Research Productivity of Residents and Surgeons With Formal Research Training

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OBJECTIVE: The spectrum of the surgeon-scientist ranges from a clinician who participates in the occasional research collaboration to the predominantly academic scientist with no involvement in clinical work. Training surgeon-scientists can involve resource-intense and lengthy training programs, including Masters and PhD degrees. Despite high enrollment rates in such programs, limited data exist regarding their outcome. The aim of the study was to investigate the scientific productivity of general surgeons who completed Masters or PhD graduate training compared with those who completed clinical residency training only.

DESIGN: A retrospective cohort study of graduates of general surgery residency was conducted over 2 decades. Data regarding graduation year, dedicated research training type, as well as publication volume, authorship role, and publication impact of surgeons during and after training, were analyzed.

SETTING: The study was conducted in 2 general surgery residency training programs in Canada (University of Alberta and University of Toronto).

PARTICIPANTS: A cohort of 323 surgeons who completed general surgery residency between 1998 and 2012.

RESULTS: Overall, 25% of surgeons obtained graduate-level research degrees. Surgeons with graduate degrees were proportionately more likely to participate in research publications both during training (100% of PhD, 82% of Masters, and 38% of clinical-only graduates, $p < 0.05$) and after training (91% of PhD, 81% of Masters, and 44% of clinical-only graduates, $p < 0.05$). Among surgeons involved in publication, the individual publication volume and impact of publication were highest among those with PhD degrees, as compared with clinical-only or Masters training.

CONCLUSIONS: The volume and impact of research publication of PhD-trained surgeon-scientists are significantly higher than those having clinical-only and Masters training. The additional 1 or 2 years of training to obtain a PhD over a Masters degree significantly nurtures trainees to hone research skills within a supervised environment and should be encouraged for research-inclined residents. (J Surg 71:865-870. © 2014 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: research, general surgery, residency, education, surgeon-scientist

COMPETENCIES: Practice-Based Learning and Improvement, Systems-Based Practice, Professionalism

INTRODUCTION

Physicians with an interest in applied research can provide a conduit for accelerated translation of basic science to clinical practice. The spectrum of the modern surgeon-scientist ranges from a clinician who participates in the occasional research collaboration to the predominantly academic scientist with no involvement in clinical care delivery. General surgeons self-report spending an average of 1.2 hours/wk dedicated toward research activities.[1] The training of surgeons over the last century has largely followed in the clinical training model proposed by Halsted in the 1890s at Johns Hopkins University. Although many surgeons conduct either basic or clinical research without supplemental research training, some have chosen to expand their training with graduate research degrees. In the United States, 36% of surgical residents interrupt their training to pursue formal research training.[2] This does not include residents with previous graduate degrees though MD/PhD programs such

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as the National Institutes of Health (NIH) Medical Scientist Training Program which supports 932 students in 43 centers.[3]

Beginning in the 1980s, the "demise" of the clinician-scientist was an emerging theme in the medical education literature.[4-8] Data extracted from the NIH granting programs drove this concern based on 2 observations. Firstly, physicians who participate in research are aging. Secondly, although the number of PhD-trained scientists applying for NIH grants was increasing every year, the number of physicians (either MD or MD/PhD trained) remained stagnant.[9] These findings prompted focus on formalized clinician-scientist (or surgeon-scientist) training programs.[10-14] Research training opportunities for postgraduate clinical trainees currently range from informal research involvements during nonclinical duty hours to dedicated graduate-level (Masters or PhD) commitments requiring 1 or more additional years of training. Specifically in Canada, the Royal College of Physicians and Surgeons of Canada (RCPSC) accredited the Clinician Investigator Program since 1995. The RCPSC identifies that "the major goal of the Clinician Investigator Program is to assist in the career development of clinician investigators in Canada by providing a minimum of 2 years of structured, rigorous research training in addition to existing specialty requirements."[15]

Despite ongoing interest in alternate training paths for surgical trainees in pursuit of research education, comprehensive data are lacking on long-term outcomes of formalized graduate-level research training upon academic productivity, publication record, or motivation to continue research pursuits after completion of surgical training.[16] As enrollment in formalized surgeon-scientist training program continues, trainees, program directors, educational institutions, granting agencies, and hospitals would benefit from assessment of objective outcomes of these programs.

We sought to clarify research productivity of surgeon-scientist training program graduates and compare research publication in peer-reviewed journals between residents and surgeons completing clinical-only training to those obtaining a Masters or PhD degree.

METHODS

Study Design

A retrospective cohort study was conducted using the roster of graduates from 2 large general surgery residency programs in Canada (University of Alberta and University of Toronto).

Trainee name, graduation year, and degree program (clinical-only or clinical plus Masters or PhD degree) were obtained from the division of general surgery at both universities. A small fraction of general surgery residents that transferred to other training programs or did not graduate were excluded from analysis owing to limitations in data tracking.

Research Productivity

Publications of each graduate were determined by searching author's name on the literature database Scopus (http://www.scopus.com). Scopus was chosen as it provides access to all peer-reviewed publications within a serial publication that has a registered International Standard Serial Number and includes a MEDLINE search via the PubMed platform. This database was chosen based on provision of the most comprehensive search and highest fidelity of extractable data.

Year of each publication was compared with the year of completion of residency and graduate training, and it was defined as an in-training publication if published before completion of training, else it was defined as a posttraining publication.

In addition to the number of publications and the year of publication attributed to each graduate, an *h*-index was calculated for each and used as a marker of impact. As defined originally by Hirsch, "A scientist has index h if h of the Np [number of] papers have at least h citations each, and other (Np $-$ h) papers have no more than h citations each."[17] *h*-Index for each graduate was obtained from Scopus.

Highest Level of Graduate Research Training

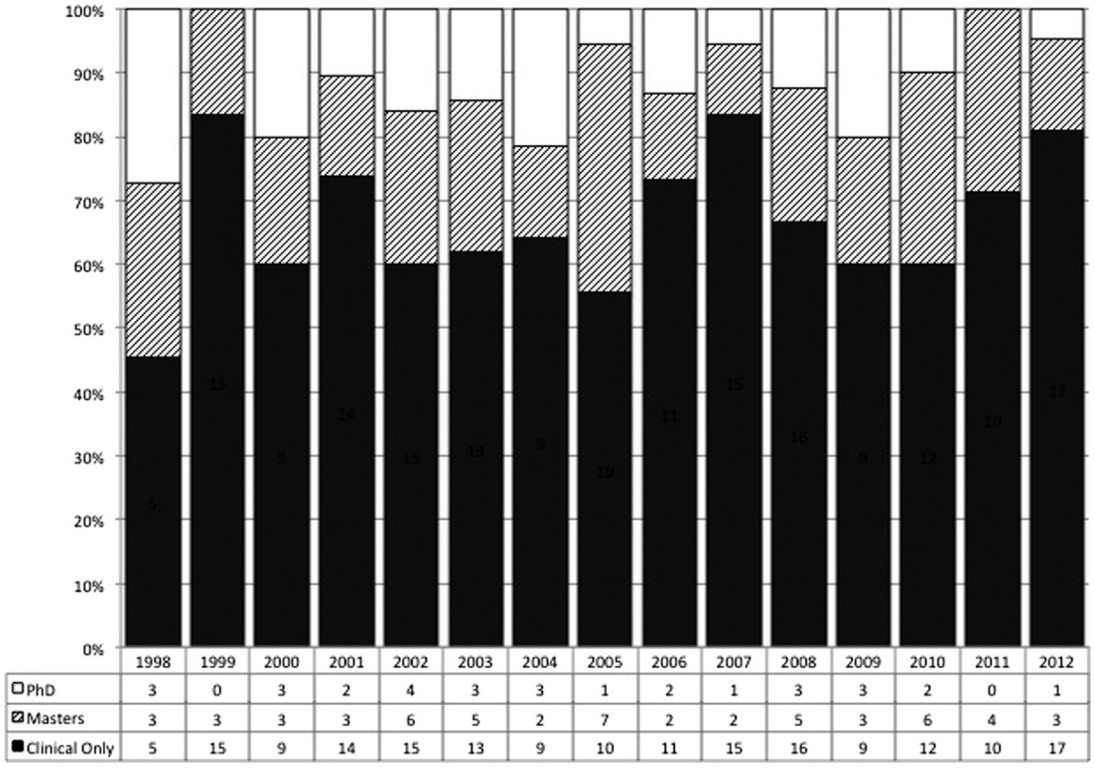
As research training can occur interlaced with clinical training at several stages of clinical education, the highest level of graduate research training (Masters or PhD) was identified for each trainee through corroboration of data obtained from the residency training program and from self-declared designations listed in peer-reviewed publications or professional websites for each individual.

Statistical Analysis

Statistical comparisons were made using the nonparametric Kruskal-Wallis test followed by the post hoc pairwise Mann-Whitney U test with Bonferroni correction for continuous and ordinal outcomes. The Pearson chi-square test was used for categorical outcomes. The data were tabulated using Microsoft Excel 2011 (Microsoft Corp.) and statistical analysis was conducted using SPSS Statistics 17.0 (SPSS Inc.).

Ethics

The health research ethics review board at both the University of Alberta and the University of Toronto reviewed and approved this research.



	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
PhD	3	0	3	2	4	3	3	1	2	1	3	3	2	0	1
Masters	3	3	3	3	6	5	2	7	2	2	5	3	6	4	3
Clinical Only	5	15	9	14	15	13	9	10	11	15	16	9	12	10	17

FIGURE 1. Graduates of clinical-only or combined clinical plus Masters or PhD surgery residency training per year.

RESULTS

Participant Demographics

Between 1988 and 2012, a total of 323 surgical residents graduated from either of the 2 institutions. Accurate records of residents were obtained from 1998 to 2012 in Toronto ($n = 167$) and 1988 to 2012 in Edmonton ($n = 156$).

During the 15 overlapping years that data from both training institutions were available (1998-2012), an average of 17.9 residents graduated annually (range: 14-25), with 3 to 17 residents graduating per year from each institution. In the 15-year period studied, 25.4% of graduates additionally completed dedicated research training (Fig. 1). Each resident's highest level of graduate research training (Masters or PhD) was used for stratification for subsequent analysis.

In-Training and Posttraining Research Publication Rates and Volume

Most residents participated in research publication during training (54%, Table). Surgeons who obtained graduate

TABLE. Surgeons Involved in Research Publication During Training and Career by Training Category

	In Training,* % (*n*)	Posttraining,* % (*n*)	Any Time,* % (*n*)
Clinical-only trainee	$n = 218$	$n = 201$	$n = 218$
Any authorship role	38.1% (83)	44.3% (89)	57.8% (126)
Principal author	27.1% (59)	26.4% (53)	38.1% (83)
Senior author	5% (11)	14.9% (30)	18.3% (40)
Masters trainee	$n = 72$	$n = 69$	$n = 72$
Any authorship role	81.9% (59)	81.2% (56)	97.2% (70)
Principal author	58.3% (42)	56.5% (39)	76.5% (55)
Senior author	19.4% (14)	37.7% (26)	43.1% (31)
PhD trainee	$n = 33$	$n = 32$	$n = 33$
Any authorship role	100% (33)	90.6% (29)	100% (33)
Principal author	100% (33)	71.9% (23)	100% (33)
Senior author	12.1% (4)	46.9% (15)	51.5% (17)
Total	$n = 323$	$n = 302$	$n = 323$
Any authorship role	54.2% (175)	57.6% (174)	70.9% (229)
Principal author	41.5% (134)	38.1% (115)	52.9% (171)
Senior author	9% (29)	23.5% (71)	27.2% (88)

*$p < 0.05$ Between training strata for any publication.

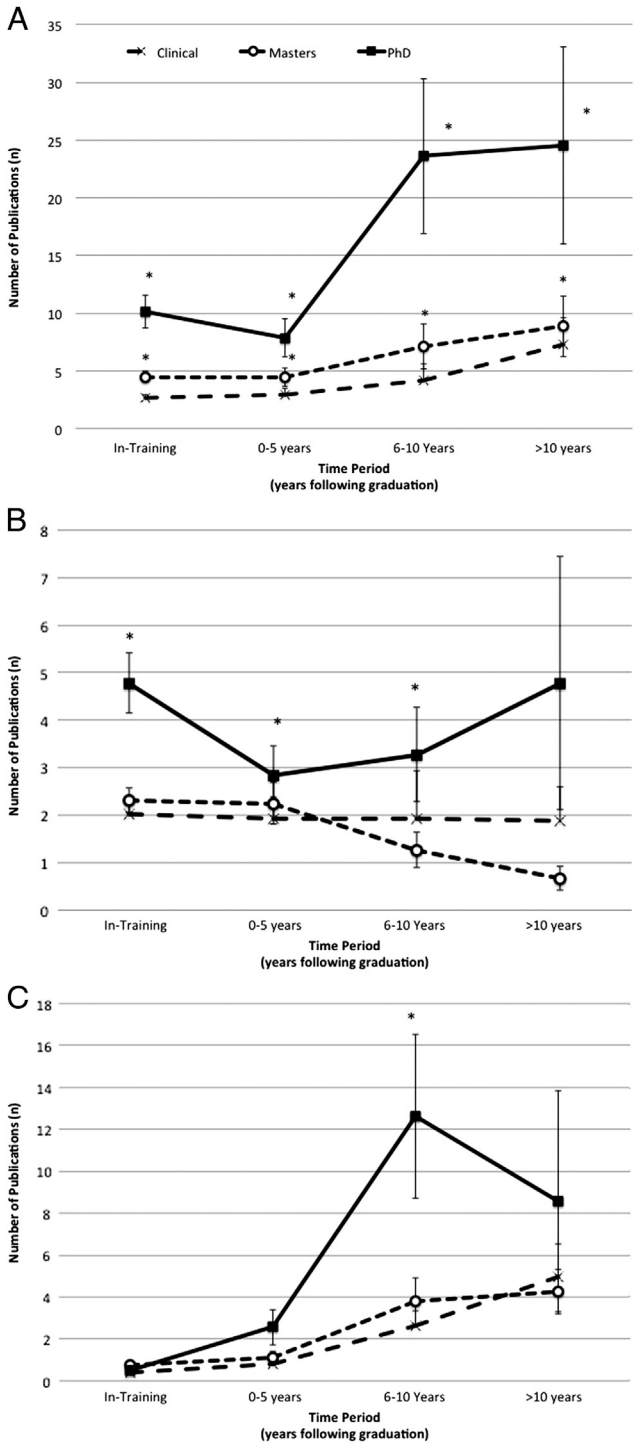


FIGURE 2. Number of publications per surgeon during training and after <5, 6 to 10, and 10 years of graduation by training category (of surgeons involved in research publication): (A) all publications, (B) principal author publications, and (C) senior author publications. *$p < 0.05$ Relative to clinical-only trainees.

degrees had higher proportions of those who published during training, Masters 82% and PhD 100%, compared with only 38% of those without any additional degree ($p < 0.05$). Furthermore, graduate degree–trained surgeons were more frequently involved in research publication after completing the surgical residency compared with their clinical-only trained colleagues (Table). The Table also shows the number of surgeons who have published at least once at any time during their career, which is either during training or after training.

Of those trainees or surgeons involved in research publication, individual publication volume was highest among those who were PhD trained (Fig. 2A). Masters-trained surgeons had a higher volume of publications compared with clinical-only trained surgeons (Fig. 2A). PhD-trained surgeons had a higher number of principal (first) author of publications (Fig. 2B) and senior (last) author of publications (Fig. 2C) compared with clinical-only trainees, a difference that was not observed in Masters-trained surgeon-scientists.

Impact of Research Publication

As publication volume alone may not accurately reflect the impact of research, the *h*-index, a more meaningful measure of impact of cumulative research publication, was examined in this cohort (Fig. 3). Because an *h*-index can only be assigned to authors of at least 1 publication, the analysis was limited to graduates participating in research publication. Graduates with formalized research training had statistically higher *h*-indices when compared with clinical-only trainees who published their research.

DISCUSSION

Surgeon-scientists can serve as vital conduits between scientific research and clinical health care delivery. The productivity of these individuals in both clinical and

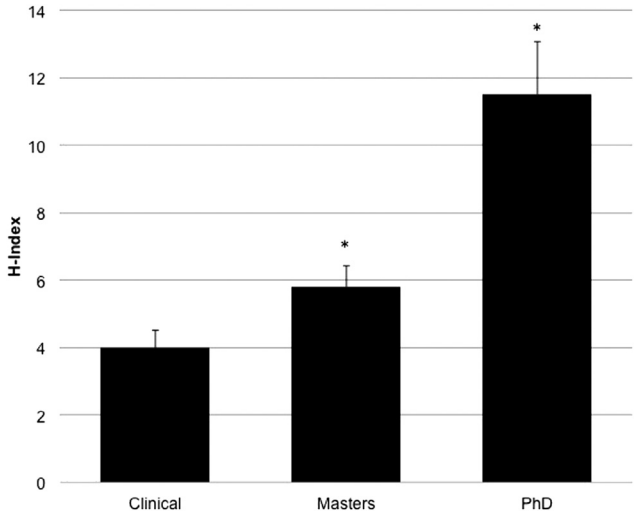


FIGURE 3. *h*-Index of surgeons by trainee category (of those involved in publication at any time during training or career). *$p < 0.01$.

research domains is a marker of success of dedicated and resource-intense combination training programs.

This study indeed confirms that more than half of residents are involved in research publication at the 2 largest general surgical training programs in Canada. Trainees who achieved graduate degrees published more frequently during training and maintained higher publication volumes following graduation than clinical-only surgical trainees. The impact of research performed by PhD-trained surgeons was highest among all training strata. More than half (58%) of clinical-only trained surgeons participated in research and published their findings during their training and career. Conversely, 19% of Masters- and 10% of PhD-trained surgeons did not remain productive in research following graduation.

As neither publication volume nor *h*-index reflect the contribution of a particular coauthor to a given research endeavor, the role of surgeon-scientists as principal or senior authors of publications was used as a surrogate measure of scientific contribution. As anticipated, those residents who had dedicated research training were more often involved in these roles.

The nadir of publication volume described during the 5 years following the graduation of PhD-trained surgeons may reflect the time needed to establish independent research programs. This period necessitates establishment of funding, laboratory and research personnel or both, model generation, and data acquisition before the generation of publishable research results. This observation identifies an ongoing opportunity for critical supportive strategies for junior faculty members.[18]

The 2 institutions studied here have a strong focus on research and academia. Both have dedicated seminars and mandated in-training research participation for all trainees as per accreditation standards of the RCPSC. As a result, it is likely that even clinical-only trainees are exposed research support and an environment that fosters inquiry.

As most clinical-only trained surgeons did not participate in research publication, we limited our analysis of research publication volumes and impact to only those individuals involved in research publication. This strategy was chosen so as not to underestimate the research productivity of clinical-only trained surgeons who participate in research.

The search strategies employed in this study did not capture research activities published in non–peer-reviewed journals, conference proceedings, or gray literature, nor did it capture involvement in all team-based research or grants and are limitations of our study. Additionally, the present method was limited to research activities and did not account for the scientific merit of academic work, including the delivery of education, seminars, and administrative duties carried out by surgeons.

The present findings clearly demonstrate a strong association between research training and productivity, but they do not fully imply causality. Indeed, residents that self-select for PhD programs may be intrinsically more motivated to be academically productive. Dedicated research training fosters a preexisting trainee interest in research.

CONCLUSION

We believe that the additional 1 or 2 years of training to obtain a PhD over a Masters degree significantly nurtures trainees to hone research skills within a supervised environment and should be encouraged for research-inclined residents.

The present findings both illustrate the positive outcomes of combined clinical research training programs and highlight opportunity for improvement in academic productivity of surgeons undergoing formal research training. More than a quarter of PhD-trained surgeon-scientists do not publish as first authors and only half publish as senior authors following training. Elucidating factors influencing interest, productivity, support, and motivation of graduates of clinical investigator training programs could lead to improved academic productivity of these individuals and more appropriate selection of future applicants.

Although the clinician-scientist was waning in the 1980s,[4-7] the academic productivity of the surgeon-scientist remains strong based on the current data, with formal training programs for surgeon-scientists equipping trainees with tools to deliver meaningful impact in research and scientific discovery.

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