

The scientific value of medical student research: The experience at the Arrow Program for Medical Research Education

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Abstract

This study presents a comparative analysis of the publications of students participating in the Arrow Research Program in comparison to those of attending physicians and researchers at the same tertiary medical center in order to assess the impact of the Arrow Research Program on the students' scientific achievements. The study encompassed 90 Arrow Research Program students who were involved in the program at the Sheba Medical Center between 2019 and 2021. As a comparison group, 2082 attending physicians and researchers affiliated with the same center during the same period of time were considered. Publications were collected from The Web of Science Database, and the publication data parameters of each group were compared to assess scientific outcomes. The Arrow Research Program students collectively published 67 articles, and the 2082 physicians and researchers in the comparison group produced 4283 papers during the study timeframe. Similarly, the average impact factor of the journals in which the Arrow Research Program papers were published was 4.16 ± 2.68 , similar to the average impact factor of 4.74 ± 6.26 in the comparison group ($p = 0.388$). Likewise, the average quartile of the journals in which the Arrow Research Program articles were published was 1.39 ± 0.59 , which is similar to the comparison group's average quartile of 1.39 ± 0.63 ($p = 0.997$). In conclusion, the Arrow Research Program demonstrates its effectiveness in empowering young students to execute successful research projects. This study may help develop educational programs worldwide.

Keywords

Mentoring program, medical education, research project for students, coaching

Introduction

In many medical schools, different research mentoring programs are offered to students.^{1–4} These programs are recognized for their role in helping students acquire essential scientific skills, fostering curiosity among future clinicians, and contributing to valuable research in the medical field.^{1,5,6} The development of scientific skills, such as critical thinking and understanding research methodologies, not only aids students in their own research endeavors but also enhances their ability to evaluate and interpret medical literature, thereby benefiting clinical care.

The incorporation of mentoring programs into medical education has been an official practice since the late 1970s.^{7–15} These programs have diverse goals, ranging from cultivating interest in academic careers to fostering

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specialization in specific medical fields such as internal medicine or emergent medicine. Some programs aim to familiarize students with various medical departments prior to their residency programs.^{5,16,17} Mentoring models vary, encompassing one-on-one, small group, or large mentoring setups. Additionally, virtual advisor programs with a second-tier mentor or a combination of mentoring approaches are also encouraged.¹⁷

Program eligibility requirements also differ among institutions. Some programs are exclusively for first- and second-year medical students, while others cater to more advanced students. Certain programs have no restrictions based on the academic year, and some may focus exclusively on younger or more advanced students.^{16,17}

At the Sheba Medical Center, the largest tertiary health center in Israel, the Arrow Research Program was initiated in 2006¹⁸ and has evolved to include medical students from various Israeli and international universities. The average number of students participating in the program is 30 each year.¹⁸

The primary objective of the Arrow Research Program is to involve students in clinical, epidemiological, technological, and basic science research, all of which is conducted under the guidance and supervision of at least one mentor who is a health care professional and scientist. The multidisciplinary program has a diverse group of mentors from many subspecialties. This program is unique as students can participate in research on the topics that interest them, from internal medicine to ophthalmology and even subspecialties such as pediatric hemato-oncology. In addition to performing laboratory work and “wetting the hands and mind” from the early steps of research work, students practice lectures, present data in scientific meetings, and are taught to write scientific papers. As part of their involvement, students dedicate a minimum of 30 h per month to work in laboratory or clinical settings, and the duration of the student’s project is at least 1 year, which the student and mentor can renew depending on their progress. Some students join an existing research project, and some students design and conduct their independent research project under the supervision of a faculty member. The excelling students continue their medical studies while participating in the project, and they receive a scholarship for their work that is renewed for each year the student spends in the program. Additionally, they actively participate in monthly meetings where they present and discuss the progress of their research project and acquire various skills such as scientific writing and presentation, research methods, critical thinking, leadership, and more.¹⁸ Participation in the program is not mandatory and students accepted into the program exhibit academic excellence, curiosity, and

WHAT IS ALREADY KNOWN ABOUT THIS SUBJECT:

- This study aims to evaluate the scientific and academic contributions of a medical student research program, the Arrow Research Program.
- This evaluation involves comparing the publications of the students with those of attending physicians and researchers at the Sheba Medical Center.
- The goal is to assess the impact and significance of the Arrow Research Program on the students’ scientific achievements within the program’s time frame.

WHAT ARE THE NEW FINDINGS:

- The findings of our study highlight that the Arrow Research Program effectively empowers young students to engage in successful research endeavors, yielding positive scientific outcomes when compared to attending researchers at a tertiary medical hospital.
- This mentoring program not only cultivates youthful interest in research but also fosters remarkable accomplishments.
- Learning about such a program may contribute to developing other multidisciplinary research programs for students and help improve medical education worldwide.

a willingness to learn new skills. A faculty member is expected to arrange regular research meetings with the student and administer commitments so that students have necessary and appropriate access to the faculty member and assistance in their project.¹⁸ This study focuses on the description and outcome of a multidisciplinary research educational program.

This study aims to evaluate the scientific and academic contributions of a medical student research program, the Arrow Research Program participants. This evaluation involves comparing the publications of the students with those of attending physicians and researchers at the Sheba Medical Center. The goal is to assess the impact and significance of the Arrow Research Program on the students’ scientific achievements within the program’s time frame.

Materials and methods

Theoretical framework

This is a retrospective cohort study designed to analyze and compare the publications of articles published by

Table 1. Data that were recorded from each paper.

Data	Details
Number of citations	Including the mean number of citations per year since publication (The Web of Science database was searched between the years 2019 and 2021)
Journal details	The journal name, impact factor for the year 2022, quartile for the year 2022, the year of publication, and the publication language
Type and methodology of article	The type of article based on the different types of articles listed in <i>JAMA Ophthalmology Journal</i> ^a
Field of research	The title of the study, and the specific field of research. Papers were reviewed by three authors (RS, TWJ, and SD)

^aJAMA Ophthalmology. Instructions for Authors. [September 2021]. Available from: <https://jamanetwork.com/journals/jamaophthalmology/pages/instructions-for-authors>

students participating in the Arrow Research Program under the guidance of health care professionals. The study's focus is on comparing these student-authored publications with the publications of attending physicians and researchers at the Sheba Medical Center.

Sampling

The study involved 90 Arrow Research Program students enrolled through the first to sixth years of medical school programs at the Tel Aviv University, the Faculty of Medicine New York State/American Program of the Tel Aviv University, the Hebrew University in Jerusalem, Ben-Gurion University, the Azrieli Faculty of Medicine at Bar-Ilan University, and Sheba-St. George's University of London between the years 2019 and 2021. All students at the affiliated sites underwent the Arrow Research Program at the Sheba Medical Center and received the same mentoring from the Sheba Medical Center faculty.

Two thousand eighty-two attending physicians and researchers were employed at the Sheba Medical Center in the same years, and they comprised the comparison group for this study to compare the scientific contributions of students to the accomplishments of attending researchers.

Data collection

The Web of Science Database was searched for the keywords "Arrow Project", "Arrow Program," and "Sheba Hospital Israel" in the title in all languages published between 2019 and 2021. This search was conducted in December 2021. This time period was selected since the majority of publications by Arrow Research Program students were between these years. The parameters included were the title of the study, field of the study, type of research, journal name, journal impact factor, and number of citations. To enable a comprehensive

review of the Arrow Research Program students' accomplishments during the program, we searched for all Arrow Research Program's publications from the establishment of the program in 2006 until 2021 in a similar manner as described above. The data regarding each publication was collected in 2022, and the impact factor for publications was documented for 2022 to enable a consistent and updated comparison between the journals included in the study. Data parameters recorded from each paper are presented in Table 1.

This research study was conducted retrospectively from data obtained from publications published in The Web of Science Database. We consulted extensively with the IRB of the Sheba Medical Center who determined that our study did not need ethical approval. Consent of patients was waived by the IRB of the Sheba Medical Center as the study does not contain patient details.

Statistical analysis

Descriptive statistics are provided, mostly describing the mean and standard deviation of each category. Univariate analyses were used to compare the numerical variables. Statistical tests were two-sided, and $p < 0.05$ was considered significant. The SPSS software was used (IBM SPSS Statistics for Windows, version 24, Armonk, NY, USA 2016).

Results

Scientific outcomes between 2019 and 2021

Sixty-seven articles were published by 90 students as part of the Arrow Research Program between 2019 and 2021. The total years of participation of students at the Arrow Research Program between 2019 and 2021 were 106 years, thus the article per year ratio was 0.63. Four thousand eight hundred eighty-three papers were

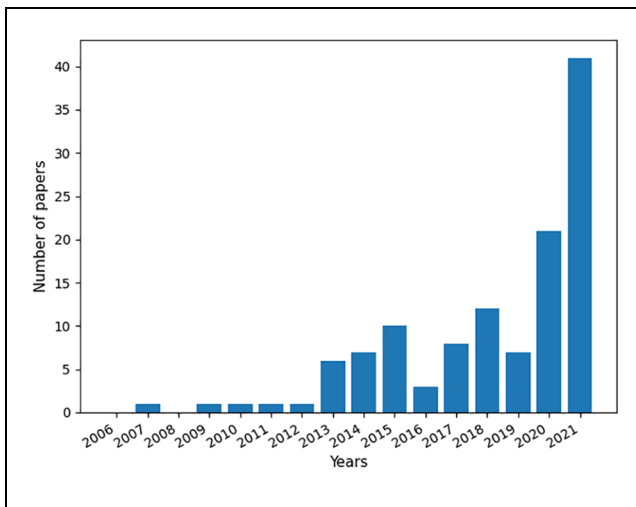


Figure 1. The distribution of publications among Arrow Research Program students between 2006 and 2021.

published by 2,082 attending physicians and researchers who were employed at the Sheba Medical Center during the same time frame. The average impact factor of the journals in which the articles of the Arrow Research Program were published was 4.16 ± 2.68 , similar to the average impact factor of 4.74 ± 6.26 in the comparison group ($p = 0.388$). The average quartile of the journals in which the Arrow Research Program articles were published was 1.39 ± 0.59 , which is similar to the average quartile of journals published by the comparison group, 1.39 ± 0.63 ($p = 0.997$).

Scientific outcomes of the Arrow Research Program students between 2006 and 2021

One hundred twenty articles were published by 308 students as part of the Arrow Research Program between 2006 and 2021. There was an increase in publications throughout the years. The distribution of publications among students throughout the years is shown in Figure 1. The average impact factor of the journals in which the articles of the Arrow Research Program were published was 4.17 ± 2.94 . The average quartile of the journals in which the Arrow Research Program articles were published was 1.43 ± 0.66 .

Field of research

The different fields of scientific publications in the comparison group that comprised attending physicians and researchers between the years 2019 and 2021 (4283 articles) were more versatile than the fields of publications of the Arrow Research Program students (67 articles). The main research fields of published articles in the

comparison group were pediatrics (11.27%), obstetrics and gynecology (7.56%), oncology (7.14%), hematology (6.67%), cardiology (6.15%), and autoimmunity (5.96%). All research fields of the comparison group publications are depicted in Figure 2. In comparison, the main scientific fields studied in articles published by the Arrow Research Program were neurology (15.46%), pediatrics (10.31%), radiology (7.22%), oncology (6.19%), and rheumatology (4.12%), with all other fields of research constituting less than 4% of all published articles. All research fields of the Arrow Research Program publications are depicted in Figure 3.

Citations and language

The average and standard deviation of the number of citations of articles by year in the Arrow Research Program group (i.e., calculated by dividing the number of citations by the number of years from publication to 2022) were 2.56 ± 4.85 , with most studies receiving one to five citations each year. Of the 67 studies, 95% were published in English, with the remaining published in Hebrew in an Israeli journal of medicine, "Harefuah."

Methodology

The two leading types of study designs published by participants in the Arrow Research Program were observational studies (73%), and basic science studies (16%). This was followed by clinical trials, which constituted 8% of all studies, while only 2% and 1% were meta-analyses and review studies, respectively.

Authorship position of students

The students' position of authorship was most frequently in the middle (66.3%); nevertheless, 33.7% received the first or last author's position. Overall, the average and standard deviation of the number of authors participating in a paper were 7.2 ± 10.1 .

Project duration

Most authors (89%), participated for a year in the Arrow Research Program. However, the average and standard deviation of the duration from the onset of the project to publication by each student were 3.1 ± 1.6 years.

Discussion

This study analyzed the scientific and academic outcomes of medical students participating in the Arrow Research Program. The study aims to compare these

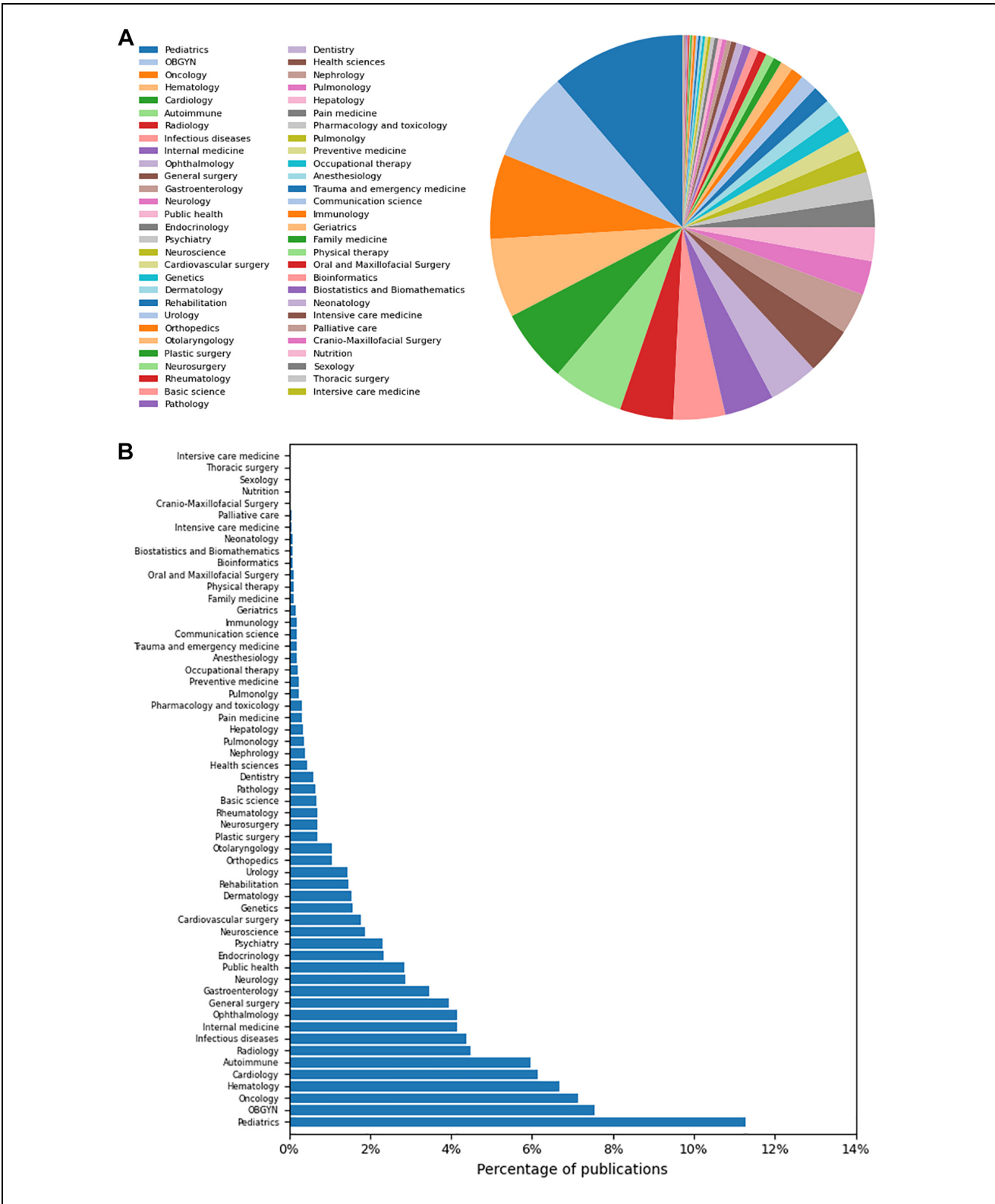


Figure 2. (a) Publications by the field of research in the comparison group. A pie chart of the different fields of research of the comparison group that comprised attending physicians and researchers at the Sheba Medical Center between the years 2019 and 2021. (b) The percentage of publications by the field of research in the comparison group. A histogram chart of the percentage of publications in the different fields of research in the comparison group.

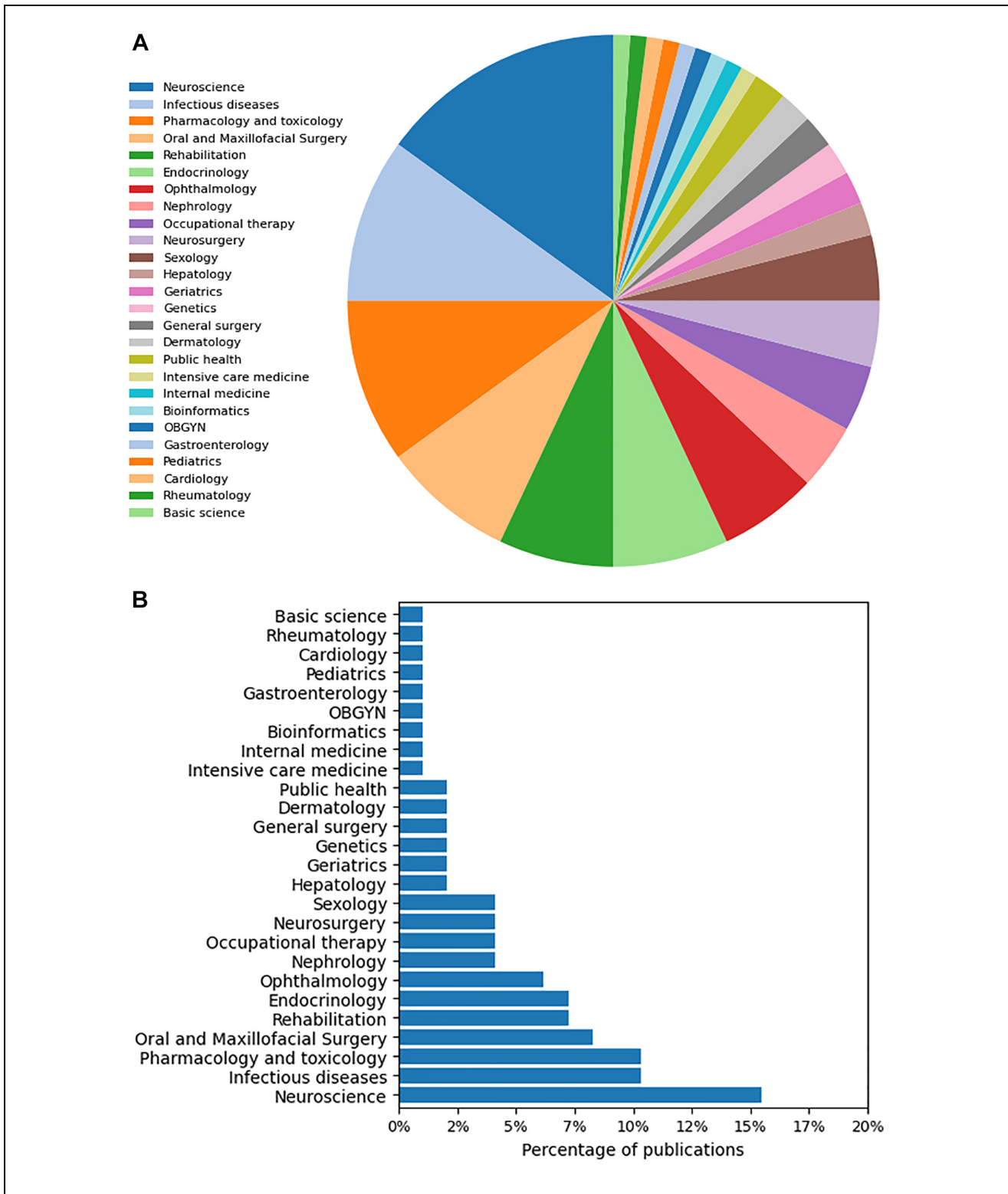


Figure 3. (a) Publications by the field of research in the Arrow Research Program group. A pie chart of the Arrow Research Program's fields of publication between the years 2019 and 2021. (b) Percentage of publications by the field of research in the Arrow Research Program group. A histogram chart of the percentage of publications in the different fields of research in the Arrow Research Program group.

outcomes with those of attending physicians and researchers at a large tertiary hospital, with the intention of evaluating the scientific and educational contribution of such a program. Prior studies examined the outcome of individual research programs within specific disciplines.^{16,17} Dorrance et al. observed significant improvements in scientific accomplishments such as presentations, research awards, and publications among students participating in an internal medicine research program.¹⁶ Coates et al.¹⁷ investigated a virtual advisor program catering to students interested in emergency medicine and found a positive outcome for the majority of students.¹⁷ This current study, to the best of our knowledge, is unique in its focus on the description and outcome of a multidisciplinary educational program that allows students to engage in research across various fields of their choice. Estapé et al. have studied the implementation of a multidisciplinary academic graduate program in clinical research for medical students and physicians,¹⁹ yet this program requires a significant amount of designated time and effort and, as such, requires much more commitment from the students as opposed to the Arrow Research Program, which enables the students in the program to conduct meaningful research projects during their medical studies.

Substantial effort and resources are invested in guiding students participating in the program to achieve the notable milestone of publishing their research in reputable scientific journals. A review conducted by Farkas et al.²⁰ on research and mentoring initiatives in the United States revealed that common challenges included the cost of running these programs and the time commitment required from faculty members. Despite these challenges, such mentoring programs for medical students were found to have a positive influence on student satisfaction within medical school and their overall career development.²⁰ The annual cost of the Arrow Research Program is about 200,000 dollars, which includes the salary of a program coordinator, scientific advisor, and statistician. In addition, each student receives a scholarship for their work, and four additional scholarships are given to students to travel abroad during their summer vacation to share their expertise, research findings, learn new research methodologies, and develop innovative ideas.

This study indicates that the impact factor of publications in the Arrow Research Program had a comparable impact factor to those published by attending physicians and researchers within the same time periods. Moreover, the average journal quartile of papers produced by participants in the Arrow Research Program was similar to that of papers published by attending physicians and researchers, indicating that the program

significantly contributes to the scientific impact made by innovative students.

The program entails regular monthly meetings attended by both students and mentors. During these gatherings, each student presents their research project, covering various aspects such as the study's rationale, methodology, results, and conclusions. Following the presentation, an open discussion occurs among mentors and students, fostering a collaborative environment where researchers from diverse fields can provide suggestions for research improvements, and propose new ideas, and collaborations. This environment also enables the practice of proper research presentation and even explores possibilities for collaboration. This format not only aids in refining the research itself but also serves as a platform for practicing effective research presentation skills, improving methodology, and enhancing overall presentation abilities. The program contributes to the growth of young researchers by offering them a space to develop their skills and fostering an interest in a wide range of subspecialties. This aligns with the findings of a study by Barrios-Anderson et al., which emphasized the significance of such gatherings for medical students in the field of neurosurgery. The study revealed that students particularly valued the "lower stress environment" and the "opportunity to get feedback on their research."²¹

In addition, recent research has indicated that not all medical students express a keen interest in research during their medical education, as highlighted by additional studies.^{22,23} Muhandiramge et al.²² found that time limitations and a lack of clarity about how to locate research opportunities are primary obstacles for medical students when it comes to engaging in research projects. These challenges can hinder their participation in research activities. The Arrow Research Program could potentially address these barriers by offering a structured and supportive environment for medical students to engage in research endeavors. The program enables the development of physicians working not only in clinics but also in pursuing valuable scientific research. This approach might lead to the cultivation of physicians who are not only involved in clinical practice but also actively pursue significant scientific research, thereby bridging the gap between clinical work and research.

As outlined in the present study, this highlights the positive outcomes of the Arrow Research Program, as evidenced by the fact that many students managed to publish their research in reputable journals with both high impact factors and quartile ranks. This suggests the program is effectively fostering high-quality research output among its participants. Previous research

indicates that individuals who became scientific leaders often demonstrated an early interest in research, as evidenced by a strong publication record and an impressive biometric profile. This aligns with the concept that early engagement in research can be indicative of future success in scientific endeavors.^{21,24} Carberry et al.²⁵ demonstrated the significance of research involvement during one's medical education. This research likely establishes a link between engaging in research activities as a student and its potential impact on subsequent career paths, achievements, and overall career satisfaction. In future research, it would be interesting to evaluate the career trajectories of the students who participated in the Arrow Research Program over the years. Such a study could provide insights into the long-term effect of such a program on the career paths of its participants. In addition, future studies could explore the student feedback from the program and faculty mentors to learn more about the student's experience in the program.

An increase in publication of the Arrow Research Program group was seen throughout the years (Figure 1), which could be explained by the increase in demand for participation in the program throughout the years. The greatest increase in publications between the years 2019 and 2021 could be explained by the fact that starting in 2019, the program defined that one of the main goals of participating in the program is to publish an article. In addition, the number of students was highest between 2019 and 2021. Lastly, the contribution of the Corona epidemic enabled a knowledge and global publication outburst.

The limitations of this study include the retrospective cohort study design and the time period of comparison between the groups (2019 and 2021). This time period was selected since the majority of publications by Arrow Research Program students were between these years; thus, this time period reflects the outcomes of the students in the project. The comparison between the attending research group and the Arrow Research Program group limits the ability to make a comparison of the years 2006–2021, as the attending research group published a large number of papers during this time. In future studies, we would like to compare the count of publications of students outside the program to those of students participating in the program using Poisson or negative binomial regression. Lastly, our study was conducted at a large tertiary hospital that contains many attending researchers, and we did not have the total number of years of work of the attending researchers. Thus, we could not calculate the article per year ratio for the attending researchers as we did for the students.

In summary, the findings of our study highlight that the Arrow Research Program effectively empowers young students to engage in successful research

endeavors, yielding positive scientific outcomes when compared to attending researchers at a tertiary medical hospital. This mentoring program continues to hold a central role in medical and scientific education, by bridging the gap between the high research skills required for physicians and researchers, and those acquired in medical schools. Beyond that, the evolving nature of the medical field, with its numerous subspecialties and diverse research areas, has underscored the need for innovative, multidisciplinary research mentoring programs. These programs play an important role in guiding students as they cultivate their interests, enhance their scientific knowledge, and advance their professional growth. This study may provide ideas for the development of other multidisciplinary research programs for students worldwide.

Declaration of conflicting interests

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