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Creating and Sustaining Effective Pipeline Initiatives to Increase Diversity in Biostatistics: The ENAR Fostering Diversity in Biostatistics Workshop

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ABSTRACT

Biostatisticians with advanced degrees are highly sought after. Employment opportunities in the fields of mathematics and statistics are expected to increase dramatically by 2028. Underrepresentation of minorities in biostatistics has been a persistent problem, yielding a demographic landscape that differs substantially from the general U.S. population. In some instances, students may have the appropriate quantitative skills, but are unaware of biostatistics and in other instances, students may not yet have the appropriate quantitative background, but are intellectually capable and willing to shore up those skills once they learn about biostatistics as a viable, exciting career option. Therefore, to ensure robust scientific advancement, there must be a concerted effort to increase the pipeline of intellectually talented persons available with exposure to the appropriate quantitative skills who are interested in careers in biostatistics. The overarching goal of this article is to discuss the development, implementation, and impact of a federally funded pipeline initiative aimed at increasing the number of underrepresented minorities successful in graduate training and professional careers in biostatistics as well as establishing effective mentoring and networking relationships. Our findings provide a roadmap for the development of sustainable initiatives to promote diversity in biostatistics and science, technology, engineering, and mathematics fields more broadly. Supplementary files for this article are available online.

KEYWORDS

Biostatistics; Diversity; Mentoring; Pipeline; Statistics; Science, technology, engineering, and mathematics

1. Introduction



1.1. The Importance of Biostatistics in Biomedical and Public Health Research

Biostatistics is the science that applies statistical theory and mathematical principals to research in medicine, biology, environmental science, public health, and related fields. It remains a rapidly growing field, with a vibrant job market for graduate trained professionals in traditional domains including academia, government, and industry. However, in the era of “big data” these skills are becoming even more relevant in emerging sectors that seek to process, synthesize, and make inference from larger and larger volumes of data (e.g., informatics, machine learning, data mining, artificial intelligence). Biostatisticians with advanced degrees will continue to be highly sought after as research questions increase in complexity as does the data to answer those questions. Thus, biostatistics will continue to play an integral role in future medical and public health decisions and in shaping policy in contributing to the body of sound evidence. According to the U.S. Bureau of Labor Statistics (BLS), employment of mathematicians and statisticians is expected to increase by 30% in the decade from 2018 to 2028, much

faster than the average increase for all occupations (BLS 2019). They attribute the projected growth to the need to analyze the increasing volume of digital and electronic data available ubiquitously. Biostatisticians will continue to make important contributions, both by carrying out methodological research required to develop new techniques for analyzing these complex data, and by participating directly as collaborators in the design and analysis of studies in all domains of health research.

1.2. The Need for Underrepresented Minority (URM) Pipeline Initiatives in Statistics and Biostatistics

According to the Higher Education Research Institute’s 2016 Freshman Survey (Eagan et al. 2017), 66.9% of all freshmen in college/university in the United States were white, 13% were African-American and 19.3% were Hispanic/Latino. Although only 1.7% intended to major in mathematics or statistics, 35.6% intended to pursue a science-based career upon graduation and, similarly, 41% and 12.9% intended to pursue MS and PhD degrees upon completion of their current bachelor’s degree, respectively. The Survey of Earned Doctorates (SED) is the sole

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data source for recipients of doctoral degrees from U.S. colleges/universities. According to SED, the proportion of doctoral degrees earned by persons of color has increased slightly in the decade from 2006 to 2016. Specifically, the number of doctoral degrees earned increased from 6% to 7% and from 5% to 7% by African Americans and Hispanic/Latinos, respectively, and has remained <1% for individuals self-identifying as American Indian or Alaska Native (National Science Foundation, National Center for Science and Engineering Statistics 2018).

Data summarizing degrees awarded at various levels in statistics and biostatistics with respect to racial/ethnic distribution of graduates are not routinely collected. However, a recent assessment by the American Statistical Association (ASA) of data from the Department of Education's National Center for Education Statistics (NCES) Integrated Postsecondary Education Data System Completion Survey and the National Science Foundation's National Center for Science and Engineering Statistics (NCSES) provides an informative breakdown (Pierson 2018; NCES 2020). More specifically, between 2011 and 2017, the percentages of graduates (restricted to US citizens or permanent residents) receiving a BA/MS/PhD in Statistics or an MS/PhD in Biostatistics ranged from 3% to 6% for Blacks, 3% to 7% for Hispanics, and 0% to 1% for Native Hawaiian or Other Pacific Islanders. The percentages fluctuated around 60% for Whites, 20% for Asians, and 2% for those reporting ≥ 2 racial/ethnic groups. When focusing specifically on graduates from Biostatistics programs, the percentages of graduates who are African American remained stable over the 7-year period around 5% for the MS in Biostatistics and ranged from 9% and 8% in 2011 and 2012 to 3% and 6% in 2016 and 2017 for the PhD in Biostatistics. The percentages were also relatively stable for Hispanics with a range from 3% and 8% in 2011 and 2012 to 6% and 5% in 2016 and 2017 for the MS in Biostatistics, and 5% and 1% in 2011 and 2012 to 2% and 7% in 2016 and 2017 for the PhD in Biostatistics. One limitation of these databases is that they do not capture other biostatistics degree-granting programs, including the MPH or DrPH. Overall, although there have been some gains, in terms of representation of earned graduate degrees, there are still disparities in the relative number of underrepresented minorities earning those degrees.

The United States is the world's leader in science and maintaining this distinction is considered a national priority. Therefore, to ensure robust scientific advancement, there must be a concerted effort to increase the pipeline of intellectually talented persons available with exposure to the appropriate quantitative skills who are interested in careers in biostatistics. One such effort is ensuring that future generations of biostatisticians and data scientists fully engage and take advantage of the spectrum of diversity represented in the United States to access the widest pool of creativity and ingenuity. Some argue that the lack of diversity in science, technology, engineering, and mathematics (STEM) (Valantine and Collins 2015; Canner et al. 2017; Nielsen et al. 2017) disciplines greatly diminishes the nation's ability to maintain a competitive global economic edge (Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development 2001) and our ability to solve pressing health issues in all domains.

1.3. The Importance of Mentoring for Underrepresented Minority (URM) Success in Statistics and Biostatistics

The significance of mentoring on success among URM students in STEM fields is well-documented. In a mixed-methods study conducted by Griffin et al. (2010) to explore the experiences and perceived contributors to success among Black professors in STEM, respondents consistently highlighted the importance of mentoring and advising on their success in their undergraduate and graduate educational pursuits as well as with their preparation for professional careers as academics. Estrada, Hernandez, and Schultz (2018), in their longitudinal study of almost 1500 URM undergraduate biomedical/science majors across 50 academic institutions nationwide, observed that quality mentorship combined with being engaged in research experiences within their junior and senior years increased students' ability to function as scientists (i.e., science efficacy), along with their sense of belonging to the scientific community (i.e., science identity) and how much they value scientific innovation (i.e., science community value) (Estrada et al. 2011). The American Statistical Association has advocated for the development and implementation of conference-based mentoring programs as a means to foster long-term sustainable mentor-mentee relationships that can be crucial for promotion and advancement in statistics and biostatistics (Vance, LaLonde, and Zhang 2017). This is particularly important for minorities and women who are disproportionately affected by inequitable opportunity structures that may continue to persist in our field.

In an opinion piece in *Nature Medicine* (2014), Sally J. Rockey, Deputy Director for Extramural Research at the National Institutes of Health (NIH), describes the importance of mentoring to the advancement of science and highlighted initiatives and programs at the NIH to support these efforts after the NIH noted an increase from 60% in 2001 to 65% in 2011 in the number of graduate students and postdoctoral fellows that were supported by research grants, as opposed to career- or training-focused awards. Some include requiring Individual Development Plans (IDPs) for all trainees (pre- and post-doctoral), Innovative Programs to Enhance Research Training (IPERT), Broadening Experiences in Scientific Programs (BEST), NIH Postbaccalaureate Research Education Programs (PREP) as well as various NIH R25 initiatives, all with the overarching goal of enhancing mentorship for the burgeoning biomedical workforce (Rockey 2014).

Mentoring is, by nature, much more involved than academic advising. Mentoring is a unique combination of academic and personal guidance, career development and support as well as being a familiar model for the norms of a given profession. Minority students, for example, even when mentored, tend to get less access to career guidance or development and thus have a more limited understanding of the vast opportunities available to them in their field of study (McGuire 1999; Thomas, Willis, and Davis 2007). A good mentor is often the source of both technical knowledge and understanding as well as a source of support, empathy, and respect for mentees as they make their way through the challenges of matriculating through their training program. Perhaps more so than for other groups, URM graduate and undergraduate students may seek out more faculty support to navigate the particulars of academic success, especially if

they are first generation students. Similar to most students who are identifying mentors, it is often desirable to connect with individuals with whom they share common interests (research and personal) and perhaps from individuals who “look like them” as a tangible example of success by someone with shared life experiences. This may be particularly true for students of color in STEM concentrations who more often than not have matriculated as students in similar settings (e.g., historically black colleges and universities) and have a unique perspective from which to mentor URM students. Finally, Segarra et al. (2020) recently acknowledged the potential role of scientific organizations in advancing the diversity of the STEM workforce, which highlighted mentoring as a key component of diversity focused efforts.

1.4. The Eastern North American Region of the International Biometric Society and the Fostering Diversity in Biostatistics Workshop

The International Biometric Society (IBS) is an international society promoting the development and application of statistical and mathematical theory and methods in the biosciences, including agriculture, biomedical science and public health, ecology, environmental sciences, forestry, and allied disciplines (<https://www.biometricsociety.org>). IBS has more than 6000 members from more than 80 countries identified by location and regional affiliation (31 regions). Members include statisticians, biostatisticians, mathematicians, data scientists, biologists, and others devoted to interdisciplinary efforts in advancing the collection and interpretation of information in the biosciences. IBS sponsors a major international conference, the International Biometric Conference, biennially (most recently, 2018 in Barcelona, Spain and planned for Seoul, Korea in 2020, but recently canceled due to the novel coronavirus (COVID-19)). In addition, each region may hold its own program of conferences. IBS publishes two highly regarded journals, *Biometrics* and *The Journal of Agricultural, Biological and Environmental Statistics*.

The Eastern North American Region (ENAR) of IBS includes members residing east of approximately 104° west longitude in the United States and Canada (www.enar.org). ENAR is the largest and most active region of IBS, with roughly 1450 members, on average. ENAR members include statisticians from academia, government (e.g., National Institutes of Health, Centers for Disease Control and Prevention, US Food and Drug Administration), the pharmaceutical industry, data science organizations, as well as public and private research institutes. Among ENAR members, around 8% are graduate students, 40% are women, and 3% are underrepresented minorities. ENAR is one of the key professional statistical organizations in the U.S. ENAR members participate in an annual meeting, which ranks as the largest biostatistics professional meeting in the world with more than 1100 attendees. In addition to the annual meeting, ENAR currently hosts a comprehensive WebENAR series throughout the year with regularly scheduled, synchronous online webinars, which serves to introduce ENAR members to novel methodologies in statistics and data science, and, in general, promotes continuing education for professionals and students within the field.

In an effort to address the lack of representation of underrepresented minorities in biostatistics, a small group of ENAR members, led primarily by Drs. Louise Ryan and Amita Mantunga, representing academia, industry, and government developed the Fostering Diversity in Biostatistics Workshop (FDBW) in 1999 as an effective and sustainable strategy to get more students from traditionally underrepresented groups interested in and enrolled in advanced degree programs in biostatistics. More specifically, this pipeline initiative, held annually as a half-day workshop as a pre-meeting event just prior to ENAR's annual spring meeting, sought to fulfill the following objectives: (1) increase the active participation of U.S. minorities in ENAR/IBS; (2) establish mentoring and networking relationships at all training and career levels; (3) increase the number of minorities successful in graduate training and professional careers; and (4) to increase the number of minorities entering graduate study in (bio)statistics. The spirit of the workshop is closely aligned to the sentiment published in Rudine Sims Bishop's seminal 1990 essay “Mirrors, Windows, and Sliding Glass Doors” highlighting the lack of children's books with African American characters and themes (Bishop 1990). The piece called upon books to act as windows and mirrors allowing all children to see themselves (mirrors) and the experiences of others (windows) in what they read. Although this is an example from childhood education, FDBW serves to address similar issues, acting as mirror, window and sliding glass door for participants at each level starting from high school students and STEM undergraduates with a budding interest in biostatistics up to and including graduate education and beyond. Including FDBW as a key component of the annual ENAR (IBS) meeting gives all FDBW participants a unique opportunity to expand their professional and peer mentoring networks, as well as giving access to the latest, cutting-edge research in the field.

Since its inception, the FDBW has targeted high school students primarily residing in the host city in which the ENAR annual meeting takes place, undergraduates from Historically Black Colleges and Universities (HBCUs), high-Hispanic-enrollment institutions (HHEs), Native American Tribal Colleges (TCs), and majority-serving institutions (MSI), graduate students in statistics, biostatistics, and data science, undergraduate and graduate faculty, and industry and government professionals. The inclusion of local high school students is particularly important as they benefit from an even earlier introduction to biostatistics, and can begin seeing their broader coursework in math as preparation for future studies in biostatistics.

This FDBW is innovative in its brief (half day) introduction to the many aspects of pursuing a graduate degree in biostatistics, immediate peer and professional networking opportunities, and also serves as an overview of the variety of career paths for both Master's (e.g., MS, MSPH, MPH) and doctorally (e.g., PhD, ScD, DrPH) trained biostatisticians. Additionally, the FDBW serves as an introduction to understanding what graduate programs are looking for when selecting graduate students, what students might expect as graduate students training in biostatistics, and what they might expect once they have completed their graduate training through a series of interactive presentations, roundtable and panel discussions, and numerous networking opportunities.

From the perspective of undergraduates and their faculty mentors from their home institutions, the FDBW provides a unique opportunity to interact with: (1) graduate faculty to learn about the admissions process, (2) professionals in the field to learn about unique aspects of their current and past positions, and (3) current graduate students to learn about the training experience from students at various stages (pre-dissertation and post-dissertation). Current graduate students have similar opportunities to interact with graduate-level trained biostatisticians to learn about more immediate internship and career opportunities (e.g., current and anticipated job openings, including post-doctoral opportunities). This aspect of the FDBW experience is also very beneficial to those seeking to fill open positions for graduate-level trained biostatisticians and to identify strong graduate student candidates as the workshop enrolls a highly engaged, self-selected group of individuals typically underrepresented in the field who are quantitatively gifted and training-grant eligible. By facilitating this intensive introductory (for those from undergraduate institutions) and networking opportunity, the FDBW continues to attract the brightest young scholars to the field so they may ultimately become engaged in scientific research, applying their quantitative expertise to many challenging research problems in a variety of applications. Recently, we have also introduced two additional workshop activities: (1) a 1.5 hr “Introduction to Statistical Programming and Data Visualization” hands-on interactive activity in R or SAS for undergraduates and high school students; and (2) an intensive “Critically Appraising the Scientific Literature” workshop for graduate students and post-doctoral scholars. Professionals from a variety of settings, including academia, government, and industry facilitate engaging roundtable discussions focused on effective strategies for: (1) recruiting and retaining biostatisticians of color and, (2) supporting students of color in graduate programs in biostatistics.

1.5. Study Objective

While other diversity in statistics workshops (i.e., the ASA StatFest and Joint Statistical Meetings Diversity Workshop and Mentoring Program) have been initiated since the inception of the FDBW, to our knowledge, the FDBW remains one of the few workshops that is focused specifically on increasing diversity in biostatistics. In an effort to evaluate the impact of this initiative on helping to build and sustain effective networks and mentoring relationships among URM students and professionals, we surveyed individuals who had participated in the workshop over an 11-year period. Thus, the purpose of this paper is to disseminate our findings from our evaluation of the FDBW, which we hope will help to guide the development and implementation of other diversity initiatives in biostatistics and STEM fields more broadly in the future.

2. Methods

2.1. Data Collection

In addition to annual evaluations of the FDBW, in March 2019 we conducted a brief survey to evaluate the impact of the FDBW on past participants. The survey, conducted in the research

electronic data capture system (REDCap, Harris et al. 2009) was distributed via e-mail to all previously registered attendees ($n = 587$) of the FDBW between the years of 2010 and 2018, using the e-mail address that the participant used at the time of registration. The survey remained open for eight days from March 4, 2019 to March 11, 2019.

2.2. Survey Questionnaire

The survey consisted of 12 items that can be categorized into three themes: attendee demographics, timing of participation, and impact of the workshop on attendee and others. Specifically, we asked about current educational/professional status as well as the educational/professional status of participants when they first attended the FDBW. Operationally, we combined this information into one variable categorized into three mutually exclusive groups. The first group, *professional*, consists of participants who are currently professionals and were also professionals when they first attended the FDBW. Similarly, the second group, *student*, consists of participants who are currently students and were also students when they first attended the FDBW. Lastly, the third group, *student to professional*, consists of participants who were students when they first attended FDBW and are currently professionals. To assess participation timing, we assessed the year in which participants first attended the FDBW as well as the total number of FDBWs participants had attended. Lastly, the impact of the FDBW was assessed on the following domains: (1) impact on participants’ own training and/or professional career, (2) impact on developing a network of students and/or professionals in biostatistics, and (3) impact on identifying mentors or mentees. Related to mentoring, for respondents who indicated that they identified mentors or mentees, we also assessed whether they identified peer mentors, senior mentors, or mentees. Lastly, we asked participants if given the opportunity, would they be interested in volunteering or contributing toward future FDBW planning efforts.

2.3. Statistical Analysis

Survey data were summarized descriptively. Continuous measures were summarized using means and standard deviations or medians and interquartile ranges, whereas categorical measures were summarized as frequencies and corresponding percentages. Assessments of impact were further stratified by educational/professional status. All analyses and data visualizations were conducted using R 3.5.1.

3. Results

3.1. Demographics of Participants and Participation Timing

Of the 587 former FDBW participants contacted, 72 respondents completed the survey within the eight-day response period, yielding a 12% response rate. Table 1 summarizes key characteristics of the sample. Approximately one-third of respondents were professional (35%, $n = 25$) or student to professional (37%, $n = 26$), whereas 28% ($n = 20$) of respondents

Table 1. ENAR FDBW sample characteristics ($n = 72$).

	Total
Status ^a	
Professional	25 (35.2%)
Student	20 (28.2%)
Student to professional	26 (36.6%)
First year of attendance ^a	
1999–2004	8 (11.3%)
2005–2009	9 (12.7%)
2010–2014	14 (19.7%)
2015–2018	40 (56.3%)
Frequency of attendance ^a	
1–3	51 (71.8%)
4+	20 (28.2%)
Impactful workshop ^a	64 (90.1%)
Developed a network ^b	60 (85.7%)
Identified mentor or mentee ^a	47 (66.2%)
Would volunteer to plan future workshop ^c	61 (88.4%)

Cells, N (%); ENAR, Eastern North American Region; FDBW, Fostering Diversity in Biostatistics Workshop.

^aMissing information for 1 (1.4%) respondent.

^bMissing information for 2 (2.8%) respondents.

^cMissing information for 3 (4.2%) respondents.

were students. Most (56%, $n = 40$) respondents attended the FDBW for the first time between the years of 2015 and 2018, 20% ($n = 14$) first attended between 2010 and 2014, and 13% ($n = 9$) and 11% ($n = 8$) first attended in between 2005 to 2009 and 1999 to 2004, respectively. Most respondents (72%, $n = 51$) reported attending the FDBW between 1 and 3 times, whereas 28% ($n = 20$) of respondents had attended the FDBW at least 4 times.

3.2. Impact of Participation

Table 1 also summarizes impact measures and basis sample summaries. Most (86%, $n = 61$) respondents identified a network of students and/or professionals mentors/mentees in

biostatistics. Specifically, approximately two-thirds (66%, $n = 47$) identified a mentor or mentee as a result of participating in the FDBW. Most respondents (90%, $n = 64$) indicated the FDBW to be impactful with respect to their training or professional career. The majority of respondents (88%, $n = 61$) responded affirmatively to being interested in volunteering or contributing toward future FDBWs.

We examined the impact of the FDBW by educational/professional status. There were similar numbers of respondents in each group ($n = 25$ professional; $n = 20$ student; and $n = 26$ student to professional). We found that 88% ($n = 22$) and 90% ($n = 18$) of the professional and student groups, respectively, developed a network, whereas 80% ($n = 20$) of the Student to Professional group reported developing a network (Figure 1). More respondents in the student to professional group (77%, $n = 20$) identified a mentor or mentee compared to either the professional (60%, $n = 15$) or student (60%, $n = 12$) groups. All 20 respondents in the student group and 96% ($n = 25$) of those in the student to professional group found the FDBW to be impactful with respect to their training or professional career, whereas about three-quarters (76%, $n = 19$) of those in the professional group found the FDBW to be impactful.

Among the 47 respondents who identified a mentor or mentee, 46 (98%; 14 professionals, 12 students, and 20 students to professionals) additionally responded to subsequent questions shedding light on the proportion identifying mentees, peer mentors and/or senior mentors. Among those in the professional group, 36% ($n = 5$) identified both a peer and senior mentor, 14% ($n = 2$) identified a senior mentor only, 21% ($n = 3$) identified a peer mentor only, and 29% ($n = 4$) identified a mentee only (Figure 2). The majority (70%, $n = 14$) of those in the Student to Professional group identified both a peer and senior mentor, whereas one-quarter ($n = 5$) identified a senior

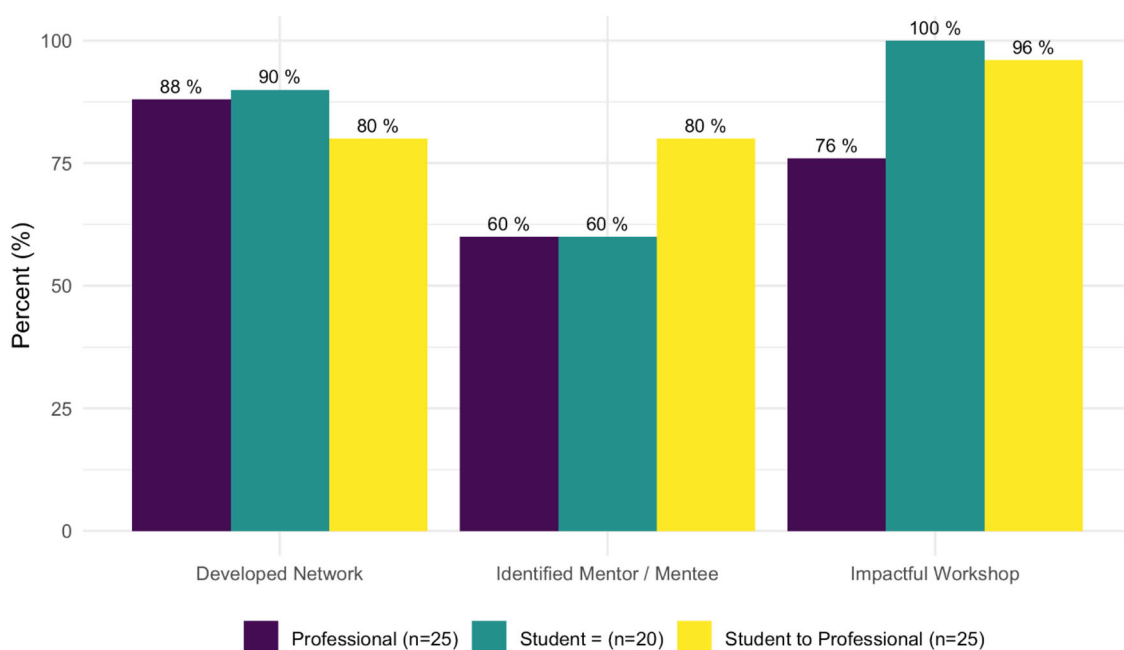


Figure 1. Percentage of ENAR (Eastern North American Region) FDBW (Fostering Diversity in Biostatistics Workshop) respondents who developed a network of students and/or professionals in biostatistics, identified a mentor/mentee, and found the workshop to be impactful stratified by educational/professional status.



Figure 2. Percentage of respondents who identified a peer and senior mentor, senior mentor only, peer mentor only, or mentee only, stratified by educational/professional status, among those who responded affirmatively to identifying a mentor or mentee.

mentor only, and 5% ($n = 1$) identified a mentee only. Two-thirds of those in the student group identified a peer and senior mentor (33%, $n = 4$) or a senior mentor only (33%, $n = 4$), respectively, whereas one-third identified a peer mentor (17%, $n = 2$) or mentee only (17%, $n = 2$), respectively.

Finally, the impact survey included one open-ended question where respondents could give an overall assessment of their FDBW experience. Here we present a few anonymized responses from a variety of attendee perspectives.

Undergraduate student: “The impact of the ENAR FDBW has had a major impact on my future and training for the real world. I have expanded my mindset in regards of going into biostatistics and there are more job opportunities and great positions available. Overall it has helped me to become more clear minded about things I want to do in life.”

Graduate student: “The ENAR FDBW is very impactful but I believe it should be advertised more. If I had not met Dr. B at JSM Boston or JC at UPenn through BRAIN, Inc., almost 9 years after graduating from my MS Stats program, I would not have known about ENAR. None of the faculty in my program (all of whom are Caucasian), told us about JSM nor ENAR. My suggestion is to send an announcement to Stats Departments so that students know about ENAR FDBW. The connection I made at ENAR in 2016 was life changing in that the suggestion that a panelist, EB, gave me resulted in a connection with a future dissertation committee member. FYI I selected ‘no’ for question 7 because I had already been introduced to a mentor through a different minority mentoring program at JSM Boston. This is not to say that I could not have found a mentor at ENAR FDBW.”

Post-doctoral Fellow 1: “It was great to meet other under-represented graduate students and professionals in statistics and biostatistics.”

Post-doctoral Fellow 2: “I am grateful to have had the opportunity to participate in the ENAR FDBW. Through this workshop, I learned strategies to help me complete my degrees and identify biostatistics research topics to pursue. Attending this workshop always felt like coming home to a community where you can find support, guidance, mentorship and encouragement. I also networked and discovered career and job openings at these workshops. The travel support also provided me with financial resources to attend the ENAR conference.”

Post-doctoral Fellow 3: “The themes differ with each year. The panels have always fostered great candid discussion amongst both peers and perspectives gained from senior personnel. The greatest impact for me was connecting me to great senior mentors who have been instrumental in helping navigate me through graduate school and considerations for my career path and exposing me to the wide variety of options in a safe and welcoming space that I otherwise would not get from my own institution.”

Professional, Government 1: “Taking this survey has really made me think back to the beginning of my career journey. I have benefitted tremendously from the support and encouragement of so many leaders in the field who have also been a part of this program for many years. This is a wonderful environment for students to thrive and grow in their journey to becoming young professionals.”

Professional, Government 2: “Networking with peers and mentors is by far the most important aspects of FDBW. I had extremely valuable conversations there that gave me perspective beyond my immediate social circle and professional setting.”

Professional, Industry: “The ENAR FDBW was a fantastic program. The sessions were led by knowledgeable people that were always friendly and gave lots of great advice. I learned

about scholarships, fellowships, and internships. It gave me an invaluable opportunity to network with other junior scientists. I appreciated the financial support of the program, as it made it possible for me to attend the ENAR meeting and learn from seasoned biostatisticians. After reaping the tremendous benefits of the FDBW, I was inspired to give back and serve as a mentor in other diversity programs for junior statisticians. It was an amazing program, and I am grateful that I had the opportunity to participate.”

Undergraduate Faculty: “The workshop provides an excellent and broad platform for connecting with the relatively small number of biostatistics academic professionals of color within the U.S. Connecting faculty, scientists, and graduate students under one umbrella is already powerful but then adding undergraduates and even high school students to the experience adds additional—wonderful—dimensions. My professional development has been greatly enhanced by the connections that I have been able to establish through participation in these workshops (helping to defeat feelings of cultural and ethnic isolation). In addition, the impact of being given the opportunity to hear and share experiences and advice with others in the field cannot be overstated.”

Graduate Faculty: “The ENAR FDBW has been extremely instrumental in helping me to navigate my professional career as a graduate faculty. Through the Workshop, I have also become a part of a diverse community of colleagues, mentors, and mentees committed to helping underrepresented groups thrive in the field of Biostatistics. ENAR FDBW continues to make a very valuable contribution to creating a more inclusive and equitable culture in our field.”

Administrator: “I believe that the ENAR FDBW has broad reach and strong impact on young people. Even if they decide that biostatistics is not the right field for them, they are making informed decisions.”

4. Discussion

4.1. Brief Summary

Data from the brief “impact” survey of former FDBW participants demonstrates that the workshop has been well-received and impactful, in terms of graduate training and to the professional careers of attendees. Further, many respondents were long-time attendees, having attended several FDBWs, likely spanning both their time as students and as working professionals. The results also suggest that FDBW participants progress from mentee to mentor through the experience of attending multiple workshops. This is an essential component of FDBW and represents one aspect of how the workshop fosters and nurtures participants at every stage from training up to and including, providing support as junior and senior professionals. One can argue that this group must find value in returning to the FDBW, either for themselves (e.g., mentoring) or in what they may have to give to others (e.g., identifying mentees and/or networks). In addition, the majority of respondents indicated they would be willing to serve in organizing future workshops, again demonstrating value and impact of the FDBW.

To our knowledge, our study is the first of its kind to quantitatively evaluate the impact of a diversity focused workshop on

the field of biostatistics, where the original intention of the study was to conduct a rapid data collection to be responsive to an application for funding. Therefore, the survey was available for completion for only eight days in March 2019 and the response rate was 12%. The survey was sent to all e-mail addresses of former FDBW attendees who had attended the workshop at any time between 2010 and 2018, using the e-mail used to register for the workshop. Many participants surveyed attended FDBW as students (undergraduate and graduate), therefore, many of the e-mails were no longer active or were not monitored regularly for many past participants and do not have access to the e-mails that they used to register for the workshop. The same is true for non-students, who may have transitioned professional positions since they attended FDBW. In spite of this limitation, the distribution of participants who completed the impact survey summarized in this paper is consistent with the distribution of attendees who completed the evaluation of the workshop each year (53% undergraduate and graduate students; 39% professionals; 55% first time FDBW attendees), which remains open for completion much longer (e.g., typically 4–6 weeks following each FDBW). Therefore, there is some evidence that the data from the Impact Survey, summarized here, may be representative of former attendees. While we do believe that this study presents a rigorous analysis of the long-term impact of this workshop model of increasing diversity in biostatistics, we also acknowledge the potential for response bias due to the low response rate.

4.2. Implications and Impact

Cultivating and maintaining robust, diversity-related mentoring structures creates both formal and informal relationships that are critical to fostering the discovery of top talent in any professional sector. Additionally, programs such as the FDBW also serves as a resource to support both students and professionals from groups traditionally underrepresented in biostatistics, at every stage of their training and professional careers. Participants who find value in attending early become repeat attendees and even seek opportunities to contribute to the success of future workshops. Diversity mentoring in this context combines all of the benefits of informal relationships on individual career and training goals with a collective goal of promoting diversity in biostatistics. Again, FDBW has served as a mirror, reflecting positive images of diversity in biostatistics upon participants and a window and sliding glass door where participants get a glimpse of what is possible from others at different professional or training stages. A strength of the FDBW model is that it can be easily customized to any discipline, particularly other STEM disciplines.

Finally, many former workshop attendees become very involved in ENAR leadership, broadening their contributions to the field and beyond. For example, former student attendees after completing their graduate training have held several prominent positions including two Treasurers, members of ENAR’s governing bodies (the Regional Advisory Board (RAB) and the Regional Committee (RECOM)), including two RAB Chairs and two Presidents (Scarlett Bellamy, ScD, Associate Dean, Diversity, Inclusion and Faculty Development at

the Dornsife School of Public Health, Drexel University and F. DuBois Bowman, PhD, Dean University of Michigan School of Public Health). Additionally, the current Vice-President of the American Statistical Association (Dionne Price, PhD; Director of Division of Biometrics IV in the Office of Biostatistics, Office of Translational Sciences, Center for Drug Evaluation and Research, FDA) is also a former student attendee and organizing Co-Chair of FDBW. Indirectly, FDBW has also become a prominent pipeline for ENAR leadership as well, cultivating leadership skills relevant beyond this single professional organization. Beyond ENAR, former FDBW attendees have gone on to become Department Chairs, Directors of Centers, Directors of Graduate Programs, Associate Deans and Deans of their home institutions. In short, the impact of FDBW is wide, far reaching and lasting.

4.3. Next Steps

As with any such effort, securing funding for its long-term sustainability is critical. The FDBW has been generously supported since 2005 by an R13 grant (R13GM075338) from the National Institutes of General Medical Sciences (NIGMS), however, this support will end soon and we will be seeking other sources to continue support for the workshop. Specifically, the bulk (~90%) of the funds cover all travel-related expenses to attend the workshop, many of whom are undergraduate and graduate students, who would find it difficult to secure travel-related funds or to self-pay. We have partnered with several sponsors, including specific academic institutions, to support other aspects of the program not covered by the grant, including meals and audio-visual support. In the past, ENAR has discounted registration fees for the larger conference for student workshop attendees, giving them access to the larger scientific offerings of the conference. Additionally, given that many of our participants attend over the course of multiple years, we are constantly revising agenda offerings to ensure that we continue to provide offerings that are of value to repeat attendees, as well as offerings that are focused on addressing pipeline issues and engaging with new students interested in pursuing graduate degrees in biostatistics. The sustainability of the FDBW also hinges on the support of those committed to successfully increasing diversity within the field of biostatistics. With the overwhelming support of past participants, where over 85% of survey respondents indicated they would volunteer to help plan future workshops, this is also completely feasible.

Additionally, given the comments of FDBW participants regarding the positive mentoring aspect of the workshop, we will continue elevating this portion of the program in the future. In particular, FDBW will seek to strengthen partnerships with diversity efforts, particularly focused on mentoring. Some of those efforts are summarized in Hughes-Oliver (2017) and includes, for example, the JSM Diversity Workshop and Mentoring Program where several leaders of FDBW also serve as leaders in both efforts.

Supplementary Materials

Supplementary details regarding the Fostering Diversity in Biostatistics Workshop Impact Survey are provided including the full text inviting participants to complete the survey as well as survey questions.

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