Program Evaluation 2020

Joint DMS/NIGMS Initiative to Support Research at the Interface of the Biological and Mathematical Sciences

BBCB and DIMA

I. Introduction

Since 2002, the National Institute of General Medical Sciences (NIGMS) and the Division of Mathematical Sciences (DMS) at the National Science Foundation (NSF) have jointly supported research at the interface of the biological and mathematical sciences (BioMath program). The BioMath program has been addressing the pressing need to bring quantitative methods into the core of biological and biomedical research, and to broaden the use of innovative mathematics and statistics in understanding life processes. Applications are accepted once a year and reviewed by a joint NSF/NIGMS panel run by NSF. Slightly more than half of the awards were funded by NIGMS and the rest by NSF.

This evaluation compared NIGMS BioMath recipients (who were funded by R01 grants) to NIGMS R01 recipients from the five most mathematically oriented study sections (comparison group):

- Modeling and Analysis of Biological Systems Study Section (MABS)
- Molecular Structure and Function Study Section D (MSFD)
- Biodata Management and Analysis (BDMA)
- Biostatistical Methods and Research Design (BMRD)
- Genomics, Computational Biology and Technology Study Section (GCAT)

These study sections were chosen because a large majority of the applications in the computational BBCB portfolios were reviewed in these panels. Since none of these study sections existed prior to 2006, NIGMS R01 recipients from PA-98-077, "Quantitative Approaches to the Analysis of Complex Biological Systems", were also included in the comparison group. Only PIs, in either group, who received a Type 1 (T1) R01 between 2002 and 2019 were included. These constraints resulted in the selection of 605 PIs:

- 165 BioMath PIs
- 440 Comparison Group PIs

Unless stated otherwise, the results shown below were aggregated for the 2002-2019 evaluation period. Reported p-values were computed using a Fisher's exact test when comparing percentages, and a Wilcoxon rank-sum test when comparing distributions.

In this evaluation, the following four main questions were addressed:

1. How did the demographics of the two groups compare?
2. How did the T1 R01s of the two groups compare in terms of prior NIH support and number of awards?
3. How did the renewal behavior and funding longevity of the two groups compare?
4. How did the productivity of the two groups compare?

II. Demographics

In this analysis, the gender, race/ethnicity (representation), and department types of the BioMath and comparison group PIs were compared.

II.A Gender Composition

The BioMath program had a numerically higher percentage of women PIs than the comparison group; however, the difference was not statistically significant (Figure 1).

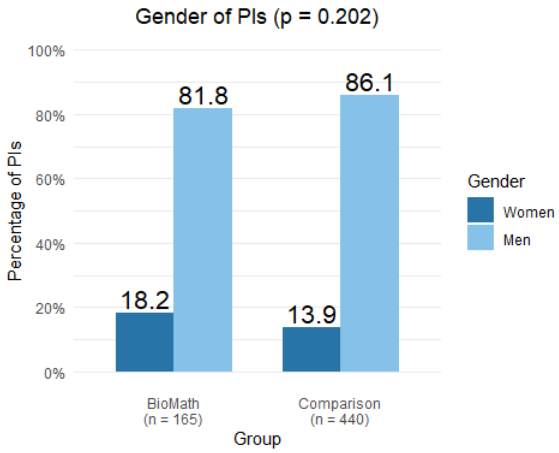

Figure 1: Gender distribution of PIs.

II.B Underrepresented PI Composition

The BioMath program had more underrepresented PIs than the comparison group (Figure 2). Underrepresented PIs were defined as individuals of non-White and non-Asian race, or Hispanic ethnicity.

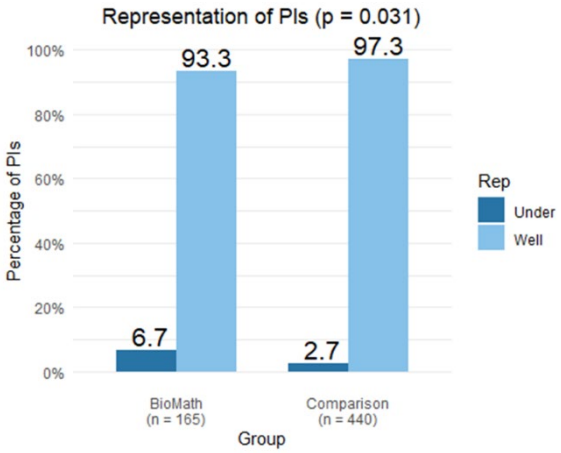

Figure 2: Representation distribution of PIs.

II.C Department Types

Department information was obtained from the applications at the time proposals were submitted. Although PI department information was lacking for a sizable number of awards in each group, BioMath PIs were much more likely to come from Math and Engineering departments than the comparison group PIs (Figure 3).

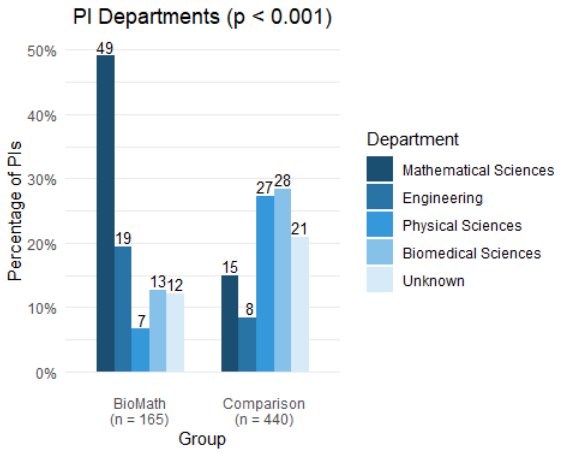

Figure 3: PI department distribution.

III. Prior NIH Funding and Number of T1 R01s

This analysis compared the percentage of PIs with NIH support prior to receiving their T1 R01s, and the number of T1 R01s received by the PIs during the evaluation period.

III.A Prior NIH Support

i) All NIH Awards

BioMath PIs were 2.4 times less likely to have NIH support prior to receiving their T1 R01s than the comparison group PIs (Figure 4A).

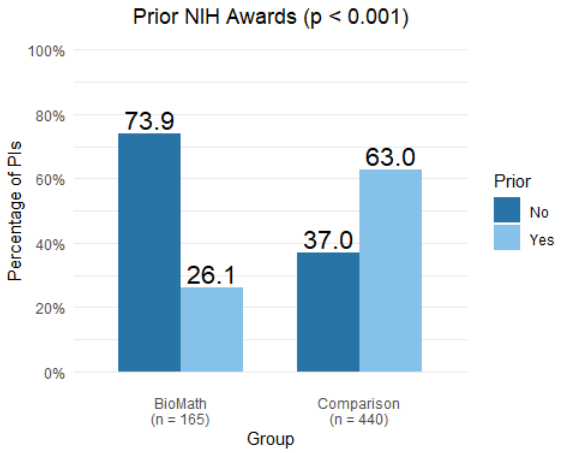

Figure 4A: Prior NIH support of PIs (any NIH award).

ii) Major Research Grants

Major research grants are awards that invalidate a PI's Early Stage Investigator/New Investigator (ESI/NI) status. For example, R01s and P01s are major research grants, while R15s and R21s are not. The full list of awards that do not invalidate a PI's ESI/NI status can be found at https://grants.nih.gov/policy/early-investigators/list-smaller-grants.htm.

When only prior major research grants were considered, BioMath PIs were 2.6 times less likely to have received NIH support prior to their T1 R01s than the comparison group PIs (Figure 4B).

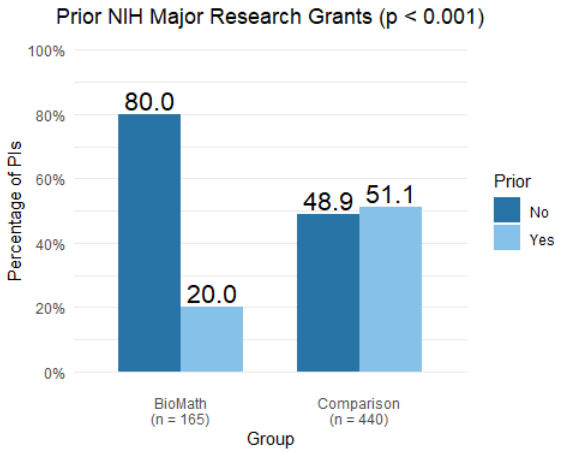

Figure 4B: Prior NIH support of PIs (major research grants only).

iii) R01s

When only prior R01 awards were considered, BioMath PIs were 2.4 times less likely to have received NIH support prior to their T1 R01s than the comparison group PIs (Figure 4C).

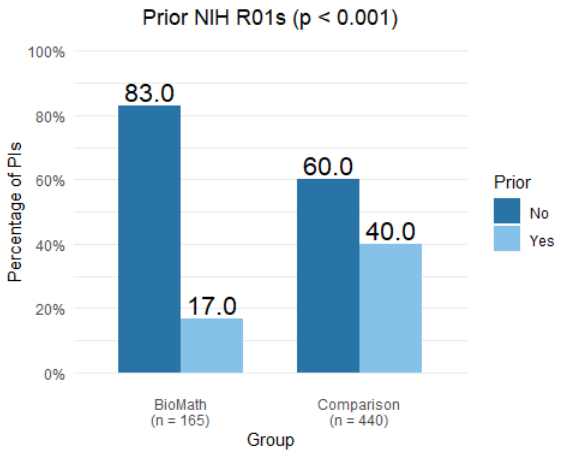

Figure 4C: Prior NIH support of PIs (R01s only).

Thus, regardless of which award mechanisms were considered (Figures 4A-C), BioMath PIs were far less likely to have a prior NIH support than the comparison group PIs.

III.B Number of T1 R01 Projects

Only 2.4% of BioMath PIs received more than one T1 R01, which was significantly smaller than the percentage of PIs in the comparison group who received more than one T1 R01 (11.8%; Figure 5).

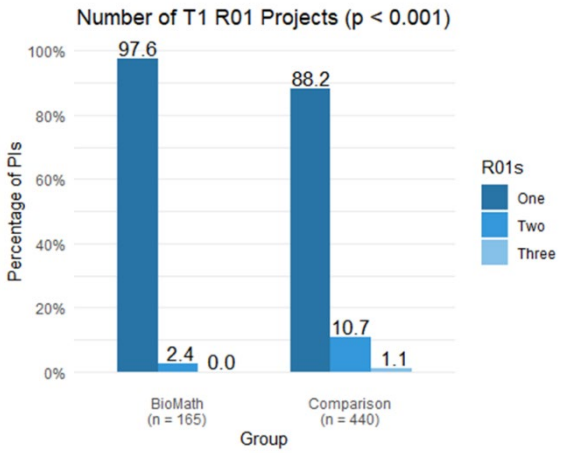

Figure 5: Number of T1 R01s received by PIs.

IV. Award Renewals and Funding Longevity

This analysis focused on Type 2 (T2) R01 renewals and NIH funding longevity of the PIs.

IV.A Renewal Attempts

Only awards that were eligible for renewal were included in the analysis of renewal attempts. Eligible awards are those for which a T2 application was submitted, or those that were no longer active as of September 30th, 2019. Also note that in the following two subsections, the analyses were done by project, not by PI. Thus, if a PI had multiple T1 R01 grants, each grant was treated as a separate entity.

BioMath PIs were far less likely to try to renew their awards than the comparison group PIs (Figure 6A). The difference in the percentages of renewal attempts was strikingly different – almost two thirds for the comparison group PIs and only one third for the BioMath R01s.

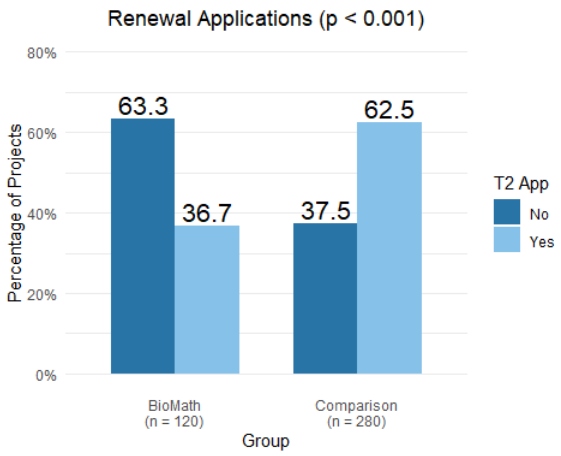

Figure 6A: Percentage of T1 R01 projects that were attempted to be renewed.

IV.B First Renewal Success Rates

This analysis examined the first renewal success rates of the projects that were attempted to be renewed. Only first renewals were considered because later renewals are usually far more successful. An R01 was considered successfully renewed only if a T2 award was issued with the same grant number. Continuation projects submitted as new applications (e.g. if the renewal attempt was not successful), which receive new grant numbers, were not included in this analysis.

BioMath PIs were less successful in getting their first renewal applications funded than the comparison group PIs; however, the difference was not statistically significant (Figure 6B).

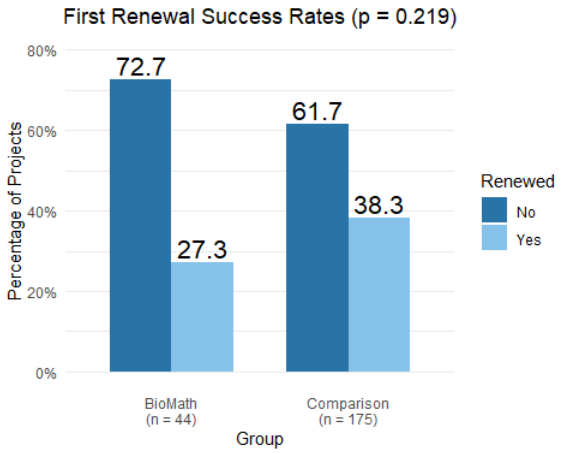

Figure 6B: First renewal success rates.

IV.C Funding Longevity

Funding longevity was defined as the difference between a PI's last year of NIH major research grant support and a PI's first year of major research grant support. To make the comparison as fair as possible, the analysis was restricted to New Investigators (NIs); i.e., PIs whose first major research grant was their T1 R01.

Kaplan-Meier survival curves were used for the analysis of NIH funding longevity. In order to give PIs sufficient time to renew their grants, PIs were deemed to have left the NIH funding pool (the survival event) after at least three consecutive years of zero NIH funding (and no later funding through 2019). Thus, only PIs who received their T1 R01s prior to 2017 were included, since 2017 was the last year in which a PI can be deemed to have left the funding pool (if that PI did not receive any funding from 2017 to 2019).

After the first three years of funding, the confidence intervals of the Kaplan-Meier survival curves no longer overlapped, and a statistically significant difference in survival emerged (Figure 7). Since a sizable portion of the BioMath R01s were funded for only three years, the noticeably large drop after three years in the BioMath group was most likely due to BioMath PIs being less likely to submit renewal applications (Fig. 6A) and having lower success rates on their renewal applications (Fig. 6B).

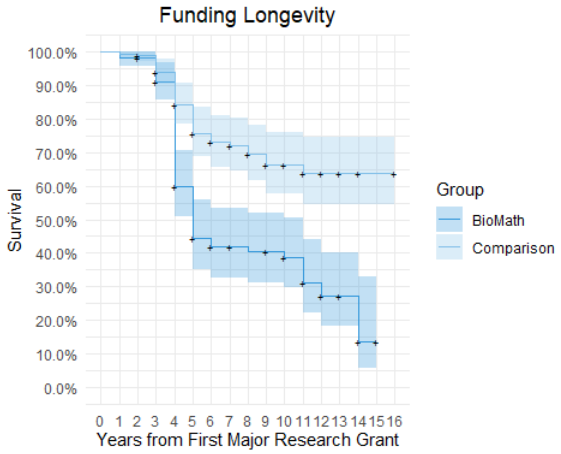

Figure 7: Kaplan-Meier survival curves for NIH funding longevity with 95% confidence intervals.

V. Productivity

This analysis examined the number of publications per R01 project and the number of citations per R01 project. Note that publication/citation data were available for most, but not all, projects. Also note that the analyses in this section were done by project.

V.A Publications per Project

The number of publications per project was numerically higher for the BioMath projects than the comparison group projects in terms of both the median (15 for BioMath vs 12 for control group) and the mean (19.5 vs 18.5); however, the difference between the distributions was not statistically significant (Figure 8A).

Figure 8A: Standard boxplots of publication counts per project. The black dots in the figure represent the mean values and the black lines represent the median values.

V.B Citations per Project

The median citations per project (259 vs 205) and mean citations per project (740 vs 718) of the BioMath projects were numerically higher than the comparison group projects; however, the difference between the distributions was not statistically significant (Figure 8B).

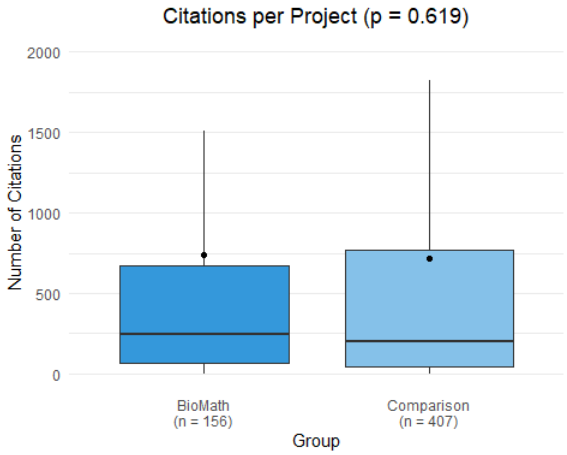

Figure 8B: Standard boxplots of citation counts per project. The black dots in the figure represent the mean values and the black lines represent the median values.

VI. Summary of Findings

1) How did the demographics of the two groups compare?
   - Even though the BioMath program had a numerically higher percentage of female PIs, the difference was not statistically significant (Fig. 1).
   - BioMath PIs were more diverse than the comparison group PIs in terms of race/ethnicity (Fig. 2).
   - BioMath PIs were much more likely to come from Mathematics and Engineering departments (Fig. 3).

     ➢ The evaluation indicated that the BioMath program has been fulfilling its goal of recruiting PIs from quantitative fields while helping to increase the diversity of the PIs.

2) How did the T1 R01s of the two groups compare in terms of prior NIH support and number of awards?
   - Regardless of which award mechanisms were considered, BioMath PIs were far less likely to have prior NIH awards (Figs. 4A-C).
   - A much smaller percentage of BioMath PIs received more than one T1 R01 award than the comparison group PIs (Fig. 5).

     ➢ The evaluation indicated that the BioMath program has been fulfilling its goal of recruiting PIs who would be less likely to receive NIH funding otherwise. Additionally, it should be noted that the BioMath program has continued to place an emphasis on recruiting new investigators since the last reissue of the program in 2016. Of the 28 NIGMS funded projects during the last three years, 25 were awarded to NIs (of which 13 were also ESIs).

3) How did the renewal behavior and funding longevity of the two groups compare?
   - The success rate for the renewal of BioMath projects was numerically lower than the success rate for the renewal of comparison group projects; however, the difference was not statistically significant (Fig. 6B).
   - BioMath PIs were far less likely to attempt to renew their R01s than the comparison group PIs (Figs. 6A-B). The latter was also reflected in BioMath PIs' lesser funding longevity (Fig. 7).

     ➢ Even though the BioMath projects have been performing as well as the comparison group, why BioMath PIs have not attempted to renew their awards was a puzzling finding. To help rectify this problem, program staff reached out to the PIs of the recently ended and current BioMath projects to emphasize that their projects are eligible for renewal and encouraged them to apply for a T2 award. Efforts to reach out to the BioMath PIs on a regular basis to encourage them to renew their projects will continue in the future.

4) How does the productivity of the two groups compare?

- BioMath projects were numerically more productive than the comparison group projects in terms of publications per project (Fig. 8A) and the number of citations that these publications received (Fig. 8B); however, these differences were not statistically significant.

  - The evaluation indicated that the BioMath program has been fulfilling its goal of receiving and funding good quality projects by productive PIs.