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Original Research

Impact of co-investigators on pharmacy resident research publication

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Abstract

Objective: To explore influences of co-investigators on the successful publication of a pharmacy residency project.

Methods: We analyzed published and non-published research presented at a regional pharmacy conference. Abstracts were matched 1:1 based on state and abstract year. We assessed university affiliation, number, degree, and H-Index of co-investigators on the abstract. Descriptive and inferential analyses were used to identify variables associated with resident publication.

Results: University-affiliated programs (p=0.015), highest H-Index of a non-physician co-investigator (p=0.002), and positive H-Index (≥1) of a non-physician co-investigator (p=0.017) were significant predictors of resident publication on univariate analyses. There were no differences in the number of co-investigators (p=0.051), projects with physician co-investigators (p=1.000), or projects with Doctor of Philosophy (PhD) or Master of Science (MS) co-investigators (p=0.536) between published and non-published projects. Multivariate analysis found that the highest H-index of non-physician co-investigator remained significant as a predictor to resident publication (odds ratio (OR) 1.09, 95% Confidence Interval (CI) 1.01-1.17).

Conclusions: The quality of co-investigators, as measured by an increasing H-Index, is associated with the successful publication of residency projects. More emphasis may need to be placed on resident research co-investigator selection and training to prepare pharmacy residents for research and scholarly activity.

Keywords

Education, Pharmacy, Graduate; Internship, Nonmedical; Mentors; Publishing; Pharmacy Service, Hospital; Pharmacists; Research; United States

INTRODUCTION

Pharmacists with adequate skills and abilities to conduct translational research are needed in the pharmacy profession[1], but common training pathways may not be adequately preparing pharmacists to meet research and scholarship expectations in practice. The demand for academic and clinical pharmacists has made a Doctor of Pharmacy (PharmD) and 1-2 years of residency training the common training requirement before entering these roles.[2,3] Programs intending to develop competent pharmacist-researchers, such as post PharmD research fellowships or research-related degrees (e.g., Master of Science (MS), Doctor of Philosophy (PhD)), are encouraged but often not required.[4-6]

Pharmacists completing American Society of Health-System Pharmacists (ASHP) accredited pharmacy residencies are required to demonstrate the ability to evaluate practice, review data, and assimilate evidence to improve patient care and/or the medication use system; however, minimum competency standards that are specific to research and scholarship abilities have not been established across the United States (U.S.).[7] It is difficult to compare resident research training outcomes between programs due to the lack of universal standards or expectations. Inadequate research training can have several consequences during and after residency training. Pharmacy residents may not be able to translate research interests into research productivity without minimal research competence. This circumstance negatively impacts residents' abilities to improve healthcare and promote pharmacy services within their institutions through scholarly activity in practice.[8] The mismatch between job expectations and research ability can lead to stress, burnout, and turnover for new practitioners in academic and clinical positions.[9,10] Inexperienced pharmacists serving as research mentors or project preceptors can lead to a perpetual cycle of inadequate research training for pharmacists.[11]

Publication of resident research has been used as a convenient surrogate marker for research training and experience; however, publication rates are less than 16% across the U.S.[12-15] Several barriers to publication of resident projects have previously been identified, including lack of mentorship, poor journal acceptance of resident research, and resident research may not be intended for broad dissemination.[16-18] Nonetheless this subjectively low proportion of residents publishing projects may, in part, suggest inadequate research training and mentorship during residency training. To this point, studies examining improvements in residents' research knowledge, abilities, and attitudes have been mixed.[19-21] This is important because a majority of residency graduates go on to be involved in research along with assisting other learners with research projects.[22]

Mentorship is considered a crucial component of career development in any profession, and pharmacy is no exception. Pharmacy residents may have several individuals contribute to their residency research projects and those

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most involved are likely to be listed as a co-investigator. Working with co-investigators who have a history of scholarly activity may affect the residents' training experience and impact future publications. In this manuscript, we aim to determine the impact of resident research co-investigators on the publication of pharmacy resident research projects.

METHODS

This is a case-control analysis of pharmacy resident research abstracts presented at the Great Lakes Pharmacy Resident Conference (GLPRC). This study was deemed exempt by the St. Louis College of Pharmacy Institutional Review Board, as all data was accessed on the conference website (http://www.glprc.com/).

Outcomes and Covariates

Study investigators previously identified that the resident research publication rate after presentation at the GLPRC in 2003, 2005, and 2007 was 11.4%.[15] Briefly, investigators used a systematic search strategy to determine publication rates, defined as the ratio of resident abstracts with subsequent publication within 5 years of abstract date divided by all abstracts presented at GLPRC.[15] Investigators chose 2007 as the final year of investigation to allow up to 5 years post-presentation for publication and selected odd years to avoid residents being counted twice if participating in two years of residency training. The year 2003 was the earliest year abstracts were available online. Published abstracts did not differentiate postgraduate year 1 or 2 projects or which co-investigator was the lead project mentor. For the current study, all publication positive abstracts were randomly matched 1:1 to publication negative abstracts based on the state the residency was located and abstract year.

We examined several co-investigator characteristics. First, we assessed university-affiliation as it influenced the outcome of publication in our previous study.[15] Second, we looked at the number of co-investigators as this may suggest diversity of mentorship on a research project. Third, we examined the physician co-investigators on the project, as they may have provided access to unique populations, expertise, or research tools such as research coordinators and funding; however, it is uncommon for them to serve as primary mentors to residents. Fourth, we assessed co-investigators with research-related degrees (i.e., PhD, MS). Lastly, we examined the H-Index of co-investigators and the H-index of non-physician co-investigators.

The H-Index is a measure of a researcher's scientific impact based on the number of his or her published works and the number of citations for the published works.[23] H-index was chosen as a measure of research productivity as opposed to the number of publications or the number of first author publications, because H-index is considered a better estimate of research importance, significance, and overall impact.[23] It can be accessed through Scopus®, the database used for this investigation.[24] An H-Index of 1 would indicate that an author has published at least one paper that has been cited in other published works at least once. In our study the H-Index was assessed as a dichotomous variable to assess if a co-investigator with any level of publication success would influence the publication of a residency project. It was also assessed as a continuous variable and in quartiles to identify different levels of co-investigator research and publication experience.

As we could not determine which co-investigator was the pharmacy resident's primary research mentor, all co-investigator variables were weighted equally. All individuals listed with the resident on the GLPRC abstract were considered co-investigators. Degrees of co-investigators (e.g., PharmD, MD, PhD, MS) were confirmed through credentials listed on published works accessed through Scopus®.

Variable Confirmation

Two independent investigators collected variables and used a pre-defined systematic search strategy to identify outcomes and covariates. The number of co-investigators and university affiliation were collected from the GLPRC abstracts. For publication positive abstracts, we used the resident's publication indexed in Scopus® to identify co-investigator H-Index and degrees. For publication negative abstracts, we used the author identification search feature in Scopus® to search for each co-investigator in the following order using 1) last name, 2) last name with first initial, 3) country, and 4) affiliation. If co-investigators were not able to be identified using this procedure, we considered them as PharmD with an H-index of 0. If there was no agreement on the publication result, a consensus was formed between the two investigators, and the result was carried forward for analysis.

Statistical Analysis

Descriptive statistics were used to analyze nominal and continuous data. Chi-square or Fisher's exact and Wilcoxon rank-sum tests, as the H-Index was not normally distributed, were used to compare characteristics in published versus non-published abstracts to compare differences in university-affiliated residencies, median (IQR (interquartile range)) number of co-investigators, physician on project, co-investigator with research-related degree (i.e., PhD, MS), highest H-Index of co-investigators, and H-Index ≥1 for any co-investigator.

Multivariate logistic regression was used to determine variables that predict the publication of a pharmacy residency research project. Multicollinearity, interactions, and outliers were tested and none were identified. We performed univariate analyses and forced variables into a multivariate analysis when the p-value <0.2. Highest H-Index of co-investigators and H-Index ≥1 for any co-investigator were analyzed in two separate multivariate analyses, planned *a priori*, since these may be collinear. H-index was analyzed in quartiles in a *post hoc* analysis. Additionally, it was planned *a priori* to only include non-physician co-investigators H-index as a physician co-investigator often do not serve as primary research mentors to pharmacy residents. Univariate analysis of H-Index including the physician's showed no difference between publication-positive and publication-negative projects (OR 1.0, 95%CI 0.99 1.01); therefore, the physician co-investigator was included as a dichotomous variable in the primary multivariate model. All data was considered two-sided with an alpha of 0.05. All statistical analyses

Table 1. Characteristics from Resident Abstracts			
	Resident research publication (+) (n=76)	**Resident Research publication (-) (n=76)**	**p-value**
Residency Type – n (%)			0.015
University-affiliated residency program	48 (63.2)	33 (43.4)	
Non-university affiliated residency program	28 (36.8)	43 (56.6)	
Number of co-investigators – median (IQR)	2 (2-3)	2 (1-3)	0.051
Physician co-investigator – n (Row %)	16 (21.1)	16 (21.1)	1.000
Co-Investigator with research-related degree* – n (%)	13 (17.1)	16 (21.1)	0.536
Highest non-physician H-Index– median (IQR)	5 (1-11)	2 (0-6)	0.001
H – Index – n (row %)			0.016
0	13 (17.1)	26 (34.2)	
1 or more	63 (82.9)	50 (65.8)	
(+) = positive; (-) = negative; IQR = interquartile range *Doctor of Philosophy (PhD) or Master of Science (MS)			

were performed using IBM-SPSS version 22.0 (IBM Corp., Armonk, NY).

RESULTS

A total of 152 abstracts were reviewed (76 publication positive and 76 publication negative). Abstracts were matched by year (2003, n=42; 2005, n=56; 2007, n=54) and location of residency by state (Illinois, n=36; Indiana, n=8; Kentucky, n=2; Michigan, n=32; Ohio, n=50; Wisconsin, n=24). University-affiliation of the program, number of co-investigators, highest non-physician co-investigator H-Index, and non-physician co-investigator H-Index ≥1 influenced resident research publication success (Table 1).

Based on the univariate analyses, having a physician co-investigator (p=1.000) or co-investigator with a research-related degree (p=0.536) did not meet the threshold to be entered into either multivariate analysis. University-affiliated residency program and number of co-investigators had p-values <0.2 and were entered into both models. H-indexes of the highest non-physician co-investigators as continuous and dichotomous variables were entered into separate models. In the first multivariate analysis, only the highest H-Index of a non-physician co-investigator remained significant with odds ratio (OR) 1.09, 95% confidence interval (CI) 1.01-1.17, whereas university-affiliated residency programs and number of co-investigators were no longer significant (Table 2). In the second multivariate analysis, no variables remained significant including H-Index ≥1 (OR 1.74, 95%CI 0.74-4.07).

When assessed in quartiles, a co-investigator H-Index of 4-7 (OR 3.1, 95%CI 1.2-7.8) and 8 or greater (OR 4.0, 95%CI 1.6-10.3) compared to an H-Index of 0 was statistically significant regarding the rate of resident publication. After this step we entered the H-index of the highest non-physician quartiles into the multivariate analysis, along with university-affiliation and number of co-investigators. In this model, having only co-investigators with an H-Index of 8 or greater compared to an H-Index of 0 was associated with rate of resident publication (OR 2.9, 1.02-8.3).

DISCUSSION

Several factors, when examined separately, appeared to influence pharmacy resident research publication success in this analysis of abstracts from 2003 to 2007. However, in the multivariate analysis only the publication experience of non-physician co-investigators (using the H-Index) remained significantly associated with the publication of a resident project. Based on the multivariate model for each incremental increase in the highest non-physician co-investigator's H-Index (i.e., a resident project with a co-investigator's H-Index of 8 would have 72% increased odds of publication).

These results support the idea that a co-investigator or mentor with an established track record is an important influence for investigators-in-training.[11] Mentorship from seasoned researchers helps ensure that resident projects are feasible to complete during their year of residency to provide them a thorough research experience. Utilizing a mentor can help residents understand and incorporate appropriate study designs and statistical analyses to improve knowledge and abilities. It is the investigators' opinion that most pharmacy resident primary research mentors are pharmacists. Our results show physician co-investigator's previous publication successes did not influence resident publications.

A 2006 systematic review by Sambunjak and colleagues[25] highlighted results from 21 studies investigating the impact of mentorship on research productivity in medical education. Mentorship led to increased feelings of confidence and support, mentees were more likely to allocate time to research activities, and having mentorship led to higher research productivity. Mentors were identified as a motivating factor in pursuing research traineeship or research-focused careers, and residents with mentors were more likely to serve as mentors themselves in the future. Lack of mentorship was identified as a specific barrier to completing scholarly projects and publications.[25] Residency programs may consider offering mentor development opportunities or protected time to allow staff to provide mentorship to residents.

Many U.S. residency programs have embedded longitudinal, structured research programs to improve resident research training. We could not identify which residencies offered such programs at time of abstract presentation. Content and organization of these programs

Table 2. Multivariate analysis of residency publication success – incorporating highest non-physician H-Index	
	OR (95%CI)
University-affiliated residency program	1.75 (0.88-3.50)
Number of co-investigators	1.11 (0.84-1.47)
Highest (non-physician) H-Index	1.09 (1.01-1.17)
OR = odds ratio; CI = confidence interval	

vary from one residency to the next, but often include supplemental research curricula, mentor selection assistance, mentor development, or advisory board to screen and oversee residency projects.[26-29] Some residencies partner with nearby or affiliated programs to improve collaboration and share resources. National research education programs are also being developed.[30] Uniform standards have not been developed to ensure that minimal requirements are being provided to pharmacy residents within these programs. The importance of uniform standards is highlighted by the few studies that have attempted to objectively evaluate pharmacy residents' research knowledge and abilities after the completion of pharmacy residency training programs.[19-22]

Studies show a resident's research confidence and self-reported abilities may improve after completing a pharmacy residency, but his or her objective research knowledge and skills show little to no improvement.[19-22] Billups and colleagues compared resident research knowledge, confidence, and attitude after completing a structured research program focused on research education and mentor support to a non-randomized national control group.[21] Residents in the intervention group reported a 48% increase in research confidence scores compared to a 15% improvement in the control group ($p<0.001$); however, improvements in research knowledge did not differ significantly (absolute score improvement 11.8% vs. 11.3%, $p=0.935$) between these groups.[21] More research is needed to assess whether residency-trained pharmacists have functional research skills to meet the demands for research and research mentorship in their post-residency positions.

University-affiliation has previously been found to influence resident publication success.[15] This may be explained in part by the co-investigator publication record based on H-Index, as many researchers with a high H-Index may be affiliated with universities. Residents with research or scholarship interest may inherently be more motivated to publish and select a university-affiliated residency programs which may have more established research mentors and research resources. We were unable to incorporate all potential variables that may influence publication due to the low number of publications and risk of over-fitting the model. Previous research using these data also found research designs that may be more feasible to complete in one year (cross-sectional, survey, and retrospective studies) to be associated with greater publication success.[15] We could not identify which residents were first or second year residents. The latter may have more research experience, history of mentorship, and complete a study with a focus more suitable for publication.

There are additional limitations to our study. Matching on year and state reduced bias from large differences in program representation from year to year; however, other program characteristics could not be incorporated such as a program's access to institutional review boards and other research resources. We used a historic cohort of resident abstracts from the Midwest region of the U.S. While this may limit generalizability, we were able to capture publications that occurred 5 years after residency to avoid underreporting; this remains one of the most current cohorts of resident publication rate to date. Using two independent researchers, a pre-determined search strategy, and multiple databases increased our confidence in these data; however, we are limited to variables that are available in the databases being searched. H-index was used to assess both quantity and value of published works. While there are other metrics available to measure research and scholarly output, the H-index was readily available and widely recognized. Finally, we were unable to explicitly identify the research mentor for each pharmacy resident research project, as it was not described in the abstract; therefore, we assessed all co-investigators.

There are also many strengths to our paper. We confirmed a correlation with high-quality research co-investigator, potentially the research mentor, and publication success. Many studies have suggested that mentorship is a contributing factor for various successes including publication.[25] Our results may also suggest that a pharmacy resident should seek a well-published co-investigator if he or she has the goal to publish. Additionally, institutions with pharmacy residency programs should recruit and/or help develop pharmacists with research experience and interest to create more effective research mentors for future pharmacists.

Larger studies should be performed to prospectively assess factors influencing the success of resident research training, as it cannot be fully assessed retrospectively. Success is defined beyond publication rate and may include pharmacy residents' research interests, abilities, comfort levels, and productivity as they progress through residency training and beyond.

CONCLUSIONS

Based on our findings, there is a 9% increase odds in resident publication for each incremental increase in the highest non-physician co-investigators' H-Index. However, in our *post hoc* analyses, having a non-physician co-investigator with an H-Index of 8 or greater is associated with the publication of residency projects. More emphasis may need to be placed on resident research co-investigator selection to continue preparing pharmacy residents for research and scholarly activity.

CONFLICT OF INTEREST

None declared.

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