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Article

The Faculty Costs to Educate a Biomedical Sciences Graduate Student

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Academic medical centers nationwide face numerous fiscal challenges resulting from implementation of restructured healthcare delivery models, contracting state support for higher education, and increased competition for federal and other sources of biomedical research funding. In pursuing greater accountability and transparency in its fiscal operations, the Medical University of South Carolina (MUSC) has implemented a responsibility centers management budgetary model, which requires all MUSC colleges to be eventually self-sustaining financially. Graduate schools in the biomedical sciences are particularly vulnerable in the face of these challenges, depending traditionally as they do on financial support from training grant tuition, occasional medical school tuition and medical practice plan revenues, graduate college–based revenue-generating programs, and faculty payment of PhD tuition. The revenue streams are often insufficient to support PhD training programs, and supplemental financial support is required from the institution. In the context of a college of graduate studies, estimates of the cost of educating a graduate student become a significant necessity. This study presents a readily applicable model of empirically estimating the faculty salary costs that may provide a basis for budgetary planning that will help to sustain a biomedical sciences graduate school's commitment to its teaching, research, and service mission goals.

INTRODUCTION

The Medical University of South Carolina (MUSC) is a freestanding academic health sciences center composed of six professional colleges. MUSC recently adopted a new budgeting model known as responsibility centers management (RCM). Under this accounting model, individual colleges retain all the tuition and other revenues generated by their activities; in turn, however, they are held accountable for all expenses incurred by the university and the college. Included in the expenses that the College of Graduate Studies (CGS) has to pay are those related to didactic education and mentoring of graduate students in the CGS, which includes eight basic science graduate programs.

MUSC graduate faculty members have primary appointments in one of the five other colleges, and they have secondary appointments in the CGS. In the past, the faculty members involved in educating or training graduate students were not compensated by the CGS. Some funds may have been set aside by the other colleges to partially compensate the faculty members involved in graduate education. No funds were provided by the CGS. However, there was a period of time when there was an understanding that the money for teaching of graduate students was part of the teaching funds provided by the College of Medicine. In essence, the faculty members were donating their time for this important educational and research responsibility. The new RCM budgeting model has necessitated an estimation of the cost of educating a graduate student so appropriate compensation of faculty members teaching in the CGS can be allocated.

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With this in mind, the CGS dean (P.V.H.) commissioned a faculty committee to determine the cost of faculty teaching effort in educating a graduate student. The committee was chaired by the chairman of the college's curriculum committee (A.J.S.) and consisted of faculty members actively engaged in graduate education. Included in this group was a faculty member (E.G-M.), a biostatistician from the Department of Public Health Sciences, who took on the primary responsibility for compiling and analyzing data acquired from a custom-designed survey of MUSC graduate faculty members.

METHODS

A comprehensive search of all relevant databases (PubMed, ERIC [Education Resources], the Grey Literature Report, Web of Science, Science Citation Index, SciFinder Web, Academic Search Premier, and Google Scholar) was carried out to identify prior literature addressing the teaching costs of educating graduate students. Several studies over the years have sought to account for all costs involved in higher education, including operating costs, maintenance costs, and physical capital costs (Fischer and Jons, 1981; Flower, 1998; Winston, 2000; National Association of College and University Business Officers, 2002; Cash, 2004; Hedrick *et al.*, 2009). However, these studies were focused largely on undergraduate institutions, and none of them offered quantitative insight into the problem of assessing graduate faculty teaching costs. Two citations of potential interest were identified (Roberts, 1989; Anonymous, 2001), and a third that had closer relevance to the current study was found (Byrne, 2010). A four-part process was adopted to arrive at an estimate of CGS costs to educate graduate students. First, a graduate school–wide survey was designed to establish the number of hours in the 2010–2011 academic year expended by graduate faculty members in directing and teaching graduate courses and mentoring graduate students. Second, the acquired data were analyzed and interpreted to remove improbable and erroneous responses, account for underreporting, and determine the number of hours spent on a variety of activities as part of didactic teaching and mentoring. Third, Association of American Medical Colleges salary tables (AAMC, 2011) were used to identify appropriate salary levels for the MUSC graduate faculty members. Finally, mean teaching and mentoring hours were converted to dollar amounts (deduced from the appropriate salaries) based on mean faculty percent effort, taking into account salary differentials based on academic rank and the balance of responsibilities across ranks.

Survey Development

An ad hoc subcommittee (A.J.S., E.G-M., and Dr. Maurizio del Poeta) created a survey using the RedCap Data Analysis and Survey tool. Subsequent meetings of the subcommittee and of the full committee focused on expanding and refining the survey questions in order to maximize the yield of information relevant to the committee's charge. A close-to-final draft of the survey was test run by three graduate faculty members (Drs. Craig Beeson, Christopher Davies, and Donald Menick), and several additional substantive modifications were adopted. The final survey was made up of five sections: general information, course directing, teaching, student mentoring, and postdoctoral trainee mentoring. The survey (Supplemental Material) was distributed to the graduate faculty Listserve, which contained 509 email addresses in January 2012, and remained available to graduate faculty members for 17 d. The Listserve included additional faculty members who were either former members of the graduate faculty or adjunct members, so the survey was sent to more faculty members than teach courses in the CGS. Subsequent meetings of the committee and several informal subcommittee meetings focused on analysis and distillation of the acquired data, discussion of the most appropriate sources of salary data, and optimal and most equitable presentation of the data in terms of the potentially reimbursable cost of graduate school faculty teaching effort.

Data Collection and Analysis of Hours

Data were downloaded from RedCap, and exploratory data analyses were performed in Stata (StataCorp, 2009). The primary variables of interest were those reflecting the number of hours devoted to each activity. For example, the survey asked faculty members who acknowledged teaching in a CGS course, "For each contact hour, how many hours on average did you spend on lecture preparation or other activities related to teaching?" To identify improbable or erroneous values, graphical displays were used to demonstrate distribution of the hours reported for each activity of interest (i.e., hours of activity). Suspected cases of misunderstanding of questions or overreporting (e.g., 1000 h of mentoring per year) were excluded from analysis. This was relatively rare, and these instances are described in the *Results* section. For each activity, both the median and mean number of hours for each reported activity were calculated and included in the analysis described in the following sections. Graphical displays were created using R (R Development Core Team, 2011).

Assignment of Salary Values

The survey categorized faculty members by rank (assistant, associate, and full professor) and by degree type (PhD vs. MD or MD/PhD). A few faculty members did not fall into these categories (e.g., instructors [$n = 2$] and DO degree [$n = 1$]), and due to their infrequency, these results were not included in the summaries. For each category of rank and degree, data were acquired from the AAMC 2010–2011 summary statistics on medical school faculty compensation for the U.S. Southern Region, PhD or other doctoral degree and MD degree, public and private institutions, and basic science and clinical science departments/specialties. The relevant clinical science departments/specialties were internal medicine, cardiology, gastroenterology, infectious diseases, nephrology, rheumatology, pathology, and ophthalmology. For the basic sciences, aggregated data for all departments/specialties were used. Based on these published data, the mean salaries for PhD faculty members in the CGS were assigned from the AAMC tables as $79,500 for an assistant professor, $107,000 for an associate professor, and $158,600 for a full professor. The mean salaries for MD faculty members were assigned as $188,500 for an assistant professor, $217,600 for an associate professor, and $265,600 for a full professor. For each rank and degree type, the balance of time spent on each activity was estimated. For example, full professors spent more

time on mentoring than assistant professors did. Given that the salaries of full professors are higher, the salary used for estimating the average cost of mentoring hours should be weighted to reflect that it is more often higher-ranked faculty members who are engaged in mentoring activities.

Cost Calculation

The cost calculation was based on summation of the cost of the following activity categories:

1. Course directorships
2. Lecture time
   a. Dissertation committee time
   b. As committee chair
3. As committee member (not chair)
4. Lab rotations
5. Mentoring

The total cost for course directorships and lecture time was based on the known number of courses in the CGS. The total cost for dissertation committee time, lab rotations, and mentoring was based on the known number of students in the college (divided into their first and subsequent years, as first-year students do not have dissertation committees). The total cost was calculated using both median estimates of hours per faculty member (conservative) and mean estimates (anticonservative). These costs were divided by the number of CGS students to arrive at a cost per student. Additional details of the calculation are presented in the *Results* section.

RESULTS

The survey faculty respondent population and its distribution according to terminal degree and faculty rank is shown in Figure 1. A total of 223 faculty members completed the survey. Survey data were analyzed from a total of 190 respondents; 79 full professors, 49 associate professors, and 62 assistant professors with PhD, MD, or MD/PhD degrees. Data provided by 33 respondents were excluded from analysis for the following reasons: 1) Faculty members with terminal degrees other than PhD, DrPH, MD, or MD/PhD were excluded based on the inability to estimate salary. This removed seven respondents: three DDS, two DDS/PhD, one ArtD, and one DO. 2) Among PhD, MD, and MD/PhD respondents, there were two instructors and six respondents reporting ranks other than instructor or assistant, associate, or full professor; these eight faculty responses were removed. And 3) data from 18 faculty respondents who clearly misinterpreted questions and/or provided highly improbable or impossible data were excluded from the analysis (see Figure 1).

The degree to which survey responses corresponded to reality was assessed by comparing the number of reported course directorships (74) with the number of graduate faculty members named as course directors of courses offered by the CGS in the 2010–2011 academic year (77; data provided by the MUSC Office of Enrollment Management). Also, the number of faculty members reporting graduate student primary mentorship or coprimary mentorship (176) corresponded closely with the number of graduate students in the 2010–2011 academic year (165; excluding first-year students). The distribution of 190 respondents reporting

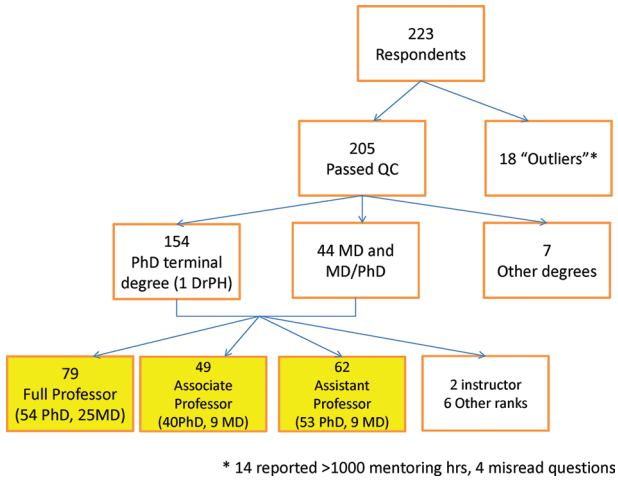

Figure 1. Distribution of faculty members responding to the CGS survey of teaching participation according to terminal degree and faculty rank. Other degrees that were reported were DDS (3), DDS/PhD (2), ArtD (1), and DO (1).

primary graduate program affiliations with one or more of the nine CGS PhD programs is shown in Figure 1. Thirteen respondents indicated no affiliation, and 24 respondents indicated more than one affiliation.

In completing the survey, each of the 190 faculty respondents provided detailed reports of hours spent in course directing, didactic teaching, lecture preparation, student committee activities, lab rotations, and mentoring (the survey can be found in the Supplemental Material). Figure 2 shows, for each activity, the number of hours reported and the percent effort (assuming 40 h per week and 50 work weeks per year) for each of the 190 faculty members by rank. Forty hours per week was used because the university uses that as a method for calculating salaries. We recognize that faculty members often work considerably more than 40 h per week. Nonetheless, it is possible to use the survey to gather the necessary data to then calculate a cost based on the university's method of calculating salaries. Using the estimated salary per rank, the estimated cost of the activity per faculty member is also shown. Green circles represent individual faculty members reporting in the depicted activity; orange data points are means; blue data points are medians. As is easily seen in Figures 2, A–D, the reported number of hours spent (per year) per activity varies widely across faculty members. Much of the variability is expected. However, for graduate student mentoring (shown in Figure 2B), some of the variance may also be attributable to the subjectivity of the question regarding mentoring (see question 6.2 of the survey).

Details of salary cost calculation for each activity, using weighted average salaries derived from reported individual faculty survey responses and factoring in enrollment of a combined total of 195 MS and PhD graduate students in the 2010–2011 academic year, are shown in Figure 3. Weights were derived from the reported proportion of faculty type (MD vs. PhD) and rank (assistant, associate, or full professor) for each activity. For example, full professors spend relatively more time engaged in mentoring than in lecturing as compared with assistant professors. Both medians and mean effort levels per activity were used to provide a

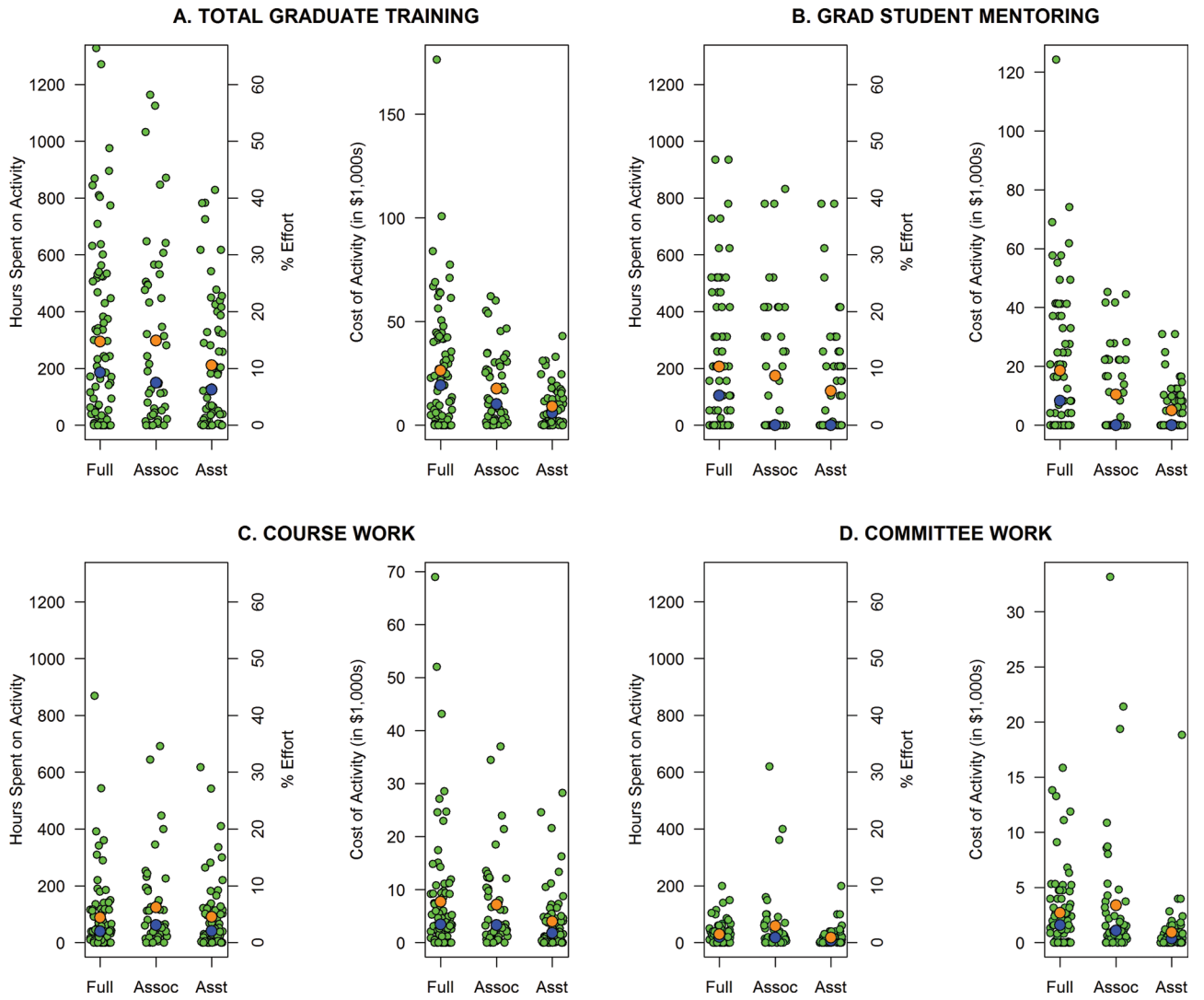

Figure 2. Time and cost of faculty participation in total graduate training. (A) Total graduate training includes cumulative participation in student mentoring, committee work, teaching, course directorship, and lab rotation. (B) Graduate student mentoring includes time spent as the primary mentor (divided in half as described in the text). (C) Course work includes both teaching and course director time. (D) Committee work includes time spent working on student committees, including administrative aspects. Data points are grouped according to faculty rank; green circles represent individual faculty responses, and orange and blue points represent means and medians, respectively. Note that faculty salary estimates (right panel in each figure) differ by PhD vs. MD/PhD, so two individuals with similar hours spent may yield different costs.

range of costs per activity. Distribution of time spent per activity is right-skewed for all activities, causing medians to be more conservative, while the means will better recognize that some faculty members spend large amounts of time on training activities. These can be viewed as representing two estimates for estimated cost per activity.

The results of these calculations are summarized in Table 1, which shows the estimated costs of faculty time dedicated to graduate student education in the 2010–2011 academic year. Specific data focusing on costs of didactic teaching and research training of graduate students (including hours spent on each activity) are presented in Table 2. Student mentoring includes time spent as the student's primary mentor, in which the end result is not only a dissertation that serves as the basis for the student's successful PhD defense but the mentor reaping benefits as well, including a highly trained lab member, publications, and potentially data to support a grant submission. As a result, including all of the mentoring time as a "cost" of training would be an overestimate. There is no metric that can be used to determine the appropriate discount for mentoring hours. But after thoughtful discussion, the committee agreed on the conservative estimate of a 50% discount. Thus, in Table 2, the total cost of graduate student mentoring is shown as Mentoring, and committee consensus indicated that 50% of the cost of mentoring could be justified as student training (Mentoring, training only).

In keeping with the charge to the committee, Table 3 presents the two estimates of the expected cost (in terms of graduate faculty compensation) of educating a graduate student in the 2010–2011 academic year. Analysis of data presented

Course directorship:

Weighted average salary = $128,091;
Cost per hour = $128,091/2000hrs = $64.05
118 courses yielding at total of 346.5 credit hours (Office of Enrollment Management data)
Median hours spent on course director activities per credit hour is 10
Total expenditure based on median = $64.05 x 346.5 x 10 = $221,918

Lecture time:

Weighted average salary = $131,488
Cost per hour = $131,488/2000hrs = $65.74
Based on contact hours, there were 5197.5 hours of teaching (Office of Enrollment Management data)
Median hours spent prepping for lecture is 3 + 1 hour giving lecture = 4 hours
Total expenditure based on median = $65.74 x 4 x 5197.5 = $1,366,820

Committee time:

Committee chair

Weighted average salary for primary mentor is $146,854
Cost per hour = $146,854/2000 = $73.43
As primary mentor, median time per year for committee work is 11 hrs/student
There are 165 students beyond 1st year with committees
Total expenditure based on median = $73.43 x 165 x 11 = $133,270

Committee member (not chair)

Weighted average salary is $142,550
Cost per hour = $142,550/2000 = $71.28
Median time per year assuming two committees is 14 hrs
Assume each committee has 4 members in addition to primary mentor.
There are 165 students beyond 1st year with committees.
Total expenditure based on median = $71.28 x 165*4/2 x 14 = $329,290

Lab Rotations:

Weighted average salary is $136,552.
Cost per hr = $136,552/2000hrs = $68.28
Median time reported on one lab rotation is 15 hrs
There were 30 first year students and 4 rotations per student
Total expenditure based on median = $68.28 x 30 x 4 x 15 = $122,897

Mentoring*

Weighted average salary for primary mentor is $146,854
Cost per hr = $146,854/2000 = $73.43
Median time per week per mentee is 4 hrs, or 200 hrs per year.
There are 165 students beyond their 1st year.
Total expenditure based on median = 165 x 200 x $146,854/2000 = $2,423,091
*The committee agreed that 50% of mentoring time is teaching, and 50% advances the P.I.s research goals. **Thus the total expenditure on mentoring was divided by 2, yielding an estimated cost of mentoring of $1,211,546 using the median.**

Figure 3. Illustration of calculation of costs based on median estimates of the time per graduate training activity. To derive the calculations based on mean estimates, the values shown in Table 3 can be substituted for the median estimates in the figure.

in this report indicates that the component of the cost of educating a graduate student attributable solely to potentially reimbursable compensation for faculty teaching effort has a lower limit of $17,363 and an upper limit of $24,223 annually.

DISCUSSION

This study provides an estimate of the cost of faculty time to educate a graduate student using a systematic approach based on reported faculty graduate training efforts at the MUSC. To the best of our knowledge, there is no prior published accounting of such a cost. The general framework for the survey questionnaire that we developed can be used at any institution training biomedical science graduate students, since it was comprehensive and took into account all the associated educational activities. The use of AAMC salary information was central in obtaining a reasonable estimate of the cost. The true cost will vary depending on the institution, since it could be heavily influenced by the academic rank of

Table 1. Estimated costs based on time spent by graduate faculty members in 2010–2011

	Median based		Mean based		
	Total ($)	Cost (%)	Total ($)	Cost (%)	Percent difference between mean and median estimates[a]
Graduate teaching	2,174,195	64	3,087,927	65	34
Course directorships	221,918	7	343,972	7	43
Lecture/prep time	1,366,820	40	1,708,522	36	22
Committee time	462,560	14	842,075	18	58
Lab rotation	122,897	4	193,358	4	45
Mentoring time	1,211,543	36	1,635,587	35	30
Total	3,385,738	100	4,723,514	100	33

[a]Calculated as the difference divided by the average of median and mean total dollars.

the involved faculty members. The cost will also depend on a number of other factors, including the number of graduate students, the number of credit hours, the sizes of classes, all of which will affect the total number of hours spent on teaching, mentoring, and committee work. For example, a larger graduate program (i.e., one with more students than MUSC's program) would likely not have a substantial increase in teaching costs, assuming the number of courses is approximately the same, but the mentoring costs would increase. Also, note that the course work component would be smaller per capita due to increases in the number of students per class. Nonetheless, the survey provides a valuable tool, and the data obtained provide a reasonable assumption as to the actual faculty costs based on effort.

To put these costs in the perspective of how they may apply to other colleges of graduate studies, the following is a description of the demographics of the college. As noted in the introduction, the college is one of six freestanding professional colleges in an academic medical center. There are ~150 PhD graduate students, 56 MD/PhD students, and 200 postdoctoral fellows. The college maintains a full-time support staff of six individuals, two associate deans, and one assistant dean. Thus, the cost per student as estimated for this college could be significantly different, as the demographics of one's individual college are markedly different from this one. However, we believe that the survey used to generate these data would allow any college of graduate studies to gather the data necessary to make the needed calculations.

Byrne *et al.* (2010) estimated the cost to their institution for training MD/PhD students in 2007 dollars. A previous study at their institution estimated the cost of a graduate student to the institution to be ~$51,000 per year and did not include the stipend. In their 2010 study, Byrne and colleagues estimated the institutional costs of the PhD portion of the

Table 2. Didactic training: cost of time spent teaching and administering didactic courses (details of calculations are shown in Figure 3)

	Weighted salary	Administrative units[a]		Estimated cost (salary/hour × hours)	
		Median	Mean	Median	Mean
Didactic training					
Course director	$128,091	10	15.5	$221,918	$343,972
Lecture time	$131,488	4	5	$1,366,820	$1,708,522
Lab rotations	$136,552	15	23.6	$122,897	$193,358
Total didactic training costs				$1,711,635	$2,245,852
Research training					
Primary mentor	$146,854	11	29.9	$133,270	$362,252
Nonprimary mentor	$142,550	14	20.4	$329,290	$479,823
Mentoring[b]	$146,854	4	5.4	$2,423,091	$3,271,173
Mentoring, training only 50%	$146,854	4	5.4	$1,211,546	$1,635,587
Total research training costs				$1,674,106	$2,477,662

[a]Administrative unit definitions: Course Directors: Hours spent per credit hour (346.5 credit hours for 118 courses). Lecture time: 1 h class time + indicated preparation time/hour for 5197.5 h of total teaching time. Lab rotations: hours/rotations with a total of 120 rotations/year (30 first-year students × 4 rotations per student). Primary mentor: hours/year for committee work (based upon 165 students beyond the first year). Nonprimary mentor: hours/year for committee work for students for whom they are not the primary mentor. Mentoring: hours/week spent with a student as a primary mentor.

[b]Mentoring defined by student training and progress toward research goals.

Table 3. Estimated range of cost of educating a biomedical graduate student for 1 yr[a]

	Lower and upper limits of cost per student ($)
Graduate course work	11,150–15,836
Course directorships	1138–1764
Lecture and prep time	7009–8792
Committee time	2372–4318
Lab rotation	630–992
Mentoring time	6213–8388
Total	17,363–24,223

[a]Graduate course work includes all of the costs except mentoring costs. The total cost is the sum of course directorship, lecture and preparation, committee work, lab rotation, and mentoring costs. The lower (upper) end of the ranges is based on the assumption that the median (mean) is the best measure to use for the cost per student.

MD/PhD student's training using four different models. Interestingly, some of the models included the contribution of students' research to the mentors' acquisition of extramural research support. Depending on the model chosen, student activities could produce a net financial gain for the university. The present study only considered faculty time devoted to didactic and mentoring time and did not take into account the other costs associated with graduate education or the potential financial contribution of graduate students' research efforts in faculty acquisition of extramural research funding. It also did not take into account the students obtaining their own fellowships and the indirect costs associated with such fellowships. Clearly, estimating the cost to educate a graduate student is highly complex; however, instead of representing an institutional financial burden, PhD students may actually contribute a net financial gain to the institution.

We divided graduate training activities somewhat arbitrarily into two main categories. The first category was didactic, as defined by classroom-based lecturing or interactive discussion with graduate students. The second category was mentoring, as defined by time spent with graduate students on a one-on-one basis, not in the classroom. This included activities such as serving as a primary mentor, serving on advisory committees, or hosting a student on a laboratory rotation. This distinction, while potentially arbitrary, may be viewed as having some merit. Lecturing to graduate students may be perceived as conferring minimal value to faculty members in terms of advancing their own research, justifying compensation of teaching costs from sources other than the department's budget. On the other hand, mentoring a student has significant benefit to the mentor, because the graduate student's laboratory activities will benefit the faculty member's research.

Understanding how much it costs to educate a graduate student has another aspect that has not been previously considered. The data raise the question "Does the tuition charged for the PhD degree cover the costs of providing the education/training of a biomedical sciences graduate student?" While biomedical sciences PhD graduate students do not pay their own tuition, there are multiple sources that do. The present data can be used to determine the relative extent to which these sources are paying the true costs compared with institutional subsidies of these costs. This question is broached but not resolved in the form of a quantitative survey in the provocative discussion by Erskine (2009).

The recent National Institutes of Health (NIH)–sponsored Biomedical Research Workforce Group report highlighted that there are multiple career opportunities for PhDs (National Institutes of Health, 2013). In a climate of decreasing support for educating PhDs from the NIH and the other previous sources and multiple beneficiaries of the PhD, one has to raise the question "Who else should support the education of PhDs?" Perhaps the private sector and even federal agencies that hire PhDs should be required to provide some support to the institutions from which the PhDs graduated. Contributions to a common pool from which appropriate graduate schools would draw would be a possible alternative to direct reimbursements. This somewhat radical suggestion addresses the undeniable fact that institutions hiring trained PhD graduates derive significant benefit from their skills and expertise yet incur no obligation to cover any of the costs of their education. No one would argue about the need and importance of PhDs in the biomedical sciences. If we do not identify additional revenue sources to fund PhD biomedical scientists, society as a whole may lose in the long run.

The present study was restricted to accounting of costs associated with faculty compensation for education of graduate students, and addressed neither the costs of student stipends nor administrative costs, which would necessarily include salaries of designated graduate office support staff and essential overhead. The latter costs are readily determined as part of routine accounting of graduate office activities and are unique to each institution. In contrast, information regarding faculty time, effort, and compensation is not routinely available and is therefore not included as a matter of course in graduate office budgeting. Thus, the present data underscore the necessity of identifying funding sources to fully support the education and training missions of the college. Because the college is an umbrella for institutional PhD programs, these costs may ultimately be considered an expense shared by all colleges, under the purview of the MUSC vice president for academic affairs and provost.

The survey was designed by faculty members who are actively involved in graduate student education and thus offers a comprehensive assessment of faculty didactic and mentoring activities pertinent to an education leading to a biomedical sciences PhD. Data acquired from the survey was highly informative and sufficiently wide-ranging to allow both straightforward analysis and relatively more complex understanding of how graduate faculty members apply their time and effort in training graduate students. We believe the methodology used to gather and analyze this information is a valuable adjunct to budgetary planning in biomedical science and other graduate schools and can easily be adapted to the needs of any institution. As in many research endeavors, in retrospect, we might have implemented our study slightly differently. Despite pilot testing of the survey on several faculty members from the MUSC, the description of mentoring in the survey was necessarily somewhat vague. In future applications of the survey, we would encourage providing stronger guidance regarding what activities would be included in mentoring time.

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