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## Domestic Job Shortage or Job Maldistribution? A Geographic Analysis of the Current Radiation Oncology Job Market

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### Abstract

**Purpose**—To examine whether permanent radiation oncologist (RO) employment opportunities vary based on geography.

**Methods and Materials**—A database of full-time RO jobs was created by use of American Society for Radiation Oncology (ASTRO) Career Center website posts between March 28, 2016, and March 31, 2017. Jobs were first classified by region based on US Census Bureau data. Jobs were further categorized as academic or nonacademic depending on the employer. The prevalence of job openings per 10 million population was calculated to account for regional population differences. The  $\chi^2$  test was implemented to compare position type across regions. The number and locations of graduating RO during our study period was calculated using National Resident Matching Program data. The  $\chi^2$  goodness-of-fit test was then used to compare a set of observed proportions of jobs with a corresponding set of hypothesized proportions of jobs based on the proportions of graduates per region.

**Results**—A total of 211 unique jobs were recorded. The highest and lowest percentages of jobs were seen in the South (31.8%) and Northeast (18.5%), respectively. Of the total jobs, 82 (38.9%) were academic; the South had the highest percentage of overall academic jobs (35.4%), while the West had the lowest (14.6%). Regionally, the Northeast had the highest percentage of academic jobs (56.4%), while the West had the lowest (26.7%). A statistically significant difference was noted between regional academic and nonacademic job availability ( $P=.021$ ). After we accounted for unit population, the Midwest had the highest number of total jobs per 10 million (9.0) while

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the South had the lowest (5.9). A significant difference was also observed in the proportion of RO graduates versus actual jobs per region ( $P=.003$ ), with a surplus of trainees seen in the Northeast.

**Conclusions**—This study presents a quantitative analysis of the RO job market. We found a disproportionately small number of opportunities compared with graduates trained in the Northeast, as well as a significant regional imbalance of academic versus nonacademic jobs. Long-term monitoring is required to confirm these results.

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## Introduction

In 2010 Smith et al (1) forecasted that over the next decade, the demand for radiation therapy would be expected to grow 10 times faster than supply. As a way to address this shortage, they recommended exploring a gradual but meaningful increase in the number of trainees. Since then, the number of available radiation oncology residency positions has increased to a total of 200 spots in 2015, a 27% and 115% increase compared with the 157 and 93 spots that were available in 2010 and 2001, respectively (2). Shah (3) was the first author to express concern that an increase in radiation oncology trainees would result in a radiation oncologist (RO) oversupply, with further consequences of a tight labor market. Indeed, the latest supply-and-demand analysis in 2016 showed that the supply of ROs is projected to exceed radiation treatment demand (4).

The predictions of a tighter labor market are beginning to manifest for senior radiation oncology residents (5, 6). A survey of the 2014 graduating class showed that 71% of respondents believed the job market was worse than what they anticipated when beginning residency (7). In addition, 33% found no job openings within their geographic area of preference. Geography is of particular interest as prior data has demonstrated that the majority of graduates practice in the same region as their schooling or residency training (8). Furthermore, residents self-report location to be one of the most important factors for future employment decisions (8, 9).

Given these findings, it is imperative to have an accurate estimation of available RO positions. This study provides a quantitative report of RO employment opportunities, reported as both absolute and population-normalized numbers, stratified by geographic region, to present a snapshot of the current RO job market.

## Methods and Materials

A database of available jobs and their characteristics was constructed using publicly available information from the American Society for Radiation Oncology (ASTRO) Career Center website (10). This online resource contains the most comprehensive list of available RO employment opportunities in the United States. All posts from this website between March 28, 2016, and March 31, 2017, were queried. Only permanent full-time domestic physician jobs were included for this analysis. Repeated job postings were only considered as 1 position. Nonphysician jobs, international postings, fellowship positions, part-time or locum tenens opportunities, and jobs for which the location could not be ascertained were all excluded.

Job characteristics were next categorized as either academic or nonacademic. A job was given a designation of academic if the employer was a medical center or hospital that contained physician residency training programs. Academic jobs were then subcategorized as being located on the center's main campus or at a satellite facility. Medical centers or hospitals without any physician training programs, freestanding cancer centers, or individual or group practices were considered nonacademic.

The location of each listed job on the ASTRO Career Center website was then cross-referenced with data from the US Census Bureau (11–13) to obtain information on official US region designations (Northeast, Midwest, South, and West), US region population, and individual state and city populations. We used  $\chi^2$  tests to compare city size, position type (academic vs nonacademic), and academic site (main vs satellite) across regions. To account for variances in US regional populations, we calculated the number of jobs in each region per 10 million people.

We also used published data from the National Resident Matching Program (14) to obtain the number of graduating radiation oncology trainees in each US Census region who would be applying for jobs during our study time frame. The  $\chi^2$  goodness-of-fit test was applied to a 1-way frequency table to compare a set of observed proportions of jobs per region with a corresponding set of hypothesized proportions of jobs per region based on the proportions of students graduating from each region. Statistical significance was assessed at the .05 level. All statistical analyses were performed with SAS software (version 9.4; SAS Institute, Cary, NC).

## Results

A total of 211 unique jobs (Fig. 1) met the inclusion criteria during the time frame of our study. In terms of geographic distribution, the greatest numbers of jobs were located in the South ( $n=67$ , 31.8%), followed by the Midwest ( $n=60$ , 28.4%), West ( $n=45$ , 21.3%), and Northeast ( $n=39$ , 18.5%). Forty-one of the fifty states and Washington, DC (80%) were represented (Fig. 2A). The 3 states with the greatest numbers of openings were California ( $n=22$ ), New York ( $n=14$ ), and Pennsylvania ( $n=13$ ); however, after normalization to state population (per 10 million people), these and other large states, such as Texas and Florida, actually had noticeably small numbers of job opportunities (Fig. 2B).

### Job type

Of the 211 total jobs, 82 (38.9%) were designated academic (Table 1). The majority of these positions (69.5%) were located on the main campus of the respective institution. The South had the highest percentage of overall available academic jobs (35.4%), while the West had the lowest (14.6%). When we performed analysis within regions (Table 2), the Northeast had the highest regional percentage of all available jobs in its specific region subclassified as academic (56.4%), while the West had the highest regional percentage of all available jobs in its region subclassified as nonacademic (73.3%). A statistically significant difference was seen between position type, academic versus nonacademic, among the regions ( $P=.021$ ). No difference was seen between academic subsites ( $P=.751$ ) among the regions.

### City size

When we performed analysis by city population, 53 jobs (25.1%), 42 jobs (19.9%), 15 jobs (7.1%), 10 jobs (4.7%), and 92 jobs (43.1%) were available in cities with populations of 50,000; 50,001 to 100,000; 100,001 to 150,000; 150,001 to 200,000; and >200,000, respectively. The median city population per region was 178,042 in the Northeast; 111,399 in the Midwest; 193,524 in the South; and 104,170 in the West. The South had the highest percentage of jobs in cities with a population >200,000 (34.8%), a population of 150,001 to 200,000 (40.0%), and a population 50,000 (34.0%), whereas the Midwest had the highest percentage of jobs in cities with a population of 100,001 to 150,000 (50.0%) and a population of 50,001 to 100,000 (35.7%). No statistically significant difference was noted in job availability between a city size 200,000 and city size >200,000 ( $P=.622$ ) among the regions.

### Job availability per unit population

According to the latest US Census data, a total of 55,317,240 people reside in the Northeast; 66,927,001 in the Midwest, 114,555,744 in the South, and 71,945,553 in the West. Thus the number of total jobs per unit population (measured in 10 millions) was 7.0, 9.0, 5.9, and 6.3 in each respective region. The number of academic jobs per unit population was 4.0, 2.8, 2.5, and 1.7 in the Northeast, Midwest, South, and West, respectively, whereas the number of nonacademic jobs per unit population was 3.1, 6.1, 3.3, and 4.6, respectively.

### Job availability per region versus residents trained per region

A total of 169 graduates of the class of 2017 were identified through National Resident Matching Program data (corresponding to the total number of radiation oncology residents beginning their postgraduate training in 2012). Of these, 50 (29.6%), 39 (23.1%), 52 (30.8%), and 28 (16.6%) were trained in programs located in the Northeast, Midwest, South, and West, respectively. We also calculated the number of regional graduates per unit population (measured in 10 millions). The largest number of graduates relative to the region's population was seen in the Northeast, with 9.0; followed by the Midwest, 5.8; South, 4.5; and West, 3.9.

The proportion of total job openings to graduates per region was 0.78, 1.54, 1.29, and 1.61 in the Northeast, Midwest, South, and West, respectively. The respective proportions of academic and nonacademic jobs to graduates per region were 0.44 and 0.34 in the Northeast, 0.49 and 1.05 in the Midwest, 0.56 and 0.73 in the South, and 0.43 and 1.18 in the West. A statistically significant difference was found in the hypothesized proportions of jobs per region (based on the number of graduating trainees) compared with the actual observed proportions of jobs in each region ( $P=.003$ ) (Table 3).

### Discussion

The projections by Pan et al (4) and the concomitant increase in annual radiation oncology graduates have led to concern among US trainees (6) over a potential shortage of future employment opportunities. This problem is not unique to US radiation oncology graduates; for example, delayed workforce entry for Australian (15) and Canadian (16) trainees has

resulted in extended resident training via single or multiple fellowships and even increased emigration. At this time, however, it is unclear whether the current labor concerns of recent US radiation oncology graduates are because of graduating trainees' personal preferences, a geographic maldistribution, or an actual lack of employment opportunities.

The most recent domestic workforce survey (17) showed that 33% of responding ROs thought that radiation oncology supply exceeded demand. Thirty-five percent of respondents had looked for a new position within the past 3 years, with 47% indicating difficulty in obtaining a satisfactory position. However, a significant majority of job seekers (78%) stated the difficulty in securing employment stemmed from a lack of positions in a desired geographic area. Subsequently, Bland et al (7), through surveys or direct communication, were able to obtain occupation information for 98.2% of the 2014 graduating class of ROs (164 of 167). Although postgraduate employment was secured for 151 trainees (92.1%), 71% of respondents felt that the job market was more difficult than anticipated. Furthermore, 33% found no job openings in their geographic area of preference.

Our findings suggest that there are enough potential opportunities (n=211) available for the current number of graduates (n=169). The majority of jobs were available in the South (31.8%) and Midwest (28.4%), with a significant drop-off seen in the West (21.3%) and Northeast (18.5%). In terms of city population, the South contained the most jobs both in cities with >200,000 people (34.8%) and in rural localities with < 50,000 people (34.0%). Although the South contained the greatest number of total academic jobs (n=29), the Northeast had the highest regional percentage of academic jobs (56.4%). Conversely, the West region showed the most disproportionate difference in academic versus nonacademic jobs (26.7% vs 73.3%). Furthermore, there was a statistically significant difference between academic and nonacademic job availability among regions.

After accounting for variations in regional population, we noted a slightly different picture. Despite a lower number of total jobs, the Northeast contained more jobs in proportion to unit population, 7.0, when compared with the South, 5.9, or West, 6.3, but the number was still below that seen in the Midwest, 9.0. The Northeast and West again demonstrated the highest and lowest regional proportions of academic jobs per unit population, 4.0 and 1.7, respectively. Notably, the Midwest, rather than the West, contained the highest number of nonacademic jobs and showed the greatest difference in academic versus nonacademic positions (2.8 vs 6.1).

Prior reports have also shown that graduates tend to obtain employment "close to home." Ahmed et al (8) reported on 146 of the 154 graduating radiation oncology residents from 2013, among whom employment information could be obtained for 142 (97%). Of trainees, 66 (46.5%) accepted academic positions, with 27 remaining at the institution where they trained. Overall, graduates did not have to travel far from where they trained: 36.6% of graduates were employed in the same state as their residency, 62% in the same region as their residency, and 73.9% in the same region as their medical school or residency completion. Notably, the Northeast region contained a lower number and percentage of accepted jobs (n=29, 20.4%) than applicants trained (n=39, 27.5%). Our results similarly showed a mismatch (0.78) between available jobs (n=39, 18.5%) and number of graduating

trainees (n=50, 29.6%) in this region, which was significant on statistical analysis ( $P=.003$ ). In contrast, each of the other regions contained more jobs than graduates.

Although these concerns are valid, other reports have also shown that geographic physician maldistribution is a problem in radiation oncology. Aneja et al (18) found that from 1995 to 2007, the radiation oncology workforce grew by approximately 24%. Despite the robust growth, 44% of domestic health service areas still lacked ROs. While health service areas within the Northeast, California, and Florida exhibited a high ratio of ROs to population aged 65 years between the years studied, rural areas within the Midwest continued to experience low rates of ROs. Furthermore, increased RO distribution was found to occur in areas with lower unemployment rates, higher household incomes, and greater minority populations (18). In concordance with these findings, we noted the greatest number of job opportunities in the Midwest per unit population. This disproportion has recently been recognized to the point that there is a call to emphasize more community-based training during residency, as well as to prioritize those applicants more willing to address this gap (19).

Through the aforementioned studies as well as our results, we identified the following as potential explanations for resident discontent and concern. First, the Northeast contained a significant percentage of overall radiation oncology residents (29.6%) but a statistically significantly low ratio of jobs to graduates (0.78). Furthermore, this result is exacerbated by the Northeast containing the highest ratio of graduates adjusted per unit population (9.0). This finding implies that there is a surplus of trainees in the Northeast relative both to the noted job availability and to the US population as a whole. Given that geography is the second most important factor for graduates when choosing a job (9), this likely represents a dominant factor contributing to overall resident dissatisfaction. Second, we noted an unequal job distribution. Specifically, we found that the majority of available jobs were located in cities with a population of <200,000 (56.4%). Furthermore, the majority of these jobs were concentrated in cities with a population between 0 and 100,000 (79.8%). These findings, in concordance with the findings of Aneja et al (18)—that increased RO density is found in more populous cities and states—indicate that the current labor concerns partly stem from applicants not wanting to pursue available opportunities in “less desired” locales. Last, we discovered a large and statistically significant dichotomy between posted academic and nonacademic jobs, which in terms of total numbers was particularly prominent in the West (26.7% vs 73.3%). After we accounted for regional population differences, this split was actually largest in the Midwest (2.84 vs 6.13 per 10 million), although it continued to remain large in the West (1.67 vs 4.59 per 10 million) as well. This finding only serves to amplify concerns for individuals pursuing academic careers in these specific regions.

Our study contains some limitations. The ASTRO Career Center website does not list jobs indefinitely, so postings prior to our study start date were not available. Therefore, we are only able to provide a snapshot of the job market over a 1-year span rather than a definitive long-term trend. In addition, the Career Center website is not the exclusive method of obtaining employment, and other websites or job recruiters may aid residents with their job search. Moreover, anecdotal evidence points toward applicants individually contacting academic department chairs for unadvertised job opportunities. Nonetheless, the Career

Center website is the most exhaustive and well-known resource for residents to view open positions. Moreover, our observed job distribution is consistent with those of prior publications. Specifically, the comprehensive searches of 2013 and 2014 graduates by Ahmed et al (8) and Bland et al (7), respectively, found that 46.5% and 41% of applicants obtained academic positions, which is close to our finding of approximately 40% of total academic positions in this report.

## Conclusions

Our study is the first quantitative and geographically stratified analysis of the RO job market. We found that while there are indeed numeric differences in job availability among regions, the effect is exacerbated by unequal geographic distribution both before and after adjustments per regional unit population. A significant number of open positions are in smaller, more rural locations, which have historically been disregarded by applicants seeking larger, metropolitan areas. Furthermore, the Northeast has the smallest percentage of jobs relative to the number of radiation oncology residents trained. These factors, in concordance with applicants' personal preferences, likely contribute to the apprehension and discontent graduating residents feel. Long-term monitoring of the available job market is necessary to further identify geographic and temporal trends.

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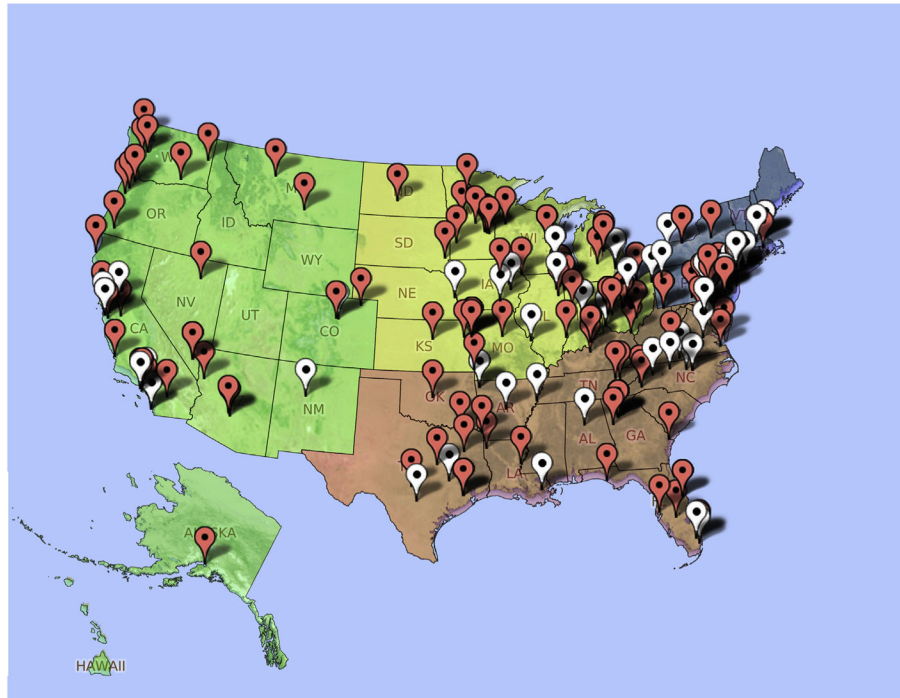
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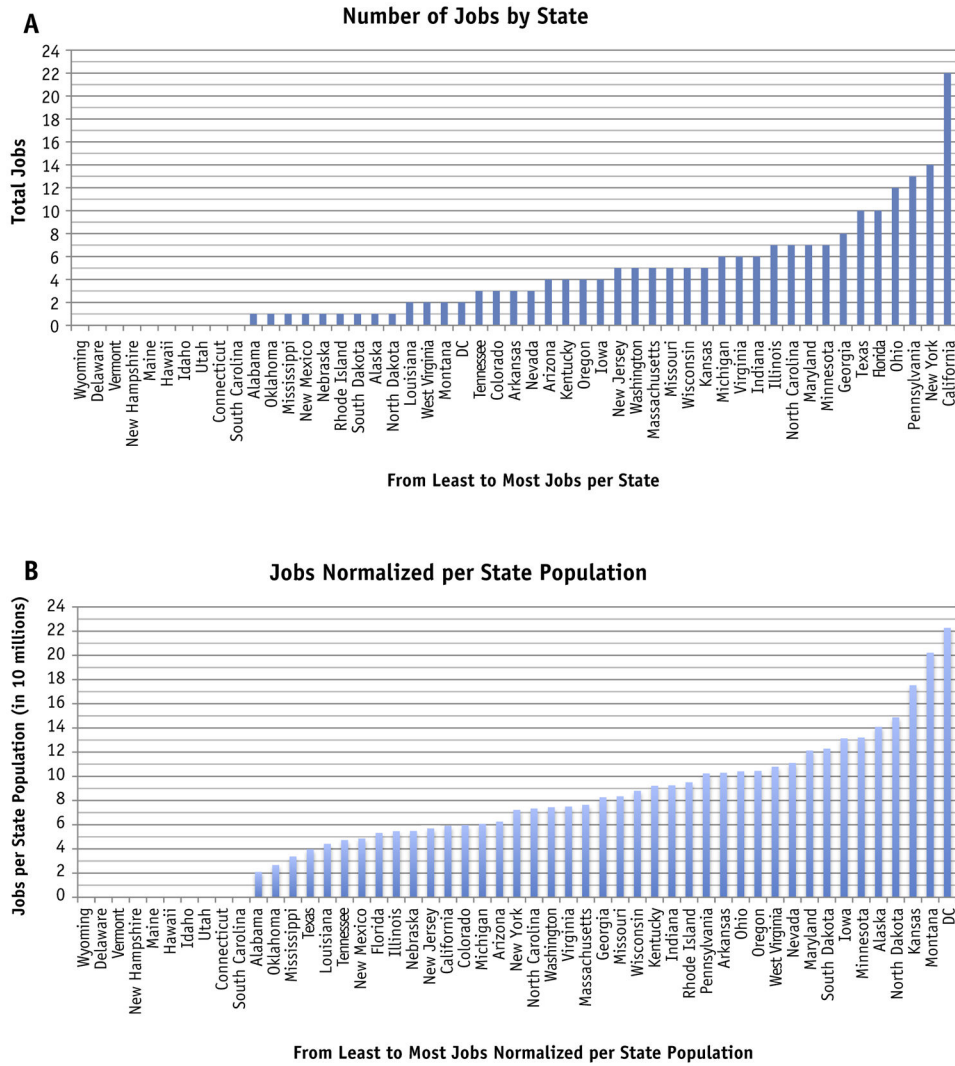


### Summary

This study presents a quantitative geographic analysis of the radiation oncologist workforce. There was a notable variation regarding job availability, both adjusted and unadjusted for regional population. A statistically significant imbalance between academic and nonacademic job availability among regions was seen. In addition, we found a significant difference in job distribution whereby proportions of employment opportunities stratified by geographic region were not commensurate with proportions of graduates for the given region.



**Fig. 1.** US map showing locations of all radiation oncologist job opportunities. Highlighted regions indicate US Census region designations: Northeast (blue); Midwest (yellow); South (red); and West (green). Pins indicate job opportunities: academic (white pins) and nonacademic (red pins) positions. (A color version of this figure is available at [www.redjournal.org](http://www.redjournal.org).)



**Fig. 2.** Radiation oncologist job opportunities organized by increasing number of jobs by state (A) and increasing number of jobs by state normalized by unit population (B).

**Table 1**

National job distribution by type and city size

	US Census region			
	Northeast	Midwest	South	West
Total jobs (n=211)	39 (18.5%)	60 (28.4%)	67 (31.8%)	45 (21.3%)
Nonacademic (n=129)	17 (13.2%)	41 (31.8%)	38 (29.5%)	33 (25.6%)
Academic (n=82)	22 (26.8%)	19 (23.2%)	29 (35.4%)	12 (14.6%)
Main site (n=58)	14 (24.1%)	15 (25.9%)	20 (34.5%)	9 (15.5%)
Affiliate site (n=25)	8 (32.0%)	4 (16.0%)	9 (36.0%)	4 (16.0%)
City size (n=211)				
50,000 (n=53)	9 (17.0%)	13 (24.5%)	18 (34.0%)	13 (24.5%)
50,001–100,000 (n=42)	8 (19.0%)	15 (35.7%)	10 (23.8%)	9 (21.4%)
100,001–150,000 (n=14)	2 (13.3%)	8 (53.3%)	3 (20.0%)	2 (13.3%)
150,001–200,000 (n=10)	2 (20.0%)	2 (20.0%)	4 (40.0%)	2 (20.0%)
>200,000 (n=92)	18 (19.8%)	22 (24.2%)	32 (35.2%)	19 (20.9%)

Percentages were derived by using the corresponding number of jobs in the first column, per respective row, as the denominator.

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Table 2

Regional job distribution by type and city size

	US Census region				P value
	Northeast	Midwest	South	West	
Total jobs (n=211)	39 (100%)	60 (100%)	67 (100%)	45 (100%)	-
Nonacademic (n=129)	17 (43.6%)	41 (68.3%)	38 (56.7%)	33 (73.3%)	.021*
Academic (n=82)	22 (56.4%)	19 (31.7%)	29 (43.3%)	12 (26.7%)	
Main site (n=58)	14 (63.6%)	15 (78.9%)	20 (69.0%)	8 (66.7%)	.751
Affiliate site (n=25)	8 (36.4%)	4 (21.1%)	9 (31.0%)	4 (33.3%)	
City size (n=211)					
50,000 (n=53)	9 (23.1%)	13 (21.7%)	18 (26.9%)	13 (28.9%)	.622 <sup>†</sup>
50,001–100,000 (n=42)	8 (20.5%)	15 (25.0%)	10 (14.9%)	9 (20.0%)	
100,001–150,000 (n=14)	2 (5.1%)	8 (13.3%)	3 (4.5%)	2 (4.4%)	
150,001–200,000 (n=10)	2 (5.1%)	2 (3.3%)	4 (6.0%)	2 (4.4%)	
>200,000 (n=92)	18 (46.2%)	22 (36.7%)	32 (47.8%)	19 (42.2%)	

Percentages were derived by using the corresponding number of total jobs in each respective region as the denominator.

\* Statistically significant.

<sup>†</sup> Comparison between 200,000 and >200,000 among regions.

**Table 3**

Number of jobs compared with graduates per region

	US Census region				P value
	Northeast	Midwest	South	West	
No. of graduates (n=169)	50 (29.6%)	39 (23.1%)	52 (30.8%)	28 (16.6%)	.003 *
No. of jobs (n=211)	39 (18.5%)	60 (28.4%)	67 (31.8%)	45 (21.3%)	
Proportion of total jobs per graduates trained	0.78	1.54	1.29	1.61	-
Proportion of academic jobs per graduates trained	0.44	0.49	0.56	0.43	-
Proportion of non-academic jobs per graduates trained	0.34	1.05	0.73	1.18	-

\* The  $\chi^2$  goodness-of-fit test was applied to a 1-way frequency table comparing a set of observed proportions of jobs per region with a corresponding set of hypothesized proportions of jobs per region based on the proportions of students graduating from each region.