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Biostatistics Faculty and NIH Awards at U.S. Medical Schools

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Abstract

Statistical principles and methods are critical to the success of biomedical and translational research. However, it is difficult to track and evaluate the monetary value of a biostatistician to a medical school (SoM). Limited published data on this topic is available, especially comparing across SoMs. Using National Institutes of Health (NIH) awards and American Association of Medical Colleges (AAMC) faculty counts data (2010–2013), together with online information on biostatistics faculty from 119 institutions across the country, we demonstrated that the number of biostatistics faculty was significantly positively associated with the amount of NIH awards, both as a school total and on a per faculty basis, across various sizes of U.S. SoMs. Biostatisticians, as a profession, need to be proactive in communicating and advocating the value of their work and their unique contribution to the long-term success of a biomedical research enterprise.

Keywords

Biomedical and translational research; Biostatistical collaboration; Extramural funding

1. INTRODUCTION

Statistical principles have been increasingly accepted by the biomedical community as an integral part of sound research and biostatistical methods drive many health-related discoveries reported almost daily (Zelen 1983; Ellenberg 1990; Khattry 2004; Geller 2011; Davidian and Louis 2012; Davidian 2012). Biostatisticians serve a critical role in an interdisciplinary biomedical research team, contributing their expertise in design and implementation of experiments, data analysis and results dissemination, and novel methodology development. However, it has been difficult to justify the hiring/retention of biostatistics faculty or the expansion of biostatistics groups in a biomedical research institute based on a return-on-investment (ROI) analysis. This is primarily due to the fact that the “benefits” of biostatisticians to a biomedical research organization may not be immediately or directly measurable as compared to the “costs” of hiring biostatistical staff. Therefore, a biostatistics unit may be perceived as an institutional “cost center” rather than part of a revenue generation center.

In the current era of cost-effective research, biostatisticians, as a profession, must be able to demonstrate clearly and quantitatively their contribution and take initiative in communicating their value and importance to the administrators, biomedical and translational researchers, the scientific community and the public in general, i.e., building statistical bridges (Scheaffer 2002).

Many papers have been published on the biostatistics profession, emphasizing the importance and development of communication and interpersonal skills as a collaborating biostatistician (Zahn and Isenberg 1983; Johnson and Warner 2004; Begg and Vaughan 2011), on how to budget biostatistics involvement and on time-management and authorship issues (Lesser 1996; Parker and Berman 1998), and on how to effectively provide statistical training for clinical researchers (Deutsch et al. 2007; Swift et al. 2009). The creation and operation of biostatistics units/programs have also been extensively discussed, in terms of organization, training program development, financial and staff models, and activities and concerns (Arndt and Woolson 1991; Derr 1993; DeMets et al. 1994; Niland et al. 1995; DeMets et al. 2006; Hurwitz 2008; Strom et al. 2012; Welty et al. 2013).

One important outcome of effective interactions between biostatisticians and biomedical and translational researchers – the securing of extramural research funding, has not been extensively evaluated. Several articles briefly discussed specific practical aspects of grant preparation (Lesser 1996; Adams-Huet and Ahn 2009) and a few case studies on individual biostatistical unit's contribution to a specific institution have been reported (Parker 2000; Strom et al. 2012). A general association between biostatistics group and extramural funding has not been established across national institutions.

In this paper we proposed a straightforward approach to evaluate the value of biostatisticians across over a hundred U.S. medical schools (SoMs). We used a convenient but objective outcome measure, National Institutes of Health (NIH) awards, and two relevant factors, the SoM faculty count and the number of biostatistics faculty at each institution, to test the hypotheses of whether the total and per faculty NIH funding awards for a SoM are positively associated with the number of biostatistics faculty.

2. DATA

The study data were created by merging online databases on NIH awards and SoM faculty, together with information on biostatistics faculty identified through an extensive web search. Figure 1 illustrates the stages of the data collection process.

NIH awards data

The NIH awards data for U.S. Medical Schools from 2010 to 2013 are publically accessible at http://www.brimr.org/NIH_Awards/NIH_Awards.htm. The NIH awards data tables listed the amount and ranking of total NIH awards by SoM for each year. The amount of awards included both direct and indirect costs. There were 139 SoMs listed in 2013 NIH awards data, while there were only 134, 138, and 137 SoMs listed in 2010, 2011, and 2012 data respectively. To be consistent and limit some of the year-to-year variability, seven SoMs

were excluded because of their relatively brief NIH awards history. The remaining 132 SoMs with NIH awards data for all four years (2010 – 2013) were included in the study.

SoM faculty data

The composition of SoM faculty was downloaded from American Association of Medical Colleges (AAMC) website: <https://www.aamc.org/>. The publicly available AAMC data tables listed the total faculty counts of major U.S. medical schools and the number of three types of SoM faculty (basic science, clinical, and other) separately. Faculty count data from 130 SoMs with data available for all four years (2010 – 2013) were included in the study.

The SoM faculty data were merged with NIH awards data by SoM names. A few schools changed their names during the 2010 – 2013 period and some of the SoM names used were slightly different between the NIH awards and the AAMC faculty databases. These discrepancies were carefully reviewed and the names were appropriately matched. The merged data contained 126 SoMs with both AAMC and NIH awards data across all four years (2010 – 2013).

Biostatistics faculty data

Two independent and extensive web searches were conducted by two biostatisticians (GZ and JJC) using the same inclusion/exclusion criteria to determine the number of doctoral level biostatistics faculty at each of the 126 institutions. If the two independent online assessments of a specific institution produced different outcomes, the search results were reviewed together and further online search of that institution was conducted, if necessary, to reach a consensus.

The search was conducted in a five-step sequential manner. First, 51 institutions were identified with an academic department with the term “Biostatistics” or “Biostatistical” in its name (e.g., Biostatistics, Biostatistical Sciences, Biostatistics & Epidemiology). Second, 29 additional institutions had an academic division with the term “Biostatistics” or “Biostatistical” in its name. Third, 23 other institutions were identified with a biostatistics academic/institutional structure (e.g., center, group, program, section, office, core, or unit). Fourth, an academic/institutional structure providing biostatistical support and services was identified for eight other institutions through key word search using the following terms: “clinical research”, “data analysis”, “data management”, “quantitative”, “research design”, “research support”, “statistical analysis”, “statistical consult”, “statistics”, and “statistical support”. Last, biostatistics groups/teams were identified at nine remaining institutions through a targeted search at relevant Departments/Programs (e.g., Community Health, Environmental Medicine, Epidemiology, Family Medicine, Preventive Medicine, and Public Health). Sixty percent of the units were located within SoM and another 33% were located within School of Public Health, with remaining eight units located in other colleges/schools or academic structures.

The numbers of regular/primary biostatistics faculty with PhD/ScD/DrPH degrees were determined for each institution using the following criteria: for the 103 institutions with a biostatistics academic unit (identified in steps 1 – 3 above), the counts of biostatistics faculty were obtained from the units’ web listings for 97 institutions. For the additional six

institutions where the academic unit contained more than one subject area, but no individual faculty information (such as research area) was provided, the numbers of biostatistics faculty were estimated based on the “proportional split” of the total number of faculty (e.g., one-half for a department with a name containing two subject areas, e.g., “Epidemiology & Biostatistics”). For 17 remaining groups/units that provide biostatistical support (identified in steps 4 and 5 above), faculty webpages were reviewed and the number of doctoral level faculty with biostatistics/statistics degree and biostatistical research areas were counted. If available, the numbers of faculty listed with joint and secondary biostatistics appointments at each institution were also determined separately.

Adjunct, retired, or visiting faculty members were not included. Though the online evaluation of biostatistical faculty counts may not be as complete as the NIH awards or the AAMC faculty data, the data serves as a reasonably accurate assessment of biostatistics faculty resources at these institutions. Among the 126 academic institutions with both NIH awards and AAMC faculty data for their SoMs, the numbers of biostatistics faculty were determined for 120 SoMs based on the online search. One institution was excluded from the final dataset due to its extreme large number of clinical faculty for a total SoM faculty of over 8,000, with the next largest SoM having a faculty count of less than 3,000. The final study sample included 119 academic institutions.

3. ANALYSIS

For more stable estimates, the amounts of NIH awards and the numbers of total faculty were first averaged over the four year period (2010 – 2013), and labeled as “total NIH awards” and “SoM faculty count” for each SoM in the analysis. The total funding was then divided by the SoM faculty count to calculate the “per faculty NIH awards” for each SoM. Per faculty funding was considered an important performance measure of a SoM in its ability in obtaining extramural funding, adjusting for the size of the SoM. To further investigate the impact of the size of a SoM, the 119 SoMs were further grouped into three roughly equal sized categories (small, medium and large), using 700 and 1,200 of the SoM faculty counts as the cut points.

Table 1 summarizes the characteristics of the 119 SoMs, their NIH awards and faculty, and their associated primary biostatistics faculty. The mean (median) of the SoM faculty counts were 1069 (941). The mean (median) for the number of biostatistics faculty were 11 (8). The mean (median) for the total NIH awards were \$93.5 (\$50.1) in millions, indicating some skewness of the data. The skewness was reduced when the data was stratified by SoM size. The data was more symmetric on a per faculty basis, with the mean (median) for NIH awards being \$74.6 (\$64.5) in thousands. After stratifying by SoM size, the “per faculty NIH awards” had means (medians) of \$49.2 (\$37.6), \$68.7 (\$50.8) and \$103.5 (\$95.2) in thousands for small, medium and large SoMs, respectively.

To explore the different association patterns of biostatistics faculty and general SoM faculty with the amount of NIH awards, we generated nonparametric locally weighted scatterplot smoothing (LOWESS) curves (Cleveland 1979) based on default settings (two-thirds proportion of points) using R-package (R version 3.0.1) (Figure 2). It was not surprising that

the total NIH awards for a SoM tended to increase with more general SoM faculty (Figure 2A). For per faculty NIH awards, Figure 2B showed that the fitted LOWESS curve also increased, though at a slower rate. The number of biostatistics faculty was positively associated with general SoM faculty count (Figure 2C), but the LOWESS curve for the “per faculty NIH awards” increased at a higher rate for the number of biostatistics faculty compared to that of the SoM faculty count (Figure 2D).

Two simple linear regressions of NIH awards against each of the two faculty factors (general SoM faculty and biostatistics faculty) were first performed. The R-squared values were obtained from these simple regression models (Table 2, last 2 columns). To estimate and compare the relative impacts of biostatistics faculty and general SoM faculty on the total and per faculty NIH awards, multiple linear regression models were then used for all SoMs and by different SoM size categories (Table 2). Overall, the total NIH awards were influenced by both types of faculty (p -values <0.001), but on a per faculty basis, the NIH awards was associated mainly with the number of biostatistics faculty. When the per faculty NIH awards was considered, the SoM faculty count was no longer significant, but the number of biostatistics faculty was still significant (all p -values <0.01) for all SoM size categories. The R-squared values also implied that the biostatistics faculty explained more variation of the “per faculty NIH awards” than the general SoM faculty. For example, when all 119 SoMs data was considered, the SoM faculty count alone explained only 14% of the outcome variation of the per faculty NIH awards, while about 39% of the variation was explained by the number of biostatistics faculty alone, or when considered jointly with the SoM faculty count.

Not all SoM faculty members actively participate in research or pursue extramural funding. For example, the main focus for many clinical faculty members can be on patient care or medical education. It is possible that the biostatistics faculty count might be confounded with the effort of active and grant-seeking researchers count. Therefore, basic science faculty count, rather than total SoM faculty count would serve as a better surrogate for active grant-seeking SoM faculty. To take this potential confounding effect into consideration, we refitted the regression models using “basic sciences faculty” count, replacing the “general SoM faculty” count. The general patterns held for both “total NIH awards” and “per faculty NIH awards”, and for each of the three size categories of SoM (see Supplementary Table S1). Overall, the model diagnosis suggests that the data satisfied the regression assumptions quite well. Considering the slight skewness of some of our data, we conducted a separate set of analyses based on log-transformed data. To validate the robustness of our results, we also conducted nonparametric rank regression analyses, using the ranks of NIH awards rather than the actual awards. The resulting patterns were very similar to those presented in Table 2 (see Supplementary Tables S2 for log-transformed analysis results and S3 for nonparametric rank regression results).

4. DISCUSSION

The purpose of this study is to raise the awareness and appreciation of the unique contribution biostatisticians make to a biomedical research organization. We concur with

Parker (2000) that biostatisticians have much to offer, providing “statistical thinking and reasoning” during all phases of a research project.

Institutional administration and biomedical research colleagues sometimes do not duly recognize the contribution of biostatisticians. One of the main reasons may be the difficulty in tracking and quantifying the direct or indirect contribution of a biostatistician or a biostatistics group to a biomedical research institution, e.g., securing extramural funding. The lack of a clear understanding about the nature of biostatistical work and the true value of a trained biostatistician may also be a factor. For biostatisticians as a profession, we need to be proactive in documenting, educating, and promoting our activities and contributions.

At the institution level, the financial model and stability of a biostatistics group will influence the effectiveness of the biostatistics team, including the statistical quality of grant applications. This is particularly challenging for a small-sized SoM and for a new biostatistics group, where the biostatistician team is usually small and less stable. We are pleased to observe a transition from the traditional biostatistical consulting model to a biostatistical collaboration model in academic institutions in recent years (Keller 2010). Under a collaboration model, the stable and diversified financial support from various biomedical research units will allow the biostatistics group to grow and strengthen to meet the increasing and diverse collaboration and support needs.

Using cross-sectional data, we attempted to quantify the value of biostatisticians to a SoM. The results indicate a strong association between the number of biostatistics faculty and the NIH awards of SoMs across all size categories of SoMs in the country. The analysis results suggest that hiring additional biostatisticians could potentially significantly enhance the likelihood of securing extramural funding for the institution.

There are several limitations to this study. This study is cross-sectional rather than a longitudinal or cohort study. As a result, no causal inference could be made based on the associations. We concur with Welty et al. (2013) that research tracking the development and impact of biostatistics programs across the country over time would be useful to our biostatistician profession.

The observed effects of biostatistics faculty could also be confounded by other factors not currently adjusted in the models. Besides the number of biostatistics faculty, per faculty NIH awards might also be affected by other institutional factors, such as faculty incentives for doing research. Some institutions may provide more supporting infrastructural resources for biomedical researchers, e.g., office of grant development and management, other research facility cores. For biostatistics groups, besides regular faculty, the collaborations and services they provide will also significantly depend on the availability and skills of master-level biostatisticians, programmers, database managers and other information technology personnel.

The AAMC faculty report is updated annually and may not reflect the official faculty counts at SoMs. According to an AAMC medical school faculty appointment study, approximately 95% of the full-time faculty in U.S. medical schools was captured by the AAMC Faculty

Roster (Liu and Mallon 2004). For our analysis, we also used the average of four years' AAMC data to further stabilize the data.

The NIH grant awards data is also a lagging indicator. The current year's funding awards usually reflect the collaborative effort of the previous year or years. As the competition for limited funding increases, it is taking longer for a grant proposal to be funded and for the "benefits" of a biostatistics faculty to be realized. By using a four-year average of NIH awards we reduced some of the temporal factors impacting our cross-sectional data. Besides NIH awards, biomedical and translational researchers are also supported by other extramural funding sources, e.g., National Science Foundation and other foundation funding mechanisms. In this analysis, only NIH awards were considered. NIH is the dominant source of biomedical research funding and the amount of its awards is also well documented. At some institutions, a single or a few highly recognized researchers could significantly impact the funding situation of a SoM. In our analysis, only the average contribution from a general SoM faculty, across different expertise and faculty levels, was considered.

The data on biostatistics faculty is usually not as well documented and/or readily available compared to the general SoM faculty at the same institution. Though an objective approach was taken, it is possible that a miscount and/or misclassification might have occurred. We recognize that some academic institutions have separate biostatistics and statistics programs, however, only biostatistics groups were considered in the main analysis. Some faculty members in statistics programs also collaborate in biomedical research and contribute to the extramural funding of a SoM. Most of these statistics faculty members are affiliated and also listed with the biostatistics programs. As a sensitivity analysis, we reran the models including affiliated faculty into the biostatistics faculty counts. The result patterns were very similar (Supplementary Table S4). Many biostatisticians collaborate with myriad researchers outside the SoMs, and these contributions to NIH grants awarded to non-SoM academic units were not included in this analysis. Also, our approach could not capture or separate the impact of cross institutional collaborations where biostatisticians and biomedical researchers are affiliated with different academic institutions.

Our research fills a critical literature gap on the quantification of biostatistics faculty contribution across U.S. SoMs. Even though the data presented can only be regarded as suggestive, due to the cross-sectional nature of the data, this study takes the first step in addressing an interesting and important topic that affects the growth and development of the biostatistics groups across the country. It has direct implications in biostatistics faculty recruitment and evaluation at biomedical institutions. The study is straightforward and provides intuitive information on the importance and relevance of biostatistics groups to the research quality and to securing extramural funding opportunities of a SoM.

With the challenges of "-omics" data and the arrival of other "Big Data", biostatistical expertise for biomedical research has become more valuable and the demand is expected to increase significantly. Biostatisticians should seize this golden opportunity and take the lead. It is our responsibility to inform and advocate to our administration and research colleagues our value and contribution.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Data collection flow chart

Figure 2. Nonparametric LOWESS curves: A). Total NIH awards against the SoM faculty count; B). Per faculty NIH awards against the SoM faculty count; C). The SoM faculty count against the number of biostatistics faculty; D). Per faculty NIH awards against the number of biostatistics faculty

Table 1

Summary of NIH awards and faculty counts* of 119 U.S. Schools of Medicine (SoMs) and the numbers of biostatistics faculty at these institutions

Variable	Mean	Std. Dev.	Minimum	Q1	Median	Q3	Maximum
All SoMs (n=119)							
SoM NIH Awards (\$1,000,000)	\$93.5	\$98.8	\$0.9	\$18.0	\$50.1	\$141.1	\$390.3
Per faculty NIH Awards (\$1,000)	\$74.6	\$56.3	\$2.5	\$37.3	\$64.5	\$98.0	\$342.4
SoM Faculty Count	1,069	659	78	605	941	1,483	2,854
Basic Sciences Faculty Count	142	84	30	77	126	196	420
Clinical Faculty Count	917	591	27	495	794	1,276	2,625
Number of Biostatistics Faculty of the Institution	11	10	1	4	8	16	45
Large-sized SoMs: faculty count more than 1,200 (n=43)							
SoM NIH Awards (\$1,000,000)	\$185.7	\$99.9	\$10.1	\$105.0	\$159.7	\$292.2	\$390.3
Per faculty NIH Awards (\$1,000)	\$103.5	\$54.2	\$7.9	\$62.2	\$95.2	\$128.7	\$242.9
SoM Faculty Count	1,800	450	1,212	1,409	1,769	2,079	2,854
Basic Sciences Faculty Count	215	85	37	157	204	252	420
Clinical Faculty Count	1,568	415	976	1,212	1,542	1,801	2,625
Number of Biostatistics Faculty of the Institution	19	12	1	9	18	26	45
Medium-sized SoMs: faculty count between 701 and 1,200 (n=35)							
SoM NIH Awards (\$1,000,000)	\$64.1	\$56.2	\$2.2	\$32.3	\$48.8	\$82.5	\$297.2
Per faculty NIH Awards (\$1,000)	\$68.7	\$61.1	\$2.5	\$38.5	\$50.8	\$83.3	\$342.4
SoM Faculty Count	927	127	712	806	940	1,036	1,137
Basic Sciences Faculty Count	130	48	43	96	128	168	236
Clinical Faculty Count	788	115	579	700	785	873	1,020
Number of Biostatistics Faculty of the Institution	9	6	1	4	7	13	23
Small-sized SoMs: faculty count less or equal than 700 (n=41)							

Variable	Mean	Std. Dev.	Minimum	Q1	Median	Q3	Maximum
SoM NIH Awards (\$1,000,000)	\$21.9	\$22.9	\$0.9	\$6.9	\$17.6	\$29.1	\$123.3
Per faculty NIH Awards (\$1,000)	\$49.2	\$38.9	\$4.1	\$19.7	\$37.6	\$73.4	\$179.2
SoM Faculty Count	424	196	78	231	414	616	690
Basic Sciences Faculty Count	75	28	30	52	66	97	133
Clinical Faculty Count	344	177	27	176	333	515	632
Number of Biostatistics Faculty of the Institution	5	6	1	1	4	7	36

Notes:

* NIH awards and SoM faculty counts were averaged over a four-year period (2010 – 2013).

The basic sciences and clinical faculty counts do not add up to the SoM faculty count as the category of "Other faculty" (around 1 %) is not shown.

Regression results of NIH awards against the SoM faculty count and the number of biostatistics faculty across different sizes of SoMs

Table 2

SoMs	Regression Coefficient and p-value			R-Squared	
	NIH Awards	General SoM Faculty	Biostatistics Faculty	Both SoM Faculty Count and Number of Biostatistics Faculty	SoM Faculty Count Only Number of Biostatistics Faculty Only
All SoMs (n=119)	Total NIH Awards = \$38,151,221 (p-value < 0.001)	+ \$74,888 X (# Faculty - 1,000) (p-value < 0.001)	+ \$4,431,978 X (# Biostatistics Faculty) (p-value < 0.001)	0.726	0.582
	Per Faculty NIH Awards = \$37,019 (p-value < 0.001)	+ \$3 X (# Faculty - 1,000) (p-value = 0.76)	+ \$3,302 X (# Biostatistics Faculty) (p-value < 0.001)	0.387	0.140
Large-sized SoMs (n=43)	Total NIH Awards = \$92,944,774 (p-value < 0.001)	+ \$72,095 X (# Faculty - 1,800) (p-value = 0.007)	+ \$4,941,482 X (# Biostatistics Faculty) (p-value < 0.001)	0.492	0.168
	Per Faculty NIH Awards = \$51,258 (p-value < 0.001)	- \$14 X (# Faculty - 1,800) (p-value = 0.38)	+ \$2,785 X (# Biostatistics Faculty) (p-value < 0.001)	0.350	0.001
Medium-sized SoMs (n=35)	Total NIH Awards = \$19,715,625 (p-value = 0.18)	+ \$43,137 X (# Faculty - 900) (p-value = 0.52)	+ \$4,778,280 X (# Biostatistics Faculty) (p-value = 0.001)	0.311	0.043
	Per Faculty NIH Awards = \$21,841 (p-value = 0.19)	- \$24 X (# Faculty - 900) (p-value = 0.75)	+ \$5,245 X (# Biostatistics Faculty) (p-value = 0.002)	0.276	0.004
Small-sized SoMs (n=41)	Total NIH Awards = \$10,504,807 (p-value = 0.002)	+ \$46,411 X (# Faculty - 400) (p-value = 0.001)	+ \$1,881,554 X (# Biostatistics Faculty) (p-value < 0.001)	0.571	0.337
	Per Faculty NIH Awards = \$32,896 (p-value < 0.001)	- \$8 X (# Faculty - 400) (p-value = 0.79)	+ \$3,053 X (# Biostatistics Faculty) (p-value = 0.003)	0.228	0.018

Notes:

1. SoMs were grouped into three size categories, based on the SoM faculty count: Small (≤ 700), Medium (701–1,200), and Large ($> 1,200$).

2. SoM faculty count was centered at the average # of faculty