



AOA Critical Issues in Education

Decoding the Signals: An Analysis of Preference Signaling in the 2023 Orthopaedic Surgery Residency Match

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Background: While previously used in other specialties, the preference signaling program (PSP) was implemented in the 2022 to 2023 orthopaedic surgery residency application process for the first time. The PSP allowed for 30 signaling tokens to be sent by applicants to programs of their choice to indicate particular interest in a program. It remains unknown how the PSP affects applicants and programs in the orthopaedic surgery residency match. Thus, this study's purpose was to assess the utility of preference signaling within the orthopaedic surgery residency application process in its inaugural year of use.

Methods: An anonymous electronic survey was emailed to all orthopaedic surgery residency applicants who applied to the authors' institution during the 2022 to 2023 application cycle. The survey was sent after match lists were submitted and closed before the release of match results. The survey collected information regarding applicant demographics, preference signaling habits, and attitude toward preference signaling.

Results: The survey was completed by 101 applicants. Applicants applied to a mean of 90 programs (range: 10-197) and received an average of 12 interview invitations (range: 0-39). Applicants almost uniformly used all 30 signals, with nearly two-thirds signaling their home programs (65%, 49/76), and nearly all applicants sending signals to programs at which they performed away rotations (95.7%, 88/92). Applicants received a mean of 9 invitations from programs they signaled, compared with 2 invitations from programs they did not signal. Applicants were significantly more likely to receive an interview invite at a program they signaled than one they did not ($p < 0.01$). Overall, 57% of applicants (57/101) found the PSP to be helpful, whereas 28% (28/101) found it to be unhelpful, and 16% (16/101) had a neutral opinion.

Conclusions: This study reports that the PSP in the 2022 to 2023 orthopaedic surgery match was an effective method of expressing interest in a program because applicants were significantly more likely to receive interview invites to signaled programs. More than half of respondents felt PSP to be helpful; however, the effect on application numbers is still unclear.

Level of Evidence: III

Introduction

Orthopaedic surgery applicants applied to an average of 77 residency programs in the National Resident Matching

Program (NRMP) in the 2022 to 2023 application cycle¹. The number of applications received per program was 774¹. For orthopaedic surgery programs, the high quantity of applications

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results in several challenges for reviewing all applicants holistically. Two newer factors have likely also contributed to the large number of applications: 1) the COVID-19 pandemic caused restrictions on away rotations and most interviews became virtual in nature and 2) the transition of the United States Medical Licensing Examination Step 1 to Pass/Fail². Although most restrictions for away rotations have been lifted, many interviews remain virtual which causes concern for possible “stockpiling” or “interview hoarding” among a select few applicants. The virtual setting can allow an individual to participate in multiple interviews in a weekend or a single day, whereas in the past, same day, in-person interviews would have likely precluded this from occurring³. The Association of American Medical Colleges (AAMC) corroborated this concern for disproportionate numbers of interviews for only the highest tier applicants which could threaten the success of the NRMP match⁴.

From the applicant perspective, the competitive nature of successfully matching into orthopaedic surgery residency is limited by the inability to express interest in programs, causing reliance on nonstandardized means of signaling interest in programs such as self-advocacy, departmental or institutional advocacy, or participation in visiting rotations or other events. These methods are highly variable and may perpetuate inequities in the already competitive application process based on financial considerations for away rotations, access to mentorship and networking, and discrepancies of an applicant's home institution and faculty members' social capital within the field of orthopaedic surgery⁵.

Valid solutions have previously been proposed to curb increasing application numbers such as increasing cost per application, restricting the total number of applications, and mandatory specific essays for each program⁶. Preference signaling, a process by which applicants send a notification to schools to show an applicant's high interest, has been proposed routinely in both orthopaedic and academic literature and is described as sending a “rose” to program directors^{6,7}. Other competitive specialties have successfully used preference signaling with early adoption by urology and otolaryngology showing favorability among applicants. Program directors, applicants, and scientific literature have supported adopting preference signaling due to its positive influence on interview rate and applicant discernability^{3,5,8,9}.

The American Orthopaedic Associations (AOA) Council of Orthopaedic Residency Directors (CORD) announced its support of a preference signaling program (PSP) in the 2022 to 2023 orthopaedic residency application cycle¹⁰. AOA described the signaling process for orthopaedic surgery as a tool to help medical students find the best orthopaedic surgery residency and to help residency directors gauge genuine applicant interest in their program. The orthopaedic surgery PSP allowed for 30 signaling tokens to be sent by applicants to programs of their choice³. In addition, the AAMC released preliminary data in its first stage of evaluation on preference signaling from the 2022 to 2023 cycle indicating 16 specialties participated in the PSP demonstrating that 76% to 98% of intraspecialty programs participated¹¹. With adoption of PSP by orthopaedic surgery

residency programs and utilization of the program by the senior author's institution during the 2022 to 2023 cycle, we surveyed orthopaedic applicants on the utility of preference signaling to better understand the inaugural use of the PSP within orthopaedic surgery residency applications in an attempt to support an equitable and holistic application process.

Materials and Methods

Data Collection

The study was approved by the home institution's institutional review board, and no funding was received. Applicants to the senior author's orthopaedic residency program during the 2022 to 2023 application cycle were emailed a link to complete an anonymous survey, along with details regarding the study methods and goals in March 2023 (Appendix 1, <http://links.lww.com/JBJSOA/A552>). This was sent through an institutional email separate from official communication from the program and after rank lists had been submitted. As participation was anonymous, 2 reminder notification emails were sent to all applicants at 1-week intervals and before match results being released. Applicants were informed that the survey was voluntary, confidential, and anonymous, and no incentive for completion was offered or provided. The survey was closed before the release of match results.

The online survey was administered through Qualtrics (Qualtrics International). The survey included questions regarding preference signaling, interview invitations, away/audition rotations, and demographics. Data from the NRMP's publicly accessible *Main Residency Match Data and Reports* webpage were queried for historical comparisons. Descriptive statistics were performed using Microsoft Excel (Microsoft).

Results

Applicant Demographics

Eight hundred seven applicants were sent the online survey. One hundred one unique responses were obtained, representing an 12.5% response rate. Respondents' average age was 28 (range: 25-34) years (Table I). Women made up 19% (19/99) of respondents. Overall, most respondents reported their race/ethnicity to be White (89%, 89/97), followed by Asian (8%, 8/97), Hispanic/Latino/Spanish (8%, 8/97), Black or African American (2%, 2/97), Native Hawaiian/Pacific Islander (1%, 1/97), and Native American/Native Alaskan (1%, 1/97). Applicants most frequently reported attending medical school in the Midwest (31%, 31/99), Southwest (15%, 15/99), South Atlantic (14%, 14/99), and Mid-Atlantic regions (11%, 11/99) in the United States.

Use of Signals

Applicants applied to a mean of 89.6 programs (range: 10-197) and performed a mean of 2.7 away rotations (SD: 1.4) (Table II). All respondents used the PSP and almost uniformly reported using all 30 signals. Nearly two-thirds of applicants with home programs signaled their home program (65%, 49/76), and nearly all applicants sent signals to programs at which they performed audition rotations (96%, 88/92).

TABLE 1 Demographics*

	n (%)
Sex	
Female	18 (19.1)
Male	74 (78.7)
Nonbinary/other	2 (2.1)
Age	
<25	6 (6.6)
25-30 yrs	77 (84.6)
≥31 yrs	8 (8.8)
Average age	27.7
Race/ethnicity	
Native American or Alaskan Native	1 (1.1)
Native Hawaiian or Pacific Islander	1 (1.1)
Black or African American	2 (2.2)
Hispanic/Latino/Spanish	8 (8.7)
Asian	8 (8.7)
White	81 (88.0)
Geographic location of medical school	
Puerto Rico	2 (2.1)
Non-US Medical Graduate	4 (4.3)
New England (CT, ME, MA, NH, RI, and VT)	5 (5.3)
Pacific West (AK, CA, HI, OR, and WA)	7 (7.4)
South Central (AL, KY, MS, TN, AR, LA, and OK)	8 (8.5)
Mid-Atlantic (NJ, NY, and PA)	11 (11.7)
Southwest (AZ, NM, TX, CO, and UT)	13 (13.8)
South Atlantic (DE, FL, GA, MD, NC, SC, DC, VA, and WV)	14 (14.9)
Midwest (IL, IN, MI, OH, WI, IA, KS, MN, MO, NE, ND, and SD)	30 (31.9)
Enrollment status	
Senior/4th yr students	81 (87.1)
Graduated/research yr	11 (11.8)
Preliminary year in other specialty	1 (1.1)
Application attempt(s)	
First time applying	83 (89.2)
Second time applying	9 (9.7)
≥3 times applying	1 (1.1)

*Respondent demographics with percentages based on total that answered question, excluding those who preferred not to respond.

Signal Impact on Interview Invitations

Respondents received a mean of 11.6 total interview invitations (SD: 6.9, range: 0-39), and a mean of 2.5 (SD: 2.0) of these were in person. On average, respondents received 9 interview invitations (SD: 5.1, range: 0-23) from signaled programs, compared with 2.3 invitations (SD: 2.8, range: 0-16) from nonsignaled programs. Applicants were significantly more likely to receive an interview invite at a program they signaled than one they did not ($p < 0.01$). Women were significantly more likely to receive an interview from a signaled program compared with men ($p = 0.006$) yet were not more likely to receive an interview from nonsignaled programs ($p = 0.223$).

Applicant Response on Signals

Overall, most applicants (57/101) found the PSP to be helpful, whereas 28% (28/101) found it to be unhelpful, and 16% (16/101) had a neutral opinion (Fig. 1). There was no statistically significant relationship between whether an applicant found the signaling process helpful or unhelpful. Although there was no statistical significance, those who reported the process to be unhelpful reported a median of 8 interview invites compared with those who found it to be helpful or felt neutral with a median of 11 and 11.5 interview invites, respectively.

Discussion

Our study supports the use of PSP as an equitable methodology to express interest in orthopaedic surgery programs, with favorable outcomes for applicants. Nearly all applicants reported using program signaling in the 2022 to 2023 application cycle and most applicants felt it was helpful. Applicants received more interview invitations from programs that were signaled compared with those that were not signaled.

A similar survey of 223 applicants applying to otolaryngology during the 2021 to 2022 application cycle showed a 58% rate of receiving interviews from a signaled program compared with 14% nonsignaled⁵. Interestingly, the orthopaedic surgery PSP allowed for signaling of 30 programs compared with the otolaryngology PSP with signaling of only 4 to 5 programs. Ninety-one percent (182/199) of orthopaedic surgery residency programs participated in the PSP in the 2022 to 2023 match and nearly all applicants sent signals (97%, 1,556/1,603)¹¹. The orthopaedic surgery PSP differs from other signaling methodology used in both other medical specialties like otolaryngology and in other fields such as economics. Limited signals such as those in otolaryngology are believed to increase the odds of receiving a preferred interview^{12,13}. Despite these differences, our data suggest that PSP programs, regardless of number of signals, are associated with an increased rate of interview offers. In addition, compared with other programs using only 5 signals, the orthopaedic surgery PSP allowance of 30 signals may have the added benefit of acting as a possible surrogate to an application cap to deter increased application numbers as seen by the drop in the mean average number of total applications from 87 in the 2021 to 2022 application season to 77 in the 2022 to 2023 application season^{1,3}. As Feroe et al. opined, this system will hopefully decrease “interview hoarding” by highly competitive

TABLE II Comparison of Applicants and Historical AAMC Data*

	Authors' Data	AAMC Data
No. of Applicants, median (range)	86 (10-197)	n/a
No. of applicants sending signals, n (%)	96 (100%)	1,556 (97%)
No. of signals sent, mean (SD)	29.6 (2.4)	28.6 (5.1)
% of applicants who signaled home program, % (n)	65.3% (47/72)	n/a
% of applicants who signaled away/audition rotations, % (n)	95.5% (84/88)	n/a
No. of interview invites, mean (SD)	11.9 (7.0)	n/a
No. of interview invites from signaled programs, mean (SD)	9.4 (5.6)	n/a
No. of interview invites from programs not signaled, mean (SD)	2.4 (2.8)	n/a
No. of away/audition rotations performed in orthopaedics, median (SD)	3 (1.4)	n/a
No. of interview invites from away/audition rotations, median (SD)	3 (1.3)	n/a

*AAMC = Association of American Medical Colleges.

candidates with numerous interviews³. At this point, 30 signal tokens seem effective, but longitudinal match data will be needed to fully assess the appropriateness of this number.

In the 2022 study of orthopaedic surgery residency program directors, 68% of program directors agreed that applicants will have increased chances of interview invitations at signaled programs¹⁴. Program directors, on average, rated performance on away rotation, personal knowledge of the applicant, and receiving a preference signal as the top 3 most important aspects of an application. These 3 aspects of an application are not a metric of an applicant's knowledge, rather a demonstration of the importance of nonscored metrics since the implementation of Step 1 Pass/Fail. With the increased number of applications

caused by challenges posed by COVID-19 and increased interest in orthopaedic surgery, PSP methodology incentivizes intentional interest in programs for applicants and allows programs the potential to review applications rigorously and holistically for interview invitations. A lower number of applications to review because of a systematic implementation of PSP decreases the potential for bias at that stage of the residency application process. Our study did not ultimately seek to address these potential biases, and the relatively modest decrease in applications and thus decrease in application review time may not necessarily be of utilitarian value to programs.

According to the AOA CORD, the primary purpose of PSP implementation was to allow a reliable and equitable method for

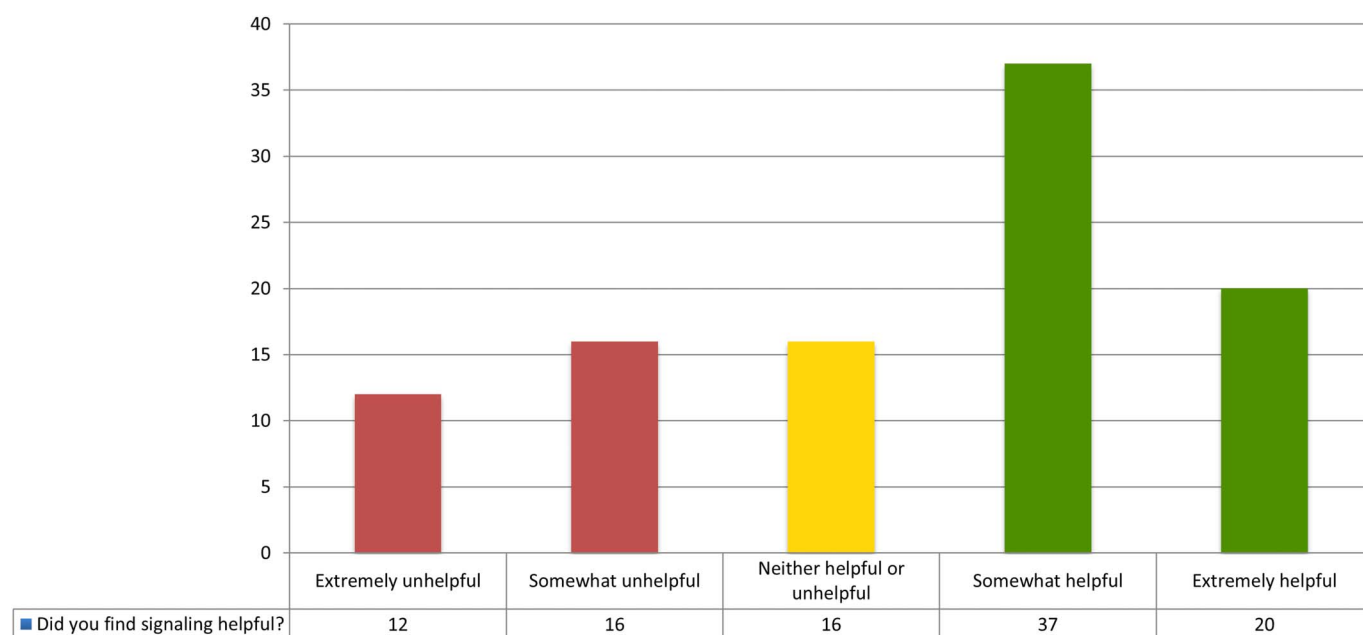


Fig. 1
Survey responses to “Did you find signaling helpful?”

applicants to demonstrate interest in programs¹⁰. Although not the primary purpose, the possibility for reduction of programs applied to per applicant could likely reduce the financial burden of applicants. In the 2022 to 2023 cycle, students applied to an average of 77 orthopaedic residency programs, costing roughly \$1,700¹⁵. As match rates into orthopaedic surgery decrease, widening disparities among orthopaedic surgery applicants due to financial inequities may be perpetuated without national guidelines on application or interview caps. Applicants may apply to many programs and cast a “wide net” because of low match rates or “stockpile” interview offers. Our data on the efficacy of PSP implemented in the orthopaedic surgery application are encouraging as most applicants found PSP to be a helpful stratagem. Further studies should investigate the impact PSP may have on reducing the number of applications received per program and the optimal signaling number that carries enough weight for informative value to programs. As the residual changes from the COVID-19 abate and interviews potentially return to in-person, program directors, AOA CORD, and the AAMC should continue mutually beneficial efforts to mitigate inequity and interview congestion in the orthopaedic surgery application process.

Overall, the PSP seems to be a positive change for both programs and applicants alike. Yet, there does seem to be uncertainty regarding the use of these signals at home programs and away rotation programs. Nearly two-thirds of respondents to the present study with home programs signaled their home program and most applicants sent signals to programs at which they performed audition rotations. These data suggest that there was not uniform guidance on signaling of home and away rotation programs, which highlights the ambiguity regarding instructions as to which programs to signal. For future application cycles, AOA CORD should provide guidance on the use of signals for home and away rotation programs.

Limitations


Our study is not without limitations. Our findings are based on a surveyed subset of applicants applying to a specific orthopaedic surgery residency program with a response rate of 12.4% and thus may not reflect the entire applicant population and be subject to response bias. Comparing our respondents' demographics to the entire orthopaedic surgery applicant pool of 2023, our proportion of female respondents (19.2%) was similar to the 22.7% of female applicants, yet our cohort was slightly less ethnically/racially diverse than the entire cohort¹⁶. However, our response rate was higher than the AAMC survey to orthopaedic applicants regarding preference signaling (12.4% [100/804] vs. 7.6% [124/1,637])¹¹. In addition, applicants who had specific

opinions about their application process may be overrepresented in the results of our study. Our respondent pool reported receiving an average of 11.7 interview invites, which is likely more than the average applicant. Accordingly, our results may be more reflective of the successful applicant instead of the entire applicant pool. Many challenges of the residency application process for orthopaedic surgery are not representative of other medical and surgical specialties and a PSP model different from other surgical specialties was used. Finally, owing to the cross-sectional nature of this study, long-term implications of PSP methodology on the orthopaedic surgery application process are unknown and should be further investigated longitudinally. This study was performed before match results being released, and as such we did not capture the rate at which applicants ended up matching at a signaled program, which would provide important information to both applicants and programs.

Conclusion

This study reports that the PSP in the 2022 to 2023 orthopaedic surgery match was an effective method of expressing interest in a program as applicants were significantly more likely to receive interview invites to signaled programs. More than half of respondents felt PSP to be helpful; however, it may not address the underlying and growing problem of the increasing application burden on applicants and programs alike.

Appendix

 Supporting material provided by the authors is posted with the online version of this article as a data supplement at [jbjs.org \(http://links.lww.com/JBJSOA/A552\)](http://links.lww.com/JBJSOA/A552). This content was not copyedited or verified by JBJS. ■

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References

1. AAMC. ERAS Statistics Preliminary 2023 Residency Data. AAMC; 2023. Available at: <https://www.aamc.org/data-reports/data/eras-statistics-data>. Accessed March 1, 2023.
2. USMLE Step 1 transition to Step 1 Pass/fail only. USMLE. 2021. Available at: <https://www.usmle.org/usmle-step-1-transition-pass-fail-only-score-reporting>. Accessed March 1, 2023.

3. Feroe AG, Smartt AA, Pulos N, Aiyer AA, Levine WN, Barlow JD. Preference signaling during the orthopaedic surgery residency application process. *J Am Acad Orthop Surg.* 2023;31(1):1-6.
4. Whelan A. Open letter on residency interviews; 2020. Available at: <https://www.aamc.org/media/50291/download>. Accessed March 3, 2023.

5. Pletcher SD, Chang CD, Thorne MC, Malekzadeh S. The otolaryngology residency program preference signaling experience. *Acad Med.* 2022;97(5):664-8.
6. 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):30-5.
7. Bernstein J. Not the last word: want to match in an orthopaedic surgery residency? Send a rose to the program director. *Clin Orthop Relat Res.* 2017;475(12): 2845-9.
8. Leopold Z, Rajagopalan A, Mikhail M, Lee G, Tabakin A, Park JH, Jang T, Elsamra SE, Singer EA. Preference signaling in the 2022 urology residency match—the applicant perspective. *Urology.* 2022;170:33-7.
9. Pelletier-Bui AE, Schnapp BH, Smith LG, Franzen D, Werley E, McDonough E, Camejo M. Making our preference known: preference signaling in the emergency medicine residency application. *West J Emerg Med.* 2021;23(1):72-5.
10. Hendrix SM. The American orthopaedic association announces participation in preference signaling; 2022. Available at: <https://aoaproducts.wpenginepowered.com/wp-content/uploads/2022/03/FINAL-AOA-Signal-1.pdf>. Accessed March 1, 2023.
11. AAMC. Supplemental ERAS® 2022-2023 Application Cycle: Evaluation of Program Signaling; 2023:60. Available at: <https://www.aamc.org/data-reports/students-residents/report/supplemental-eras-application-data-and-reports>. Accessed March 3, 2023.
12. Coles P, Cawley J, Levine PB, Niederle M, Roth AE, Siegfried JJ. The job market for new economists: a market design perspective. *J Econ Perspect.* 2010;24(4):187-206.
13. Coles P, Kushnir A, Niederle M. Preference signaling in matching markets. *Am Econ J Microeconomics.* 2013;5(2):99-134.
14. Mun F, Suresh KV, Li TP, Aiyer AA, LaPorte DM. Preference signaling for orthopaedic surgery applicants: a survey of residency program directors. *J Am Acad Orthop Surg.* 2022;30(23):1140-5.
15. AAMC. Fees for ERAS® residency applications. Washington, DC: AAMC. Accessed March 1, 2023.
16. NRMP. Charting Outcomes™: Demographic Characteristics of Applicants in the Main Residency Match. National Resident Matching Program; 2023. Available at: <https://www.nrmp.org/match-data-analytics/interactive-tools/charting-outcomes-demographic-characteristics-of-applicants-in-the-main-residency-match/>. Accessed June 3, 2023.