Analysis of National Institutes of Health Grant K99 to R00 Transitions from 2007 to 2022

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Abstract

Postdoctoral research fellows are highly skilled and trained researchers within the academic biomedical research workforce. Those that aspire to continue academic research careers typically seek tenure-track faculty positions as a principle investigator. In the United States of America, the National Institutes of Health (NIH) sponsors a Pathway to Independence Award (K99/R00) mechanism designed to facilitate the transition from postdoctoral fellow to faculty by providing 5-years of funding support during the postdoctoral and faculty phases. This makes postdoctoral fellows with K99/R00 awards attractive candidates for institutions looking to hire faculty because it shows that the candidate has a track record of NIH funding and the institution gets a significant amount of funds in the form of indirect costs once the R00 phase is awarded. This analysis explores how many K99 recipients successfully converted to R00 awards from 2007 to 2022. This analysis also examines which institutions these conversions occurred at and how often postdoctoral fellows with K99 awards were retained at their home institution for the R00 portion of the award or moved to a different institution. The findings of this analysis show that ~170 K99 awardees convert to R00 each year and between 20-35% of those are retained at the institution they received their K99 award at for the R00 phase.

Introduction

Postdoctoral research fellows are a driving force of academic biomedical research. They typically have either a terminal medical degree (i.e., MD) or doctorate (i.e., PhD) which means they have completed a significant amount of education and training. Postdoctoral fellows that aspire to continue in academic research typically seek faculty appointments on the tenure-track. These tenure-track faculty positions are highly coveted and competitive positions that often require significant success as a graduate student and postdoctoral fellow in publishing manuscripts and receiving extramural grant funding.[1] These positions are also becoming more difficult to achieve due to the increasing number of PhD graduates but stagnant number of tenure-track faculty positions.[2]

Within the United States, one of the most prestigious award mechanisms to facilitate the transition from postdoctoral fellow to tenure-track faculty member is the Pathway to Independence Award (K99/R00) mechanism sponsored by the National Institutes of Health (NIH). This provides salary support and funding for postdoctoral fellows during the K99 phase of the award and provides $250,000 in total support for 3 years during the R00 phase of the award. There are many benefits to the individual and institution for having a K99/R00 award.

The candidate has protected funds for their salary during both the postdoctoral phase and faculty phase in addition to some funds for research during the postdoctoral phase, depending on the NIH granting institute. During the R00 phase, the award provides a significant amount of indirect funds to the faculty's institution. Having a K99/R00 award also demonstrates to the hiring institution that the candidate has a track record of receiving extramural funding which is a requirement for future success in the academic research career. The success rate for receiving a K99/R00 award is relatively high compared to research project grants (i.e., R01s) at 26.5% for FY 2022.[3]

The K99/R00 pathway to independence award was launched in 2006[4], and there is one K99 that was awarded in the year 2006. The following year, there were 184 funded K99 projects according to NIH Reporter. In 2007, the first four R00 awards were also funded, and these increased to 67 projects in the year 2008, according to NIH Reporter. Thus, by 2007-2009, the K99/R00 grant mechanism was beginning. K99 awards undoubtedly help candidates achieve a tenure-track faculty position, and the topic of what faculty hiring committees look for or expect has been published previously.[5] It has been about 15 years since the K99 mechanism was introduced, and to our knowledge, the trajectories of K99 awardees has not been explored. Here, we explore how many K99 awardees successfully convert to the R00 award each year from 2007-2022. We also examine how many of those that convert the K99 to R00 award stay at the same institution for the R00 phase or move to a new institution. Finally, we examine the specific trajectory from K99 institution to R00 institution to resolve which institutions have the most K99 awardees and which institutions these awardees ultimately end up at to begin their faculty positions.

Methods

All data examined in this manuscript is publicly available from NIH Reporter (https://reporter.nih.gov/). Filtered data will be provided by the corresponding author upon reasonable request.

Data acquisition and analysis: Datasets for each K99 and R00 year were downloaded from NIH Reporter using the "Advanced Search" function to include only the year of interest (2007-2022) and only the grant of interest (i.e., K99 or R00). The "contact PI" and "institution" columns were extracted. Duplicate values containing additional awards for the same contact PI (i.e., supplemental awards) were removed, and institutions for contact PI's that had either a K99

award or R00 award but not both were excluded. Thus, the data only includes contact PI's that had both a K99 and R00 in subsequent years. The K99 and R00 institution were aligned and confirmed that the contact PI name was identical before removing the contact PI name from the dataset. The institutions were analyzed using Microsoft Excel and Graphpad Prism (version 9.4.1). The list of K99 institutions and R00 institutions were plotted as Sankey diagrams using SankeyMATIC. The images are exported at 600dpi at sufficient resolution to allow zooming in and out in order to read the institution text.

Results

In 2007, there were 56 K99 awardees that successfully converted the K99 to R00 award in 2008 (Fig. 1A). This amount increased in the following year to 168 successful conversions and averaged 169.5 conversions per year from 2008 to 2019. In 2020, there were 167 K99 awardees that converted to an R00 in 2021. In 2021, there were 250 K99 awardees that converted to R00 in 2022 (Fig. 1A). The amount of K99 candidates that converted to R00 at the same institution (retained) was 21.4% in the 2007-2008 cycle and 30.4% in the 2008-2009 cycle (Fig. 1B). The average retention rate (K99 and R00 at the same institution) was 31.8% from the 2008-2009 cycle to the 2011-2012 cycle. Beginning in the 2012-2013 cycle, the retention rate decreased and the average from the 2012-2013 cycle to the 2021-2022 cycle was 22.1%, which is a decline of ~10% from the 2008-2011 cycles (Fig. 1B).

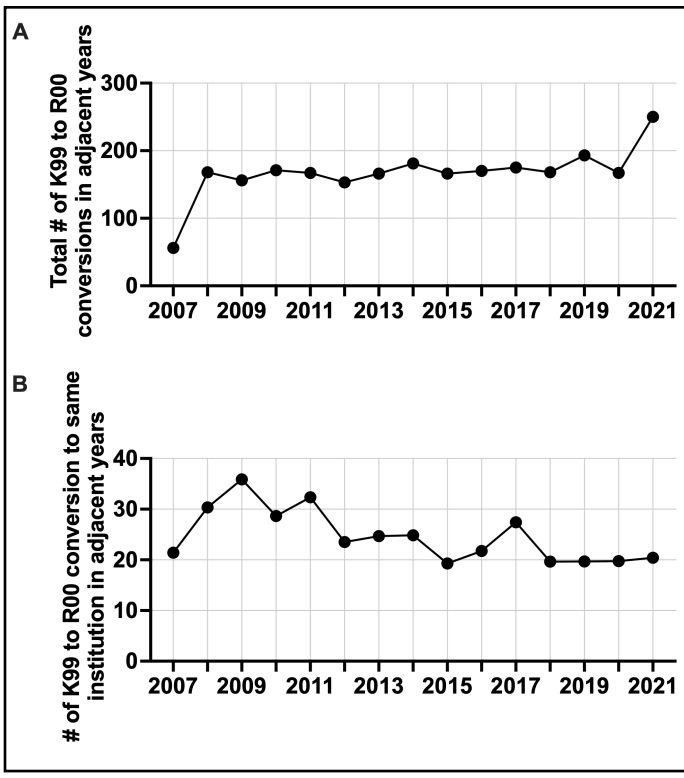

Figure 1: K99 to R00 conversions and retention rate from 2007-2022. A) Total K99 to R00 conversions from the 2007-2008 cycle to the 2021-2022 cycle. B) Number of successful K99 to R00 conversions where the K99 and R00 institution were the same from the 2007-2008 cycle to the 2021-2022 cycle.

From 2007-2022, K99 awardees that successfully transitioned to R00 awards came from 234 different institutions and the R00 awards were active at 325 unique institutions, which suggests that K99's are awarded at a smaller subset of institutions. The distribution of the number of K99 awards plotted against the number of institutions with that many awards is shown in Figure 2A. Please note that only K99 awards that were eventually converted to R00 awards are included. Stanford University has had 139 individuals awarded a K99 that eventually transitioned to the R00 phase. In contrast, there were 67 institutions that only had 1 K99 awardee that successfully transitioned to the R00 phase. In fact, Stanford University has had more K99 awardees that transitioned to the R00 phase than all institutions that had 1, 2, 3, 4, or 5 K99 awardees that transitioned to the R00 phase combined. R00 awards were more dispersed among more institutions than K99 awards. There were 98 unique institutions that have only had 1 R00 awardee and 46 institutions that have had 2 R00 awardees (Fig. 2B). There were 9 institutions that have had more than 50 K99 awards from 2007-2022; however, there were only 3 institutions that have recruited more than 50 R00 awardees.

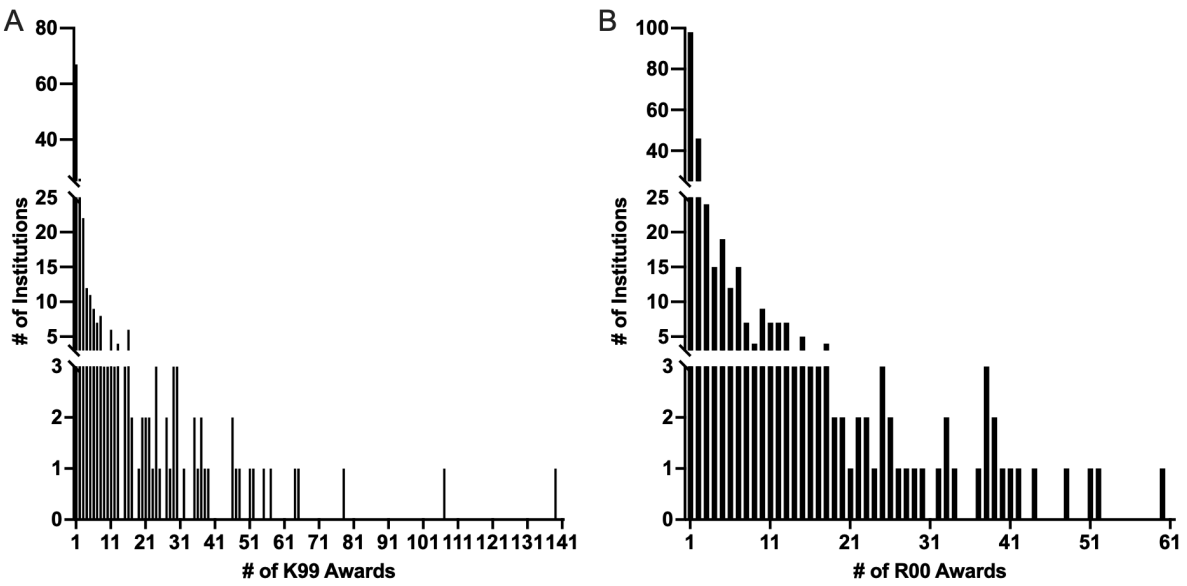

Figure 2: Bar charts showing the number of institutions with the number of K99s (A) and R00s (B) from 2007-2008 through 2021-2022. Note that K99s and R00s were only included in this analysis if the K99 was successfully transitioned to an R00 and no individual award or grant is counted more than 1 time.

To determine the flow of K99 awardees from each institution to the R00 institution, I created a Sankey diagram that includes all K99 awardees that successfully transitioned to an R00 award

from 2007 to 2022 and plotted them together (Fig. 3). Stanford University had the most K99 to R00 conversions during this timespan with 139 individuals, followed by University of California, San Francisco with 107 individuals, Massachusetts General Hospital with 78, and Johns Hopkins University with 65. The University of Michigan was the institution that has recruited the most faculty with R00 awards with 60 individuals, followed by the University of Pittsburgh with 52, Johns Hopkins University with 51 and Massachusetts General Hospital with 48. Of institutions that have produced more than 10 K99 awardees, Massachusetts General Hospital has the highest rate of institutional retention having retained 35 of the 78 K99 awardees (44.3%). There were other institutions that had higher proportion of R00 faculty candidates being retained (i.e., University of Pittsburgh, Johns Hopkins University, and Brigham and Women's Hospital). In contrast, some institutions appear to recruit most of their R00 awardees from external institutions (i.e., Northwestern University, University of Michigan, and Yale University).

To better understand how many of the K99 awardees from each institution transitioned to R00 awards each year, and at which institutions, I plotted each 2-year cycle as Sankey diagrams showing the K99 institution on the left side of the plot along with the number of K99 awardees that successfully transitioned to R00 awards the following year. The right side of the Sankey diagram shows the R00 institution for each of the corresponding K99 awardees. Thus, each awardees trajectory can be identified along with information about institutional hiring and retention practices. The first cycle that has enough data to analyze is the 2007-2008 cycle (Fig. 3A) where Stanford University had 9 K99 awardees that successfully transitioned to R00 positions across the country including 1 awardee that was retained at Stanford for the R00 phase and 2 that moved to Johns Hopkins University. The rest were dispersed across institutions. In the 2008-2009 cycle, there were about 3 times as many successful K99 to R00 transitions; however, Stanford University still had the most with 11 in that cycle, of which, 3 were retained at Stanford while the others all went to different institutions (Fig. 3B). The 2008-2009 cycle is the first in which the University of California, San Francisco has successful K99 to R00 awardees with 3; however, in the following cycles, UCSF ranks as one of the top institutions for successful K99 to R00 transitions (Fig. 3C & 3D).

The trends for all cycles from the 2008-2009 cycle through the 2021-2022 cycles are similar (Fig. 3A-O) with Stanford University and UCSF generally producing the most K99 to R00 transitions.

Discussion

The institutions that produce the highest number of successful K99 to R00 transitions are not surprising. Nor is it surprising that the institutions that produce the most K99 candidates rarely retain these individuals. Generally, a handful of top institutions have an outsized number of K99 awardees that move to similarly prestigious institutions and less prestigious institutions for their independent faculty positions. In certain years there are some instances where prestigious institutions retain a higher-than-expected number of their own K99 awardees, for example Brigham and Women's Hospital in the 2014-2015 cycle that retained all 6 of its successful K99 to R00 transitioners and Massachusetts General Hospital which retained 5 of its transitioners in the 2016-2017 cycle. Some institutions appear to have a culture of retaining their K99 awardees, which appears to be the case for the University of Pittsburgh (see the 2009-2010, 2010-2011, 2011-2012, 2013-2014, 2014-2015, 2016-2017, and 2021-2022 cycles). There are also certain institutions that appear to recruit significantly more K99/R00 holders than other institutions including Washington University in Saint Louis, University of North Carolina at Chapel Hill, Washington University, University of Michigan, and Johns Hopkins University.

This analysis clearly demonstrates that the bulk of K99 awards go to the most prestigious institutions in the United States. These institutions have international name recognition, are members of the Ivy League, receive the most NIH funding, and are ranked as some of the top medical schools in the world. Some of the institutions that recruit K99/R00 holders are also in this prestigious group of institutions, including the University of Michigan, Johns Hopkins University, Massachusetts General Hospital, and the University of Pennsylvania; however, other institutions that recruit large numbers of R00 awardees are not in that class, including the University of Alabama at Birmingham, the University of Colorado at Denver, Ohio State University, and the University of Iowa. The net effect of the K99/R00 grant mechanism may be a redistribution of scientific talent from the most prestigious institutions to other slightly less prestigious academic centers throughout the country.

There are certainly more analyses that can be performed with these data, and there are significant limitations to these datasets and these analyses. The K99/R00 grant is only one of a handful of career development awards that the NIH sponsors. By only analyzing those that successfully transitioned from a K99 to an R00 award, this analysis excludes all postdoctoral fellows who transition to a faculty position without a K99/R00 award and those in other fields

where the K99/R00 may not be applicable or available including most ecology, social science, mathematics, physics, and chemistry research. Furthermore, this analysis excludes those that received a K99 but were either unable to transition to an R00 award for various reasons and did not pursue or receive a faculty position in the United States or received a faculty position without transitioning to the R00 phase. Furthermore, this analysis is limited to academic institutions in the United States and does not provide any insight into academic centers in any other country. This analysis is also limited due to the data that is publicly available through the NIH Reporter. For example, an analysis of retention rates based on degree type or faculty type (i.e., research-only compared to physician-scientists) could be informative; however, the dataset does not include this information. Additional information on underrepresented minorities and women are also important to understand; however, the present dataset does not include this information. Future analysis should examine this.

Each line in the Sankey diagrams represent an individual researcher with their own unique motivation for choosing a postdoctoral advisor, institution, and laboratory as well as autonomy in whether or not to pursue a faculty position and where that may be. These decisions are not made solely based on the offered start-up package or institutional clout, and each individual places different weight on each factor. This dataset is agnostic to the motivation behind these complex decisions, and an understanding of these motivating factors would enrich the present analysis. I hope that these data spark discussion amongst academic researchers and those within academic research institutions to reflect on grant review and hiring practices. I hope this manuscript also sparks discussions about where resources are spent and which institutions and individuals receive them and whether these allocations should be enhanced or altered.

Disclosures: D.J.T. has no competing interests. D.J.T. was a K99 recipient who transitioned to R00 in the 2021-2022 cycle and is included in this dataset.

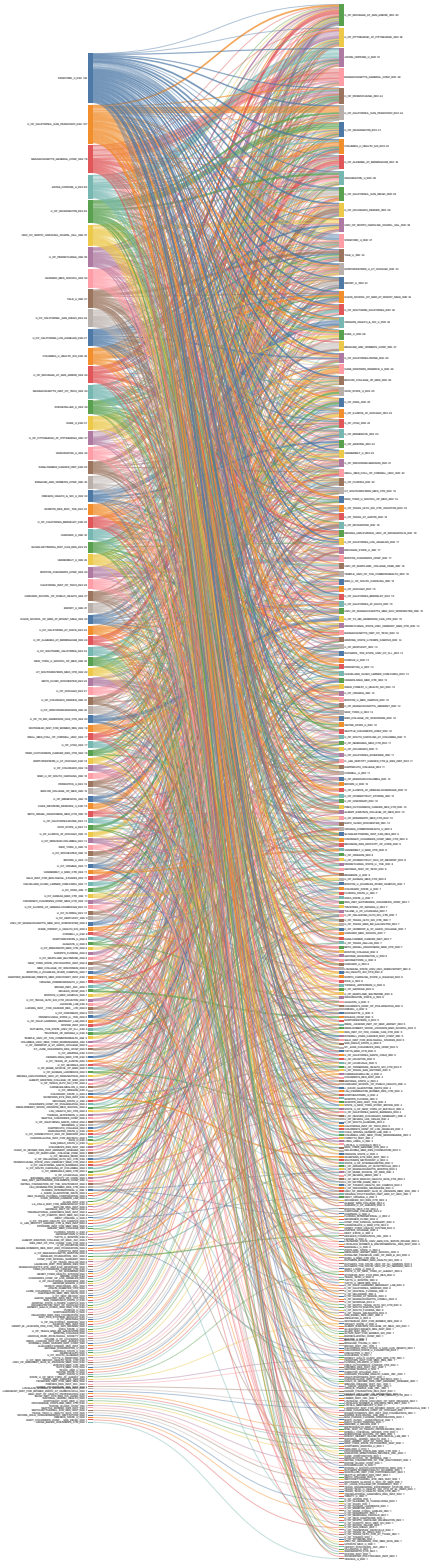

Figure 3: Sankey diagram of all successful K99 to R00 award transfers from 2007-2008 through 2021-2022 with the K99 institution on the left and R00 institution on the right. Institutions are ranked by number of K99 awards on the left and number of R00 awards on the right. High resolution image can be found at: https://sites.uab.edu/tyrrelllab/about/k99-to-r00-transfers/

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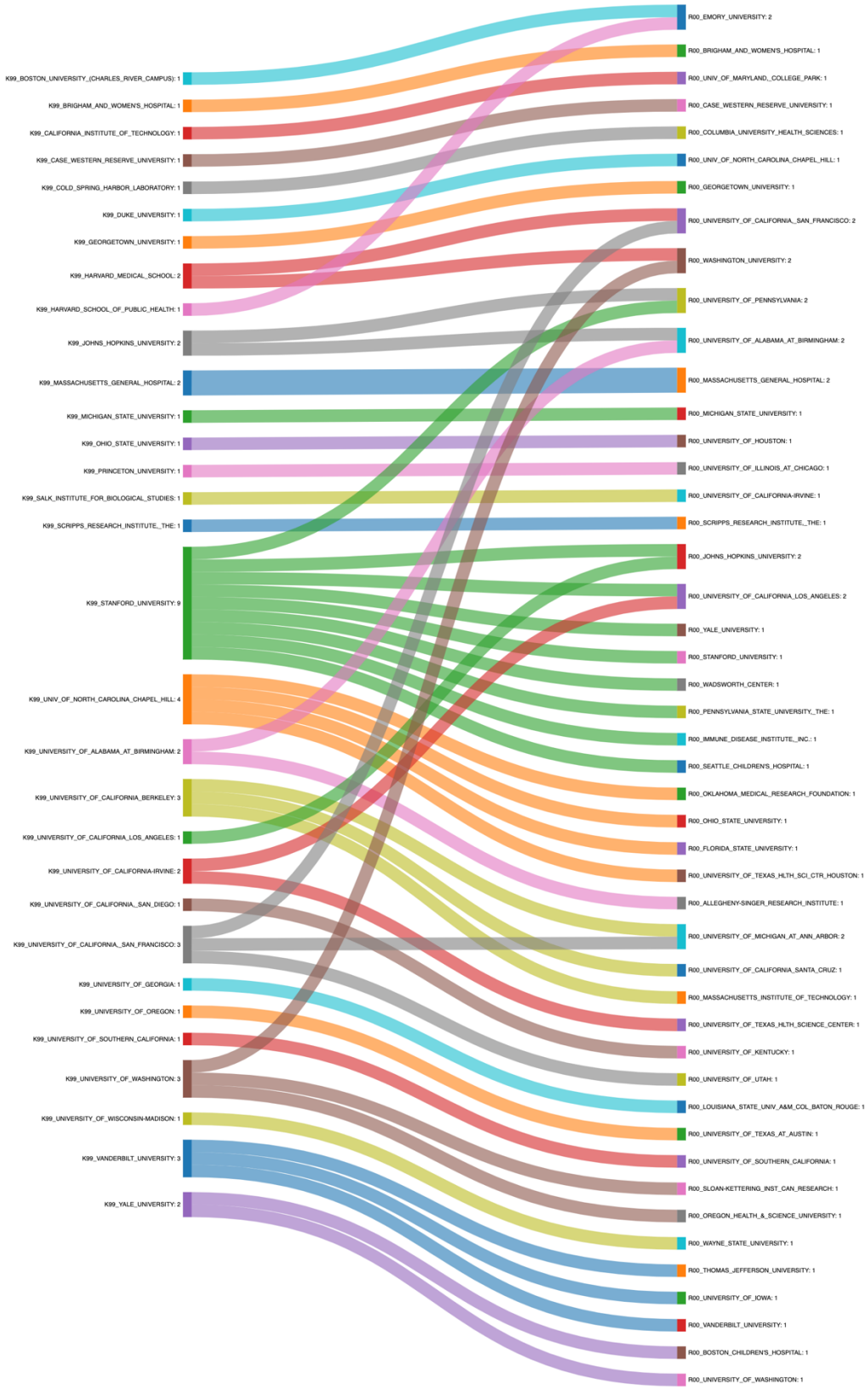

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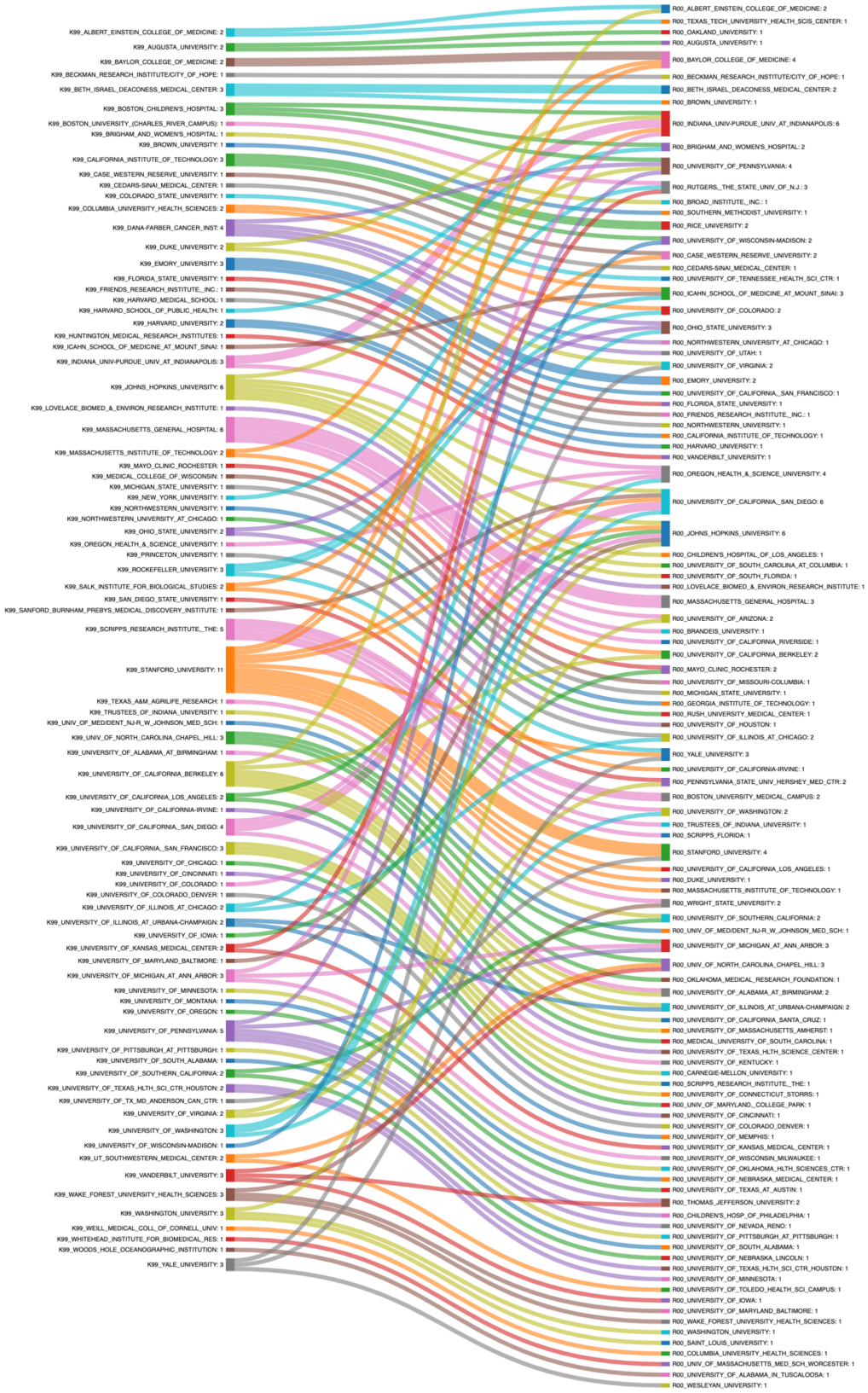

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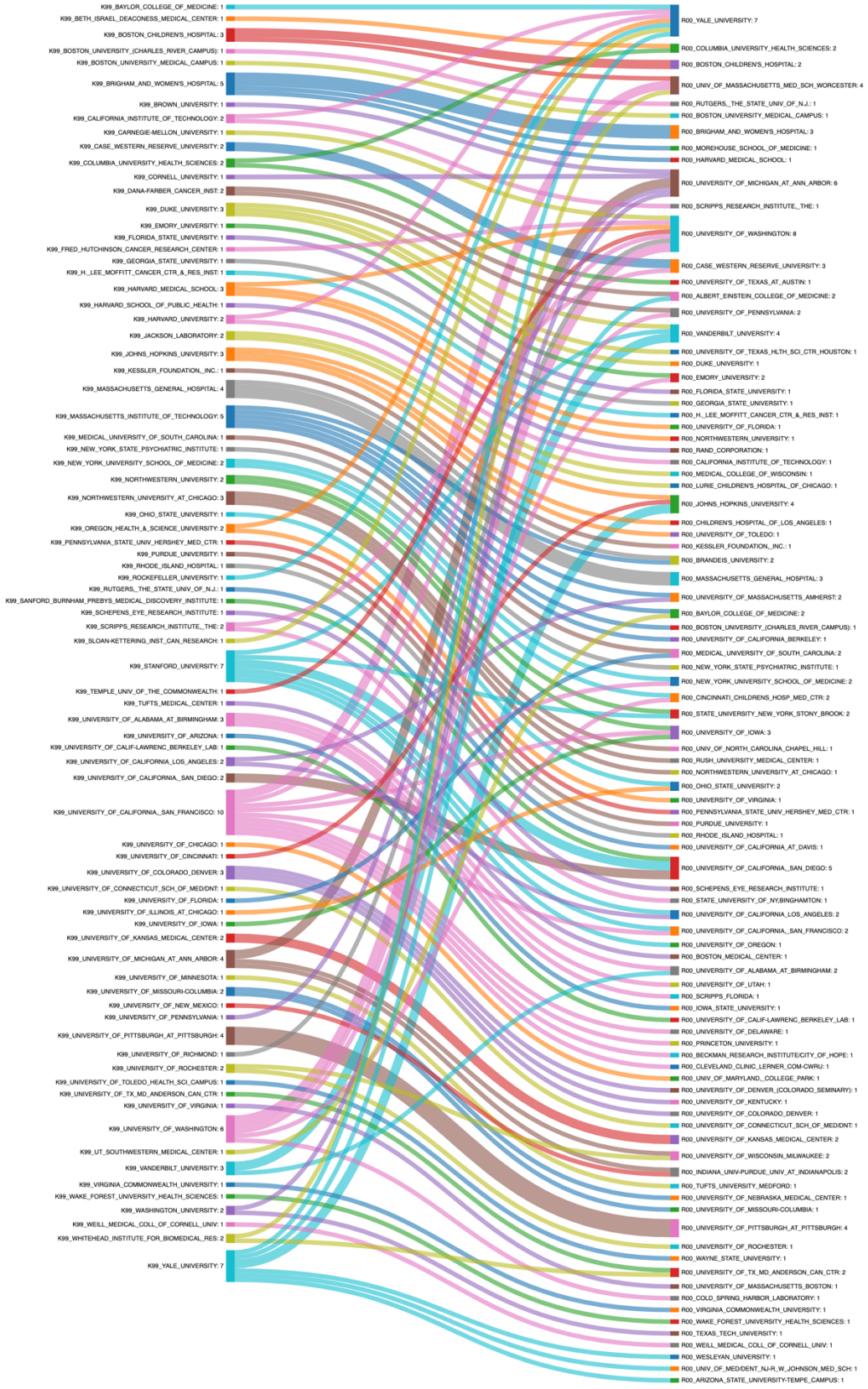

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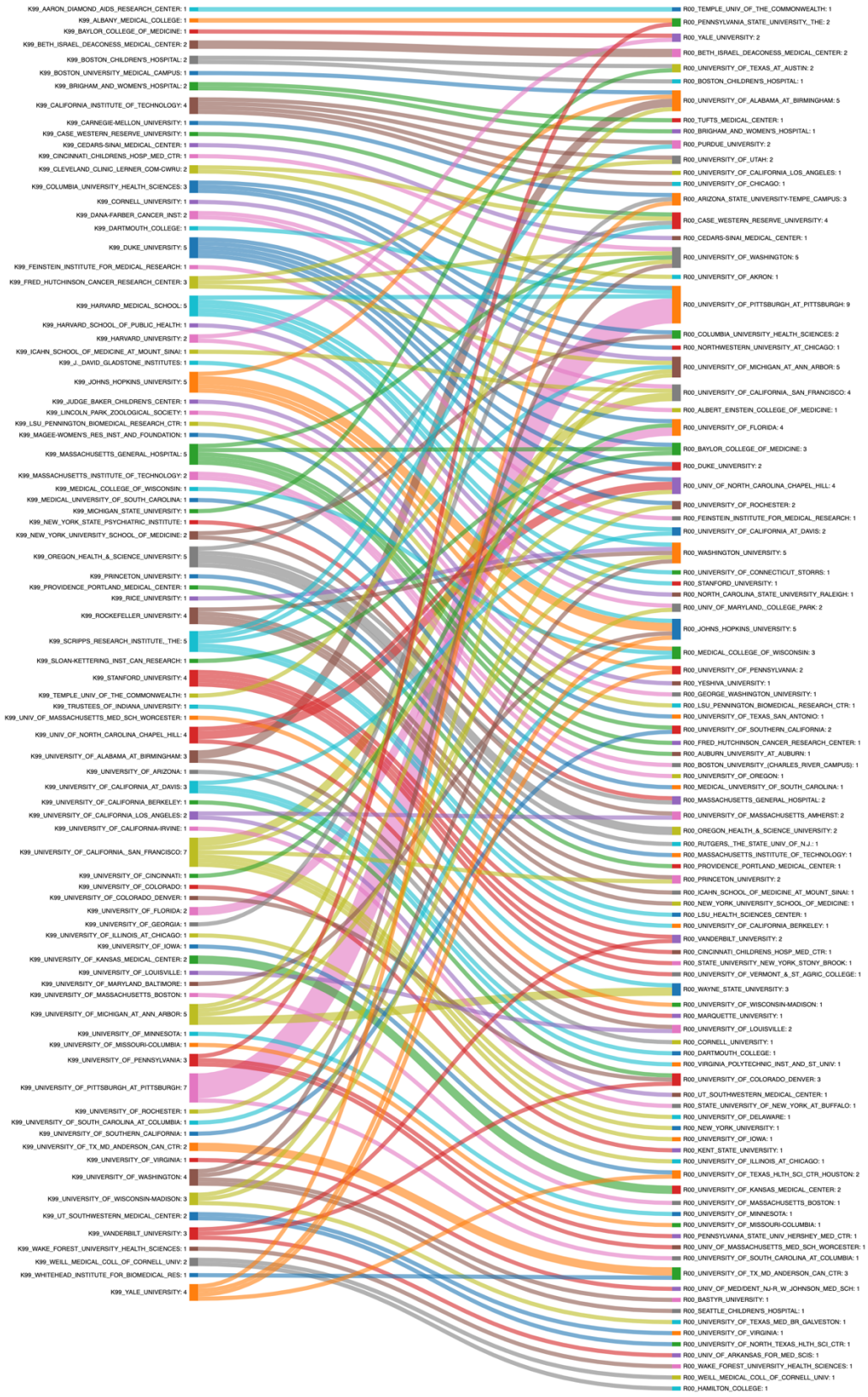

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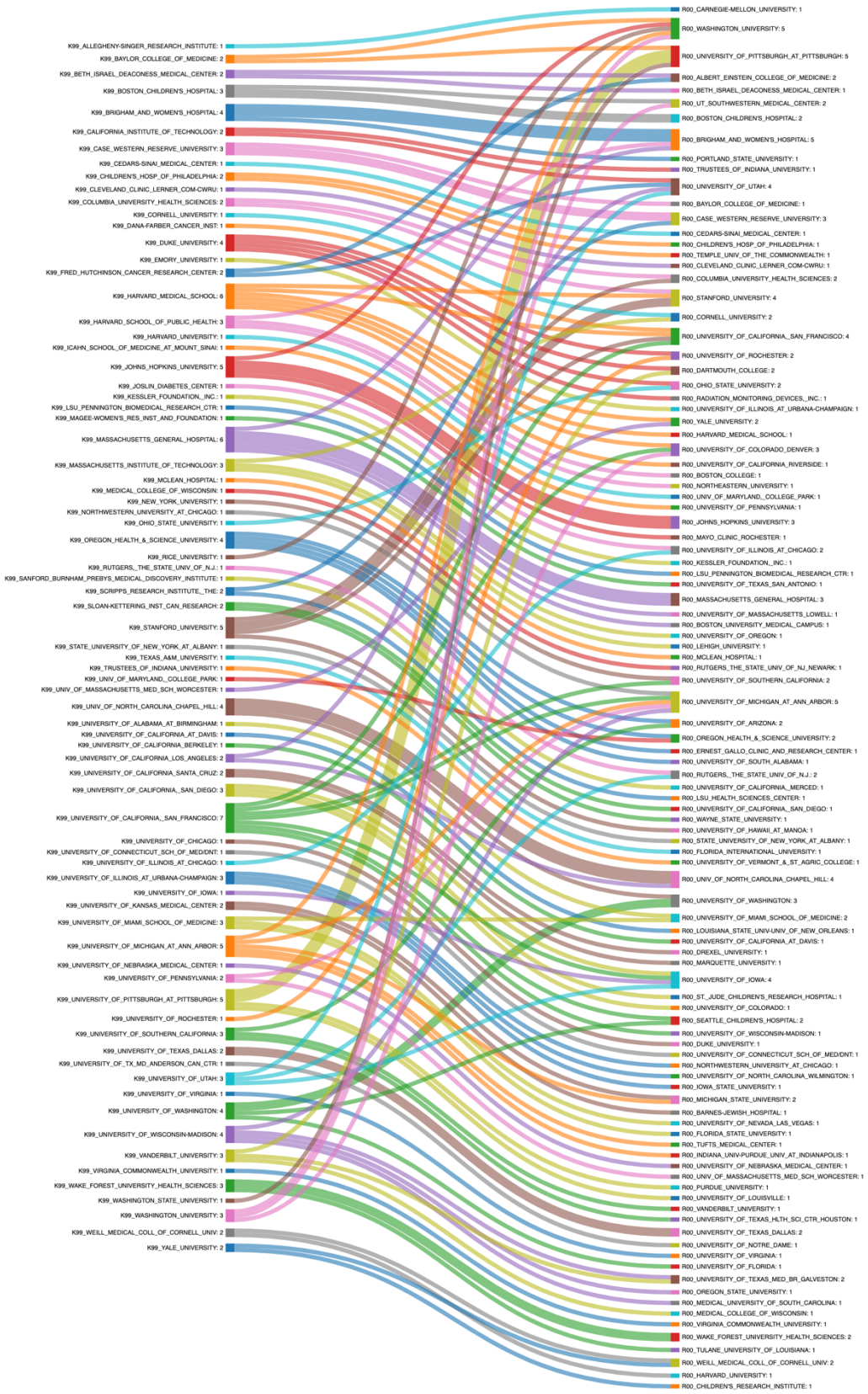

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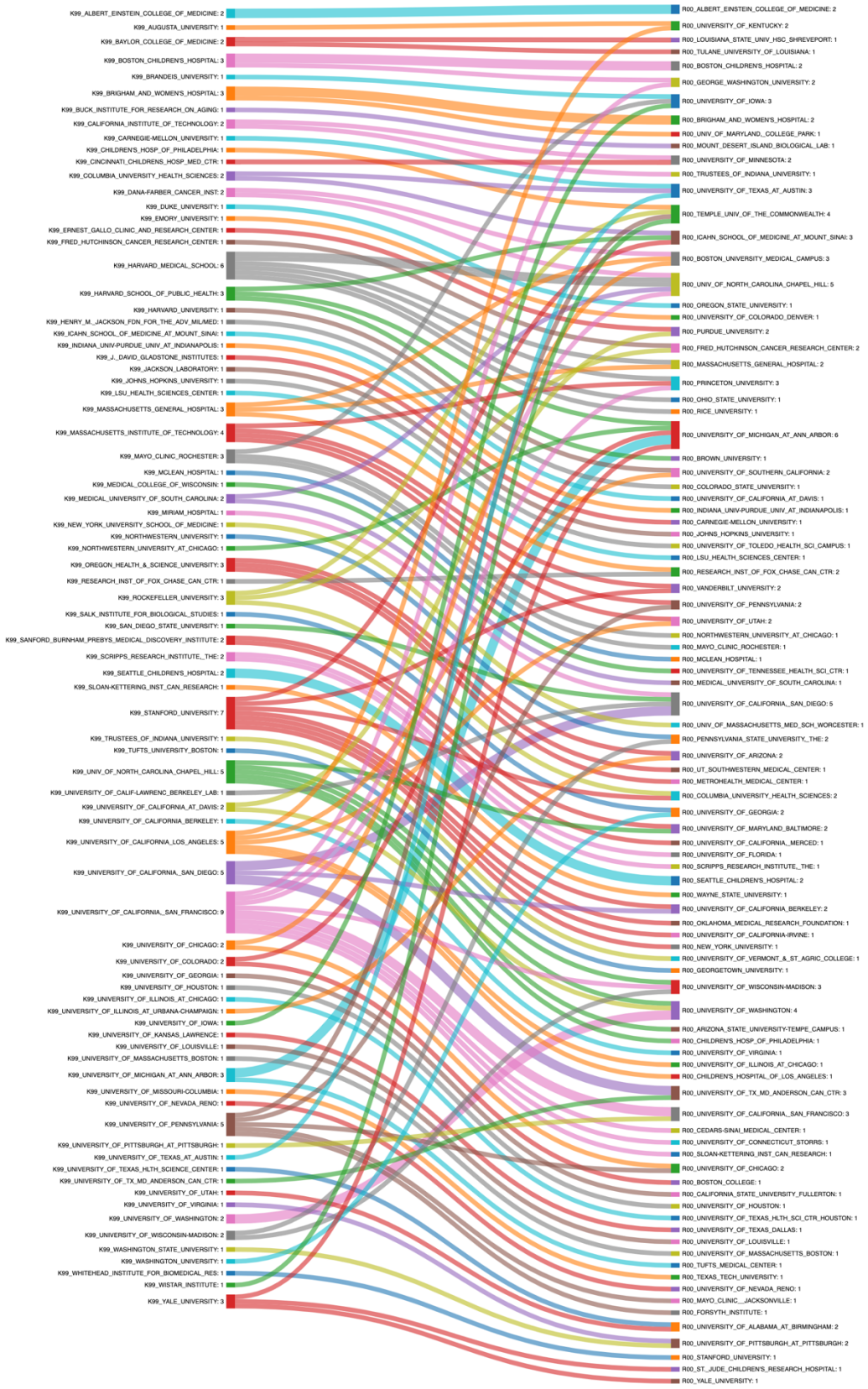
253 F 2012-2013



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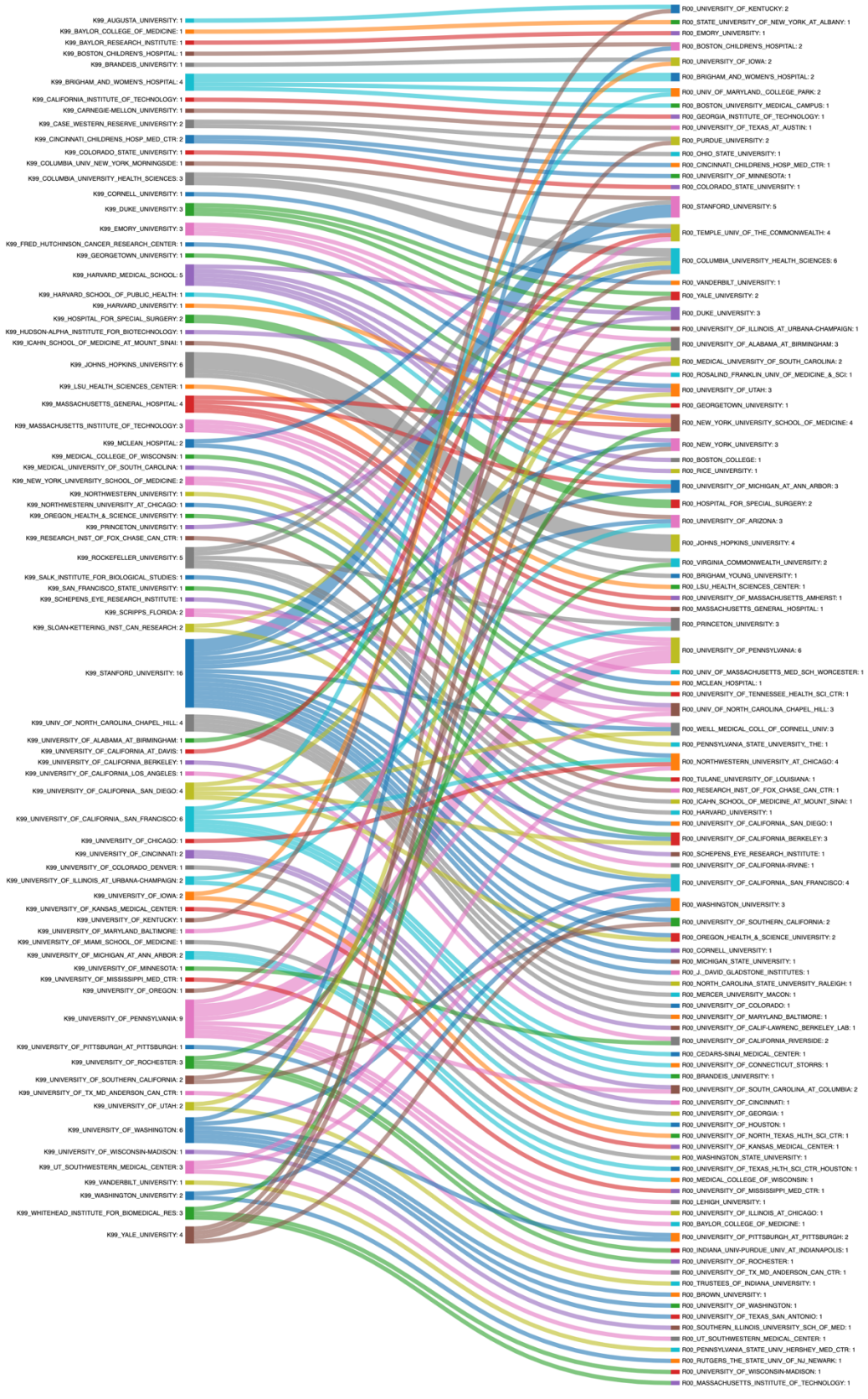

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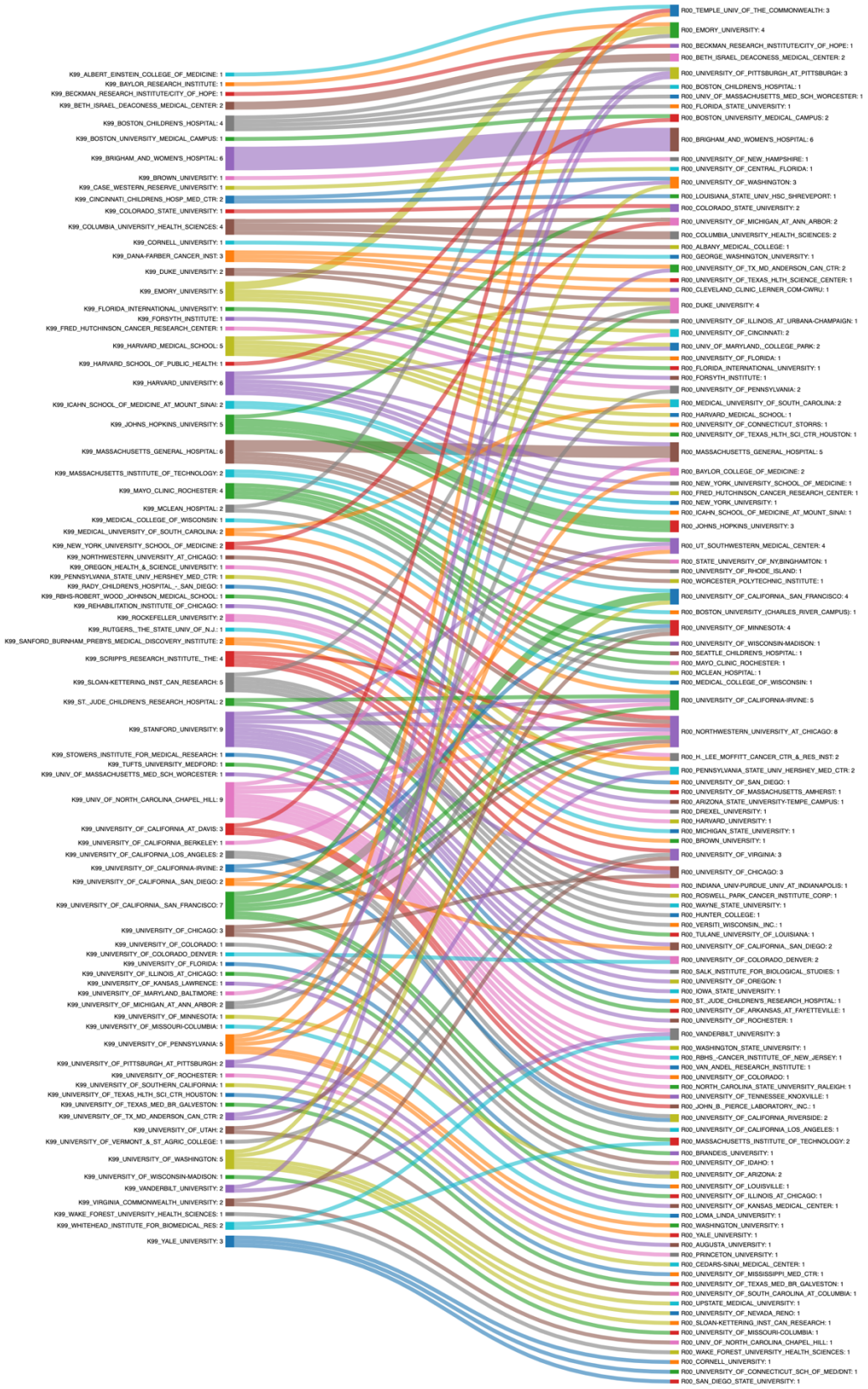

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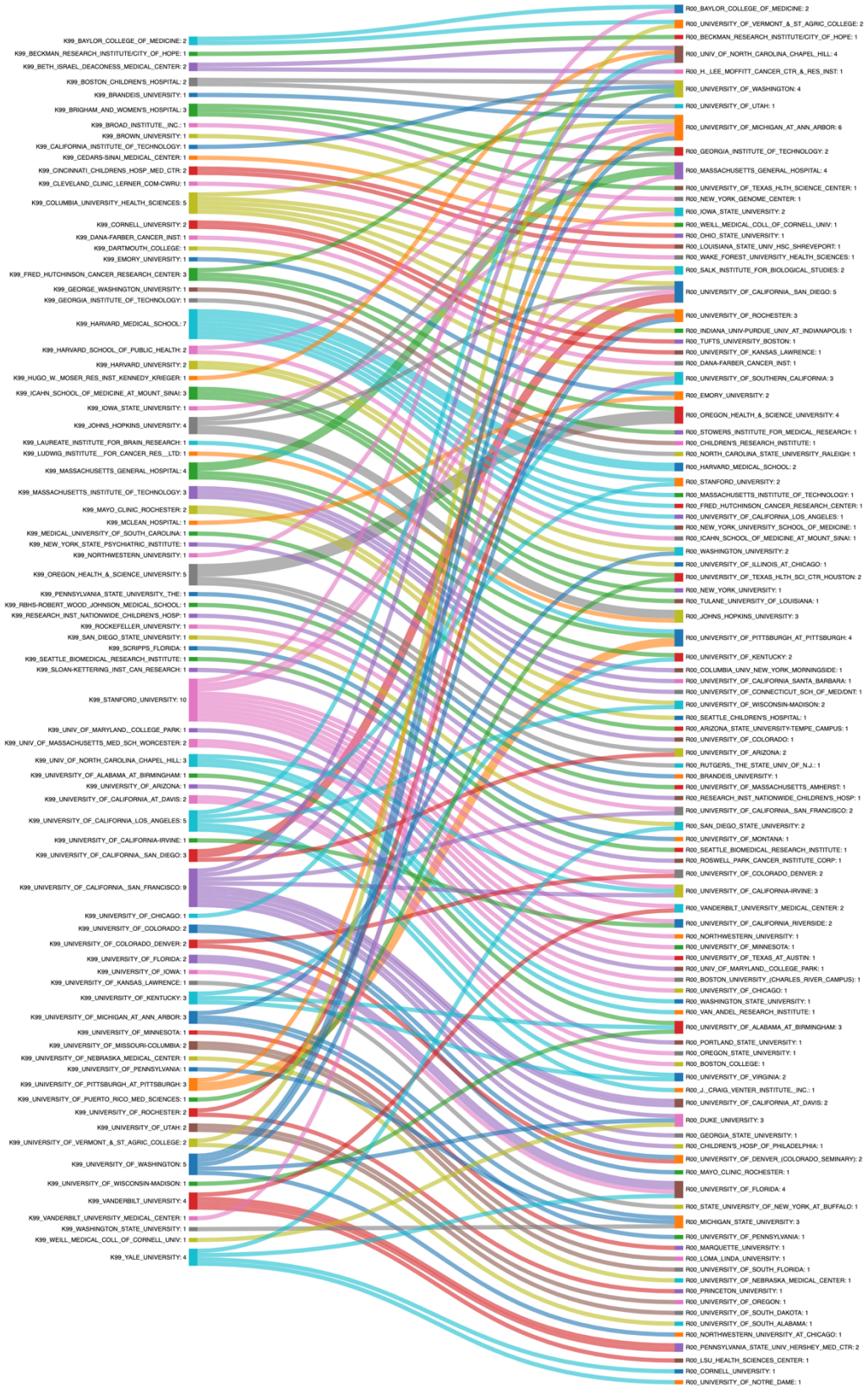
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K99_BRIGHAM_AND_WOMEN'S_HOSPITAL: 3
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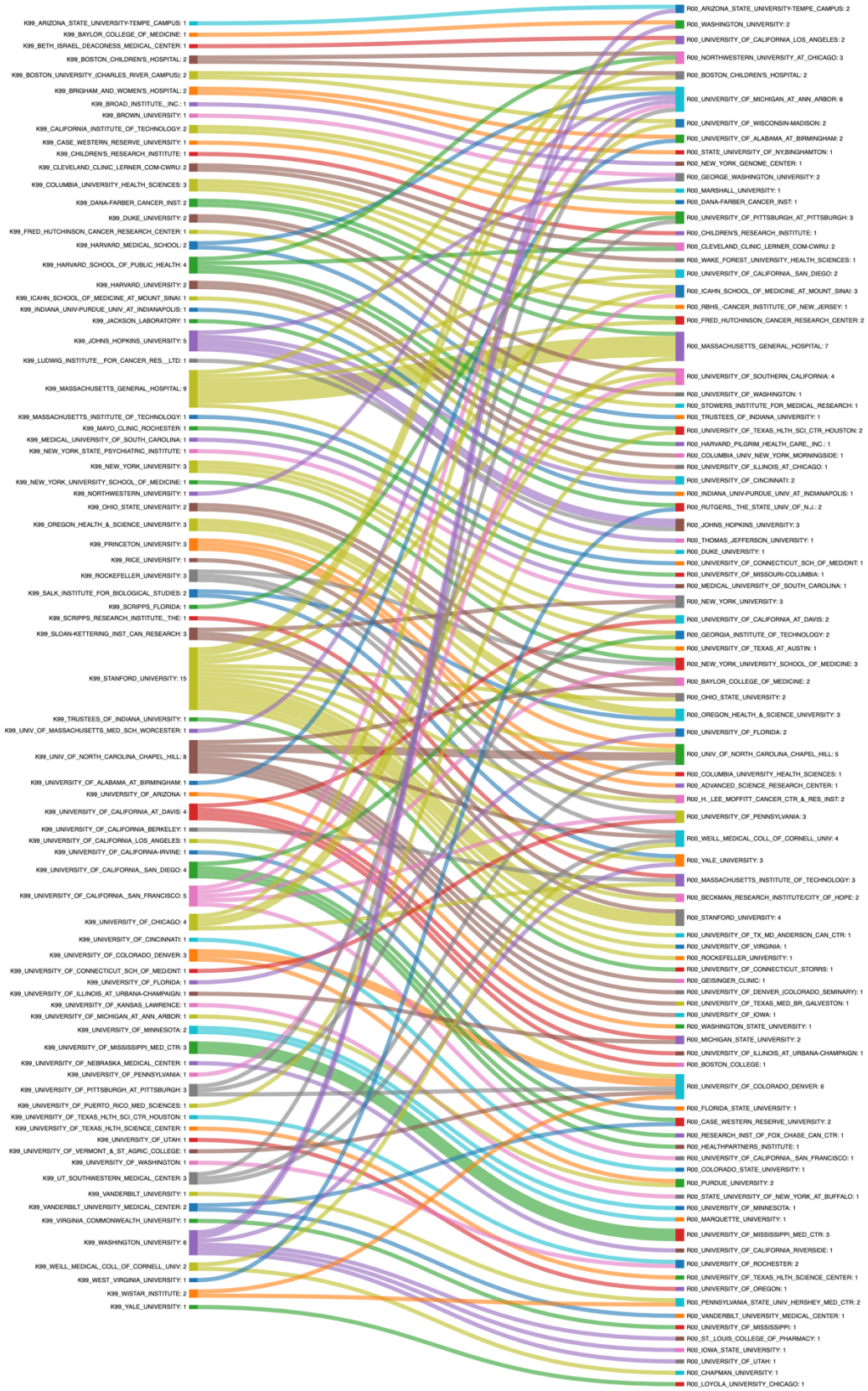
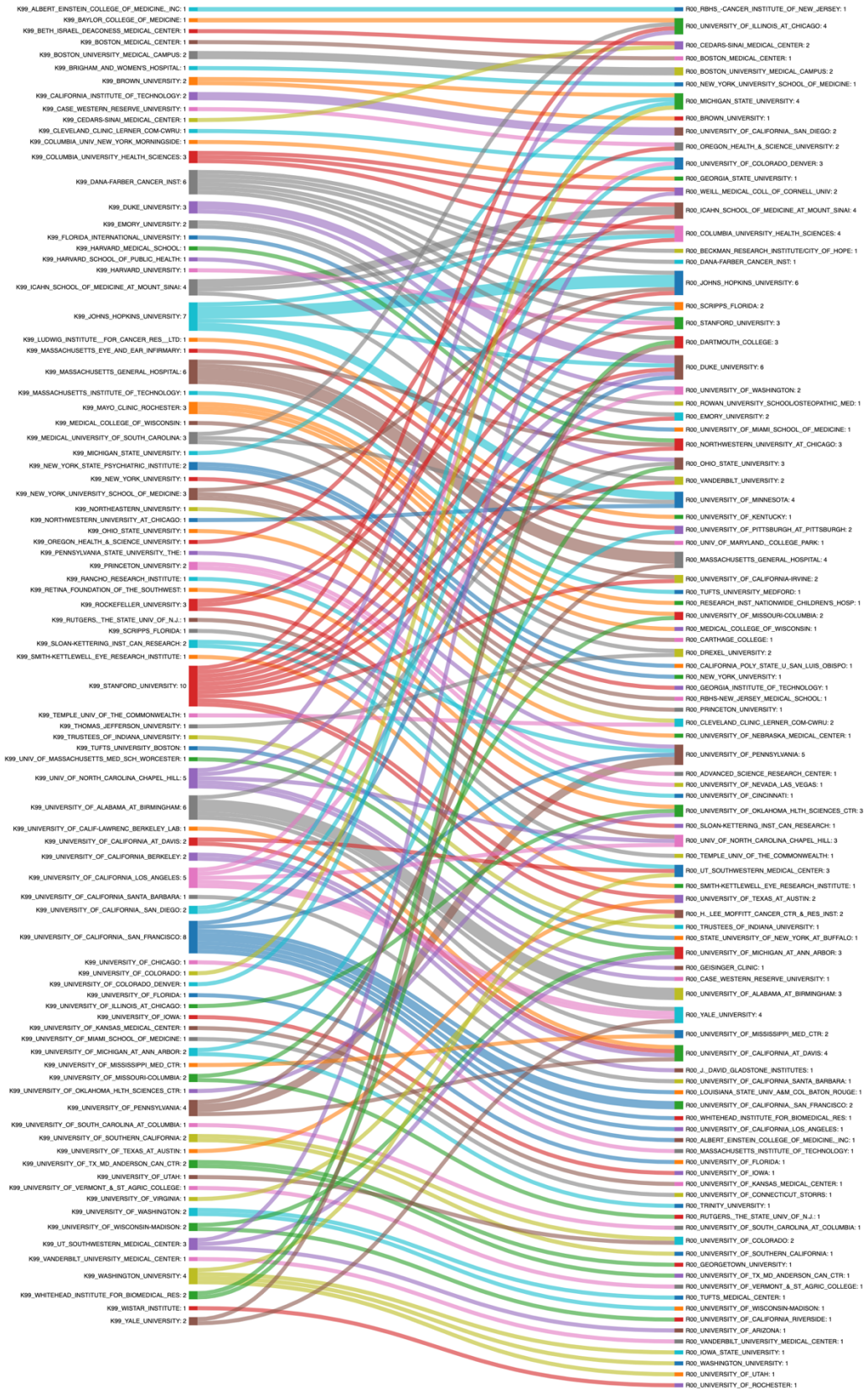
R00_UNIVERSITY_OF_COLORADO: 1
R00_UNIVERSITY_OF_ARIZONA: 2
R00_RUTGERS,_THE_STATE_UNIV_OF_N.J.: 1
R00_BRANDEIS_UNIVERSITY: 1
R00_UNIVERSITY_OF_MASSACHUSETTS_AMHERST: 1
R00_RESEARCH_INST_NATIONWIDE_CHILDREN'S_HOSP: 1
R00_UNIVERSITY_OF_CALIFORNIA,_SAN_FRANCISCO: 2
R00_SAN_DIEGO_STATE_UNIVERSITY: 2
R00_UNIVERSITY_OF_MONTANA: 1
R00_SEATTLE_BIOMEDICAL_RESEARCH_INSTITUTE: 1
R00_ROSWELL_PARK_CANCER_INSTITUTE_CORP: 1
R00_UNIVERSITY_OF_COLORADO_DENVER: 2
R00_UNIVERSITY_OF_CALIFORNIA-IRVINE: 3
R00_VANDERBILT_UNIVERSITY_MEDICAL_CENTER: 2
R00_UNIVERSITY_OF_CALIFORNIA_RIVERSIDE: 2
R00_NORTHWESTERN_UNIVERSITY: 1
R00_UNIVERSITY_OF_MINNESOTA: 1
R00_UNIVERSITY_OF_TEXAS_AT_AUSTIN: 1
R00_UNIV_OF_MARYLAND,_COLLEGE_PARK: 1
R00_BOSTON_UNIVERSITY_(CHARLES_RIVER_CAMPUS): 1
R00_UNIVERSITY_OF_CHICAGO: 1
R00_WASHINGTON_STATE_UNIVERSITY: 1
R00_VAN_ANDEL_RESEARCH_INSTITUTE: 1
R00_UNIVERSITY_OF_ALABAMA_AT_BIRMINGHAM: 3
R00_PORTLAND_STATE_UNIVERSITY: 1
R00_OREGON_STATE_UNIVERSITY: 1
R00_BOSTON_COLLEGE: 1
R00_UNIVERSITY_OF_VIRGINIA: 2
R00_J._CRAIG_VENTER_INSTITUTE_INC.: 1
R00_UNIVERSITY_OF_CALIFORNIA_AT_DAVIS: 2
R00_DUKE_UNIVERSITY: 3
R00_GEORGIA_STATE_UNIVERSITY: 1
R00_CHILDREN'S_HOSP_OF_PHILADELPHIA: 1
R00_UNIVERSITY_OF_DENVER_(COLORADO_SEMINARY): 2
R00_MAYO_CLINIC_ROCHESTER: 1
R00_UNIVERSITY_OF_FLORIDA: 4
R00_STATE_UNIVERSITY_OF_NEW_YORK_AT_BUFFALO: 1
R00_MICHIGAN_STATE_UNIVERSITY: 3
R00_UNIVERSITY_OF_PENNSYLVANIA: 1
R00_MARQUETTE_UNIVERSITY: 1
R00_LOMA_LINDA_UNIVERSITY: 1
R00_UNIVERSITY_OF_SOUTH_FLORIDA: 1
R00_UNIVERSITY_OF_NEBRASKA_MEDICAL_CENTER: 1
R00_PRINCETON_UNIVERSITY: 1
R00_UNIVERSITY_OF_OREGON: 1
R00_UNIVERSITY_OF_SOUTH_DAKOTA: 1
R00_UNIVERSITY_OF_SOUTH_ALABAMA: 1
R00_NORTHWESTERN_UNIVERSITY_AT_CHICAGO: 1
R00_PENNSYLVANIA_STATE_UNIV_HERSHEY_MED_CTR: 2
R00_LSU_HEALTH_SCIENCES_CENTER: 1
R00_CORNELL_UNIVERSITY: 1
R00_UNIVERSITY_OF_NOTRE_DAME: 1

261 J 2016-2017



262

263 K 2017-2018



264

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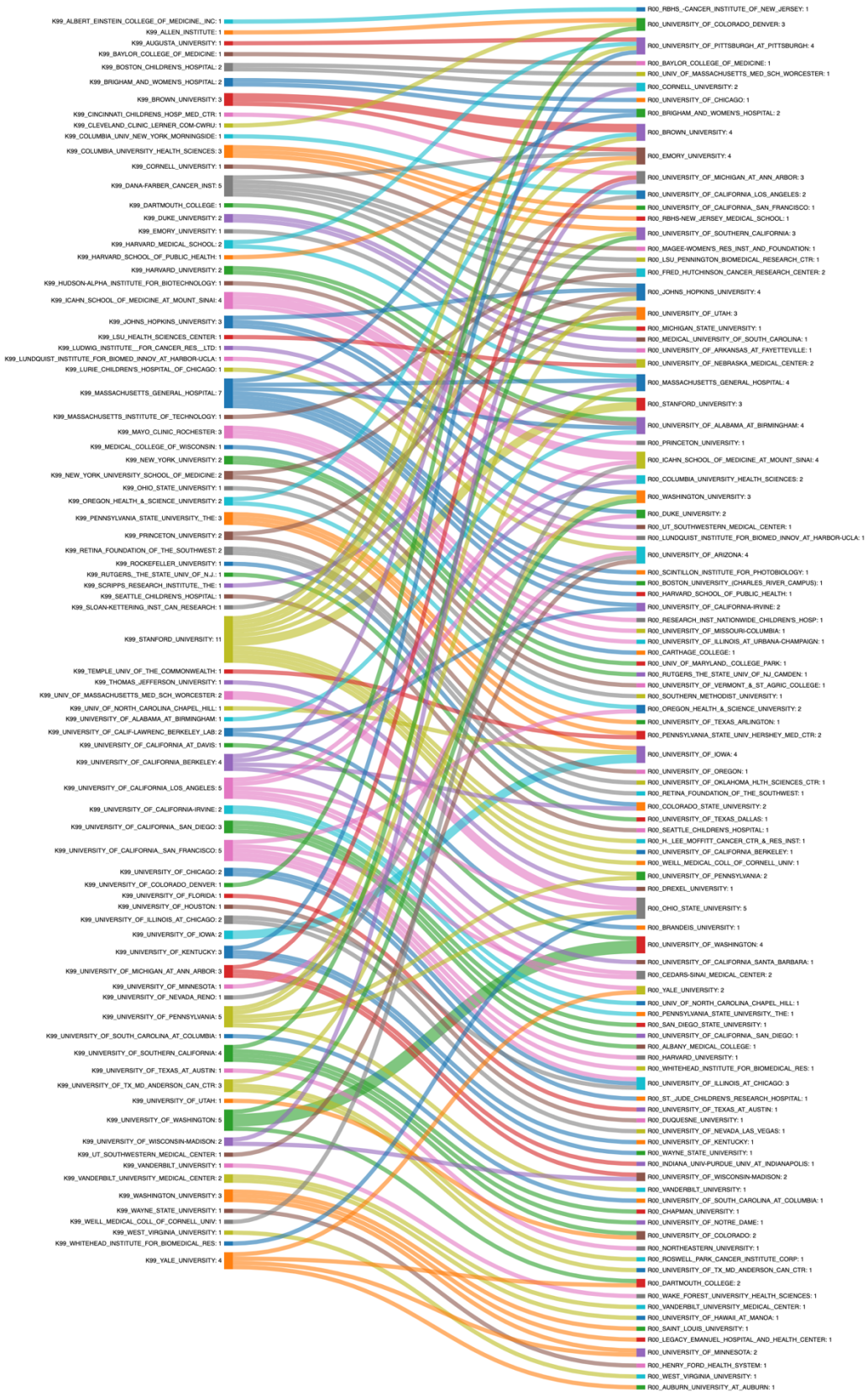
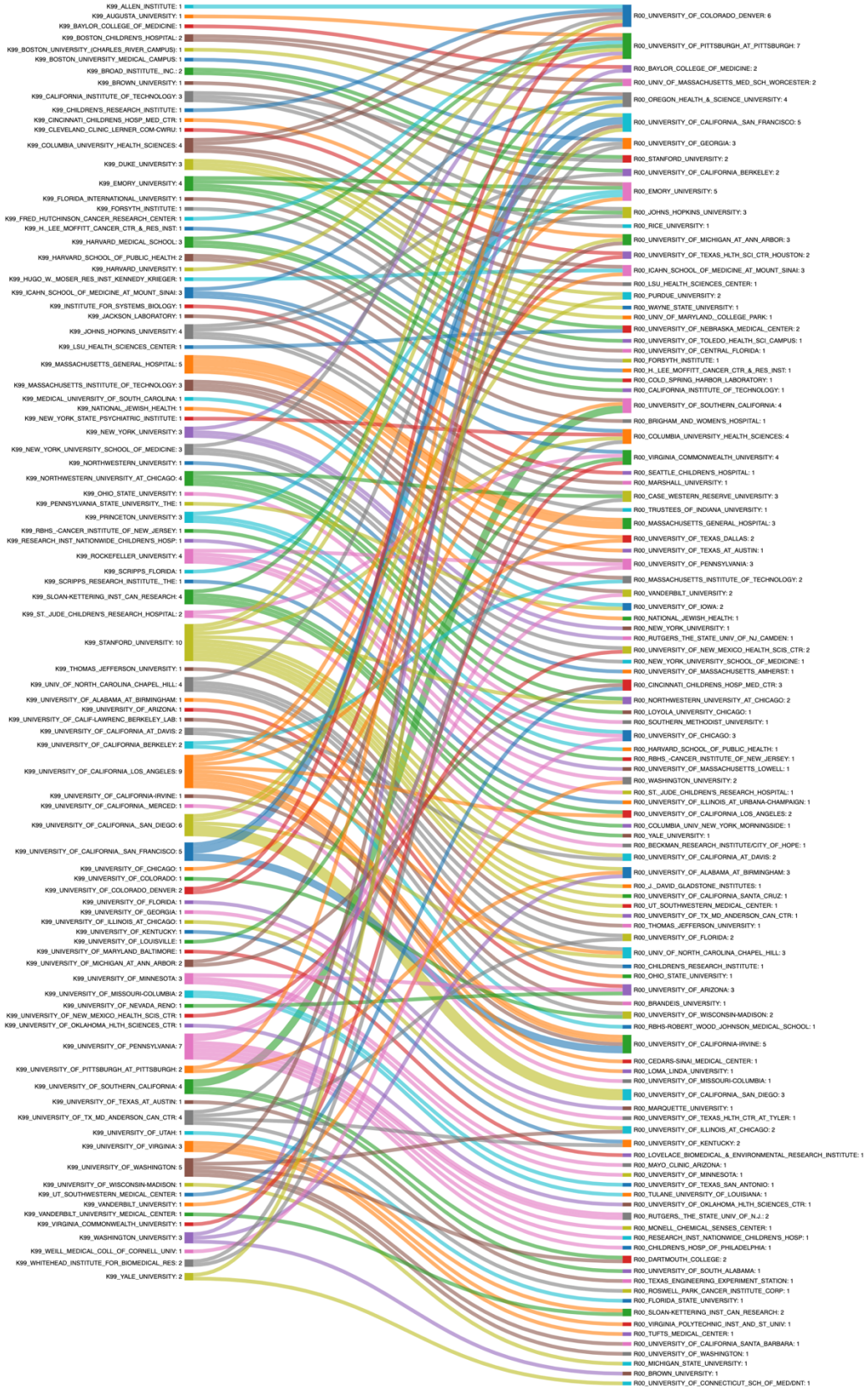


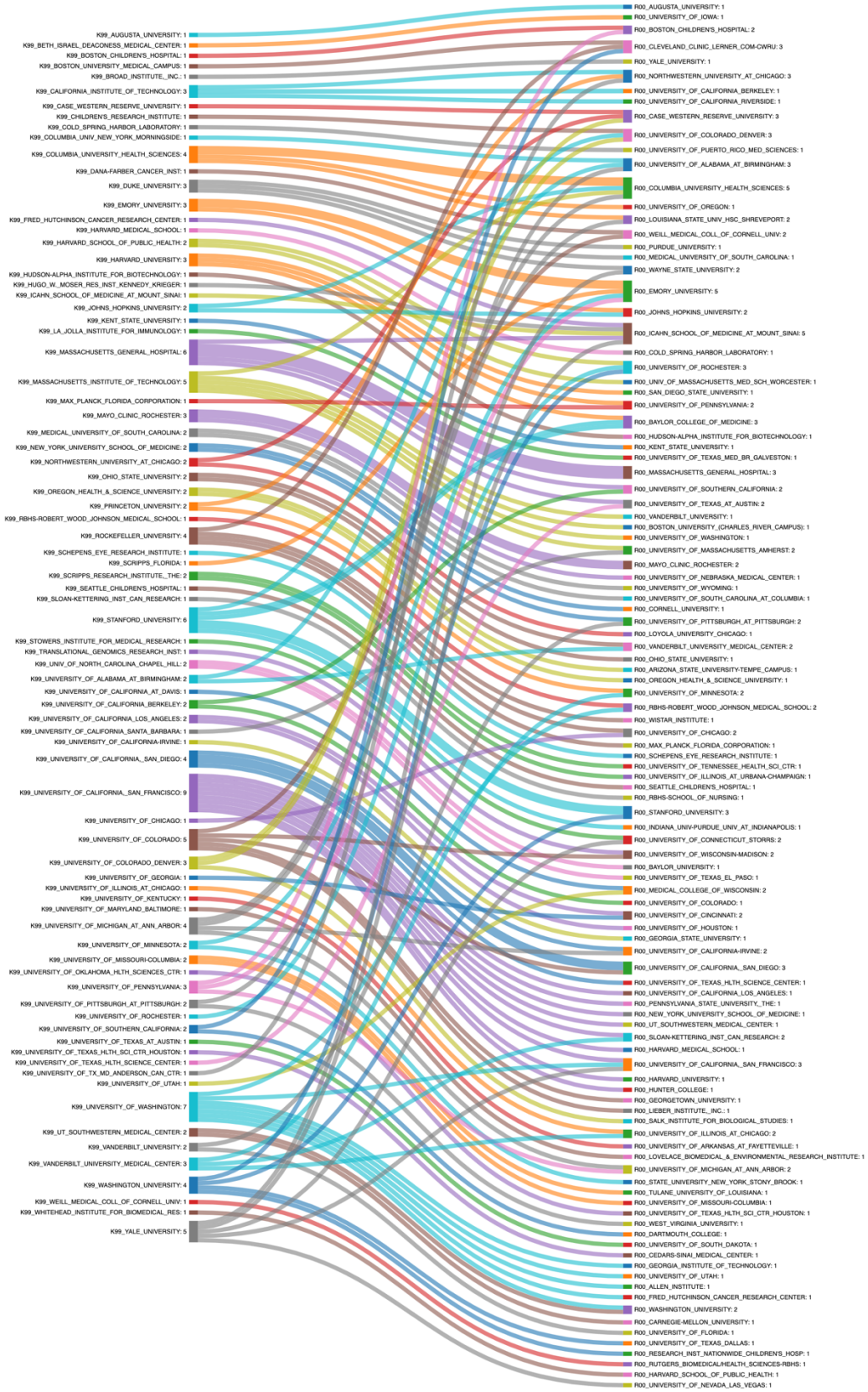
266

267 M 2019-2020



268

269 N 2020-2021



270

271 O 2021-2022

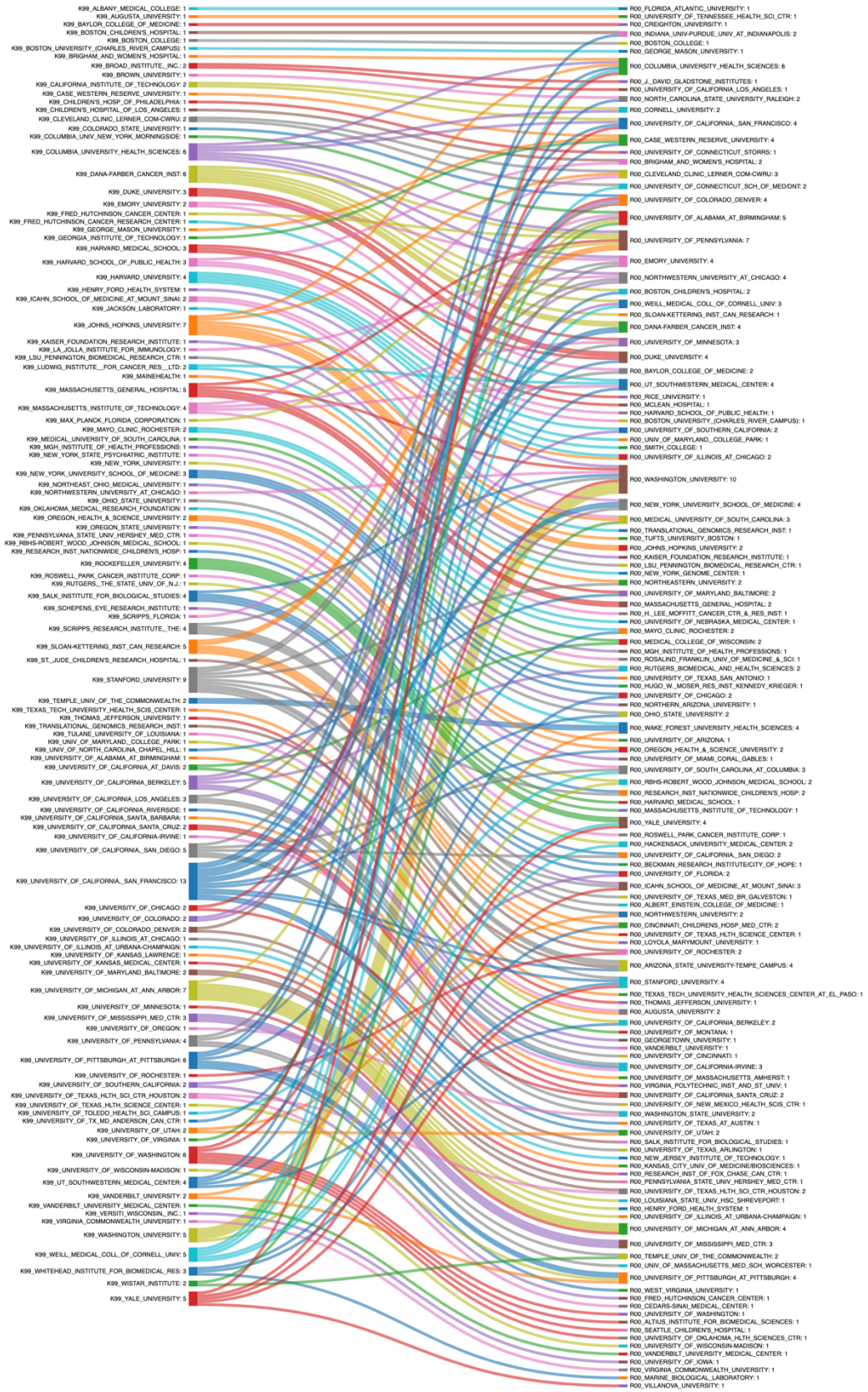


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Figure 4: A-O) Sankey diagrams of each cycle from 2007-2008 through 2021-2022 showing each successful K99 to R00 award transfer with the K99 institution on the left and R00 institution on the right.

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