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ABSTRACT

This study compared total NIH research funding across US dental institutions from 2005 to 2009. Utilizing the online NIH RePORT, we obtained comprehensive award data for US dental schools by funding NIH Institutes/Centers (ICs). Fifty dental schools were awarded a total of \$974.393 million, 69.3% from NIDCR and 30.7% from 21 other ICs. These provided the majority of support to 12 schools. Greater than 50% of non-NIDCR support came from 4 ICs. The median dental school NIH portfolio was \$14.572 million, with a minimum of \$0.241 million and a maximum of \$88.609 million. Forty-six schools received \$544.899 million for R01 awards. Thirty-five schools were awarded \$100 million in research training and career development grants. Several dramatic differences are found for dental schools' rankings based on total NIH dollars compared with NIDCR-only support. Dollars from ICs other than NIDCR increased 34.6% between 2005 and 2009. Grants to US dental institutions comprised 50% or less of total NIDCR awards globally from 2005 through 2009. Funds received from all NIH ICs are an objective metric for evaluation of the research performance of dental schools. NIDCR has played a diminishing role in funding research at US dental schools between 2005 and 2009.

KEY WORDS: research funding, dental schools, National Institutes of Health.

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Total NIH Support to US Dental Schools, 2005-2009

INTRODUCTION

A continuing concern for dentistry and dental researchers globally has been the assessment of research quality, activity, and performance. Yet data on these issues are not easy to derive. There is general acceptance in the United States that National Institutes of Health (NIH) grant funding is a reasonably objective metric for research performance (Graham and Diamond, 2004; Cole, 2010). We sought to understand the current status of NIH support to US dental schools to help inform the global debate on research performance.

We used a quantitative approach, based on total NIH funds awarded, to assess a dental institution's research performance and its position relative to other schools (NIH, 2009). Any assessment of dental schools should include information on grant dollars received from all NIH Institutes and Centers (ICs) rather than only from the NIDCR. The present analysis addresses this current deficiency by analyzing total NIH funding during 2005 to 2009 and scrutinizing its composition as well as institutional ranking based on total dollars.

MATERIALS & METHODS

Public data on all NIH grants, cooperative agreements, and contracts are available from the NIH Research Portfolio Online Reporting Tool, or RePORT (National Institutes of Health, 2009), from FY2005 to FY2009. Data do not include projects funded by the American Recovery and Reinvestment Act (ARRA) of 2009. The figures provided by the NIH are the total direct and indirect costs for each fiscal year.

The RePORT database was searched from 2005 to 2009 for the 56 organizations in the United States that contained an active dental school in 2005. NIH award data were found for 50 institutions. [The six dental schools for which no data were found are A.T. Still University, Southern Illinois University, Temple University, University of Detroit Mercy, University of Nevada Las Vegas, and West Virginia University.] These schools comprise the study population for the present investigation. For each year, NIH project data were downloaded in Microsoft Excel spreadsheets for all schools. Thus, 5 separate Excel worksheets were created with data for all universities in a particular year. Data included organization/university name, major university component (e.g., school of dentistry, medicine, engineering, etc.), project number (which contains the activity code or grant mechanism and abbreviation of the funding NIH Institute/Center), name of principal investigator, project title, and dollars awarded. Data for each university were sorted by the

Table 1. Total 5-year NIH Dollars Awarded, Percentages from NIDCR and Selected Grant Mechanisms, by US Dental Schools Receiving at least \$5 million, FY 2005-2009 (dollars in millions)

Institution	Total \$M	% NIDCR	% R01	% F,K,T
UNIV OF CALIFORNIA SAN FRANCISCO	\$88.609	57.8%	48.7%	10.4%
UNIV OF MICHIGAN AT ANN ARBOR	\$60.425	82.9%	73.6%	8.3%
UNIV OF NORTH CAROLINA CHAPEL HILL	\$50.327	84.3%	34.7%	6.7%
UNIV OF FLORIDA	\$50.074	74.7%	68.5%	13.2%
UNIV OF WASHINGTON	\$48.566	93.3%	35.4%	12.9%
NEW YORK UNIV	\$46.239	90.6%	26.9%	6.2%
UNIV OF CALIFORNIA LOS ANGELES	\$43.514	80.1%	49.4%	12.7%
UNIV OF MARYLAND BALTIMORE	\$39.950	42.9%	69.1%	12.3%
BOSTON UNIVERSITY	\$39.933	71.4%	72.6%	6.3%
UNIV OF ALABAMA AT BIRMINGHAM	\$35.980	81.1%	37.7%	9.7%
UNIV OF SOUTHERN CALIFORNIA	\$32.756	65.2%	75.3%	2.6%
HARVARD UNIV	\$27.911	14.0%	64.3%	12.3%
UNIV OF PENNSYLVANIA	\$27.772	41.9%	84.7%	3.0%
UNIV OF ILLINOIS AT CHICAGO	\$27.367	55.1%	56.4%	10.7%
UNIV OF LOUISVILLE	\$26.534	67.0%	52.4%	6.5%
UNIV OF TEXAS HLTH SCI CTR SAN ANT	\$25.250	68.7%	50.4%	19.2%
UNIV OF MINNESOTA TWIN CITIES	\$24.941	73.9%	51.0%	20.6%
UNIV OF CONNECTICUT	\$21.839	62.7%	59.3%	20.3%
OHIO STATE UNIV	\$20.991	51.0%	67.7%	22.2%
UNIV OF IOWA	\$20.052	100.0%	74.6%	15.5%
UNIV OF MISSOURI KANSAS CITY	\$18.219	45.6%	31.5%	24.6%
UNIV OF PITTSBURGH AT PITTSBURGH	\$17.226	96.6%	74.9%	8.2%
UNIV OF NEBRASKA MEDICAL CENTER	\$16.732	27.2%	40.1%	0.0%
MEDICAL UNIV OF SOUTH CAROLINA	\$15.986	33.6%	8.1%	7.4%
UNIV OF KENTUCKY	\$14.596	27.9%	14.5%	4.6%
UNIV OF COLORADO DENVER	\$14.547	89.1%	70.6%	2.8%
UNIV OF MED/DENT OF NJ	\$14.245	87.5%	89.3%	1.8%
CASE WESTERN RESERVE UNIV	\$13.376	100.0%	60.5%	15.4%
STATE UNIV NEW YORK AT BUFFALO	\$13.346	82.1%	68.9%	17.4%
TEXAS A&M UNIV (BAYLOR)	\$12.025	91.4%	66.2%	8.4%
COLUMBIA UNIV	\$8.308	64.8%	90.9%	0.0%
STATE UNIV NEW YORK STONY BROOK	\$7.697	83.3%	35.9%	4.8%
TUFTS UNIV BOSTON	\$7.185	90.1%	66.9%	0.0%
OREGON HEALTH AND SCIENCE UNIV	\$6.230	11.9%	78.4%	1.1%
UNIV OF TEXAS HLTH SCI CTR HOUSTON	\$6.145	49.6%	39.2%	35.1%
VIRGINIA COMMONWEALTH UNIV	\$6.047	78.3%	82.9%	17.1%
INDIANA UNIV-PURDUE UNIV AT INDIANAP	\$6.011	93.5%	71.0%	0.0%
Total dollars for all dental schools in millions	\$974.393	\$675.010	\$544.899	\$99.966

F, individual fellowships; K, individual career development awards; T, institutional training grants.

major component so that information about the 50 dental schools was identified by year.

To ensure that grants listed for dental schools were awarded to faculty located at the dental institution, affiliation of all principal investigators was checked through online searches by Google, PubMed, and institutional directories. Grants to faculty not affiliated with the dental school were deleted from the school's list. This step was done in duplicate by two independent researchers, and agreement was reached quickly on the relatively small number of discrepancies that arose. [For example, the University of Pennsylvania School of Dental Medicine was found to have 29 misclassified grants, for \$23.044 million. These were removed from the Penn portfolio, and dollars were subtracted from its total NIH awards.]

For each dental school, data were compiled by year and then summed, by NIH funding source, over the 5 years for dollars received, number of unique awards, activity codes, and name and number of unique principal investigators. Based on the five-year sums, percentages of total dollars and unique awards from each NIH Institute/Center (IC) and percentages of total dollars by all activity codes were computed. To divide the 50 dental schools according to level of funding, we grouped the institutions by quartiles, based on total NIH grant dollars received during 2005 through 2009. Funding performance was highest in the fourth quartile, Q4 (total dollars at or above the 75th percentile). Schools in the third quartile, Q3, received total NIH dollars between the 50th and 74th percentiles. Dental schools in the second quartile, Q2, obtained total NIH dollars between the 25th

Table 2. Rank for total NIH Dollars each year and the entire five years, and for NIDCR Dollars over five years, by dental schools in top three quartiles, 2005 - 2009, and total dollars awarded by year, in millions

Institution	Total NIH dollars					NIH \$	NIDCR \$
	2005	2006	2007	2008	2009	5 yrs	5 yrs
UNIV OF CALIFORNIA SAN FRANCISCO	1	1	1	1	1	1	1
UNIV OF MICHIGAN AT ANN ARBOR	2	2	2	3	2	2	2
UNIV OF NORTH CAROLINA CHAPEL HILL	5	3	3	5	7	3	4
UNIV OF FLORIDA	6	6	7	2	3	4	6
UNIV OF WASHINGTON	3	4	6	4	13	5	3
NEW YORK UNIV	7	5	5	10	4	6	5
UNIV OF CALIFORNIA LOS ANGELES	8	7	4	7	9	7	7
UNIV OF MARYLAND BALTIMORE	4	9	11	12	6	8	15
BOSTON UNIVERSITY	10	10	8	6	5	9	9
UNIV OF ALABAMA AT BIRMINGHAM	12	8	9	9	10	10	8
UNIV OF SOUTHERN CALIFORNIA	20	17	10	8	8	11	10
HARVARD UNIV	17	14	12	14	12	12	35
UNIV OF PENNSYLVANIA	14	13	18	15	11	13	22
UNIV OF ILLINOIS AT CHICAGO	11	16	16	13	15	14	17
UNIV OF LOUISVILLE	19	15	15	11	14	15	13
UNIV OF TEXAS HLTH SCICTR SAN ANT	13	11	14	16	17	16	14
UNIV OF MINNESOTA TWIN CITIES	9	12	13	19	25	17	12
UNIV OF CONNECTICUT	15	19	21	20	16	18	18
OHIO STATE UNIV	18	18	20	17	19	19	25
UNIV OF IOWA	16	20	17	24	21	20	11
UNIV OF MISSOURI KANSAS CITY	22	22	19	21	27	21	26
UNIV OF PITTSBURGH AT PITTSBURGH	30	23	23	18	18	22	16
UNIV OF NEBRASKA MEDICAL CENTER	25	21	24	25	26	23	33
MEDICAL UNIV OF SOUTH CAROLINA	27	28	22	22	23	24	31
UNIV OF KENTUCKY	21	25	28	27	29	25	34
UNIV OF COLORADO DENVER	24	34	26	23	24	26	20
UNIV OF MED/DENT OF NJ	26	27	25	28	28	27	21
CASE WESTERN RESERVE UNIV	29	30	27	29	22	28	19
STATE UNIV NEW YORK AT BUFFALO	23	24	31	26	32	29	24
TEXAS A&M UNIV (BAYLOR)	28	26	29	32	31	30	23
COLUMBIA UNIV	31	29	33	37	30	31	30
STATE UNIV NEW YORK STONY BROOK	40	37	37	30	20	32	28
TUFTS UNIV BOSTON	41	39	30	31	33	33	27
OREGON HEALTH AND SCIENCE UNIV	34	33	32	34	34	34	44
UNIV OF TEXAS HLTH SCI CTR HOUSTON	32	32	35	38	36	35	37
VIRGINIA COMMONWEALTH UNIV	35	35	36	33	35	36	32
INDIANA UNIV-PURDUE UNIV	33	31	34	35	38	37	29
Total Dollars in millions	\$200.072	\$191.868	\$187.288	\$192.146	\$203.019	\$974.393	\$675.010
Percent NIDCR	73.6%	71.4%	69.4%	67.1%	64.9%	69.3%	
Percent non-NIDCR	26.4%	28.6%	30.6%	32.9%	35.1%	30.7%	

and 49th percentiles. First-quartile schools, Q1, received total dollars below the 25th percentile.

RESULTS

Total NIH Support

Fifty dental schools (almost 90% of US institutions) secured at least some NIH funding during Federal fiscal years 2005 to 2009 (Table 1). Thirty-four schools (68.0%) were public or state-supported, and 16 (32.0%) were private or private-state-related. [Of the 6 dental schools that did not receive any NIH support from

2005 to 2009, 3 were public and 3 were private.] Twenty-two NIH ICs awarded a total \$974.393 million to the 50 institutions. This amount excluded 2009 ARRA funds. The median five-year NIH portfolio for US dental schools was \$14.572 million. The 13 schools in Q4 (from the University of California San Francisco to the University of Pennsylvania) were the most highly funded, receiving \$592.056 million, or 60.8% of total NIH dollars. Eight of the Q4 schools were public-supported, while 5 were private. Thus, almost one-third of the private dental schools that received any NIH support were among the top performers. The 12 schools in Q3 (the University of Illinois to the University of Kentucky) received \$249.733 million (25.6% of total NIH funds). The 12

Figure. Percentage of total NIDCR grant dollars awarded to US dental schools, 2005-2009 (total NIDCR dollars in millions shown above each bar).

institutions in Q2 (the University of Colorado Denver to Indiana University-Purdue) were awarded \$115.162 million (11.8%). The 13 schools in Q1 (not shown in Table 1) obtained \$17.443 million (1.8%).

When the cumulative distribution of NIH dollars across schools is computed from 2005 to 2009, the first 10 schools (17.9% of all dental institutions) listed in Q4 received 50% of all NIH funds awarded. Two-thirds of all NIH award dollars went to the first 16 (28.6%) ranked schools, and three-quarters of total NIH funding went to the first 19 (33.9%) ranked institutions.

Grant Mechanisms/Activity Codes

From 2005 to 2009, 46 US dental schools received \$544.899 million (55.9% of total NIH dollars) for R01 grants ("NIH Research Project Grant"). This mechanism supports a discrete research project and is the NIH's most commonly used grant program. The R01 is the "gold standard" among awards, providing the greatest prestige for the recipient investigator and institution. Median R01 value for institutions was \$9.730 million, with a minimum of \$0.547 million to a maximum of \$44.485 million. Twenty-eight schools had 60% or more of their NIH support from R01 grants, while 14 schools had 40% or less from R01 awards (Table 1).

Thirty-five US dental schools received almost \$100 million (10.3% of total NIH dollars) in research training (F, or individual fellowships, and T, or institutional training grants) and individual career development awards (K mechanisms) during 2005 to 2009. The median portfolio was \$2.555 million, with a minimum of \$0.068 million to a maximum of \$9.258 million. F, K, and/or T grants comprised at least 15% of NIH awards for 11 schools (Table 1).

Sources of NIH Funding

From 2005 to 2009, 49 US dental schools received \$675.010 million from the NIDCR. This represents 69.3% of total support to schools (Table 2). Median school value was \$10.710 million, with a minimum of \$0.020 million and a maximum of \$51.181 million. Forty dental schools obtained \$299.383 million from other NIH ICs, representing 30.7% of total NIH dollars (Table 2). Total NIH support received by dental institutions from non-NIDCR

ICs increased annually, from 26.4% (\$52.872 million) in 2005 to 35.1% (\$71.161 million) in 2009 (Table 2). This represented a dollar increase of 34.6%. The median school value of non-NIDCR awards was \$6.651 million, with a minimum of \$0.145 million and a maximum of \$37.428 million. Thirty-eight (76.0%) dental schools received over 50% of their NIH support from the NIDCR, and 12 (24.0%) obtained the majority of their grant dollars from other NIH Institutes (Table 1).

NIDCR Support to US Dental Schools

Total NIH funding to dental schools from the NIDCR decreased from 73.6% (\$147.200 million) in 2005 to 64.9% (\$131.858 million) in 2009, for a dollar decrease of 10%. When we examine total grant dollars awarded globally by the NIDCR to all organizations (Figure), the percent to US dental schools consistently decreased from FY 2005 to FY 2009, regardless of the total dollars awarded (value shown above each bar) (National Institutes of Health, 2010). Grants to dental institutions comprised only 50% of the overall NIDCR portfolio in FY 2005 and were below that level from FY 2006 (47.5%) through 2009 (43.7%). Thus, the NIDCR has played a diminishing role in funding research at US dental schools between 2005 and 2009.

Support by Specific NIH Institutes/Centers

Twenty-two NIH ICs, including NIDCR, funded US dental schools from 2005 to 2009 (Table 3). Of the dollars from non-NIDCR sources, over 50% came from the National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS), National Institute of Neurological Disorders and Stroke, (NINDS), National Center for Research Resources (NCRR), and National Institute of Allergy and Infectious Diseases (NIAID). Over 50% of unique awards were provided by NIAMS, the National Cancer Institute (NCI), NIAID, and NINDS.

Rank by Dollars

NIDCR annual data are most frequently used to identify a dental school's relative position for NIH research performance within the national dental research community. However, rankings can be markedly different when total NIH dollars are considered (Table 2). The rank for total dollars received over 2005 to 2009 is shown in the column labeled "NIH \$ 5 yrs". The NIDCR rank over the same period is in the column labeled "NIDCR \$ 5 yrs". The greatest improvement in rank (at least five positions) is found, in decreasing magnitude of improvement, at Harvard University, University of Nebraska and Oregon Health and Science University (tie), University of Pennsylvania and University of Kentucky (tie), University of Maryland and Medical University of South Carolina (tie), Ohio State University, and University of Missouri Kansas City and University of Tennessee (tie).

DISCUSSION

From 2005 to 2009, 6 dental schools (3 public and 3 private) did not obtain any NIH support, and 9 schools (3 public and 6 private) received less than \$2.0 million over this five-year period.

Table 3. Total NIH Support for US Dental Schools and Number of Unique Awards, by NIH Institutes and Centers, FY 2005 to 2009 (dollars in millions)

Institute or Center	Total \$M	Percent \$	No. of Awd	Percent Awd
National Institute of Arthritis and Musculoskeletal and Skin Diseases	\$46.885	15.7%	59	17.5%
National Institute of Neurological Disorders and Stroke	\$39.021	13.0%	33	9.8%
National Center for Research Resources	\$37.607	12.6%	10	3.0%
National Institute of Allergy and Infectious Diseases	\$32.307	10.8%	40	11.9%
National Cancer Institute	\$26.054	8.7%	46	13.6%
National Institute of General Medical Sciences	\$23.348	7.8%	20	5.9%
National Institute on Drug Abuse	\$17.491	5.8%	20	5.9%
National Institute on Deafness and Other Communication Disorders	\$12.324	4.1%	15	4.5%
National Institute of Child Health and Human Development	\$11.746	3.9%	16	4.7%
National Institute of Diabetes and Digestive and Kidney Diseases	\$11.220	3.7%	17	5.0%
National Heart, Lung, and Blood Institute	\$9.442	3.2%	8	2.4%
National Eye Institute	\$7.525	2.5%	13	3.9%
National Institute of Biomedical Imaging and Bioengineering	\$7.125	2.4%	7	2.1%
National Institute on Alcohol Abuse and Alcoholism	\$5.661	1.9%	9	2.7%
National Institute on Aging	\$4.914	1.6%	9	2.7%
National Institute of Mental Health	\$2.645	0.9%	3	0.9%
National Center for Complementary and Alternative Medicine	\$1.286	0.4%	5	1.5%
National Institute of Nursing Research	\$1.096	0.4%	1	0.3%
Fogarty International Center	\$0.801	0.3%	3	0.9%
National Library of Medicine	\$0.478	0.2%	2	0.6%
National Institute of Environmental Health Sciences	\$0.407	0.1%	1	0.3%
Total non-NIDCR funding	\$299.383	30.7%	337	29.1%
National Institute of Dental and Craniofacial Research	\$675.010	69.3%	822	70.9%
Total NIH	\$974.393			

Perhaps these schools conducted research using non-NIH resources. If not, then the question arises as to whether they are fulfilling the mission and obligation of academic health institutions for research and education and service (Field, 1995; Valachovic *et al.*, 1999; Bertolami, 2002). This is of greatest concern for private schools, since 47% were in the lowest-performing groups.

Schools were grouped into quartiles based on total NIH dollars received during 2005 to 2009. The 13 dental institutions in the highest quartile, Q4, accounted for almost 61% of all NIH dollars awarded to dental schools. These schools can be considered the “elite” NIH research performers in the dental education community. It would be useful to determine how these institutions attained and have maintained their outstanding NIH research performance. For example, are they part of a research-intensive university? Has the university provided financial support for hiring research faculty and improving research infrastructure? How extensive have been interdisciplinary activities and collaborative interactions with other university health professional schools? This information can be used by dental schools in lower quartiles to strengthen their research activities.

Almost 31% of NIH funds to dental schools came from a diverse group of 21 NIH components other than NIDCR. This is

a good indication of the breadth of research performed at US dental schools. The proportion has grown each year, with non-NIDCR support increasing from 26% to 35% between 2005 and 2009. Perhaps dental schools have been hiring more basic scientists whose interests extend beyond traditional oral health and disease. It is also possible that schools are performing more multidisciplinary research that is better supported by ICs other than NIDCR.

The need for training outstanding scientists is especially great among dental schools if they are to maintain a population of oral health researchers who could provide recognition and credibility at research-oriented universities (Bertolami, 2002; DePaola, 2008). Therefore, it is of some concern that, for 7 of the 13 schools in Q4 (the most highly funded dental institutions and probably most appropriate to provide research training), less than 10% of their NIH dollars consisted of research training and career development (F, T, and K) awards (Table 1).

Basing comparison of NIH research performance solely on NIDCR dollar figures, as many dental school and university administrators have done, undervalues the performance of particular dental institutions. Ten schools were found to have a higher national rank (at least five positions) when total NIH funds during 2005 to 2009 were used to compare institutions. Thus, it is deemed imperative to consider funds received from

all NIH ICs to obtain a comprehensive assessment of research performance.

When we consider total grant dollars awarded globally by the NIDCR to all organizations, the percent to US dental schools consistently decreased from FY 2005 to FY 2009, regardless of total dollars awarded. Grants to dental institutions comprised only 50% of the overall NIDCR portfolio in FY2005 and was below that level from FY2006 (47.5%) through 2009 (43.7%). Thus, the NIDCR has provided decreasing research support for US dental schools over the past five years.

A major limitation of this study is that NIH dollars, while not the sole metric of research support, constitute a crucial one. Such additional funding sources as other Federal agencies, state and local governments, private industry, and foundations need to be considered. Support dollars, although an excellent metric, serve as only a partial indicator of research performance. For a more complete picture, such measures as research application success rate, patents generated, publications, journals in which articles have been published, citations, h-index of faculty (Hirsch, 2005), honors, awards, and quality of contributions to biomedical and clinical science should be considered (Cole, 2010). Similar metrics certainly would be useful to assess research performance among dental schools outside the US (Braun, 2006).

In conclusion, it is expected that evaluating dental schools through the above measures will facilitate institutions globally to demonstrate a position of excellence within the health professional education community and to enhance their perceived value to their discipline, parent universities, and academia.

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