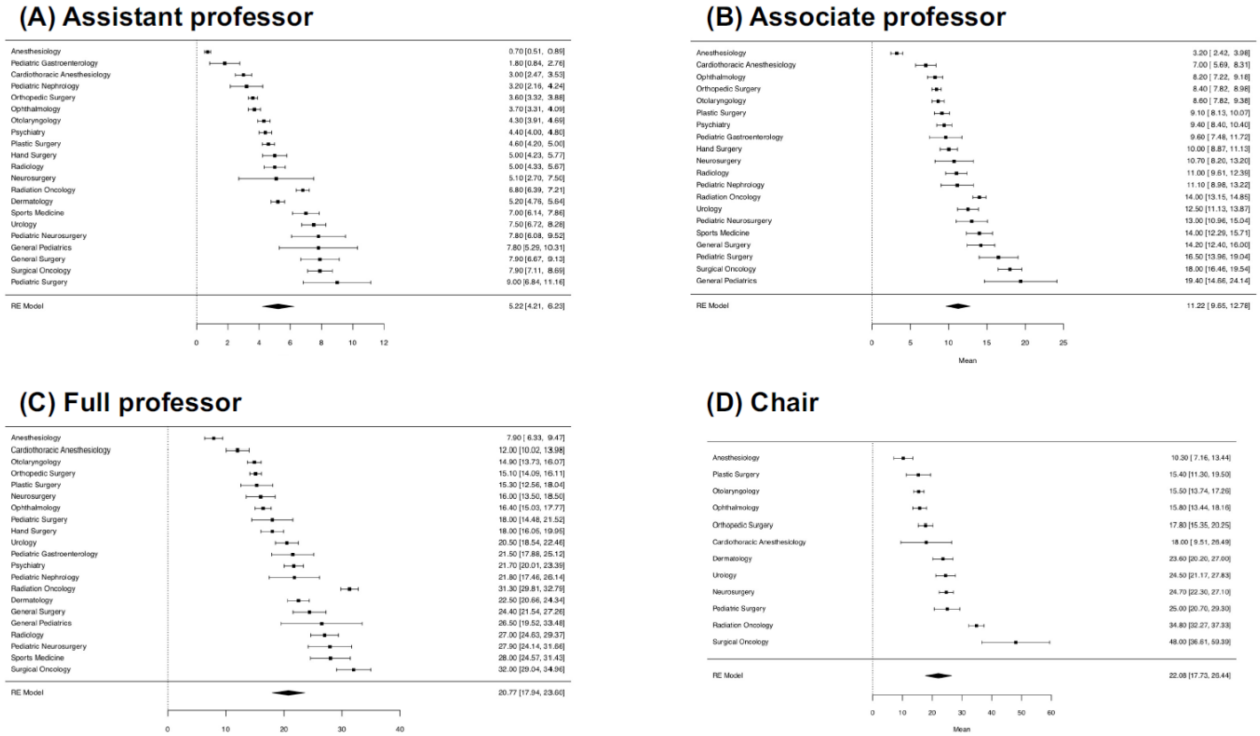


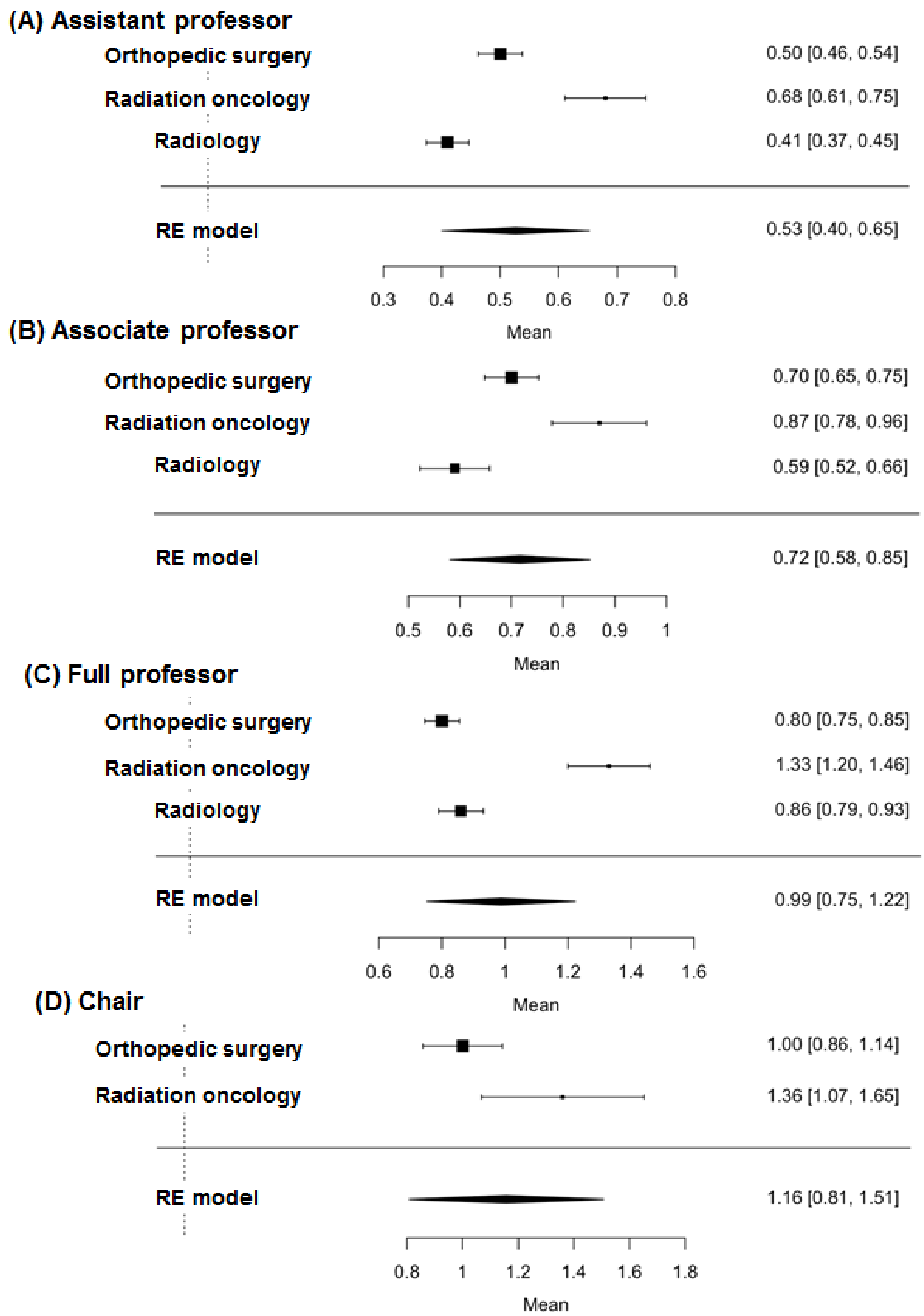
Table 2 lists the available information on four available m-indices across ranks in academic medicine: gastroenterology, radiology, radiation oncology, and orthopedic surgery. Three studies provided m-index means that could be included in the meta-analysis. The weighted random effects summary effect sizes for mean m-indices were: 0.53 (95% CI, 0.40-0.65, I^2=95.8%, n=1,188) for assistant professors, 0.72 (95% CI, 0.58-0.85, I^2=92.4%, n=632) for associate professors, 0.99 (95% CI, 0.75-1.22, I^2=96.3%, n=659) for full professors, and 1.16 (95% CI, 0.81-1.51, I^2=78.8%, n=120) for departmental chairs. Figure 2 presents mean m-indices as Forest plots by academic rank and subspecialty.

Table 2. Mean m-indices by academic rank and subspecialty

			Instructor		Assistant		Associate		Full		Chair			
		N total faculty	Mean m-index	n	Mean m-index	n	Mean m-index	n	Mean m-index	n	Mean m-index	n	References	Year published
Gastroenterology*		2,043	0.23*	136	0.37*	817	0.67*	470	0.73*	620			[33]	2016
Radiation Oncology		986			0.68	465	0.87	251	1.33	195	1.36	75	[28]	2017
Radiology		538			0.41	212	0.59	128	0.86	198			[1]	2016
Orthopedic surgery		2,061			0.5	976	0.7	504	0.8	461	1.0	120	[22]	2018
Totals included in the metanalysis		3,585		0		1,653		883		854		195		
Totals (with mean and median values)		5,628		136		2,470		1,353		1,474		195		

*Asterisk denotes median values instead of mean values.

Figure 2. Forest plots by academic rank and subspecialty for m-index



DISCUSSION

This is the first meta-analysis that characterizes promotion in academic medical centers as a function of scholarly productivity. The results show that h-index increases with academic rank. Furthermore, a similar trend was seen for the m-index, with the limited data available. The results of this study may be used as an additional metric for benchmarking research productivity in hiring, promotion, grant and award assessments based on publication productivity across certain academic medical specialties.

The h-index was first described in 2005 by Jorge E. Hirsch[4] and since its inception various fields of medicine have started to assess publication productivity and update these metrics over time. For example, anesthesiology published its metrics in 2011 [26] and 2013 [25], some of the earliest papers included in the current analysis (Table 1). In contrast, certain surgical fields have published their metrics only recently, including orthopedic surgery in 2017 [22] and surgical oncology in 2018 [18]. The h-index for faculty members is expected to rise over time, and this has been shown in the analysis of radiation oncology faculty members, where the mean h-index rose from 8.5 in 2007 to 14.5 in 2017 [34]. Thus, although some specialties in the current analysis appear to have a higher mean h-index than others, this difference may be due to time at which the studies were published. Since the studies currently published heavily represented surgical fields, academic rank based on h-indices can be more reliably concluded within those fields rather than applying the results across all medical specialties due to gaps in the existing literature.

Additionally, one of the trends seen was that specialties with longer training periods typically had higher h-indices for each rank (Table 1). We attribute the higher publication productivity to persistent commitment to research that is seen throughout residency and fellowship training. For example, surgical oncology, neurosurgery, and pediatric surgery all had consistently high mean h-indices, and these three fields have longer training periods after medical school than the average physician (Figure 1). Research productivity may be inherent among some of these specialties more than others, and this is exemplified by their training requirements. Surgical residencies generally last 7 years with 2 years of protected research time, and most radiation oncology residences provide 6-12 months of guaranteed research time. This built-in research time is usually not a part of primary care residencies and likely contributes to their lower h-indices.

Since h-index will increase with number of publications and citations, this bibliometric is dependent on the number of years someone has been publishing. In contrast, the m-index may be invaluable to identify highly productive junior faculty members because it adjusts the h-index for time since first publication. Although limited data was available for statistical analysis, Figure 2 represents three specialties comparing m-indices across academic rank; similar to the h-index, there is a positive correlation between m-index and rank.

There are limitations to our study. First, we were unable to find data on publication productivity metrics for all fields in medicine. In the systematic review portion of the work, we found little information on general internal medicine, emergency medicine and obstetrics and gynecology, and practically no information on pulmonology, occupational medicine, or many surgical sub-specialties, including cardiothoracic surgery, vascular surgery, and interventional radiology. Data from certain specialties were not available, or could not be integrated into the current work due to the nature in which the data was reported. We contacted these authors for data sets and this information was included when it was provided to us.

Second, studies included here used different databases to obtain the bibliometric data – some utilized Google Scholar, while others used Scopus. Scopus appears to have fewer duplicate entries and defects in its functionality; however, it may still list authors through multiple identifiers (e.g. maiden name, married name, nickname) and skew search results [35]. In contrast, Google Scholar may list conference abstracts that falsely increase the number of papers. Thus, the h-indices reported in the present study should be considered reliable approximations rather than exact values.

Third, faculty members' contributions to research and scholarship are measured by a variety of other indices, including the g-index, which was not measured in the current work. Next, scholarly activities compose more than just publications; clinical acumen and teaching are also important metrics of academic success, but these are not directly evaluated by the h-index or m-index. Additionally, the h-index may be inflated by self-citations and high co-authorship. An inherent limitation of the h-index is a temporal bias, where the h-index increases over time and may lean towards physicians that have been in practice for longer than their cohorts [21],[36] . Since h-indices are expected to increase over time, it is possible that some of the studies included here from an earlier time (e.g. 2011), would have higher measures if re-evaluated today. The m-index can correct for this bias as it accounts for career duration; despite this benefit, m-index has not been fully evaluated.

Lastly, in terms of statistical analysis, we did see a significant degree of heterogeneity (I^2 values) across academic rankings for both h- and m-indices. This is expected as this type of analysis closely mimics the modern climate of academic medicine, where scholarly activity varies widely across specialties. Future work is necessary to include more internal medical specialties, as these data become available.

CONCLUSION

This is the first meta-analysis that characterizes promotion in academic medical centers as a function of scholarly productivity. The h- and m-index increase with academic rank, and there are unique distributions of these metrics among medical specialties. The results of this study may be used as an additional metric for benchmarking research productivity in hiring, promotion, grant and award assessments based on publication productivity across certain academic medical specialties.

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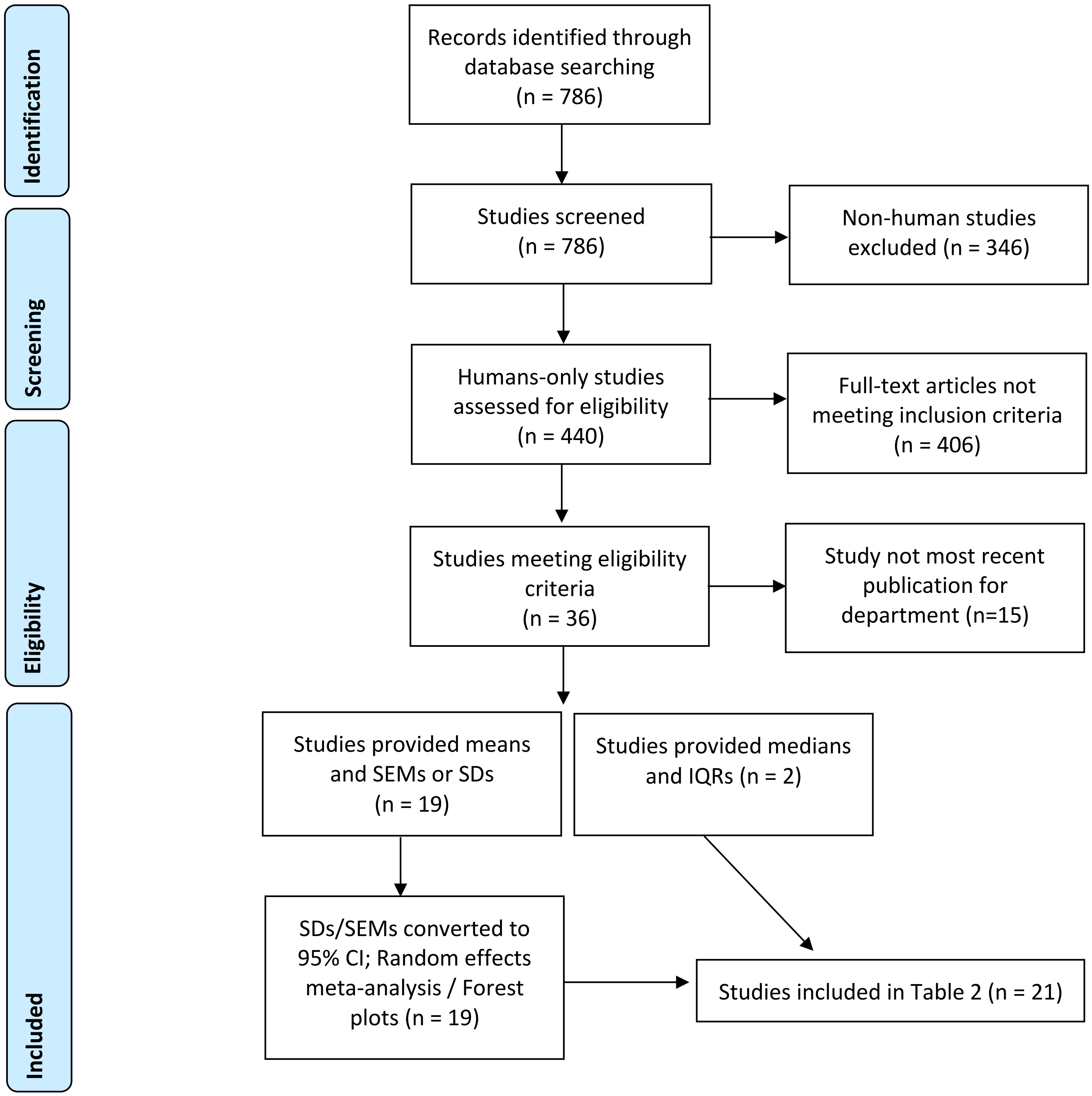
APPENDIX A

PRISMA 2009 Flow Diagram



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For more information, visit www.prisma-statement.org.

APPENDIX B

Appendix Table 1. MOOSE Checklist for Meta-analysis of Observational Studies

Item No	Recommendation	Reported in Section
Reporting of background		
1	Problem definition	Introduction
2	Hypothesis statement	Introduction
3	Description of study outcome(s)	Methods
4	Type of exposure or intervention used	Methods
5	Type of study designs used	Methods
6	Study population	Methods
Reporting of search strategy should include		
7	Qualifications of searchers (eg, librarians and investigators)	Methods
8	Search strategy, including time period included in the synthesis and key words	Methods
9	Effort to include all available studies, including contact with authors	Methods
10	Databases and registries searched	Methods
11	Search software used, name and version, including special features used (eg, explosion)	Methods
12	Use of hand searching (eg, reference lists of obtained articles)	Methods
13	List of citations located and those excluded, including justification	Methods, References
14	Method of addressing articles published in languages other than English	Methods
15	Method of handling abstracts and unpublished studies	Methods
16	Description of any contact with authors	Methods
Reporting of methods should include		
17	Description of relevance or appropriateness of studies assembled for assessing the hypothesis to be tested	Methods
18	Rationale for the selection and coding of data (eg, sound clinical principles or convenience)	Methods
19	Documentation of how data were classified and coded (eg, multiple raters, blinding and interrater reliability)	Methods
20	Assessment of confounding (eg, comparability of cases and controls in studies where appropriate)	NR
21	Assessment of study quality, including blinding of quality assessors, stratification or regression on possible predictors of study results	Methods, Table 1

22	Assessment of heterogeneity	Methods
23	Description of statistical methods (eg, complete description of fixed or random effects models, justification of whether the chosen models account for predictors of study results, dose-response models, or cumulative meta-analysis) in sufficient detail to be replicated	Methods
24	Provision of appropriate tables and graphics	Results
Reporting of results should include		
25	Graphic summarizing individual study estimates and overall estimate	Results
26	Table giving descriptive information for each study included	Results
27	Results of sensitivity testing (eg, subgroup analysis)	Results
28	Indication of statistical uncertainty of findings	Discussion
Reporting of discussion should include		
29	Quantitative assessment of bias (eg, publication bias)	Discussion
30	Justification for exclusion (eg, exclusion of non-English language citations)	Methods
31	Assessment of quality of included studies	Results, Discussion
Reporting of conclusions should include		
32	Consideration of alternative explanations for observed results	Discussion
33	Generalization of the conclusions (ie, appropriate for the data presented and within the domain of the literature review)	Discussion
34	Guidelines for future research	Discussion
35	Disclosure of funding source	Title Page

Appendix Table 2. PICOS inclusion criteria for Population, Intervention, Control, Outcome, and Study

Population	Faculty in academic medicine with reported h-index.
Intervention	None. Study must report h-index.
Control	N/A
Outcomes	H-index, either as mean or median. Other publication metrics if available, including number of citations, number of publications, m-index.
Study design	Observational studies.

APPENDIX C

	Appendix Table 3. Mean number of publications by academic rank and subspecialty													
			Instructor		Assistant		Associate		Full		Chair			
		N total faculty	Mean publications	n	Mean publications	n	Mean publications	n	Mean publications	n	Mean publications	n	Reference	Year published
Anesthesiology	Cardiothoracic	259	2	8	7	123	30	56	59	63	120	9	[26]	2011
Gastroenterology*		2043	3.25*	136	7.5*	817	31*	470	87.5*	620			[33]	2016
Pediatrics	Gastroenterology	80			5.4	28	34.4	25	109.8	27			[14]	2016
	General	116			4.7	29	30.3	29	85.7	28	111.9	30	[14]	2016
	Nephrology	80			8.7	28	32.1	25	83.9	27			[14]	2016
Radiology		538			17	212	41	128	128	198			[1]	2016
Radiation oncology		986			15.7	465	41.8	251	118.7	195	146.8	75	[28]	2017
Sports medicine		313			21	134	45	88	121	91			[27]	2016
Surgery	General	129			21.3	74	42	55					[19]	2017
Totals (with mean and median values)		4,544		144		1,910		1,127		1,249		114		

APPENDIX D

*Asterisk denotes median values instead of mean values.

	Appendix Table 4. Mean number of citations by academic rank and subspecialty													
			Instructor		Assistant		Associate		Full		Chair			
		N total faculty	Mean citations	n	Mean citations	n	Mean citations	n	Mean citations	n	Mean citations	n	References	Year published
Anesthesiology	Cardiothoracic	259	26	8	117	123	422	56	1,040	63	2,925	9	26	2011
Pediatrics	Gastroenterology	80			78.5	28	505.3	25	2,126	27			14	2016
	General	116			41.4	29	429.3	29	2,097.5	28	3,436.6	30	14	2016
	Nephrology	80			82.3	28	513.8	25	2,073.3	27			14	2016
Psychiatry		1601			258.3	911	756.3	387	2,641.5	303			30	2017
Radiology		538			205	212	687	128	3,622	198			1	2016
Sports medicine		313			321	134	921	88	3,592	91			27	2016
Totals		2,987		8		1,465		738		737		39		

APPENDIX E