

Oral Sciences Ph.D. Program Enrollment, Graduates, and Placement: 1994-2016

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Abstract

For decades, the United States dental schools have endured a significant faculty shortage. Studies have determined that the top two sources of dental faculty are advanced education programs and private practice (Wancheck et al., 2015). Those who have completed both the D.D.S. and Ph.D. training are considered prime candidates for dental faculty positions. However, there is no national database to track those trainees and no evidence to indicate that they entered academia upon graduation.

The objective of this study was to assess outcomes of dental school-affiliated oral sciences Ph.D. program enrollment, graduates, and placement between 1994 and 2016.

Using the American Dental Association annual survey of Advanced Dental Education Programs Not Accredited by the Commission on Dental Accreditation and data obtained from 22 oral sciences Ph.D. programs, we assessed student demographics, enrollment, graduation and placement. Based on the data provided by program directors, the average new enrollment was 33 and graduation was 26 per year. There were 605 graduated, 39 did not complete, and 168 were still in training. Among those 605 graduates, 211 were faculty in U.S. academic institutions and an additional 77 graduates were faculty in foreign institutions. Given that vacant, budgeted full-time faculty positions averaged 257 per year during this time period (Wancheck et al., 2015), graduates from those oral sciences Ph.D. programs who entered academia in the U.S. would have filled nine (3.6%) of the vacant faculty positions per year. Therefore, the Ph.D. programs have consistently generated only a small pipeline of dental school faculty. Better mentoring to retain talent in academia is necessary. Stronger support and creative funding plans are essential to sustain the Ph.D. program. Furthermore, the oral sciences Ph.D. program database should be established and maintained by dental professional organizations to allow assessments of training models, trends of enrollment, graduation, and placement outcomes.

Introduction

The 2014 American Dental Education Association (ADEA) Survey of vacant budgeted faculty positions revealed a prolonged faculty shortage over the preceding two decades (Kennedy and Hunt, 1998; ADEA Deans' Briefing Book 2014-2015; Wanchek et al., 2016). There continues to be a need for more faculty to support dental education. Among the 66 dental schools in the U.S., there were 28 schools offering Ph.D. training in Oral or Biomedical Sciences between 1994 and 2016. The American Dental Association (ADA) surveys these Ph.D. program enrollments and graduates annually. However, there are no analytical data on trends of new enrollment of these Ph.D. programs or placement of their graduates. These Ph.D. students, upon graduation, are presumed to be prime candidates for dental school faculty positions. However, there is no evidence to validate or disprove such an assumption. This lack of Oral Sciences Ph.D. program-specific database has made it difficult to gauge how many students are in training and how many graduates hold faculty positions to support the education and research mission of the dental profession.

Well-qualified dental faculty are essential to achieve the educational, patient care, and research missions of dental schools. Yet, as the U.S. economy sustains its vigor, the income difference between practicing dentists and academics continues to widen. Thus, attracting dental graduates or practitioners to academia becomes more challenging. U.S. dental schools are consequently confronted with the problem of a chronic faculty shortage (Kennedy and Hunt, 1998). Between 1994 and 2015, vacant, budgeted full-time faculty positions averaged 257 per year (Wanchek et al., 2015). A significant decrease from 374 to 194 vacant positions between 2006 and 2010 occurred because of a permanent loss of positions as schools experienced budget cuts (Wanchek 2015). In 2011-2014, about 15% (or 38.5) of those vacant, budgeted full-time faculty positions were Basic Sciences and Research positions (Wanchek et al., 2015), which may be best filled by individuals who have completed a rigorous graduate training program with significant research experiences.

According to Wanchek et al., 2015, the primary sources of new faculty, age 30 to 39, included private practice (32.8%), advanced dental education (25.2%), and faculty positions at other schools (15.6%). Men were more likely (57.9%) than women (46.8%) to enter academia from private practice. Female faculty are more likely to come from advanced degree program (19.2%) than male faculty (9.8%). Recruiting students in graduate studies to enter academia has been a consistent approach; therefore, sustaining rigorous graduate programs is a potential strategy to grow a stable pipeline of dental faculty. Although the ADA surveys enrollment and graduates of advanced dental education programs on an annual basis, there exists no aggregate data analyses to allow a confident projection of trends in enrollment, graduates, and placement.

The purpose of this study was to collect and analyze available data from ADA annual surveys and dental school-affiliated Ph.D. programs from 1994 to 2016. The objective was to examine program data to understand whether the oral sciences Ph.D. programs were consistently enrolling students and what percentage of those Ph.D. students upon completion of their training entered the dental faculty workforce.

Methods and Materials

The study protocol was reviewed and exempted by the Institutional Review Board (IRB) at the University of Michigan.

The Oral Sciences Ph.D. program enrollment and graduation data from the ADA annual survey of advanced dental education in oral sciences from 1994 to 2016 was collected ([ADA Survey of Advanced Dental Education](#)). The specific table used is entitled “Dental School Enrollment and Graduates of Advanced Programs Not Accredited by the Commission on Dental Accreditation.” Basic Science Ph.D. Programs, such as Oral Biology, Craniofacial Biology, Biomaterials, Microbiology, Anatomy, Histology, Pathology, Physiology, Epidemiology, and Oral Sciences were included in this study. While clinical sciences programs such as Anesthesiology, Restorative Dentistry, Dental Diagnostic

Sciences, Dental Implantology, Operative Dentistry, Preventive Dentistry, etc. were excluded.

The ADA survey published in a specific year contains data from the previous academic year. Survey data from 1993 was obtained to calculate the new enrollment in 1994. The data extracted from ADA annual surveys was compiled and the number of newly enrolled students and graduates per year was analyzed.

Separately, a survey to obtain Ph.D. program affiliation, year founded, student and graduate demographics, degree type, and placement data was constructed, reviewed and exempted by IRB at the University of Michigan. Following an internet search and website review of 66 dental schools in the U.S. in July 2016 and [institutional training programs \(T32\)](#) funded by the National Institute for Dental and Craniofacial Research (NIDCR) in September 2016, twenty-eight Ph.D. programs were identified and their directors contacted initially by email to provide study objective and project description. Next, program directors were immediately telephoned to invite their participation and to answer their questions about the study. Three of those 28 Ph.D. programs enrolled students within the study timeframe but were inactive in 2016. Follow up phone calls and emails at monthly intervals continued from November 2016 to April 2017 to encourage participation.

The survey of program directors requested that all program students be listed chronologically and anonymously. In addition, year of initial enrollment, degree type, year of graduation, gender, ethnicity, placement, and location were required. Students who did not complete their training or students who were still in training at the time of survey were also included in the analyses.

Because oral sciences Ph.D. programs differ significantly in terms of degree offered, years in operation, number of students enrolled, etc., we targeted an 80% response rate. The assumption was that having data sets from the majority of the Ph.D. programs would allow meaningful data analyses and a scientific report of study outcomes. Data sets from ADA and program surveys were compiled, cross checked and analyzed. When discrepancies were

encountered between those two data sets, the specific program directors were contacted and their confirmed reports were used as the source of correct information. Excel spreadsheets were created and statistical analyses and graphs were also constructed (Microsoft Office, 2011). Specifically, we used Chi-square analyses for comparisons and set the level of statistical significance at $p < 0.01$. This study was conducted in compliance with the “Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals” and the STROBE Checklist (STROBE Recommendations and Checklist, 2016) was referenced for the preparation of the study protocol and report.

Results

ADA surveys from 1993 to 2016 were obtained from the Hatcher Graduate Library at the University of Michigan and ADA Library. The specific table containing Ph.D. program enrollment and graduate data were compared to the same data points from the year before in order to determine the number of new enrollment and graduates. These numbers and the number of programs with active enrollment were calculated for academic years 1994 to 2015.

Based on ADA annual surveys, although the number of dental schools in the U.S. has increased, the number of oral sciences Ph.D. program remained unchanged from 1994 to 2016. Over the most recent five years, among the 65 to 66 dental schools, there were 21 active Ph.D. programs, of which 16 to 17 programs were enrolling new Ph.D. students (Figure 1A). On an average, 33 students per year were enrolled during the study period (Figure 1B). There was a decrease of enrollment to 21 students per year between 2011 and 2015. The number of program graduates was approximately 30 per year over the study period and approximately 26 per year in the most recent five years.

Data from those 22 surveys completed by program directors were cross checked against data from the ADA annual surveys. Then, we analyzed program data to assess student demographics, degree type, time to degree, location, and placement.

The primary affiliation of the 22 programs surveyed were ten programs based in dental schools, seven affiliated with health science centers, and five affiliated with graduate schools. Active collaboration between the primary affiliation and other academic units was common. The program directors reported a total of 812 students enrolled and/or graduated between 1994 and 2016. Among those students, 41 enrolled before 1994 and 771 after 1994; 605 graduated, 39 did not complete, and 168 were still in the program. The average new enrollment was 33 per year and graduation was 26 per year from 1994 to 2016. Over the most recent five years, while new enrollment remained the same, the number of graduates had increased to 34 per year (Figure 2A, B). Of the 812 students and graduates reported in these surveys, there were more females (54.7%) than males (44.5%) (Figure 3A). Students' ethnicities were reported to be White (39.1%), Asian (34.7%), Hispanic (7.1%), Middle Eastern (5.2%), Black (2.9%), Indian (2.4%) and unknown/not reported (8.6%) (Figure 3B).

The majority of the students pursued a Ph.D. degree (80%), while those who pursued a D.D.S./Ph.D. (18%) or M.S./Ph.D. (2.0%) degree accounted for only 20% of the enrollees (Figure 4A). For Ph.D. students, it took an average of more than five years to complete their Ph.D. training, with the annual average completion duration ranging between 4.69 and 5.83. For D.D.S./Ph.D. students, it took more than seven years with the annual average completion duration ranging between 6.40 and 8.00 (Figure 4B). The attrition rate was 5.1% for D.D.S./Ph.D. training and 4.6% for Ph.D. training ($p > 0.01$) (Appendix Figure 1A). Among the graduates, 75.5% of them resided in the U.S., 14.9% were outside of the U.S., and 9.6% were unknown (Figure 5A).

When evaluating students' and graduates' location by degree type, the majority of the D.D.S./Ph.D. graduates (94.8%) remained in the U.S., while 72% of the Ph.D. graduates resided in the U.S., 17.6% were outside of the U.S., and 10.4% were unknown (Appendix Figure 1B). Among those 605 graduates, 211 (34.9%) were faculty in the U.S. academic institutions, an additional 77 (12.7%) graduates were faculty in foreign institutions, 67 (11.1%) in industry/government agencies, 71 (11.7%) worked in private practice, 71 (11.7%) recent graduates were in postdoctoral training, and 65 (10.7%) were in

residency/continued training (Figure 5B). There was a significantly higher percentage of the Ph.D. graduates who entered academia (50.8%) compared to the D.D.S./Ph.D. group (29.7%) ($p < 0.01$). There were 26 (28.6%) D.D.S./Ph.D. graduates who entered private practice compared to only 45 (8.8%) of the Ph.D. graduates ($p < 0.01$). (Appendix Figure 2A).

More female graduates (14.1%) pursued postdoctoral fellowship or residency training than male graduates (8.4%), but the difference was not statistically significant. Likewise, there were more female graduates engaged in family care or personal pursuits (2.3%) than male graduates (0.8%). This difference was also not statistically significant ($p > 0.01$). The number of male graduates in faculty positions were similar to the number of female graduates in faculty positions ($p > 0.01$). Furthermore, 18.2% of male graduates and 16.7% of female graduates were affiliated with academic institutions in the U.S. There was no difference in the likelihood of selecting private practice as a career option between female and male graduates (Appendix Figure 2B). Non-White graduates were no less likely to enter academia in the U.S. or private practice compared to the White graduates ($p > 0.01$) (Appendix Figure 2C).

The ratio of graduates who entered academia in the U.S. was 119/280 (42.5%) in 1994 - 2003 and 70/283 (24.7%) in 2004 - 2013. This comparative result may seem concerning. However, it is important to note that there were significantly more graduates in 2004-2013 who held faculty positions in foreign institutions (49 vs. 28) and there were more graduates who continued to pursue postdoctoral or specialty training (100 vs. 33) than the group in 1994-2003 (Appendix Table 1). It will be important to follow up on the career choices of those individuals in continued training.

There were changing demographics of the currently enrolled graduate students. Taking only the 168 students who were still in training at the time of this survey study, 63 were White, 64 were Asian, 17 were Middle Eastern, five were Hispanic, five were African American, four were Indian, and ten were unknown/not reported. Among these current students, 127 were pursuing Ph.D. (75.6%) training and 41 (24.4%) were pursuing D.D.S./Ph.D. training. While among the 605 graduates, there were significantly more

individuals (85%) who completed Ph.D. training than the D.D.S./Ph.D. training (15%)($p < 0.01$).

Based on program directors' reports, 211 oral sciences Ph.D. graduates entered academia in the U.S. between 1994 and 2016. Given that vacant faculty positions averaged 257 per year from 1994-2015, graduates from those 22 oral sciences Ph.D. programs who entered academia in the U.S. would have filled only 3.6% of the vacant dental faculty positions per year during this time period.

Discussion

In this study, the oldest oral sciences Ph.D. program in the U.S. as reported by program directors was founded in 1964. More than half of the 22 Oral Sciences Ph.D. programs were affiliated with either Health Science Centers or Graduate Schools, although their students conducted dissertation research with dental school faculty. Programs primarily affiliated with dental schools also collaborated with other academic units to broaden didactic and dissertation research options for their Ph.D. students. The program director survey participation rate was 78.6%. While this fell short of the targeted 80% participation rate, the compiled data accounted for 104% of the enrollment and 92.5% of the graduation data of the ADA annual surveys from 1994 to 2016.

Based on the ADA annual surveys, there was a decrease of oral sciences Ph.D. enrollment from an average of 39 per year in 1994-2010 to 21 per year in 2011-2015, yet the graduation rate was sustained at 26 per year during this period of time. However, from the program directors' survey, it was observed that 22 programs collectively enrolled an average of 33 new students per year in 1994 - 2016 and the same in 2011 - 2015. The number of graduates was 26 per year in 1994 - 2016 and 34 per year in 2011 - 2015. Significant discrepancies between the survey data from the ADA and program directors were observed, which likely resulted from under reporting to the ADA (Figures 1B, 2B). The ADA annual survey captured only the number of dentists, foreign or U.S. trained, in the PhD program. Students with a bachelor or M.S. degree who entered oral sciences PhD

training would not have been reported in the ADA surveys. Based on the program directors' data, the annual new enrollment from 16-17 Ph.D. programs had not changed while there was a significant increase in graduation during the most recent five years. Sustaining Ph.D. training requires significant resources which may include, but is not limited to, the number of funded faculty mentors and funding streams such as training grants, fellowships, and R01 level research grants. Research funding and school priorities often impact academic program admissions and student support. At the national level, the policy shift resulting in diminishing institutional training grant positions and encouraging individual training grant applications likely impact program admissions.

Comparing findings of this study to the published benchmarks of the outcomes of 1,860 M.D./Ph.D. program graduates in 2000-2005 (Andriole and Jeffe, 2016), there are interesting similarities and differences. Over half (52.4%) of the M.D./Ph.D. program graduates had full-time faculty appointments. Graduates with high debt levels were significantly less likely to have full-time faculty appointments. Graduates with substantial research had a greater propensity for academic careers, while gender was not an influencing factor. The racial and ethnic diversity of M.D./Ph.D. program graduates has increased over the past 20 years, which is a significant change not yet observed in oral sciences Ph.D. program. While in the M.D./Ph.D. cohort underrepresented minorities (URM) and Asian/Pacific Islander graduates were less likely than white graduates to have held full-time faculty appointments, our study outcomes differ in that Asian students and students with URM background were equally likely to hold full-time faculty positions compared to White students. However, based on our study, only 29.7% of oral sciences D.D.S./Ph.D. graduates entered academia. The high level of student debt and the income difference between academics and practitioners are likely the significant factors impacting career choice. Enhancing mentoring and research experiences will be important to recruit and retain talents in academia (John et al., 2011; Gironda et al, 2013). From 1994 to 2004, oral sciences Ph.D. students with URM background were 12.6%, while there was an increase to 14% from 2005 to 2015, this change was not statistically significant ($p>0.01$). Despite the effort of inclusion, Profile for Success programs, and undergraduate research mentoring programs (Johnson et al., 2013), additional measures will need to be taken in

order to affect a significant increase of diversity among the oral sciences graduate student body.

It is important to note that not all dental faculty hired may have entered through the pipeline described here. Some faculty members receive Ph.D. training outside programs that reside within universities/academic health centers with dental schools. The programs analyzed in the present study would not have captured such individuals.

More than 80% of the program graduates with known location resided in the U.S. Since this survey did not ask for students' country-of-origin, we cannot begin to deduce how many foreign students decided to stay in the U.S. after completion of their Ph.D. training. While significantly more female than male graduates of advanced degree programs became dental faculty (Wanchek et al., 2015; Gadbury-Amyot et al., 2016), both male and female graduates of oral sciences Ph.D. program were equally likely to hold a faculty position after completion of their Ph.D. training.

Compared to 2005, when James Rogér conducted a survey of D.D.S.-D.M.D./Ph.D. dual-degree training opportunities at the U.S. dental schools, there were significantly more programs offering D.D.S./Ph.D. training positions and better structured curricula (personal communication with program directors) to strengthen students' academic experience in the recent decade (Rogér JM, 2008). The attrition rate of the D.D.S./Ph.D. program (5.1%) was no different from that of the Ph.D. program (4.6%) from 1994 to 2016. There is also a higher percentage of D.D.S./Ph.D. students currently receiving training compared to the percentage in the group already graduated.

Three programs provided training grant tables from which trainee information was extracted to complete the study survey. Students not funded by training grant, if any, would have been left out. The M.S./Ph.D. students were combined in the Ph.D. category in the program directors' survey, although many program directors reported the M.S./Ph.D. students separately. As reported, there were only 16 M.S./Ph.D. students during the study period. The data related with M.S./Ph.D. students should not be considered complete.

This study did not survey Ph.D. program funding mechanisms nor academic models of the D.D.S./Ph.D. training. Follow up survey of programs with a focus on finance, student loan, support needs, and support mechanisms may provide critical insights to devise a sustainable plan for oral science graduate training. Additional studies to determine predictors that distinguish the group of graduates who were faculty from the group that entered private practice would shed light into how to best mentor students and retain talents in academia.

The NIH cap of institutional research training grant direct cost may have decreased the available training positions. However, Oral Sciences Ph.D. programs managed to continue their activities using a combined strategy involving dental school funding streams, specialty foundation funding and institutional scholarships. Many D.D.S./Ph.D. and Ph.D. students are expected to secure individual National Research Service Award (F series) in order to support their academic pursuits.

Our ultimate goal is to demonstrate the outcomes of oral sciences Ph.D. programs in the U.S. With the results of this pilot study, we hope to engage the oral sciences Ph.D. program directors, the Council on Dental Education and Licensure of ADA, the Commission on Dental Accreditation, and American Dental Education Association to devote effort toward establishing, maintaining, and making available an oral sciences Ph.D. program database and to periodically assess programs' impact on dental education, research and faculty workforce.

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- Author Contributions: C.R. Herzog compiled the ADA surveys and analyzed program survey data, reviewed and edited the manuscript; D.W. Berzins, P. DenBesten, R.L. Gregory, K.M. Hargreaves, R.L.W. Messer, M. Mina, M.P. Mooney, M.L. Paine, C. Phillips, R.B. Presland, R.G. Quivey, F.A. Scannapieco, J.F. Sheridan, K.K.H. Svoboda, P.C. Trackman, M.P. Walker, S.G. Walker, and C-Y. Wang provided program-specific data set, critically reviewed and edited the manuscript, contributed insightful comments to improve the manuscript ; J.C-C. Hu designed the study, acquired, organized, and analyzed data, drafted and revised the manuscript. All authors gave final approval, and agreed to be responsible for the contents of this manuscript.
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Figure Legends

Figure 1. The ADA annual survey of oral sciences Ph.D. program in the U.S. from 1994 to 2015. (A) Number of dental schools and number of oral sciences Ph.D. programs, and (B) Ph.D. program new enrollment and graduates. The new enrollment count in 2006 may be a result of attrition, reporting errors, or under reporting.

Figure 2. Oral sciences Ph.D. program (A) number of programs and total enrollment, and (B) number of new enrollment and graduates from 1994 to 2016 based on the data from 22 programs.

Figure 3. Oral sciences Ph.D. program (A) total enrollment by gender, and (B) total enrollment by ethnicity from 1994 to 2016 based on the data from 22 programs.

Figure 4. Oral Sciences Ph.D. program students' and graduates' (A) degree type, and (B) time to degree from 1994 to 2016 based on the data from 22 programs. There were no D.D.S./Ph.D. graduates in 1996.

Figure 5. Oral Sciences Ph.D. program students' and graduates' (A) location, and (B) placement from 1994 to 2016 based on the data from 22 programs. Data from each year represents the location or placement of the individuals who were first enrolled in that year.

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