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Collaborative biostatistics and epidemiology in academic medical centres: A survey to assess relationships with health researchers and ethical implications

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Abstract

The role of collaborative biostatisticians and epidemiologists in academic medical centers and how their degree type, supervisor type, and sex influences recognition and feelings of respect is poorly understood. We conducted a cross-sectional survey of self-identified biostatisticians and epidemiologists working in academic medical centers in the US or Canada. The survey was sent to 341 contacts at 125 institutions who were asked to forward the survey invitation to faculty and staff at their institution and posted on *Community* sections of the American Statistical Association website. Participants were asked a variety of questions including if they felt pressured to produce specific results, whether they had intellectual and ethical freedom to pursue appropriate use of statistical methods in collaborative research, and if they felt their contributions were appropriately recognized by collaborators. We received responses from 314 biostatisticians or related methodologists. A majority were female (59%), had a doctorate degree (52%), and reported a statistician or biostatistician supervisor (69%). Overall, most participants felt valued by their collaborators, but that they did not have sufficient calendar time to meet deadlines. Doctoral-level participants reported more autonomy in their collaborations than master's level participants. Females were less likely to feel recognized and respected compared to males. The survey results suggest that while most respondents felt valued by their collaborators, they have too many projects and need more time to critically review research. Further research is needed to understand why response differs by sex and how these responses fluctuate over time.

Keywords

biostatistics; medical statistics; sample surveys

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Introduction:

Biostatisticians, statistical-scientists, and epidemiologists at academic medical centers often invest significant time and effort in consultation and collaboration with clinician- or translational-scientists, with the aim of improving methodological rigor in medical research. Many biostatistics or epidemiology (collectively and inclusively, methodology) units differentiate themselves from consulting services and instead describe their members as scientific collaborators. Significant contributions to medical science require a vested interest from methodologists as peer collaborators, rather than technicians, as strong collaborations with methodologists are associated with higher-quality research, as measured by manuscript acceptance rates (1). Yet perceptions and engagement from clinical and translational research colleagues often do not reflect collaboration, with the methodologist consulted late in the research study, their requested effort limited to data analysis, and they are often not appropriately recognized for their contributions with authorship (1).

Fractionated effort across medical disciplines, inefficient use of resources, and lack of biostatistics infrastructure at a unit or department level may strain the ability of methodologists to effectively collaborate and engage with clinical researchers (2). Departmental and leadership structure vary, with some biostatisticians having academic homes in dedicated biostatistics or methodology departments, others being members of interdisciplinary departments with biostatistical units, and others working in small groups or as individual statisticians directly within clinical or medical departments (3). Centralized collaborative biostatistics and epidemiology units may manage resources more efficiently and, in some cases, provide stronger leadership in policies to prevent fractionation and oversubscription (2). Differences in departmental structure, and resulting leadership, may dictate expectations for collaboration, methodology, education, and service.

Doctoral-level biostatisticians and epidemiologists may, in addition to clinical collaborations, also be tasked with varying combinations of developing and publishing novel statistical methods, teaching courses or lectures to students of statistics or to clinical colleagues, mentoring, and various service tasks, including protocol review or journal/grant refereeing (3). At the doctoral-level, strategies for development of early-stage faculty are needed to balance collaborative needs with teaching, mentoring, and additional scholarly activities (3), especially when advancement metrics do not align with collaboration (4). Similar considerations apply to non-faculty statisticians, including those with and without doctoral degrees, who are often expected to similarly contribute in a multifaceted way to the unit’s success. Such demands on time and effort may affect quality and the strength of biomedical collaborations if medical researchers do not respect time, funding, and overall effort boundaries. Recognition and value of a practicing biostatistician’s expertise by collaborators may specifically be linked with educational degree attained regardless of faculty or non-faculty appointment as an objective metric, especially since criteria for faculty vs staff appointments vary among biostatistical units (3, 4).

We developed and implemented a survey to assess the role of the collaborative biostatistician and epidemiologist at academic medical centers. We aim to quantify specific challenges biostatisticians face, including recognition, metrics for success, and upholding ethical

standards for statistical practice. We hypothesize differences on these outcomes between doctoral-level methodologists compared to bachelor's or master's trained statisticians and differences based on departmental structure, specifically whether one's chair or supervisor is also a methodologist versus a clinician-scientist or other medical professional, for example when working directly in a clinical department. We also hypothesize that differences may be observed by sex.

Method:

Survey instrument:

This study was approved by the Mayo Clinic institutional review board. Survey questions were developed by the investigators to assess the role of collaborative biostatisticians, epidemiologists, and related methodologists at academic medical centers in the United States and Canada. In particular, our target participants were methodologists who collaborate in research directed by health professionals or basic science (lab) investigators who are not trained in biostatistics or epidemiology. Our primary goal is to describe the professional relationships between methodologists and those health professionals or lab scientists. Key questions assess whether biostatisticians and epidemiologists feel respected in that relationship, whether they have intellectual and ethical freedom to pursue appropriate use of statistical methods in collaborative research, and whether adequate time and funding are provided to design studies, conduct analyses, and contribute to publications. The survey instrument is provided as Supplemental Appendix 1.

Our survey was administered, and data were collected and managed, using the Research Electronic Data Capture (REDCap) tools hosted on Mayo Clinic servers (5, 6). Data were maintained on a password protected server with limited access to protect possibly identifiable participant data.

Participants:

We sought to identify and reach as many biostatisticians as possible at academic medical centers in the United States, so we did not restrict enrollment to a set number of participants. We started by identifying academic medical centers with the intention of contacting department chairs or managers who would be encouraged to forward an invitation to participate to staff within their department or work group. Some chairs and managers were identified from membership in the Association of Clinical and Translational Science, Biostatistics Epidemiology and Research Design Special Interest Group (ACTS-BERD). Academic medical centers were identified and other points of contact were obtained through internet searches with the institution and keywords: "biostatistics", "epidemiology", "biostatistics resource", "biostatistics shared resource". When a relevant institutional website was identified, the investigators used the published website data to identify names and email addresses for individuals in leadership positions. For some institutions, a generic or shared email address was identified as a point of contact for questions to the department or work group and was used. We identified 152 possible academic medical centers in 45 US states and the District of Columbia and obtained at least one point of contact for 125 institutions.

Invitations to participate were also posted in several *Community* sections of the American Statistical Association (ASA) website (community.amstat.org). Communities included the Biometrics Section, Statistics in Epidemiology Section, Statistical Consulting Section, and Teaching Statistics in Health Sciences Section. While institutions were initially targeted in the US as described above, a modification was made to accept participants from Canadian academic medical institutions who obtained the invitation from *Community* postings.

The forwarded invitation from chairs and managers as well as the community postings included a public URL link to the survey. After opening the public link, participants were given brief information about the study purpose, incentive to participate, and asked to confirm the following inclusion criteria: (1) a degree (BA/BS, MA/MS/MPH, or PhD or Equivalent) in biostatistics, statistics, epidemiology, mathematics, or a related area or otherwise performing the work of a biostatistician or epidemiologist; (2) currently employed at an academic medical center; and (3) engaged in clinical or translational research with ≥50% effort derived from research led by a medical/health professional or basic/lab scientist. Definitions of academic medical center and clinical and translational research were intentionally not given, allowing broad interpretation from possible participants. Further, participants had to consent that de-identified responses could be used for research. We incentivized participation by randomly selecting a survey participant to receive a computer tablet device valued up to $599. To enter the drawing, participants needed to provide a name and contact email address. Participants were informed and consented to contact information being used to solicit participation in future surveys addressing other hypotheses as well as longitudinal follow up on these hypotheses.

The survey was sent to a total of 341 contacts at 125 institutions, but we are unable to track how many individuals those contacts forwarded the survey to, nor how many individuals viewed ASA *Community* postings.

Statistical Methods:

For comparisons by highest degree in a quantitative field, we combined MA/MS and MPH degrees into a “master’s” category. We also combined PhD with equivalent quantitative degrees into a “doctorate” category. Respondents with bachelor’s degree as the highest quantitative degree or a degree in a non-quantitative field such as Doctor of Medicine (MD) were excluded from the degree-type comparisons. We also compared results based on departmental and leadership structure using information about the respondent’s supervisor. Supervisor was left to the interpretation of respondents, but could include a unit supervisor or manager, or division or department chair. Specifically, we identified when the supervisor was a methodologist versus administrative or health professional. We excluded those who did not report having a supervisor from those comparisons. A secondary analysis subset to PhD-level respondents when comparing supervisor type. Finally, we compared results by self-reported sex from the survey. We excluded those not reporting sex from those comparisons.

Survey results are descriptively reported overall and by highest degree, supervisor, and sex, separately, using percentage for categorical responses. For the 5-point Likert items, the responses were dichotomized such that two response options (e.g., strongly agree and agree)

were combined into one category and the remaining three response options (e.g., neither agree nor disagree, disagree, strongly disagree) were combined into a second category. Hypothesis tests assessed responses by degree, supervisor, and sex, separately. Categorical variables were compared using Fisher's exact tests. Our survey, in order to offer greater confidentiality to respondents being asked about their working environment, did not request identification of institution; therefore, we were unable to account for potential clustering of observations. Hypothesis test results are reported with alpha level 0.05 without adjustment for multiple testing.

Results:

Overall:

Of the 412 people who opened the survey, 376 consented to the study and provided answers to the demographic questions, and 314 completed at least one of the research questions. Of the N=314 participants, 59% were female, 4% reported their race/ethnicity was non-Hispanic Black, 16% reported their race/ethnicity was Asian, 76% reported their race/ethnicity was non-Hispanic White only, 2% reported other or mixed races, 2% preferred not to answer their race, and 3% reported Hispanic ethnicity. The highest quantitative degree for participants was a bachelor's, master's, doctorate or other, for 3%, 44%, 52% and 1% of the participants, respectively, and participants had been working mean [median] of 11.9 [9.9] years since their highest degree was awarded, with a minimum of zero and maximum of 46 years of work experience at the time of the survey. Sixty-nine percent reported a statistician or biostatistician supervisor, 11% reported an epidemiologist or related methodologist supervisor, 13% reported a health professional supervisor, and 8% reported another type supervisor. Only 3% of participants reported they worked part-time.

Independent of highest quantitative degree, supervisor type, or sex, participants often agreed (i.e., agreed or strongly agreed) that their expertise as a statistician/methodologist is valued by the collaborators they work with (87%), that Principal Investigators (PIs) respect and honor their ethical boundaries (79%), and that they are provided intellectual freedom to critically review all abstracts, posters, presentations, and manuscripts (83%). Overall, there was less agreement that individuals were adequately informed of study progress (50%), and fewer than half agreed that they had sufficient calendar time (35%) or available effort (36%) to critically review abstracts, presentations, and manuscripts before deadlines. In general, participants have access to colleagues at their institution who they could ask statistical methodological questions (99%) and statistical programming questions (95%). About a third of the participants felt they are pressured to deliver specific analysis results related to the PIs hypotheses (29%) and very few participants reported their interactions with PIs were limited to brief advice and consultations so that the PI could perform their own analyses (4%). Participants felt they were supported by their supervisor (78%). Fewer than half of the participants agreed they had project managers available to support project workflow and administration (43%).

Responses by highest degree:

Of the 301 participants who reported their highest degree in a quantitative field was a master's or doctorate degree, 62% of the participants with a master's and 56% of participants with a doctorate degree were female (p=0.35). Doctoral-level participants reported fewer authorship disputes than master's participants (disagree or strongly disagree to the statement "not given authorship when I feel I should be a co-author": 85% vs. 75%, p=0.02) and reported PIs often collaborated with them early in research projects (54% vs. 39%, p=0.01). However, doctoral participants compared to master's participants more often felt that they have too many different projects to do each well (45% vs. 31%, p=0.02). No matter the degree type, most participants reported insufficient time to critically review all abstracts, posters, presentations, and manuscripts before deadlines (63% doctoral participants vs. 67% master's participants, p=0.47), but a minority reported being contacted by PIs with tight timelines that do not allow them to fully consider their hypotheses, determine or develop appropriates tests, or perform analyses well (28% doctoral participants vs. 36% master's participants, p=0.17). Doctoral participants were less likely than master's participants to have PIs tell them which statistical tests to perform instead of asking for their expertise (7% vs. 17%, p=0.01). Doctoral participants were more likely to agree that they would like more opportunities to pursue methodological research than master's participants (65% vs. 47%, p=0.002), however there was strong interest in this across all collaborative methodology participants.

Doctoral participants reported they were always or often listed as a Co-I or Co-PI on grant submissions where the PI is a heath professional or basic scientist more frequently than master's participants (63% vs. 12%, $p < 0.001$) and that they always or often discussed effort/budgets and project expectations with a PI before grant submissions (62% vs. 28%, $p < 0.001$). Additionally, doctoral participants agreed that the contributions of statisticians/methodologists as PIs or Co-PIs are appropriately recognized (when applicable) more often than master's participants (50% vs. 34%, p=0.01). Both doctoral and master's participants infrequently took on grants with less than 5% annual effort (12% vs. 9%, p=0.45) and about half agree that they are adequately informed of study progress (52% vs. 47%, p=0.42). Few doctoral or master's participants reported that abstracts, presentations, and manuscripts have been submitted always or often without their knowledge or review where the PI used the participant's name in the author block (9% vs. 6%, p=0.51). Key survey responses comparing participates with a master's vs. doctorate as the highest degree are summarized in Table 1.

Reponses by supervisor type:

Three hundred and nine participants answered the question regarding supervisor type, with 83% reporting a methodologist as supervisor while 17% reported a health professional, administrator, or other researcher ("other") supervisor. Of those with methodologist supervisors, 47% had a doctorate quantitative degree, and of those with other supervisors, 75% had a doctorate quantitative degree (p<0.001). Among only participants with a doctorate as their highest quantitative degree (N=161), those with a methodologist supervisor always or often work in collaboration with other statisticians/methodologists, statistics students, or statistical programmers on projects more often than people with other

supervisors who may work in more isolated environments (62% vs. 33%, p=0.003), and also reported a higher rate of wanting more opportunities to purse methodological research (69% vs. 51%, p=0.06). There were many areas of agreement between participants with a methodologist supervisor and participants with other supervisors (results reported as methodologist % vs. other %). Respect and honor of ethical boundaries was reported as high for both groups (83% vs. 74%, p=0.25) and there were no meaningful differences with respect to reported intellectual freedom to critically review all work (87% vs. 77%, p=0.20), feeling pressured to deliver specific analysis results (25% vs. 36%, p=0.22), and burden of being contacted with tight timelines (25% vs. 36%, p=0.22). Irrespective of supervisor type, one third of participants agree they have sufficient time and effort to critically review all work (33% vs. 33%, p=1.00) and about half of participants agree PIs collaborate with them early in projects (55% vs. 54%, p=1.00) and agree the contribution of statisticians/methodologists as PIs or Co-PIs are appropriately recognized (51% v. 49%, p=0.86). Survey responses for participants with a quantitative doctorate degree stratified by supervisor type are summarized in Table 2.

Responses by participant sex:

Of the 312 participates that reported sex, females less frequently agreed they are provided ample calendar time to critically review all abstracts, posters, presentations, and manuscripts before deadlines compared to males (30% vs. 43%, p=0.02), have sufficient time and effort available to critically review all work (31% vs. 43%, p=0.04), that the contribution of statistician/methodologist as collaborative investigator are appropriately recognized (50% vs. 60%, p=0.08), and that the contribution of statisticians/methodologists as PIs or Co-PIs are appropriately recognized when applicable (38% vs. 52%, p=0.02). Rates of reporting that their expertise as a statistician/methodologist is valued by collaborators (85% vs. 90%, p=0.24), and that PIs respect and honor their ethical boundaries (77% vs. 83%, p=0.26) were numerically lower for female participants though there is insufficient data to reject the null hypothesis of no difference. Females reported more potential isolation of their working environment, specifically reporting lower rate of always or often worked in collaboration with other statisticians/methodologists, statistics students, or statistical programmers on projects compared to males (49% vs. 65%, p=0.005), and they always or often were listed as a Co-I or Co-PI on a grant submission where the PI is a health professional or basic scientist less frequently than males (32% vs. 47%, p=0.01). Females reported a lower rate of interest in more opportunities to pursue methodological research than males (49% vs. 65%, p=0.004).

Of note, we did not observe sex differences (female % vs. male %) for the following: participants agree they are frequently given authorship when they feel they should be co-author (82% vs. 77%, p=0.31), they are pressured to deliver specific analysis results related to the PIs hypotheses (30% vs. 28%, p=0.80), they are provided intellectual freedom to critically review all abstracts, posters, presentations, and manuscripts, (82% vs. 85%, p=0.45), they always or often feel PIs tell them which statistical tests they would like performed instead of asking for their expertise based on their hypotheses (10% vs. 13%, p=0.59), and in disputes or disagreements with investigators, their supervisor will

support them (80% vs. 77%, p=0.68). Survey responses comparing females vs. males are summarized in Table 3.

Discussion:

We surveyed biostatisticians and epidemiologists working at academic medical centers in the United States, with the goal of describing relationships with health professionals and specifically assessing recognition and respect for their contributions. We found the scope of most collaborations was long-term, where a methodologist informed, developed, and performed the statistical analyses. Almost all respondents felt they had colleagues to ask their methodological or programming questions. Most respondents felt valued by their collaborators, that their ethical boundaries were respected, and they had intellectual freedom in collaborations. As we hypothesized, a majority of collaborative biostatisticians felt they were not involved early enough in projects nor given enough time to critically review research. Many respondents felt they had too many projects to do each well. As expected, doctoral respondents were more frequently given appropriate authorship and listed as a PI or Co-I compared to master's respondents. Interestingly, about half of the respondents with a master's degree reported they wanted to pursue methodological research, which was higher than we expected.

Our findings by sex both support and contrast with previous research. Smith et al conducted a survey of researchers in collaborative science and found that female respondents were more likely to report disagreements about being named as an author and the order of authors compared to survey respondents (7). This may reflect historical societal and traditional gender expectations about behavior influencing a contributor's self-advocation for recognition (8). These contrasts with our results where we found no differences by sex on whether a participant was named as an author when they felt it was deserved, however this may reflect better recognition of the contributions of biostatisticians overall rather than gender parity. On the other hand, Ibrahim et al reported female faculty in academic medicine feel more isolated compared to their male counterparts, which is line with our results combined across master's and doctoral trained biostatisticians (9).In addition to these findings, we observed that females do not feel as valued for their contributions compared to males, which may be linked to isolation as well as the lower reported rate of co-I and co-PI status when they felt it was appropriate despite no meaningful difference in authorship.

Prior studies of research ethics have focused narrowly on scientific misconduct in analysis and reporting (10, 11). In our study, nearly a third of all participants reported pressure to deliver specific results. Wang, et al previously surveyed biostatisticians about researcher requests for inappropriate analyses or reporting (12). Over half of respondents in that survey reported inappropriate requests, including nearly a fourth reporting a request to remove or alter data to support the hypothesis which was considered a severe violation by over 80% of respondents. Our survey may undercount such requests as we did not ask about specific violations nor did we specify a timeframe for consideration and instead left it to respondents to self-define such pressure or other ethical violations. Nonetheless, 29% reporting such pressure to deliver specific results is concerning (13).

Ethical violations should be interpreted more broadly, inclusive of disrespect for time, funding, and intellectual freedom. More than half of respondents reported insufficient time for review and more than 20% reported lack of intellectual freedom or disrespect of ethical boundaries. Our survey indicated that people do not have enough time to critically review work and do each project well. It is also important that further research be conducted to more fully understand barriers that limit implementation of good methodology and biostatistics. Possible barriers include funded effort, time, and knowledge. As many collaborative biostatisticians are funded via grants and other soft money sources (14), further exploration is warranted into whether the reported limitation of having too many projects to do each well or not ample time to critically review all work is due to inadequate funding or limitations imposed by funding agencies, though funding with <5% effort was reported as rare. Future research should explore gender and sex differences and reasons for why these are observed, especially related to sufficient time to do projects well and if the less time reported is perceived due to other work responsibilities or outside factors. We report little difference in time, intellectual freedom, and respect questions based on supervisor status, which is reassuring for those who may work in more isolated settings, for example when embedded within a clinical department rather than as part of a methodology unit or department (2, 3, 14).

Our survey has limitations. Since the number of collaborative biostatisticians in academic medical centers is unknown, it is hard to quantify the response rate and know if our sample is representative. Potential response bias may skew respondents as those from larger departments and collaborative units and towards units with representation in the ACTS-BERD. Responses clustered around a few institutions would limit generalizability of our results. Our survey asked for self-reported sex, whereas gender identity would have been more relevant to these hypotheses. Since our analyses and results are descriptive in nature, conclusions are limited and should be taken as a starting point for future research. Additionally, this survey was cross-sectional. Administering this survey longitudinally will allow us to see how respect and recognition fluctuate over time and if certain response patterns are associated with a change in role (e.g., leaving a job or being promoted).

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1:

Survey responses stratified by highest quantitative degree type (omitting bachelor's and other)

	Master's (N=137)	Doctorate (N=164)	Fisher's exact test p-value
Participant sex [non-missing N=137; N=162]			
Female	85 (62.0%)	91 (56.2%)	0.346
Supervisor type [N=135; N=161]			
methodologist	123 (91.1%)	122 (75.8%)	<0.001
other	12 (8.9%)	39 (24.2%)	
I am frequently given authorship when I feel I should be co-author			
agree	102 (74.5%)	140 (85.4%)	0.020
My expertise as a statistician/methodologist is valued by the collaborators that I work with			
agree	120 (87.6%)	141 (86.0%)	0.735
I have too many different projects to do each project well			
agree	43 (31.4%)	74 (45.1%)	0.018
I am pressured to deliver specific analysis results related to the PIs hypotheses			
agree	45 (32.8%)	46 (28.0%)	0.380
PIs respect and honor my ethical boundaries			
agree	105 (76.6%)	132 (80.5%)	0.480
PIs collaborate with me early in research projects			
agree	54 (39.4%)	89 (54.3%)	0.011
I am adequately informed of study progress			
agree	64 (46.7%)	85 (51.8%)	0.418
I am provided ample calendar time to critically review all abstracts, posters, presentations, and manuscripts before deadlines			
agree	45 (32.8%)	61 (37.2%)	0.468
I have sufficient time and effort available to critically review all abstracts, posters, presentations, and manuscripts before deadlines			
agree	57 (41.6%)	53 (32.3%)	0.118
I am provided intellectual freedom to critically review all abstracts, posters, presentations, and manuscripts			
agree	110 (80.3%)	137 (83.5%)	0.547
In disputes or disagreements with investigators, my supervisor will support me			
agree	112 (81.8%)	123 (75.0%)	0.165
Project managers are available to support project workflow and administration			
agree	52 (38.0%)	75 (45.7%)	0.198
PIs tell me which statistical tests they would like me to perform instead of asking for my expertise based on their hypotheses			
always or often	23 (16.8%)	12 (7.3%)	0.012
PIs contact me with tight timelines that do not allow me to fully consider their hypotheses, determine or develop appropriate tests, or perform analyses well			
always or often	49 (35.8%)	46 (28.0%)	0.171

	Master's (N=137)	Doctorate (N=164)	Fisher's exact test p-value
My interactions with PIs are limited to brief advice and consultations so that they can do their own analyses			
always or often	6 (4.4%)	4 (2.4%)	0.521
I work in collaboration with other statisticians/methodologists, statistics students, or statistical programmers on projects			
always or often	74 (54.0%)	91 (55.5%)	0.817
Abstracts, presentations, and manuscripts have been submitted without my knowledge or review where the PI has used my name in the author block			
always or often	8 (5.8%)	14 (8.5%)	0.506
On grant submissions where the PI is a health professional or basic scientist, I am listed as a Co-I or Co-PI?			
always or often	16 (11.7%)	104 (63.4%)	< 0.001
The PI and I discuss effort/budgets and project expectations before grants are submitted			
always or often	38 (27.7%)	102 (62.2%)	< 0.001
Grants are submitted without sufficiently budgeting for my effort			
always or often	24 (17.5%)	37 (22.6%)	0.315
Do you take on grants with <5% annual effort?			
always or often	12 (8.8%)	19 (11.6%)	0.452
The contribution of statisticians/methodologists as collaborative investigators are appropriately recognized			
agree	72 (52.6%)	89 (54.3%)	0.817
The contribution of statisticians/methodologists as PIs or Co-PIs (when applicable) are appropriately recognized			
agree	47 (34.3%)	82 (50.0%)	0.007
Do you have access to colleagues at your institution who you can ask statistical methodology questions? [N=130; N=152]			
yes	129 (99.2%)	150 (98.7%)	1.000
Do you have access to colleagues at your institution who you can ask statistical programming questions [N=130; N=149]			
yes	125 (96.2%)	139 (93.3%)	0.426
I would like to have more opportunities to pursue methodological research			
agree	65 (47.4%)	107 (65.2%)	0.002
Opportunities exist to collaborate with other biostatisticians and methodologists on statistical and methodological research projects			
always or often	37 (27.0%)	55 (33.5%)	0.258

Table 2:

Among participants with a doctorate for their highest quantitative degree, survey responses stratified by supervisor type

	Methodologist (N=122)	Other (N=39)	Fisher's exact test p-value
Participant sex [non-missing N=120; N=39]			
female	69 (57.5%)	21 (53.8%)	0.713
I am frequently given authorship when I feel I should be co-author			
agree	105 (86.1%)	32 (82.1%)	0.606
My expertise as a statistician/methodologist is valued by the collaborators that I work with			
agree	106 (86.9%)	32 (82.1%)	0.441
I have too many different projects to do each project well			
agree	53 (43.4%)	18 (46.2%)	0.854
I am pressured to deliver specific analysis results related to the PIs hypotheses			
agree	31 (25.4%)	14 (35.9%)	0.223
PIs respect and honor my ethical boundaries			
agree	101 (82.8%)	29 (74.4%)	0.251
PIs collaborate with me early in research projects			
agree	67 (54.9%)	21 (53.8%)	1.000
I am adequately informed of study progress			
agree	67 (54.9%)	17 (43.6%)	0.270
I am provided ample calendar time to critically review all abstracts, posters, presentations, and manuscripts before deadlines			
agree	47 (38.5%)	12 (30.8%)	0.448
I have sufficient time and effort available to critically review all abstracts, posters, presentations, and manuscripts before deadlines			
agree	40 (32.8%)	13 (33.3%)	1.000
I am provided intellectual freedom to critically review all abstracts, posters, presentations, and manuscripts			
agree	106 (86.9%)	30 (76.9%)	0.202
In disputes or disagreements with investigators, my supervisor will support me			
agree	90 (73.8%)	31 (79.5%)	0.530
Project managers are available to support project workflow and administration			
agree	58 (47.5%)	16 (41.0%)	0.580
PIs tell me which statistical tests they would like me to perform instead of asking for my expertise based on their hypotheses			
always or often	10 (8.2%)	2 (5.1%)	0.732
PIs contact me with tight timelines that do not allow me to fully consider their hypotheses, determine or develop appropriate tests, or perform analyses well			
always or often	30 (24.6%)	14 (35.9%)	0.215
My interactions with PIs are limited to brief advice and consultations so that they can do their own analyses			

	Methodologist (N=122)	Other (N=39)	Fisher's exact test p-value
always or often	3 (2.5%)	1 (2.6%)	1.000
I work in collaboration with other statisticians/methodologists, statistics students, or statistical programmers on projects			
always or often	75 (61.5%)	13 (33.3%)	0.003
Abstracts, presentations, and manuscripts have been submitted without my knowledge or review where the PI has used my name in the author block			
always or often	9 (7.4%)	4 (10.3%)	0.518
On grant submissions where the PI is a health professional or basic scientist, I am listed as a Co-I or Co-PI?			
always or often	75 (61.5%)	27 (69.2%)	0.448
The PI and I discuss effort/budgets and project expectations before grants are submitted			
always or often	72 (59.0%)	28 (71.8%)	0.186
Grants are submitted without sufficiently budgeting for my effort			
always or often	26 (21.3%)	10 (25.6%)	0.659
Do you take on grants with <5% annual effort?			
always or often	12 (9.8%)	6 (15.4%)	0.383
The contribution of statisticians/methodologists as collaborative investigators are appropriately recognized			
agree	68 (55.7%)	21 (53.8%)	0.855
The contribution of statisticians/methodologists as PIs or Co-PIs (when applicable) are appropriately recognized			
agree	62 (50.8%)	19 (48.7%)	0.856
Do you have access to colleagues at your institution who you can ask statistical methodology questions? [N=115; N=34]			
yes	114 (99.1%)	33 (97.1%)	0.405
Do you have access to colleagues at your institution who you can ask statistical programming questions [N=115; N=32]			
yes	107 (93.0%)	30 (93.8%)	1.000
I would like to have more opportunities to pursue methodological research			
agree	84 (68.9%)	20 (51.3%)	0.055
Opportunities exist to collaborate with other biostatisticians and methodologists on statistical and methodological research projects			
always or often	47 (38.5%)	6 (15.4%)	0.010

Table 3:

Survey responses stratified by participant sex

	Female (N=185)	Male (N=127)	Fisher's exact test p-value
Highest quantitative degree			
Master's	85 (45.9%)	52 (40.9%)	0.463
Doctorate	91 (49.2%)	71 (55.9%)	
other	9 (4.9%)	4 (3.1%)	
Supervisor type [non-missing N=182; N=125]			
methodologist	152 (83.5%)	103 (82.4%)	0.877
other	30 (16.5%)	22 (17.6%)	
I am frequently given authorship when I feel I should be co-author			
agree	152 (82.2%)	98 (77.2%)	0.313
My expertise as a statistician/methodologist is valued by the collaborators that I work with			
agree	157 (84.9%)	114 (89.8%)	0.235
I have too many different projects to do each project well			
agree	74 (40.0%)	46 (36.2%)	0.554
I am pressured to deliver specific analysis results related to the PIs hypotheses			
agree	55 (29.7%)	36 (28.3%)	0.801
PIs respect and honor my ethical boundaries			
agree	143 (77.3%)	105 (82.7%)	0.258
PIs collaborate with me early in research projects			
agree	91 (49.2%)	61 (48.0%)	0.908
I am adequately informed of study progress			
agree	90 (48.6%)	66 (52.0%)	0.645
I am provided ample calendar time to critically review all abstracts, posters, presentations, and manuscripts before deadlines			
agree	55 (29.7%)	55 (43.3%)	0.016
I have sufficient time and effort available to critically review all abstracts, posters, presentations, and manuscripts before deadlines			
agree	57 (30.8%)	54 (42.5%)	0.041
I am provided intellectual freedom to critically review all abstracts, posters, presentations, and manuscripts			
agree	151 (81.6%)	108 (85.0%)	0.448
In disputes or disagreements with investigators, my supervisor will support me			
agree	147 (79.5%)	98 (77.2%)	0.675
Project managers are available to support project workflow and administration			
agree	72 (38.9%)	61 (48.0%)	0.130
PIs tell me which statistical tests they would like me to perform instead of asking for my expertise based on their hypotheses			
always or often	19 (10.3%)	16 (12.6%)	0.585
PIs contact me with tight timelines that do not allow me to fully consider their hypotheses, determine or develop appropriate tests, or perform analyses well			

	Female (N=185)	Male (N=127)	Fisher's exact test p-value
always or often	55 (29.7%)	40 (31.5%)	0.802
My interactions with PIs are limited to brief advice and consultations so that they can do their own analyses			
always or often	6 (3.2%)	6 (4.7%)	0.557
I work in collaboration with other statisticians/methodologists, statistics students, or statistical programmers on projects			
always or often	91 (49.2%)	83 (65.4%)	0.005
Abstracts, presentations, and manuscripts have been submitted without my knowledge or review where the PI has used my name in the author block			
always or often	11 (5.9%)	11 (8.7%)	0.376
On grant submissions where the PI is a health professional or basic scientist, I am listed as a Co-I or Co-PI?			
always or often	60 (32.4%)	59 (46.5%)	0.013
The PI and I discuss effort/budgets and project expectations before grants are submitted			
always or often	80 (43.2%)	62 (48.8%)	0.356
Grants are submitted without sufficiently budgeting for my effort			
always or often	35 (18.9%)	27 (21.3%)	0.666
Do you take on grants with <5% annual effort?			
always or often	16 (8.6%)	16 (12.6%)	0.262
The contribution of statisticians/methodologists as collaborative investigators are appropriately recognized			
agree	92 (49.7%)	76 (59.8%)	0.084
The contribution of statisticians/methodologists as PIs or Co-PIs (when applicable) are appropriately recognized			
agree	70 (37.8%)	66 (52.0%)	0.015
Do you have access to colleagues at your institution who you can ask statistical methodology questions? [N=166; N=124]			
yes	164 (98.8%)	122 (98.4%)	1.000
Do you have access to colleagues at your institution who you can ask statistical programming questions [N=165; N=122]			
yes	151 (91.5%)	121 (99.2%)	0.003
I would like to have more opportunities to pursue methodological research			
agree	90 (48.6%)	83 (65.4%)	0.004
Opportunities exist to collaborate with other biostatisticians and methodologists on statistical and methodological research projects			
always or often	46 (24.9%)	50 (39.4%)	0.009