Whipple ME, Law AB, Bly RA. A Computer Simulation Model to Analyze the Application Process for Competitive Residency Programs. *J Grad Med Educ*. 2019;11(1):30–35.

Supplement: Detailed Version of the Simulation Process

A computer model of the residency application process was created using Matlab R2012a (Mathworks, Natick, MA). The program simulated students' application to residency programs, residency programs' screening and review of the received applications, and residency programs' extension of interview invitations to students. For each student, the simulation randomly generated a score (a real number between 0 and 1) that represented the "easy to review" metrics. These included such items as: USMLE scores, class rank, grade point average, medical school reputation, Alpha Omega Alpha status, numbers of publications, and whether there was a known geographic student preference. The simulation also generated a score (a real number from 0 to 1) that represented "hard to review" metrics that require more time or effort. These included: letters of recommendation, personal recommendations, personal statement, qualitative performance reviews, awards, volunteer activities, and research interests. The sum of the "easy to review" and "hard to review" scores created the "total" score for each student.

Each student's program preference was made up of three components. Each residency program was assigned an "individual preference" value from 1 to 5 for each student, which represented a student's individual preference for a particular program. In addition, each program was assigned a "national preference" value from 1 to 5, which was constant across all students and represented that certain programs are generally more popular with applicants than others. Finally each program was assigned a "regional preference," in which all programs were placed into 1 of 5 groups (representing geographic regions). Each student was also randomly assigned into 1 of these 5 "geographic region groups." If a program was in the same geographic region group as the student, then 2 points were added to that program's total score for that student. For each student, each program was assigned a total preference value by adding the “individual,” “national,” and “regional” preferences. From these values the simulation generated an ordered list of programs by each student’s preference.

We used the specialty of Otolaryngology–Head & Neck Surgery as an example of a competitive specialty and utilized statistics from the 2014 NRMP match consisting of 99 residency programs with 293 residency spots, and 460 student applicants. We extrapolated from our own institutional experiences with residency and medical student programs in order to assign the following values:

- A program could holistically review a maximum of 40 applications per residency slot.
- A program could interview a maximum of 10 applicants per residency slot.
- A student could interview at a maximum of 20 residency programs during an interview season.

A simulation consisted of the following steps:

1. Each student sends out a defined number of applications to residency programs in the student’s preferred order.
2. If a residency program receives a greater number of applications than it has resources to review (> 40 applications per slot), it screens the applicants based solely upon “easy to review” scores. This results in a subset of applicants that undergo a full review using the “total” score (both the “easy” and “hard to review”)
3. If the residency program receives a greater number of applicants than it can interview (> 10 applications per slot), it ranks all applicants undergoing a full review by utilizing the students’ total scores.

4. Each residency program sends out interviews up to the limit that they can accommodate in order of program preference based upon the student's total scores.
5. If a student receives more interview invitations than that student can attend (> 20), the student declines the least preferred invitations.
6. Residency programs that have invitations declined send out invitations to the next preferred student on the program's list.

In the simulation outlined above, residency programs were unaware of student preferences. In some simulations we allowed students to convey their preferences to residency programs by revealing whether the program fit into the student's top 10 preferred programs or the student's next 10 preferred programs. If a program did not fit into either of these categories then no preference would be reported. This was done to simulate a system in which students are able to submit an initial number of applications at a set cost, a certain number of applications at a secondary cost, and all applications beyond this at an additional cost. The Electronic Residency Application Service (ERAS) uses such a model of breaking down application costs into several tiers of ten applications. If students chose to convey preferences, the student's "easy to review" score was enhanced by residency programs in that student's top 10, and enhanced to a lesser degree by programs in that student's next 10. This was done to simulate the value to the program of knowing a student's interest in the program (ie, that a program would be more willing to fully evaluate the application and potentially interview a student who demonstrates a greater interest). We assigned an additional 0.5 standard deviations (roughly equivalent to 10 points on USMLE Step 1) to the "easy to measure" score for a student that ranks that program in their top 10, and an additional 0.25 SD (roughly 5 points on Step 1) to a student ranking that program in their next 10. We also ran simulations with values of up to +2 SD for the top 10 and +1 SD for the next 10.

For each simulation the number of interview invitations received by each student was recorded along with a utility score, calculated as the sum total of the preference scores for the programs from which the student received interviews. Results were averaged over 100 trials for each set of parameters. For each simulation, we inserted an index applicant with specific “easy to review” and “hard to review” values that were set a defined number of standard deviations above or below the mean of the student population. The number of interview invitations and utility of interview invitations for these index students were recorded. For some simulations, all students submitted the same number of applications, whereas for some simulations the index student submitted a different number of applications than the rest of the group. We measured the number of interviews and utility for all potential number of applications submitted.

We performed simulations: (1) without residency programs having knowledge of any student’s preference, (2) with programs knowing the preferences of all students, (3) with programs knowing the preferences of only the index student, and (4) with programs knowing the preferences of all students except the index student. The latter 2 simulations were performed to explore the impact of an individual student making a decision that is different then that of the rest of the group. This lets us explore the motivation of a single student to act in a variety of situations relative to the other students. In multiple simulations, we set the index student to +2, +1, 0, -1, or -2 standard deviations from the mean for “easy” and “hard” scores. The study has no human subjects and was exempt from IRB approval.