

Extracurricular scientific production among medical students has increased in the past decade

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ABSTRACT

INTRODUCTION: Undergraduate research among medical students is essential in the education of future physicians and scientists. This study aimed to evaluate the scientific yield of extracurricular undergraduate research among medical students.

METHODS: Medical students at the University of Copenhagen who completed an extracurricular research year between January 2004 and June 2013 were evaluated through a manual search in PubMed MEDLINE. The primary focus was the number of peer-reviewed, published articles.

RESULTS: Of the 363 included students, 3.1% did their research in 2004-2005 compared with 46.5% in 2012-2013. After three years, 70.4% of the students had published a peer-reviewed article; and of all the 363 students, 36.5% had published as a first author. In total, 87.7% had a medical specialty as their research area versus a surgical specialty. Most students were involved in cardiology (14.1%). Cardiology was also associated with the greatest scientific yield with a median number of 0.8 publications per year after the students concluded their undergraduate research period. Three or more years after concluding their undergraduate research, 32.8% of the students had continued with research in the context of a PhD programme.

CONCLUSION: Overall, the number of medical students who engage in extracurricular research follows an increasing trend, and more than two-thirds of these students publish a peer-reviewed paper within three years. Cardiology was the most popular specialty and also the specialty with the greatest scientific yield. A third of the undergraduate research students continued doing research in the context of a PhD programme.

FUNDING: none.

TRIAL REGISTRATION: not relevant.

Research is an essential factor in the evolution and improvement of quality in patient care. Early initiation of research activities among medical students could potentiate the scientific yield. Furthermore, medical students who engage in research early on may use the experiences as a stepping stone to continue their career in research [1]. Publishing papers as a medical student is associated with a higher rate of publication after graduation [2]. Hence, early motivation for research and recruitment of bright minds can change patient care and help drive the

field of medicine forward. Such efforts vary substantially from one institution to the next, and the scientific yield of undergraduate research has yet to be examined. Another advantage of student research is that when trained researchers collaborate with inexperienced medical students, they are motivated to evaluate their own research effectiveness and teamwork [3]. This may have a positive impact on research productivity not only for the student, but also for the mentor. Finally, undergraduate research prepares students for their future work as physicians. During a research project, students develop essential skills in organisation, teamwork, leadership and critical assessment; skills that do not only improve clinical research, but treatment of patients in general [4]. To evaluate the scientific yield of undergraduate research, we investigated whether the interest in research has been increasing, how many students publish their undergraduate research work, and how many of the undergraduate researchers continue their scientific work in the context of a PhD programme. For these objectives, we used data from the University of Copenhagen, Denmark.

METHODS

Data sources and study population

We evaluated all medical students at the University of Copenhagen who completed a research year between January 2004 and June 2013. Data from June to December 2013 were also available, although these only contained information about enrolment. Medical students at the University of Copenhagen can enrol at the Graduate School of Health and Medical Sciences to initiate an extracurricular research year. All enrolled students are registered in a central registry. The Graduate School of Health and Medical Sciences at the University of Copenhagen gave the authors permission to investigate the registry of enrolled undergraduate research students from 2004 to 2013. We also registered the number of students who joined the student association for medical research at the University of Copenhagen, The Society of Young Researchers at The Faculty of Health, in the 2009-2013 period.

Study design

Retrospectively, the scientific yield of undergraduate research was investigated. The registry holds information

ORIGINAL ARTICLE

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Dan Med J
2015;62(9):A5133

TABLE 1

Baseline demographic data of the included undergraduate research students.

<i>General</i>	
Total population, N	363
Female gender, %	60.5
Age, yrs, median (IQR)	25.9 (24.3-27.1)
Time studied ^a , yrs, median (IQR)	4.5 (4.0-5.5)
<i>Year of completed undergraduate research, %</i>	
2004-2005	3.1
2006-2007	8.2
2008-2009	17.2
2010-2011	25.1
2012-2013	46.5
<i>Undergraduate research specialty, %</i>	
Medicine	87.6
Surgery	12.4
<i>Most frequent specialties, %</i>	
Cardiology	14.1
Endocrinology	10.5
Infectious diseases	9.1
Psychiatry	7.2
<i>Major scientific category, %</i>	
Basic science	31.8
Clinical science	43.8
Population science	24.4
Duration of undergraduate research, months, median (IQR)	12 (6-12)

IQR = interquartile range.

a) Full length 6 yrs.

about: name of enrolled student, date of birth, date of initiation of project and date of termination, name of supervisor, location of investigation and project title (46.0% of the students' project titles were not described). A manual search in PubMed MEDLINE was made for each student to document the scientific yield. An article was identified as the result of an undergraduate research year by reference to the name of supervisor, project title and dates. If a search returned several authors, the author from the registry was further determined by reference to the project title, date of birth, and initiation date of the project as well as the name of the supervisor and the location of investigation. All published papers from each author were registered. The files were then automatically post-processed and a final dataset was produced so that further statistical analysis could be performed. Articles were categorised into clinical research, epidemiology or basic science and further subcategorised according to specialty.

Primary outcome

The primary focus was the number of peer-reviewed published articles, assessed one, two, and three years after the students had concluded their research year.

TABLE 2

Research productivity among medical students enrolled in an extracurricular research programme (N = 363).

<i>Undergraduate research students with publications^a and with available follow-up, %</i>	
1 yr	23.7
2 yrs	38.6
3 yrs	70.4
Publications, total n, median (IQR)	1 (0-3)
<i>Undergraduate research students with available follow-up who publish a first-author paper at any time, %</i>	
Publications per year after undergraduate research graduation, total n, median (IQR)	0.4 (0-0.8)
<i>Publications per post-undergraduate research year, most frequent specialties, n, median (IQR)</i>	
Cardiology	0.8 (0.8-0.8)
Endocrinology	0.2 (0.0-0.6)
Infectious diseases	0.7 (0.3-1.3)
Psychiatry	0.5 (0.1-0.7)
<i>Students with available follow-up who continue with a PhD after undergraduate research graduation, %</i>	
Within 1 yr	1.4
Within 2 yrs	6.4
Within 3 yrs	15.0
After 3 yrs	32.8
Time from undergraduate research graduation to PhD start, yrs, median (IQR)	2.8 (1.8-4.1)

IQR = interquartile range.

a) Calculated in years after completed undergraduate research period; a total of 351 students had available follow-up for 1 yr, 233 had for 2 yrs, and 152 for 3 yrs.

Statistics

Continuous variables were calculated as median and interquartile range (IQR), and proportions were presented as percentages (%). We analysed time-to-first-publication using the Kaplan-Meier estimator illustrated by a plot. We tested differences using the log-rank test for gender (men versus women) and age (age groups). A p-value of less than 0.05 was considered significant. All analyses were performed using the SAS statistical software (Chapel Hill, NC, USA).

Trial registration: not relevant.

RESULTS

A total of 378 students were registered as extracurricular research year students at the Graduate School of Health and Medical Sciences, University of Copenhagen between January 2004 and June 2013. A total of 15 students were excluded for the following reasons: studied at a different faculty (n = 13) and insufficient data (n = 2). A total of 363 medical students had available follow-up; all 363 students were included in the study. The median age of the included students was 25.9 years and 60.5% were women (Table 1).

Overall, the number of students enrolled in an undergraduate research year increased annually in the period from 2004-2013, as did the interest in the voluntary association The Society of Young Researchers at The Faculty of Health (**Figure 1**). The share of all enrolled medical students at the University of Copenhagen who enrolled for an undergraduate research year increased from less than 1% in 2004 to 5.4% in 2013. With regard to major scientific research area, clinical science attracted more students with a total of 43.8%, followed by basic science with 31.8% (Table 1).

Scientific yield among students

The undergraduate research period had a median duration of 12 months, while the median number of total publications was one (IQR: 0-3). It was found that one year after ending the research period, 23.7% of the students had published a peer-reviewed article that was accessible in MEDLINE, and this share increased to 38.6% after two years and further to 70.4% after three years (**Table 2** and **Figure 2**). 36.5% of the students with available follow-up had published as a first author. Neither sex nor time to graduation was associated with a greater scientific yield.

A total of 1.4% initiated a PhD within the first year after concluding the undergraduate research period. After more than three years, 32.8% had continued conducting research in the context of a PhD programme (Table 2). The median time from research year graduation to PhD initiation was 2.8 years (IQR: 1.8-4.1).

Scientific yield among specialties

The majority of the students conducted their research in a medical specialty; a total of 87.7% had a medical specialty as their research area versus a surgical specialty. We found that cardiology was the most popular specialty with 14.1% of the students doing undergraduate research in this field (Table 1). Cardiology was also the most productive specialty with a median of 0.8 publications per year after the student concluded the research year (Table 2). The most productive student did research in psychiatry and had a scientific yield of 16.3 publications per year, followed by a student from cardiology with 11.8 publications per year.

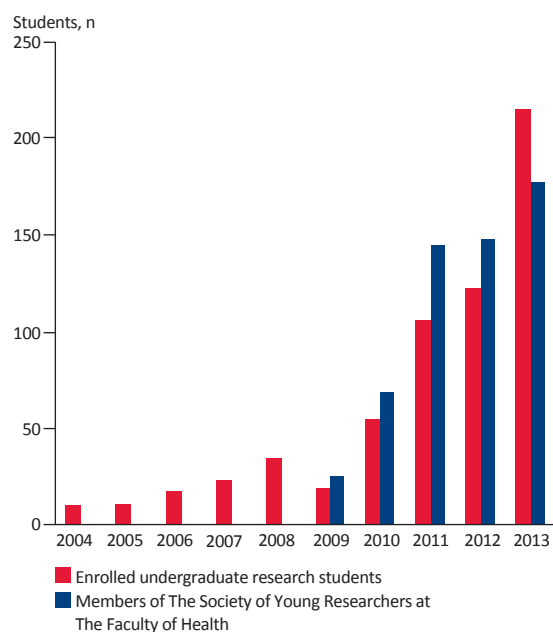
DISCUSSION

The scientific yield of extracurricular undergraduate research was investigated retrospectively using a manual search in PubMed MEDLINE. This resulted in four main findings. First of all, we found that an increasing number of medical students completed an undergraduate research year as the study period progressed. Next, it was shown that 70.4% of the students had published a peer-reviewed article within three years. Thirdly, cardiology

was associated with the greatest scientific yield and, lastly, three or more years after concluding their undergraduate research period, 32.8% of the students had

FIGURE 1

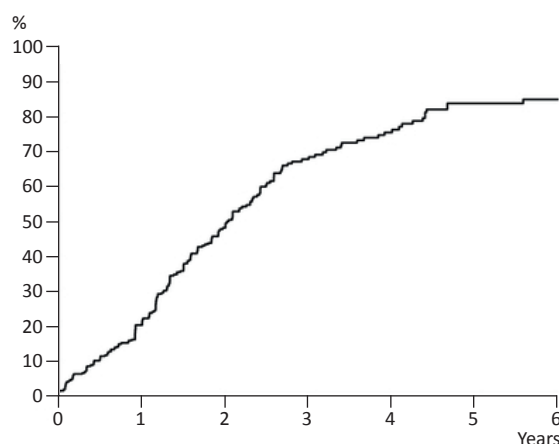
Number of students per year enrolled in an undergraduate research and members of the voluntary association The Society of Young Researchers at The Faculty of Health in the 2004-2013 period. Only medical students who completed the undergraduate research year are depicted^a.



a) 2012 and 2013: numbers also include medical students who had not yet completed their undergraduate research year at the time of this study.

FIGURE 2

Percentage with publications among undergraduate research students with available follow-up in the period following their ended extracurricular research year.





Medical students are increasing their scientific activity and productivity.

continued with research in the context of a PhD programme.

The increasing interest for undergraduate research among Danish medical students is in accordance with the analysis of Rysgaard [5], who showed how the number of junior physicians who enrol in a PhD programme in Denmark has increased from 515 in 2003 to 1,141 in 2013. A growing interest in student research is also seen in the student associations in Copenhagen, as shown in Figure 1. This suggests an increasing incentive among students to seek basic research training, create academic networks and build their curriculum. Other studies have reported that medical students show an interest in extracurricular research [4, 6-8]. Conversely, studies by Binderup et al along with studies by Nel et al found that a minority of medical students have actual research experience [8, 9], and Rubak et al showed a significant decrease in the average number of publications per junior doctor in Denmark between 1993 and 2001 [10]. That trend could change if the increased involvement of students in research projects continues in the future.

Other studies have also investigated research productivity among extracurricular research students. Wehrens & Leiner found that 46% of medical students doing extracurricular research at Maastricht University, Netherlands, published a peer-reviewed article within 4.5 years [11]. Svider et al studied manuscripts from the journal *The Laryngoscope* and found that 9.2% had a student as a first author, while 19.2% involved a student author [3]. Considering that the median duration of the extracurricular research period in our study was 12

months, we expected that a greater part of the students with follow-up had published as a first author. Svider et al along with Wehrens & Leiner have suggested that a mentorship between the physician-scientist and the student increases the research productivity and affords the student an opportunity to obtain scientific skills that could lead to the start of a career as a physician-scientist [3, 11]. We found that 70.4% of students published a paper within three years, yet only 36.5% published as a first author. The students in our study were still enrolled at the Faculty during the extracurricular research year and were supposed to have a mentorship with their official supervisor, but perhaps this was not fully established in practice. If a supervisor does not prioritise the need for guidance, it is unlikely that the student will publish as a first author. Another factor that may have influenced this finding is that some student research projects may not have addressed scientific issues of significant importance, and in these cases publication in a peer-reviewed journal is unlikely. Finally, the students must be prepared for the hard work associated with publishing a paper. Therefore, we suggest that the student and the supervisor agree on workload as well as on the scientific topic before collaboration is initiated. Student researchers should always strive towards publication and contribution to the body of scientific knowledge because it may lead to improvement of disease understanding, improvement of patient care and improvement of the student's personal and career-related output.

We found that 32.8% of the students in this study initiated a PhD programme. Recent reports have found that approximately 25% of medical students at the University of Copenhagen do a PhD [5]. Reinders et al studied the research productivity among students with and without experience as an undergraduate researcher after graduation and found that the students who had experience with undergraduate research had published four times as many articles as students without such experience [2]. These findings support the results of our study, suggesting that early involvement in research is beneficial for a career in academic medicine.

A good curriculum vitae (CV) increases the likelihood that an applicant will be considered for registrar training in popular clinical specialties, and research experience is an important improvement of the medical CV [6, 12, 13]. This increases competition among medical students and young medical doctors to participate in medical research projects. The question is whether a high level of competitiveness among young doctors who strive to improve their CV should be the foundation on which research is based. And even if the intention of early motivation towards doing research among students is accomplished, it could also lead to an increasing

amount of personal stress, which could, in turn, influence both research quality and the overall study environment in a negative manner and ultimately lead to poorer clinical physicians.

Our study had several limitations. Firstly, we did a manual search in PubMed MEDLINE to find the scientific productions of the undergraduate research students. We have not validated this search method, and we did not perform the search in other research databases. Secondly, the project title was not available for 174 of the student projects, which introduces an element of uncertainty to our results as not all articles were linked to the research year with certainty. Thirdly, students ending their undergraduate research period in 2013 have had a short follow-up period why publication of data from the period may be in progress. The lack of follow-up also influences the analysis of how many students proceed into a PhD programme. Yet, we analysed the data with this in mind and rates are given as a function of available follow-up. In addition, we only had data on PhD students from the Graduate School of Health and Medical Sciences at the University of Copenhagen. Some of the undergraduate research students could potentially have initiated a PhD programme at another Danish university (three universities in Denmark educate medical students, and as from 2010 a fourth university (Aalborg) also established a medical training).

CONCLUSION

We found that an increasing number of medical students are doing extracurricular undergraduate research and that more than two thirds of these publish a peer-reviewed article within 3 years after concluding their undergraduate research period. Cardiology was the specialty with most involved students and also the specialty with the greatest scientific yield. Lastly, we found that one third of the students continued to carry out research in the context of a PhD programme.

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ACCEPTED: 18 June 2015

CONFLICTS OF INTEREST: Disclosure forms provided by the authors are available with the full text of this article at www.danmedj.dk

ACKNOWLEDGEMENTS: The authors wish to extend their gratitude to medical student *Sine Hvid Rasmussen* for posing as model in the picture.

*) Both authors *Sofie Bech Andersen* & *Lauge Østergaard* contributed equally to the first-authorship of this article.

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