Secondary Academic Appointments: A Hidden Dimension of Disparity?

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Introduction

Although equal-employment opportunities have been protected by the Civil Rights Act for more than half a century, specific races/ethnicities, women, and the economically-disadvantaged, continue to be under-represented in biomedical research. For example, while African Americans, Hispanics, Native Americans, and Pacific Islanders are together expected to form a majority of the US population by 2050, they currently form less than 10% of the biomedical research workforce.[1] While such employment disparities are easily measurable *within* organizational units such as in a department, school, or university, other potential disparities such as in secondary academic appointments occur *across* organizational units, requiring more powerful analytical methods. Furthermore, while secondary appointments are valuable markers of multidisciplinary expertise providing access to a wider pool of collaborations, funding and publications, such appointments are not required to be reported when they are without salary (WOS), and remain under-scrutinized. Such analytical and reporting reasons could result in undetected disparities within secondary appointments. Here we demonstrate how a bipartite network analysis and visualization can help to reveal disparities concealed in secondary appointments, enabling the design of targeted interventions.

Method

Research Question. What is the nature of diversity within primary and secondary faculty appointments?

Data. We extracted all deidentified records of paid faculty (n=879) from the administrative database of an academic medical center. Variables included *appointment type* (primary, secondary), *school* (School of Medicine [SOM], School of Health Professions [SHP], School of Nursing [SON]), *department* (d=33, e.g., Neurology), *rank* (assistant, associate, professor), *gender* (male, female), and *race* (White, African American, Hispanic, Pacific Islander, American Indian, Asian). All 879 faculty members had paid primary appointments, of whom 140 also had WOS secondary appointments.

Analysis. The analysis consisted of 3 steps: **(1) Bipartite Network Analysis and Visualization.** (a) Represented the data as a bipartite network (Fig. 1), where *nodes* represented faculty members (circles) or departments (triangles). The *edges* (lines) connecting faculty members to departments represented a primary appointment (dark gray), or a secondary appointment (light gray), and weighted based on their importance (primary=2, secondary=1). Diameter of the faculty member nodes represented rank (large=professor, medium=associate, small=assistant). (b) Used bicluster modularity maximization[2] to identify the number and boundaries of department-faculty biclusters, and the degree of biclustering (Q). (c) Measured the significance of Q by comparing it to a distribution of Q generated from 1000 random permutations of the network. (d) Used the force-directed algorithm *Kamada-Kawai* to layout the nodes within each department, and then grouped by school (SOM, SHP, SON) to

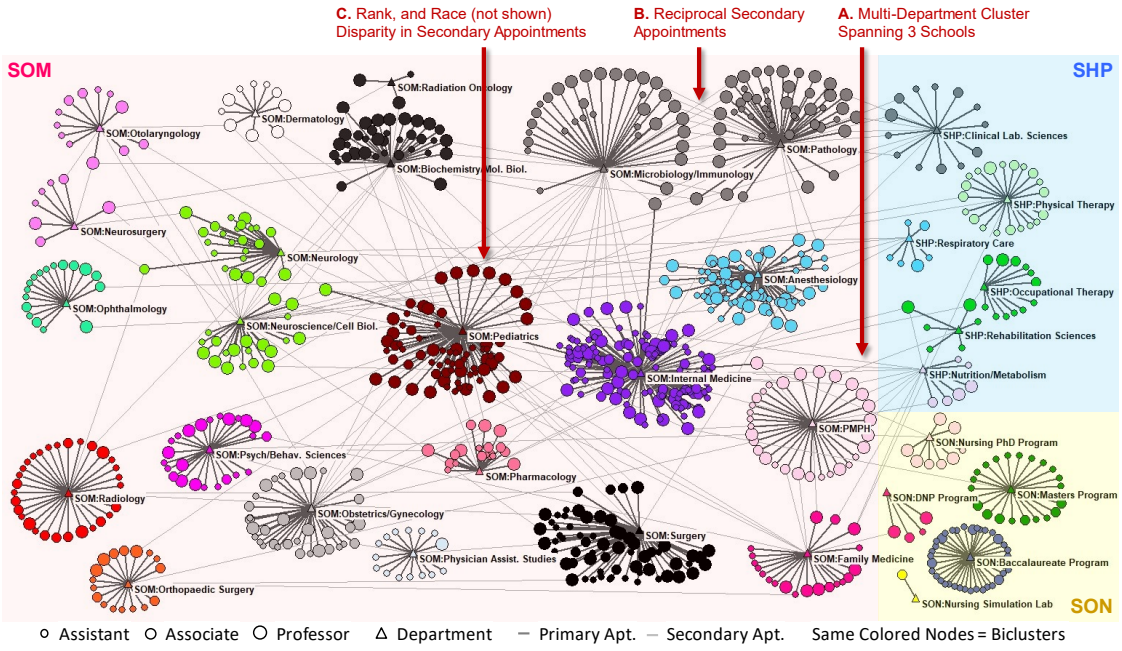

Fig. 1. Bipartite network visualization of primary and secondary appointments across departments, organized by school.

improve comprehension. **(2) Node and Edge Enrichment Analysis.** Used chi-squared with Bonferroni correction to measure: (a) the difference in proportion of race (white non-Hispanic vs. the rest of the races), and gender within each department compared to the US population; (b) the difference in proportion of race, gender, and rank of faculty members with secondary appointments, compared to those with only primary appointments. Used a binomial distribution to measure the significance of the proportion of inter-departmental edges (representing secondary appointments between pairs of departments) within biclusters in both directions, compared to the expected number of those edges (taking into consideration the department size) between all department pairs in the network. **(3) Interpretation.** The results were presented to a multidisciplinary team of data and governance administrators from the provost's office of the university to determine: (a) interpretability of the network and whether the results aligned with their administrative experience; (b) potential causal mechanisms underlying the observed disparities; and (c) potential interventions to address disparities.

Results

***Structure of Primary and Secondary Appointments*.** The bipartite network analysis and visualization revealed: (a) **departmental clustering** (same-colored nodes in Fig. 1), which was significant (Q=0.86, mean of random Q=0.59, $p<.005$, two-tailed). This resulted in 4 multi-departmental clusters within a school (e.g., SOM:Otolaryngology and SOM:Neurosurgery), 4 multi-departmental clusters that spanned 2-3 schools (e.g., SOM:PMPH, SHP:Nutrition/Metabolism, and SON:Nursing PhD Program [Fig. 1A]), and 15 clusters that contained a single department; and (b) **reciprocity** (Fig. 1B) in secondary appointments within clusters existed between 2 pairs of departments, which were significant compared to the expected across all departmental pairs. For example, SOM:Microbiology/Immunology (A) and SOM:Pathology (B) had significantly higher secondary appointments with each other (A→B=8, $p<.001$; B→A=7, $p<.001$, two-tailed), and therefore were reciprocal. In contrast, SOM:PMPH (A) and SHP:Nutrition/Metabolism (B) had significantly higher secondary appointments only in one direction (A→B=5, $p<.001$; B→A=1, $p=.9$; two-tailed), and therefore were not reciprocal.

***Diversity in Primary and Secondary Appointments*.** Enrichment analysis revealed: (a) **intra-departmental disparity** which consisted of significantly higher males within 2 SOM departments (SOM:Internal Medicine, SOM:Surgery), significantly higher females within two SON departments (SON:Baccalaureate-Prg., and SON:Master's-Prg.), and significantly higher non-whites within SOM:Internal Medicine ($p<.001$, department=58%, US population=40%), compared to the US population; (b) **inter-departmental disparity in secondary appointments** (Fig. 1C) consisted of a significantly higher number of faculty with secondary appointments that were white ($p<.05$, secondary=66%, primary=55%), and full professors ($p<.01$, secondary=72%, primary=22%), compared to those with only a primary appointment. In contrast, there was no significant difference in secondary appointments based on gender ($p=.05$, secondary=63% male, primary=53% male).

***Interpretation of Structure and Diversity*.** The executive leadership found the results to be interpretable, despite some of the findings being unexpected. The expected results included the known disparity in race within primary appointments in SOM:Internal Medicine, and known gender disparity within SON departments. They inferred that such disparity might exist because SOM departments tend to hire from a limited pool of international graduating students in the US, whereas the SON departments tend to hire from a pool of female nurses. Both imbalances could be addressed by drawing from more diverse pools, coupled with inclusion strategies to increase their retention. In contrast, as secondary appointments are rarely scrutinized, disparities in those results were unexpected. They reasoned that faculty with secondary appointments tend to be mostly white and full professors, either because such appointments were offered as administrative roles after they were promoted, or were offered as part of a start-up package during recruitment. While more data is needed to identify specific mechanisms precipitating such disparities, there was consensus that secondary appointments needed more scrutiny, with a focus on how they impact the trajectory of junior faculty. Such analyses would enable the design of targeted interventions such as offering meaningful secondary appointments to junior faculty. Furthermore, as junior faculty tend to be more racially diverse, such an intervention has the potential to address the current race and rank disparity across secondary appointments.

Conclusions and Future Research

While diversity in primary appointments is frequently and easily analyzed using conventional methods, disparity in secondary appointments can remain under the radar as they are not required to be reported when they are WOS, and require advanced methods to analyze and comprehend complex associations across departments. Here we demonstrated how bipartite networks enabled (1) the quantitative identification of significant disparities in both primary and secondary appointments, and (2) the visual interpretation of disparity patterns by a team of multidisciplinary administrators, enabling them to collaboratively reason about potential underlying mechanisms, and design potential targeted interventions. Our future research aims to test the generality of the approach, and replicability of the results using data from other medical schools, in addition to measuring the impact of diversity interventions on career outcomes of junior faculty using longitudinal data.

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