



# Publication rates of annual Research Day abstracts in peer-reviewed journals by residents and fellows at a community-based institution – A 10-year review of data and analysis

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## ABSTRACT

**Introduction:** Research and publications are becoming increasingly important for residents who want to match into competitive fellowship training programs and fellows looking to optimize career opportunities. Institutional Research Days provide trainees the opportunity to gain presentation experience and feedback about their studies. We evaluated all abstracts that were presented at Ascension Providence Hospital (APH) during Research Day over a 10-year period to determine publication rates of manuscripts in peer-reviewed journals.

**Methods:** Research abstracts presented by both residents and fellows during Research Days at APH from 2009 to 2018 were reviewed. Abstracts were classified by type of project, type of presentation, trainee, winners and non-winners, and training program. Winners were defined as abstracts which won first, second and third place awards. Publication of manuscripts was evaluated by searching PubMed and Google Scholar. Fisher's Exact test was used to analyze categorical data and Student's *t*-test was used to analyze continuous data;  $p < 0.05$  was considered significant.

**Results:** A total of 491 research and case report abstracts were presented by residents and fellows during Research Day over 10 years. For residents, 346 abstracts were presented; 25% ( $n = 85$ ) were winners. The majority (51%) of winning abstracts were published, but only 26% of non-winning abstracts were published ( $p < 0.0001$ ). More of both winning research oral (65%) and poster abstracts (61%) were published than non-winning oral (41%) and poster abstracts (22%,  $p = 0.02$  and  $p = 0.0001$ , respectively), but publication rates for case reports were similar. The vast majority of published winning oral (88%) and poster abstracts (74%) came from the surgical programs. Fellows presented 145 abstracts; 30% ( $n = 43$ ) were winners. A slightly higher percentage of winning abstracts (42%) were published compared to non-winning abstracts (32%,  $p = 0.3$ ). Unlike the residents, the fellows had no significant publication rate differences between winning and non-winning research oral, research poster or case report abstracts, or between medical and non-medical subspecialties.

**Conclusions:** Despite their award-winning presentations, residents and fellows published less than half of these projects and less than a third of non-award-winning projects. However, most publications came from the surgical specialties, indicating the colleagues in the medical specialties

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were not publishing. Further data are needed to identify factors that can improve a trainee's chances of being published in a peer-reviewed journal.

## 1. Introduction

Annual institutional research meetings provide residents and fellows an excellent opportunity to present their abstracts for review, discussion, debate and suggestions before they send their papers for publication in a peer-reviewed journal. At Ascension Providence Hospital, we invite residents and fellows to present abstracts during the annual Research Day. Research Day has been held at the institution for almost 90 years and provides an excellent opportunity for residents and fellows to present their research work. Residents and fellows are emailed about the annual research meeting in advance and are asked to submit their abstracts to the selection committee. Trainees can submit abstracts for either oral or poster presentation; all the submitted abstracts are then scored by the selection committee, and only the highest scoring abstracts are selected for presentation. Residents and fellows whose abstracts were selected by the selection committee will then present their research work in detail at the annual Research Day in the selected format.

The primary objective of the annual Research Day is to provide constructive feedback on the work of trainees, which in turn can improve their chance of research work getting published or give them new ideas for their ongoing research projects. Currently, data regarding publication rates of completed manuscripts after presentation of abstracts by residents and fellows at annual institutional research meetings are limited. Review of the medical literature showed most of the data regarding publication rates from podium presentation to publication in a peer-reviewed journal are mainly published from specialty-specific annual society meetings with the most common being orthopedic society meetings. Publication rates from these meetings ranged from 36% to 67%, with the majority published within 3 years of presentation [1–3].

The purpose of this study was to evaluate all abstracts that were presented at Ascension Providence Hospital by residents and fellows during the annual Research Day from 2009 to 2018 by determining the publication status of the project.

## 2. Materials and methods

We accessed program booklets for each Research Day from 2009 to 2018 at Ascension Providence Hospital (Southfield, MI). All the accepted oral and poster research presentations, along with case report poster presentations, by both residents and fellows were included in this study. Abstracts were then classified by type of project (research or case report), presentation (oral or poster), trainee (resident or fellow listed as first author), award winning at Research Day (won first, second or third place) and training program specialty, both individually and combined into 2 broad categories of Surgical Specialties and Medical Specialties. Resident training programs combined for the category of "Surgical Specialties" were General Surgery, Neurosurgery, Obstetrics & Gynecology, Orthopedic Surgery and Podiatry; "Medical Specialties" were a combination of Family Medicine, Internal Medicine, Radiology and Transitional Year. Fellow training programs combined for the category of "Surgical Specialties" were Hepato-pancreatico-biliary Surgery and Plastic Surgery; "Medical Specialties" were a combination of Cardiology, Gastroenterology, Hematology/Oncology, Neurology, Pulmonary and Critical Care Medicine and Sports Medicine. The training programs associated with each presentation was based on the training program of the first author, who delivered the presentation for the project.

The author information and title keywords from the presented abstracts were used to search the PubMed database and Google Scholar search engines to identify which abstracts were published in journals. Using PubMed, search strategies involving combinations of last names (with and without first initials) of the first author, second author, penultimate attending/researcher and/or senior attending/researcher author were initially used. For example, using the authors from this publication, "paluru m AND mittal v" would have been the first search followed by "paluru AND mittal v", "paluru AND mittal", "flynn j AND mittal v" and "flynn AND mittal". If further searching was required, searches using any of the four authors described above, starting with last name and initial, were combined with up to 4 different title keywords (e.g., "mittal v AND publication [Ti]" or "mittal v AND abstract [Ti]"). For Google Scholar, we also searched by using combinations of keywords from the abstract's title likely to have been included in the final publication with and without author last names. We started with full titles and progressed from there with combinations of keywords and/or phrases in quotations marks. For example, for this publication "publication rates" "abstracts" and "research day".

To determine winning presentations, the judging panel consisted of experienced physician researchers from Ascension Providence Hospital, with supplementation of judges from our local academic research institutions. Physician judges associated with a training program were excluded from judging oral or poster sessions involving trainees from the same training program. About 3–4 judges were available each year for judging orals and posters. Ten criteria, worth up to 10 points each, were evaluated in the areas of background, methodology, discussion/interpretation and presentation. Paper forms were collected from judges periodically throughout the day. To normalize score totals for each presenter from each judge, scores from each judge were converted into rankings (low to high, with lowest being the best), and the presenters with the lowest average rankings among judges were declared the winners. Once results were tabulated, they were announced at the end of the event.

One author (JCF) made the determination about the publication status of abstract data which were part of larger studies - if the majority of the data from a Research Day abstract was included in a larger publication, the abstract was considered published. Data were then analyzed and compared between residents and fellows, case reports and research projects, award-winning and non-award winning, poster and oral presentations, and surgical and medical specialties.

The research impact of publications was assessed by first identifying the journals in which publications appeared. Journals were

then evaluated by Medline indexing, CiteScore journal rank and Google H-5 index (all freely available). CiteScore metrics from 2018 were used, which covered citations from 2015 to 2018 for 5 peer-reviewed types of documents (articles, book chapters, reviews, and data and conference papers); the value reported was determined by dividing the number of citations by the number of published peer-reviewed documents indexed in Scopus [4]. The Google Scholar H-5 index metrics from 2021 were used, which covered citations from 2017 to 2021 for all articles that were indexed in Google Scholar as of June 2022 (including citations from articles not covered by Scholar Metrics). The individual publications were also evaluated by determining the total number of citations and the number of citations per year from iCite (<https://icite.od.nih.gov>), a freely available public access database (National Institutes of Health Open Citation Collection) [5].

Descriptive statistics were used to were used to characterize some of the categorical variables (i.e., percentages) and continuous variables (mean  $\pm$  standard deviation, range). Fisher's Exact test was used for statistical analysis of categorical data, and Student's *t*-test was used for analysis of continuous data, with  $p < 0.05$  considered significant.

### 3. Results

The baseline characteristics of the 491 abstracts presented during the annual Research Days from 2009 to 2018 are shown in Table 1; of these, 163 abstracts (33%) were published in peer-reviewed journals. When broken down by trainee, 346 of the 491 abstracts (70%) were presented by residents and 145 abstracts (30%) were presented by fellows. For the residents, 85 abstracts (25%) won an award and 261 (75%) did not (Table 2). About half (43/85, 51%) of the award-winning abstracts were published, while only about a quarter (69/261, 26%) of the non-award-winning abstracts were published ( $p < 0.0001$ ). Significant differences between award-winning and non-award-winning abstracts were observed for research oral ( $p = 0.0238$ ) and research poster presentations ( $p = 0.0001$ ) but not for case report presentations ( $p = 0.7578$ ). For the fellows, 43 (30%) won an award and 102 (70%) did not (Table 3). Less than half (18/43, 42%) of the award-winning abstracts were published, while only about a third (33/102, 32%) of the non-award-winning abstracts were published ( $p = 0.3$ ). No differences between award-winning and non-award-winning abstracts were observed for research oral, research poster or case report presentations ( $p = 0.7578$ ).

The data were also analyzed for differences among the training programs when divided broadly into surgical and medical specialties. Significant differences were seen with residents; residents in surgical specialties published 89 out of 190 presentations (47%) compared to residents in medical specialties who published 23 out of 156 presentations (15%,  $p < 0.0001$ , Table 4). However, fellows in surgical specialties did not publish any of their 9 presentations, whereas fellows in medical specialties published 51 out of 136 presentations (38%, Table 5).

To assess the impact of the publications, we first analyzed the journals in which the publications appeared. As shown in Table 6, there was quite a variety in the content of journals in which the residents published their manuscripts, based on titles. Of the 60 journals, 18 (30%) were the destination for 70 publications (63%). Most of the journals (60%) were indexed in Medline. When values were available for the 60 journals, the CiteScores were between 0.0 and 10.3 while the range for Google H-5 indices were between 4 and 92. The journals in which fellows published their work was similarly diverse in content based on titles; of the 29 journals, 13 (45%) accounted for 35 publications (69%, Table 7). Medline indexing (59%), and the range of CiteScores (0.0–8.6) and Google H-5 indices (11–71) were also similar to resident journals. The impact of publications was also evaluated by their citations received (Fig. 1). For both residents' and fellows' publications, the number of total citations and number of citations/year were similar, regardless of the type of Research Day presentation or if the presentation won an award. The only exception were statistically significant differences between winning ( $n = 2$ ) and non-winning ( $n = 4$ ) fellow research posters (Fig. 1).

### 4. Discussion

Research and publications are becoming increasingly important for residents who want to match into a competitive fellowship training program. Most residency training programs do not have mandatory or optional research years. Often residents find it hard to have their research get published even after presenting their work at annual research meetings. Literature review showed most of the data regarding publication rates are from specialty specific annual society meetings with most common being orthopedic society meeting and publication rates range from 36% to 67%, with the majority published within 3 years of presentation.<sup>1</sup> In this study, the publication rate for residents was 33.2%, while award-winning abstracts had a statistically significant higher rate of publication than non-award-winning abstracts. Publication rates from abstracts presented at other society meetings showed a wide range, from 23% to 74% [1–3,6–14].

The publication rate of abstracts presented by fellows was 35%, and there was no statistically significant difference in publication rates between award-winning and non-award-winning abstracts. Award-winning abstracts presented by residents had higher

**Table 1**

Baseline characteristics of abstracts presented by residents and fellows at annual research meeting.

Type of Presentation	Residents N (%)	Fellows N (%)	Total N (%)
Research Oral	122 (66)	63 (34)	185 (100)
Research Poster	117 (76)	37 (24)	154 (100)
Case Report Oral/Poster	107 (70)	45 (30)	152 (100)
Total	346 (70)	145 (30)	491 (100)

**Table 2**  
Resident presentations by winners and publications.

Type of Presentation	Winners			Non-Winners			P-Value
	Published N (%)	Not Published N (%)	Total N (%)	Published N (%)	Not Published N (%)	Total N (%)	
Research Oral	20 (16)	11 (9)	31 (25)	37 (30)	54 (44)	91 (75)	0.0238
Research Poster	19 (16)	12 (10)	31 (26)	19 (16)	67 (57)	86 (74)	0.0001
Case Report Oral/Poster	4 (4)	19 (18)	23 (21)	13 (12)	71 (66)	84 (79)	0.7578
Total	43 (12)	42 (12)	85 (25)	69 (20)	192 (55)	261 (75)	<0.0001

**Table 3**  
Fellow presentations by winners and publications.

Type of Presentation	Winners			Non-Winners			P-Value
	Published N (%)	Not Published N (%)	Total N (%)	Published N (%)	Not Published N (%)	Total N (%)	
Research Oral	10 (16)	8 (13)	18 (29)	18 (29)	27 (43)	45 (71)	0.2789
Research Poster	5 (14)	8 (22)	13 (35)	5 (14)	19 (51)	24 (65)	0.2749
Case Report Oral/Poster	3 (7)	9 (20)	12 (27)	10 (22)	23 (51)	33 (73)	1.0000
Total	18 (12)	25 (17)	43 (30)	33 (23)	69 (48)	102 (70)	0.3414

**Table 4**  
Resident presentations by training program.

Training Program	Winners			Non-Winners		
	Published N (%)	Not Published N (%)	Total N (%)	Published N (%)	Not Published N (%)	Total N (%)
Family Medicine	0 (0)	4 (12)	4 (12)	0 (0)	29 (88)	29 (88)
General Surgery	25 (31)	4 (5)	29 (36)	27 (33)	25 (31)	52 (64)
Internal Medicine	5 (5)	19 (20)	24 (25)	17 (18)	56 (58)	73 (75)
Neurosurgery	5 (16)	6 (19)	11 (35)	10 (32)	10 (32)	20 (65)
Obstetrics & Gynecology	3 (8)	4 (10)	7 (18)	2 (5)	31 (78)	33 (83)
Orthopedic Surgery	5 (16)	2 (6)	7 (22)	12 (38)	13 (41)	25 (78)
Podiatry	0 (0)	0 (0)	0 (0)	0 (0)	6 (100)	6 (100)
Radiology	0 (0)	2 (8)	2 (8)	1 (4)	21 (88)	22 (92)
Transitional Year	0 (0)	1 (50)	1 (50)	0 (0)	1 (50)	1 (50)
Total	43 (12)	42 (12)	85 (25)	69 (20)	192 (55)	261 (75)
Surgical Specialties <sup>a</sup>	38 (20)	16 (8)	54 (28)	51 (27)	85 (45)	136 (72)
Medical Specialties <sup>b</sup>	5 (3)	26 (17)	31 (20)	18 (12)	107 (69)	125 (80)

<sup>a</sup> Training programs combined for the category of "Surgical Specialties" were General Surgery, Neurosurgery, Obstetrics & Gynecology, Orthopedic Surgery and Podiatry.

<sup>b</sup> Training programs combined for the category of "Medical Specialties" were Family Medicine, Internal Medicine, Radiology and Transitional Year.

**Table 5**  
Fellow presentations by training program.

Training Program	Winners			Non-Winners		
	Published N (%)	Not Published N (%)	Total N (%)	Published N (%)	Not Published N (%)	Total N (%)
Cardiology	8 (12)	6 (9)	14 (21)	22 (33)	30 (45)	52 (79)
Gastroenterology	1 (14)	0 (0)	1 (14)	1 (14)	5 (71)	6 (86)
Hepato-pancreatico-biliary Surgery	0 (0)	0 (0)	0 (0)	0 (0)	3 (100)	3 (100)
Hematology/Oncology	2 (13)	4 (25)	6 (38)	0 (0)	10 (63)	10 (63)
Neurotology	7 (22)	8 (25)	15 (47)	8 (25)	9 (28)	17 (53)
Plastic Surgery	0 (0)	3 (50)	3 (50)	0 (0)	3 (50)	3 (50)
Pulmonary and Critical Care Medicine	0 (0)	4 (31)	4 (31)	2 (15)	7 (54)	9 (69)
Sports Medicine	0 (0)	0 (0)	0 (0)	0 (0)	2 (100)	2 (100)
Total	18 (12)	25 (17)	43 (30)	33 (23)	69 (48)	102 (70)
Surgical Specialties <sup>a</sup>	0 (0)	3 (33)	3 (33)	0 (0)	6 (67)	6 (67)
Medical Specialties <sup>b</sup>	18 (13)	22 (16)	40 (29)	33 (24)	63 (46)	96 (71)

<sup>a</sup> Training programs combined for the category of "Surgical Specialties" were Hepato-pancreatico-biliary Surgery and Plastic Surgery.

<sup>b</sup> Training programs combined for the category of "Medical Specialties" were Cardiology, Gastroenterology, Hematology/Oncology, Neurotology, Pulmonary and Critical Care Medicine and Sports Medicine.

**Table 6**  
Medline indexing and rankings of journals in which resident papers were published.

Journal	Number of Publications	Medline Indexed?	CiteScore Journal Rank <sup>a</sup>	Google H-5 Index <sup>b</sup>
American Surgeon	17	Yes	1.0	23
American Journal of Surgery	9	Yes	3.7	44
Journal of Knee Surgery	5	Yes	2.8	36
Journal of Surgical Education	5	Yes	3.5	45
Cureus	4	No	NA	69
Journal of the Society of Laparoscopic Surgeons	4	Yes	2.8	20
Journal of Arthroplasty	3	Yes	5.5	79
Reviews in Cardiovascular Medicine	3	No	1.2	20
Acta Radiologica Open	2	No	NA	15
American Journal of Case Reports	2	Yes	1.1	25
International Journal of Collaborative Research on Internal Medicine & Public Health <sup>c</sup>	2	No	NA	5
International Journal of Surgery	2	Yes	4.6	56
Journal of Clinical Hypertension	2	Yes	3.8	40
Journal of Surgical Research	2	Yes	3.6	44
Journal of the American College of Surgeons	2	Yes	8.3	59
Orthopedics	2	Yes	2.5	28
Surgical Neurology International	2	No	2.0	28
Turkish Neurosurgery	2	Yes	1.4	21
42 journals with only a single publication	42	23 Yes, 19 No	0.0–10.3 <sup>d,e</sup>	4–92

<sup>a</sup> CiteScore metrics are for 2018, which covers citations for 2015–2018. NA, not available. CiteScore 2018 is based on the number of citations received in 2015–2018 to 5 peer-reviewed document types (articles, reviews, conference papers, data papers, and book chapters) by a journal in the same four years, divided by the number peer-reviewed documents indexed in Scopus and published in those same four years.

<sup>b</sup> Google Scholar metrics for the Google H-5 index are for 2021, which covers citations for 2017–2021. Scholar Metrics currently cover articles published between 2017 and 2021, both inclusive. The metrics are based on citations from all articles that were indexed in Google Scholar in June 2022. This also includes citations from articles that are not themselves covered by Scholar Metrics.

<sup>c</sup> Only selected citations are located in PubMed.

<sup>d</sup> CiteScore not available for 2018, so earliest available CiteScore (2020) is included for 2 journals.

<sup>e</sup> CiteScore not available for 2018, so earliest available CiteScore (2021) is included for 1 journal.

**Table 7**  
Medline indexing and rankings of journals in which fellow papers were published.

Journal	Number of Publications	Medline Indexed?	CiteScore Journal Rank <sup>a</sup>	Google H-5 Index <sup>b</sup>
Otology & Neurotology	6	Yes	3.4	39
Pacing and Clinical Electrophysiology	4	Yes	2.5	28
Cardiology Research and Practice <sup>c</sup>	3	No	2.2	20
Journal of Innovations in Cardiac Rhythm Management <sup>c</sup>	3	No	0.2 <sup>d</sup>	11
Therapeutic Advances in Cardiovascular Disease <sup>c</sup>	3	Yes	3.3	17
American Journal of Cardiovascular Disease	2	No	NA	14
American Journal of Case Reports	2	Yes	1.1	25
HeartRhythm Case Reports	2	No	0.6	16
Journal of Cardiovascular Diseases & Diagnosis <sup>c</sup>	2	No	NA	NA
Journal of Interventional Cardiac Electrophysiology	2	Yes	2.7	26
Laryngoscope	2	Yes	4.3	58
Otolaryngology – Head and Neck Surgery	2	Yes	4.3	58
Texas Heart Institute Journal	2	Yes	1.6	18
16 journals with only a single publication	16	9 Yes, 7 No	0.0–8.6	13–71

<sup>a</sup> CiteScore metrics are for 2018, which covers citations for 2015–2018. NA, not available. CiteScore 2018 is based on the number of citations received in 2015–2018 to 5 peer-reviewed document types (articles, reviews, conference papers, data papers, and book chapters) by a journal in the same four years, divided by the number peer-reviewed documents indexed in Scopus and published in those same four years.

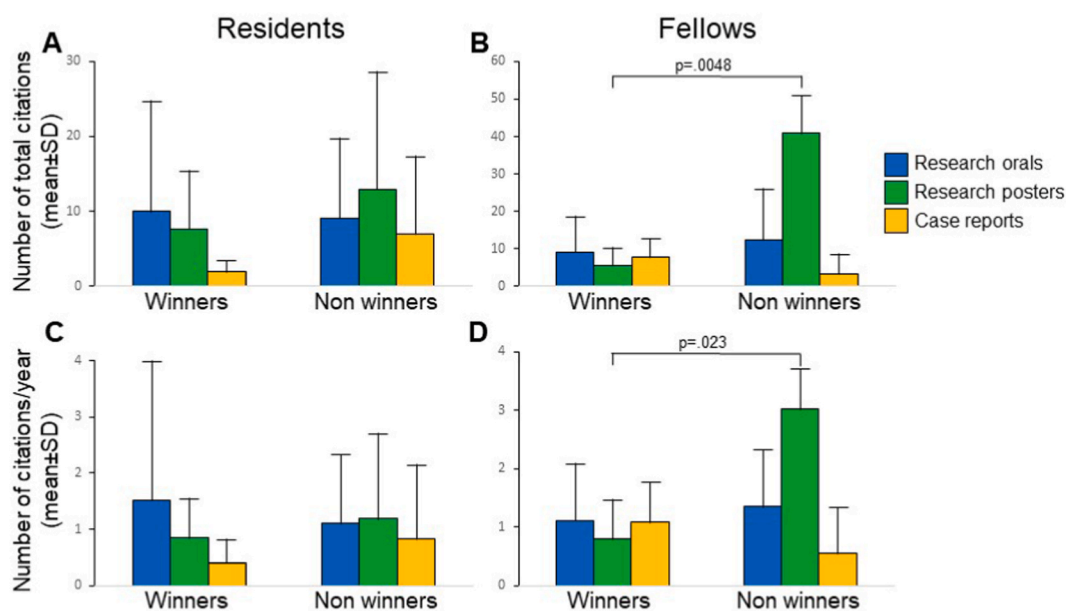
<sup>b</sup> Google Scholar metrics for the Google H-5 index are for 2021, which covers citations for 2017–2021. NA, not available. Scholar Metrics currently cover articles published between 2017 and 2021, both inclusive. The metrics are based on citations from all articles that were indexed in Google Scholar in June 2022. This also includes citations from articles that are not themselves covered by Scholar Metrics.

<sup>c</sup> Only selected citations are located in PubMed.

<sup>d</sup> CiteScore was not available for 2018, so earliest available CiteScore (2020) is shown.

<sup>e</sup> 2 abstracts were part of a single publication.

publication rate (51%) compared to award-winning abstracts presented by fellows (42%). Overall, residents in surgical programs published a higher rate of papers than residents in medicine programs. This could be secondary to surgical residents having more time to publish their data owing to longer years in residency training than their medical colleagues. On the other hand, fellows in medical specialties were able to publish more papers in peer-reviewed journals compared to fellows in surgical specialties. This was likely due



**Fig. 1.** Total number of citations (A, B) and citations/year (C, D) for resident and fellow publications, respectively. Note, the fellow non-winning research posters consisted of only 2 publications, both with a very high number of citations, and thus while statistically significant gives a false impression of the total citations and citations/year for the research poster category. SD, standard deviation.

to a much higher number of fellows in medical fellowship programs (about 15/year) compared to surgical fellowship programs (2–3/year).

Trainees from medical specialties were able to publish their work in journals such as American Journal of Cardiology, Reviews in Cardiovascular Medicine, Journal of Clinical Hypertension, Biomedical Materials & Devices, Gastroenterology Research, American Journal of Cardiovascular Disease, and others. Trainees from surgical specialties published their works in well-known surgical journals like Journal of American College of Surgeons, Journal of Surgical Research, The American Surgeon, Orthopedics, Journal of the Society of Laparoscopic & Robotic Surgeons, Ear, Nose & Throat Journal, American Journal of Surgery, and other journals. Most of these journals were Medline indexed, but some were not.

Publication rates in our study were comparable to a wide range of trainee situations, from the medical theses of French radiology residents [15] to trainees presenting abstracts at annual society meetings [1–3,6–14]. For example, in a study done by Chua et al. [6] on podium presentations done at the American Urological Association annual meeting, 51.9% of abstracts were published within 3 years, and the median time from submission to publication was 12.5 months. Similarly, a study done by Narain et al. [2] on podium and poster presentations at the 2010–2012 North American Spine Society annual meetings showed publication rate of 43.8%. Alternatively, studies done by Bowers et al. [3] on publication rates in podium and poster abstracts for the American Association of Hip and Knee Surgeons annual meeting and Milki et al. [16] on publication of oral and video presentations presented at the Society of Gynecologic Oncology annual meetings showed higher publication rates of 71% and 85.8%, respectively. This higher rate of publications might be attributed to the presence of subspecialty journals where the abstract presentations got published.

## 5. Limitations

Some of the limitations of study were that we might not have found all publications because of changes in authors and/or title keywords. Second, it was especially challenging to find publications if they were not in PubMed, since searches in Google Scholar often identified other scholarly activity (published abstracts, meeting presentations, etc.) or other content that matched the search criteria that had to be sorted through. Third, even though we limited the latest Research Day abstracts analyzed to 2018, it is possible that some of the later abstracts could still get published, which we can't account for at this time. Fourth, the conclusions from these results are limited in their generalizability to other research events and institutions, as these were the results of Research Day for our institution. Finally, training program requirements may not have compelled trainees to write or submit manuscripts, so our publication rates may be on the low end and may not reflect the “true” publication potential of these abstracts.

## 6. Conclusion

From our analysis, residents who had award-winning abstracts at the annual Research Day had a higher rate of publications than non-award-winning abstracts, 51% compared to 26%, respectively ( $p < 0.0001$ ). A similar comparison was not statistically significant in abstracts presented by fellows ( $p = 0.3$ ). Overall residents had a slightly higher rate of publications for winning abstracts 51%



compared to 42% by fellows. Furthermore, multi-institutional data are needed to analyze and identify factors that can improve the likelihood of a resident or fellow's abstract to be published in a peer-reviewed journal.

### Author contribution statement

Madan Mohan Reddy Paluru, MD: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Vijay K Mittal, MD: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Jeffrey C Flynn, PhD: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

### Data availability statement

Data will be made available on request.

### Additional information

No additional information is available for this paper.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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