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The Utility of the Plastic Surgery Standardized Letter of Recommendation Form in Predicting Residency Match Outcomes

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BACKGROUND: Letters of recommendation play an important role in resident selection. While plastic surgery's Standardized Letter of Recommendation (SLOR) form most commonly serves as an adjunct to narrative letters, the SLOR provides objective data in the review process and could eventually replace narrative letters. The utility of the SLOR in predicting Match outcomes has not been studied.

METHODS: Applicant data from 225 first-time residency applicants in 2020-21 were collected. Logistic regression modeling was used to predict Match outcomes. This model was validated using 100 randomly selected applicants from 2019-20.

RESULTS: Rank placement (SLOR Question 6) was the most important factor when predicting Match outcomes ($p<0.0001$). All other SLOR questions were not predictive and subject to notable score inflation. No SLOR score differences were noted based on race; female applicants were rated higher in two of ten domains ($p<0.05$).

CONCLUSIONS: One question on the plastic surgery SLOR was highly predictive of an applicant matching. However, the remaining SLOR questions had little utility and were subject to gross score inflation. Further work should be done to optimize the utility of the SLOR in differentiating applicants. This has important implications in ensuring the selection of professional, competent residents according to the aims of the Accreditation Council of Graduate Medical Education. (J Surg Ed 000:1−9. © 2023 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: Letters of Recommendation, Residency Application, Bias, Outcome Prediction

COMPETENCIES: Professionalism, Interpersonal and Communication Skills, Systems-Based Practice

INTRODUCTION

In the 2021-22 integrated plastic surgery (IPS) Match, 351 applicants applied for 194 positions: a Match rate of only 55%.[1] This was a decrease from 57% in 2020-21 and 62% in 2019-20.[2,3] Every year, programs choose from a pool of qualified applicants that is increasingly disproportionate to the number of IPS positions.[4] Selecting the best candidates has implications for not only the success of individual programs but also the future of plastic surgery. While many factors are involved in applicant selection, letters of recommendation (LORs) play a critical role in the decision-making process.[5-7]

In an effort to standardize LORs, Emergency Medicine was the first specialty to adopt a standardized letter of recommendation (SLOR) in 1995.[8] The American Council of Academic Plastic Surgeons (ACAPS) introduced a SLOR in 2012.[9] In 2019, substantial changes were made to the SLOR, resulting in the current form which has been used since the 2019-20 application cycle.[10,11] While SLORs vary by specialty, they are all meant to increase objectivity in the applicant review process.

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SLORs are generally faster to complete and review than narrative letters of recommendation (NLORs).[12] In addition, SLORs have been found to be less biased by gender and race.[12,13]

Studies of SLORs have demonstrated widespread score inflation, a lack of correlation with interview invitations, and some degree of gender/racial bias.[14-16] Although studies have correlated applicant characteristics, such as Step 1 scores and research output, to Match outcomes, there has not been a comprehensive study evaluating the role of SLORs in the IPS Match.[17-19] This study aims to determine whether current ACAPS SLOR responses correlate with a successful IPS Match. In addition, we sought to characterize trends of SLOR score inflation and any disparities in SLOR scores based on applicant demographics.

METHODS

Data Collection

All applications to one IPS residency program during the 2020-21 application cycle were reviewed. All first-time residency applicants from United States medical schools were included. Applicants with prior postgraduate training, who had applied in a prior application cycle, or who graduated from an international medical school were excluded. These exclusion criteria were applied to ensure uniformity in letter writer contact with applicants.[20] For data validation, 100 applications meeting the same inclusion and exclusion criteria were randomly selected from the 2019-20 applicant pool. This study was deemed exempt by Vanderbilt University's Institutional Board Review.

Match outcomes were determined based on publicly available data (residency program websites/social media platforms, Doximity/LinkedIn profiles, medical school Match Day announcements, etc.). All Match outcomes were verified with at least two data sources. Match outcomes were successfully identified for all applicants meeting the inclusion criteria. Applicant data collected are shown in Table 1. Applications in 2019-20 and 2020-21 included self-reported sex (this field was changed to gender starting with the 2022-23 cycle). Medical schools with an affiliated ("home") IPS residency program were also identified. SLOR data collection included the duration of knowing the applicant, percentile ratings for Question 3A-J (Qualification Domains), and rank placement on Question 6 (Q6).[11] Data that did not match the scaling or binning of the current ACAPS form were excluded. The percentile ratings for Questions 3A-J were treated as continuous variables rounded to the nearest 5th percentile. The responses to Q6 were converted to categorical bins, with 1 representing a rank list placement of "1″ to 5 representing "would not rank." Interpretation of ambiguous responses to any SLOR question was agreed upon by at least two authors.

Data Analysis

The scores from each SLOR question were first averaged for each applicant. This was done because the primary outcome of interest – matching versus not matching into an IPS residency—is based on the summative assessment of an applicant's LORs and other application content. To further support the rationale for averaging scores, interrater reliability of Q6 responses was determined with the Fleiss kappa value. This was calculated for applicants in the 2020-21 cohort using at least three SLORs with completed Q6 ratings. This analysis was not performed on other SLOR questions due to the narrow distribution range of scores and their continuous scaling.

Unpaired two-tailed t-tests were used when comparing continuous variables. Binary categorical variables were compared with a two-tailed Fisher's exact test, and variables with at least three categories were compared using a Chi-squared test. Logistic regression modeling was used to predict Match outcomes with applicable demographic and SLOR data from the 2020-21 cohort. The data of 215 applicants were used (10 applicants had incomplete data sets). Variables included in the logistic regression modeling were applicant age, sex, race, 2022 US News and World Report Ranking (USNWR) medical school classification, presence of a home integrated residency program, Step 1 score, number of publications, and the average response to Q6. The references used for categorical variables were: male (sex), Non-Hispanic White (race), Yes (USNWR Top 40 school), and Yes (Home integrated program). Outcome predictions were based on each variable's beta values as calculated by the model. A receiver operator characteristics (ROC) curve was generated to assess model suitability. For validation, the logistic regression model was used to predict Match outcomes for the 100 randomly selected applicants from 2019-20.

Statistical analysis and figure generation were conducted using GraphPad Prism 9.3.1, except for the Fleiss kappa analysis, which was calculated via Matlab R2022b.

RESULTS

Table 1 summarizes the demographics of applicants and letter writers included in this study. A total of 225 applications from the 2020-21 application cycle were analyzed as well as 100 randomly selected applications from 2019-20. The Match rate for the 2020-21 cohort was

TABLE 1. Applicant and Letter Writer Demographics[#]

	2019-20 Cycle	2020-21 Cycle	p-value
No. of applicants	100	225	
No. of matched applicants (%)	77 (77%)	159 (70.7%)	p=0.28
No. matched at home program (%)	12 (15.6%)	42 (26.4%)	p=0.07
Applicant self-reported Sex			
Female	54%	56%	
Male	46%	44%	
Applicant race			p=0.032*
Asian	24%	24%	
Black	4%	6%	
Hispanic	2%	8%	
Other	4%	10%	
Non-Hispanic White	66%	52%	
USNWR Top 40 Research Medical School[†]			p=0.72
Yes	39%	37%	
No, MD School	58%	58%	
No, Do School	3%	5%	
Home Integrated Plastic Surgery Residency Program			p=0.049*
Yes	78%	67%	
No	22%	33%	
Average Age ± SD, years	26.6 ± 2.03	27.0 ± 2.22 (n = 223)	p=0.13
Average Step 1 Score ± SD	254 ± 6.8	245 ± 13.2	p<0.0001*
Average Step 2 CK Score ± SD	256 ± 9.1 (n = 70)	253 ± 11.5 (n = 167)	p=0.079
Average No. of PubMed Indexed Publications ± SD	3.76 ± 4.57	6.88 ± 7.45	p=0.0001*
No. of Applicants with SLORs (Total SLORs)	100 (329)	220 (613)	
Average No. of SLORs per Applicant ± SD	3.29 ± 0.81	2.78 ± 0.95	p<0.0001*
Average Length of Contact with SLOR Writer ± SD, weeks	62.2 ± 77.0 (n = 214)	91.5 ± 62.8 (n = 365)	p<0.0001*
SLOR Writer is a Plastic Surgeon			p=0.19
Yes	96%	93%	
No	4%	7%	
Writer Affiliated with Applicant's Home Institution			p<0.0001*
Yes	55%	78%	
No	41%	22%	

[#]When information was not available or omitted, the applicable *n* value is presented.
[†]U.S. News and World Report Rankings of "2022 Best Medical Schools: Research"
*Indicates statistically significant change between application cycles (p<0.05)

70.7%, a decrease from 77% for the 2019-20 cohort. In both cycles, most applicants were female (55%), identified as Non-Hispanic White (56%), and applied from institutions with home integrated programs (70%). The writers' average length of contact with applicants increased from 62.2 weeks in 2019-20 to 91.5 weeks in 2020-21. However, this question was the most frequently omitted on the SLOR, with a completion rate of 61%.

The average percentile scores from SLOR Questions 3A-J (Qualification Domains) and the average response to Q6 (Rank Placement) are shown in Figure 1. In both application cycles, Professionalism was the highest-scored domain while Technical Ability was the lowest-scored. All domains had an average percentile rating greater than the 85th percentile. Notably, 64% of the 2019-20 cohort had average domain scores greater than the 80th percentile across all domains. This rose to 71% during the 2020-21 cycle. From 2019-20 to 2020-21, the average percentile rating improved significantly in seven of the ten domains and for Q6. Fleiss kappa analysis demonstrated fair interrater reliability among writers responding to Q6 ($\kappa = 0.203$, $p<0.0001$).

Analysis by Applicant Sex and Race

In 2020-21, no significant sex differences were found in 8 of the 10 domains for Question 3 (Figure 2A). Female applicants received significantly higher domain ratings in Overall and Communication. There were no significant differences between sexes in Q6. Additionally, there were no significant racial differences in domain scores or Q6 (Figure 2B). When considering the primary outcomes of matching versus not matching, there were no differences in the proportion of individuals matching based on sex (70% male, 71% female, P=0.88) or race (Chi-square = 1.798, p=0.77)

Predicting Match Outcomes

Table 2 highlights the variables included in the logistic regression model and their contribution to predicting

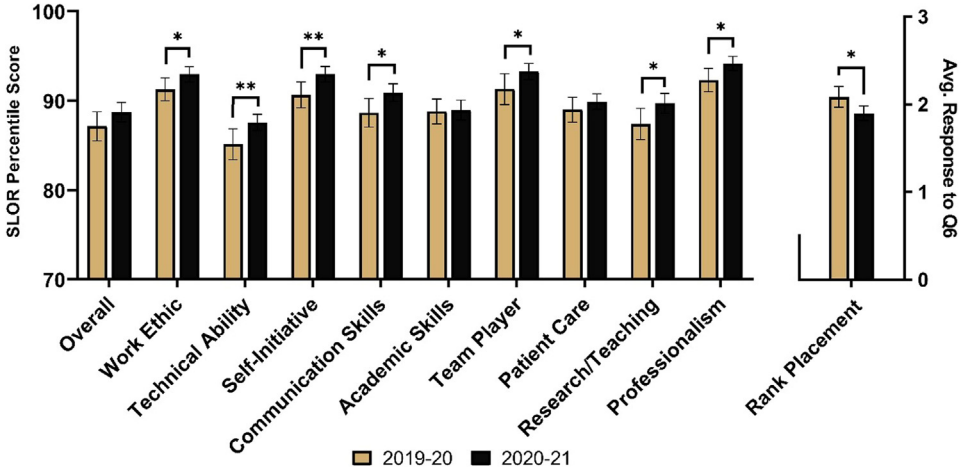

FIGURE 1. Average applicant SLOR responses from the 2019-20 and 2020-21 application cycles. Error bars represent the 95% confidence interval. * indicates $p<0.05$ and ** indicates $p<0.01$.

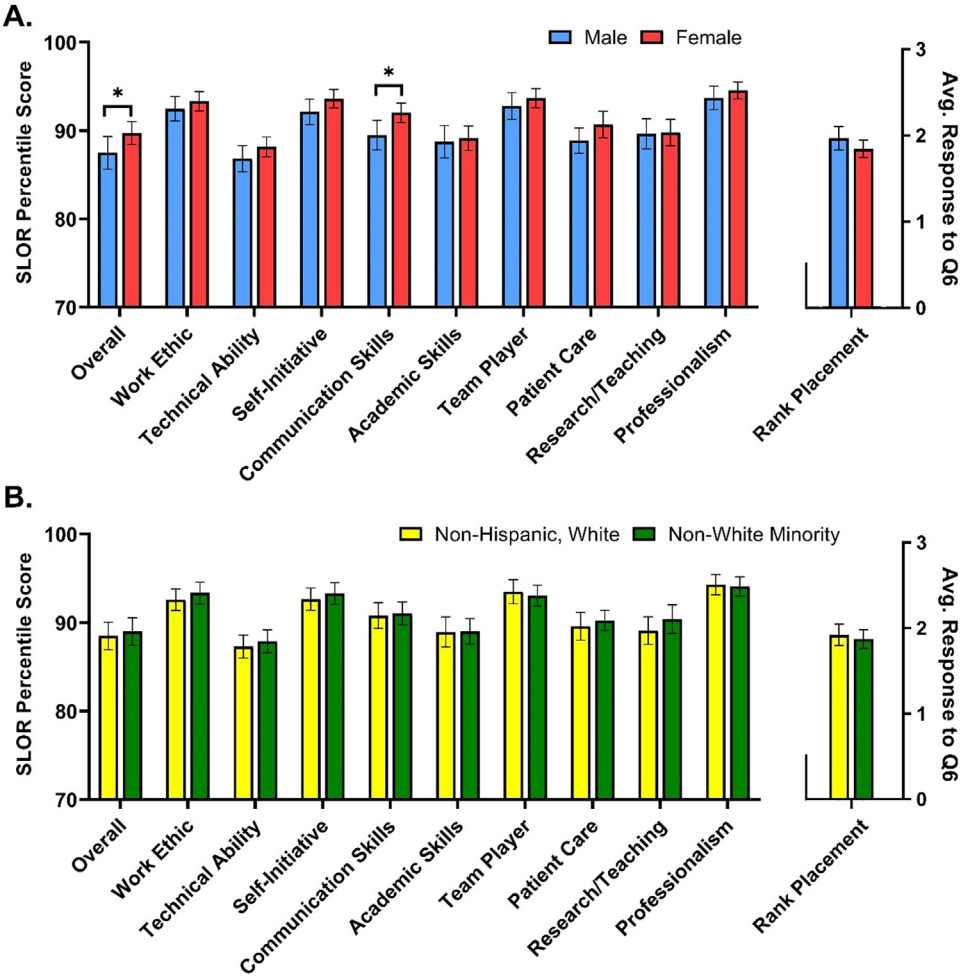

FIGURE 2. Average applicant SLOR responses from the 2020-21 application cycle based on applicant sex (A) and self-identified race (B). Error bars represent the 95% confidence interval. * indicates $p<0.05$.

TABLE 2. Logistic Regression Model Prediction of 2020-21 Match Outcomes (n = 215)

Variable	Beta Value[#]	Odds Ratio[†]	95% CI	p-value
Model intercept	−10.4	0.00003049	1.422*10^{-10}-3.315	0.0852
Applicant sex (Female)	0.07824	1.081	0.4762-2.452	0.8507
Age	−0.04479	0.9562	0.7683-1.189	0.6868
Applicant race (Other)	−0.8721	0.4181	0.1125-1.612	0.1936
Applicant race (Hispanic)	−1.244	0.2883	0.07845-1.035	0.0558
Applicant race (Black)	0.3501	1.419	0.2808-8.663	0.6851
Applicant race (Asian)	−0.6946	0.4993	0.1569-1.576	0.2335
USNWR Top40 (No, MD School)	−0.09875	0.906	0.3113-2.637	0.8552
USNWR Top40 (No, DO School)	−2.286	0.1016	0.004283-1.330	0.1057
Home integrated residency program (No)	−0.637	0.5289	0.1917-1.424	0.2102
Step 1 score	0.07101	1.074	1.036-1.117	0.0002*
No. of publications	0.1904	1.21	1.087-1.382	0.002*
Avg. response to Q6 (Ranking Placement)	−2.425	0.0885	0.03347-0.2003	<0.0001*

[#]Where each beta (β_n) is used in the probability model formula: Probability = $1/(1+e^{-(\beta 0+\ \beta 1*x1+\ \beta 2*x2\ +\ldots)})$, x_n represents each variable value (i.e. age or Step 1 score; for continuous variables, x = 1 if the categorical variable is present). A probability of 0.5 is used as the classification (Match vs No Match) cutoff

[†]An odds ratio greater than 1 indicates a positive correlation with matching

*Indicates statistical significance (p<0.05)

Match outcomes. Of the eight variables included, only an applicant's Step 1 score, number of publications, and average Q6 rating significantly contributed to the Match outcome prediction. Table 3 highlights the differences in these key variables between matched and unmatched applicants. SLOR domain scores (Question 3A-J) were not included in the model because they had no significance in predicting outcomes. Furthermore, inclusion of these variables resulted in variable collinearity that was too high for model acceptability.[21] The logistic regression model based on the 2020-21 cycle data had a sensitivity of 90.9% and a specificity of 62.9%, with a ROC Curve (Figure 3A) area-under-the-curve (AUC) of 0.894. When used to predict Match outcomes of 2019-20 applicants, the model had an overall accuracy of 84%. While the model correctly predicted outcomes for 96% of matched applicants, it correctly predicted outcomes for only 43% of unmatched applicants.

DISCUSSION

LORs play a critical role in the resident selection process.[5,6] Across specialties, program directors cite LOR content as highly influential when ranking applicants.[6,22-25] However, this is the first study to determine if responses on the plastic surgery SLOR correlate with applicant Match outcomes.

SLOR Utility in Predicting Match Outcomes

Logistic regression modeling can be applied to predict binary outcomes based on pre-specified variables.[26] This technique identifies variable weights (Beta, β) that optimally predict the correct outcome with the highest degree of accuracy. In this study, we used the data of 215 applicants to identify the variables most useful in predicting Match outcomes. Of the variables included in the final model (Table 2), the most significant predictor of Match outcomes was the average SLOR response to Q6 (rank placement). This variable had greater predictive power than Step 1 scores and applicant publication metrics, although these variables were also both significant in predicting outcomes. The importance of Q6 likely lies in the summative nature of the question. In a sense, the question provides robust pretest probability of how an applicant will perform in the Match. The model generated based on the 2020-21 data also translated well to the 2019-20 data set with a prediction

TABLE 3. Comparison of Match and No Match Applicant Variables

Variable, Mean ± SD	2019-20 Match	2019-20 No Match	2020-21 Match	2020-21 No Match
Step 1 score	254 ± 6.77	253 ± 6.77	248 ± 11.2*	238 ± 15.3*
No. of publications	3.96 ± 4.79	3.09 ± 3.79	7.22 ± 8.29*	2.82 ± 3.21*
Average response to Q6 (ranking placement)	1.94 ± 0.50*	2.58 ± 0.67*	1.71 ± 0.46*	2.46 ± 0.70*

*Indicates a significant difference between Match and No Match applicants within the same application cycle (p<0.001)

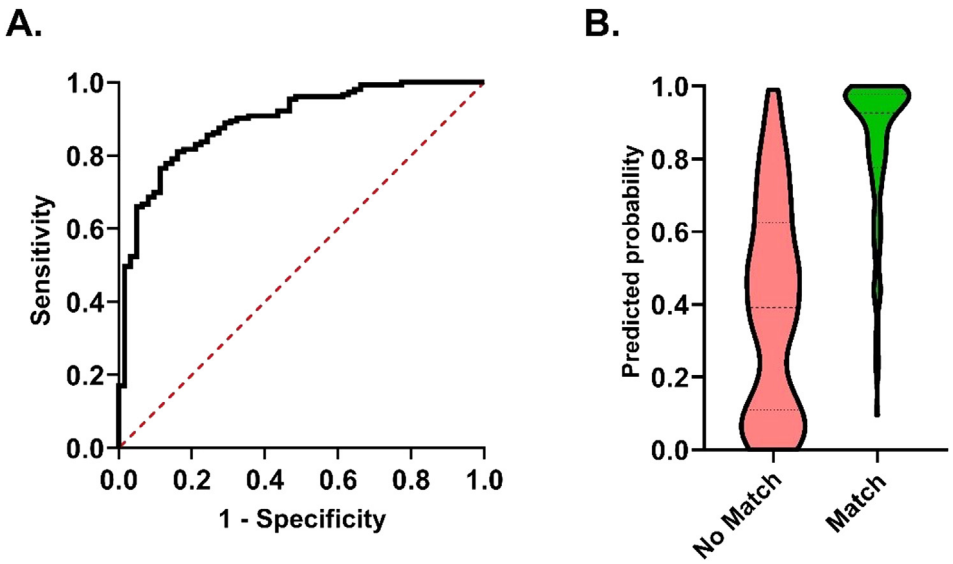

FIGURE 3. Logistic regression modeling of the 2020-21 applicant Match outcomes. (A) Receiver Operator Characteristic (ROC) Curve with an area-under-the-curve (AUC) of 0.894. (B) Violin plot of Match probability based on the model formula (Table 2) for applicants who matched versus did not match.

accuracy of 84%. In both application cycles, the prediction modeling was highly effective in predicting a successful match: 96% and 91% for 2019-20 and 2020-21, respectively. However, the model is less effective when predicting outcomes for someone who eventually did not match (43% and 63% for 2019-20 and 2020-21, respectively). This reflects intangible applicant qualities not quantified by this data set and therefore not included in the model such as interview performance. These findings are represented graphically in Figure 3B, which illustrates the distribution of model-generated probability of an applicant matching, separated by applicants who did and did not match.

Implications of Sex and Race on Match Outcomes

Prior literature has addressed concerns for gender and racial biases in both narrative and standardized LORs.[14,27-29] In our logistic regression model, applicant sex, age, and race were not significant in predicting Match outcome (Table 2). These findings may be attributed to increased awareness of these biases in addition to the increasing diversity of applicants each year.

Limitations of the Current ACAPS SLOR

Across many specialties that use SLORs, including plastic surgery, the concern for score inflation has been raised.[30-33] This finding was reproduced in this study with statistically significant increases in the average domain scores in seven of ten categories between consecutive application cycles (Figure 1). Furthermore, when attempting to incorporate the SLOR domain scores into our logistic regression model, the overall prediction accuracy decreased, indicating a lack of utility of these scores. This was shown previously when using SLOR Question 3A-J to predict interview outcomes, and our findings extended this to Match outcomes.[16] These findings highlight the need to reframe how SLOR domains are scored. It is impossible for 71% of applicants to have all ten domain scores average above the 80th percentile. The current ACAPS form presents a linear scale, encouraging letter writers to positively skew domain scores in an effort to help applicants match. It would be worthwhile to consider using a negatively skewed scale (e.g., Single Best Student; Top 5%; 6-10%; 11-50%; Bottom 50%) to achieve a more balanced distribution of responses.

Additional limitations of the SLOR observed in this study include lack of completion of certain questions, notably "Length of Contact with Applicant." This question was only completed on 60% of SLORs in 2020-21, making it difficult to study since conclusions are subject to nonresponse bias. The low response rate to this question compared to other SLOR questions may be attributed to the lack of a text box to answer this question on the current PDF.[11] The PDF formatting also allows for a combination of digital and analog form completion. When the form is completed by hand, there is no standard formatting for responses, allowing for checkmarks to be placed imprecisely and for illegible handwriting. This results in recommendations that may be challenging to interpret consistently between reviewers. Further work

should be done to optimize the SLOR user interface, while also reducing score inflation.

Influence of the COVID-19 Pandemic on Application Trends

The inability to complete away rotations led to a significant increase in SLORs from an applicant's home institution (from 55% to 78%). More SLORs from home faculty is the best explanation for the increase in the average length of contact with applicants (from 62 weeks to 92 weeks).[34] In terms of applicant characteristics, research productivity increased significantly during this time. This is possibly a result of decreased clinical responsibilities due to pandemic restrictions, freeing applicants to pursue more research opportunities, including remote collaborations.[35-37] Despite the drastic changes in the application process from 2019-20 to 2020-21 due to pandemic restrictions, this study highlights some applicant and SLOR characteristics that remain important in the Match process.

Study Limitations

Several limitations should be noted. First, the Match process is a complicated optimization of both applicant and program rank lists. There are many reasons why an applicant may not match, which are not quantified in this study, including NLOR comments, interview performance, and how an applicant structures their rank list. Despite these limitations, we felt that matching versus not matching was the most robust primary outcome for this study. Another limitation to note is the translatability of these results to future application cycles. Changes in applicant demographics were noted in the two application cycles studied, so it is anticipated that similar trends will continue in future cycles.

Notably, the Step 1 exam is now pass/fail. This eliminates Step 1 scores in prediction modeling for future application cycles. Step 2 CK scores were not included in our prediction modeling because the score was missing from many applications (27%). Moving forward, it is anticipated that Step 2 CK scores will replace Step 1 scores when evaluating applicants.[38,39] Another limitation is the possible misclassification of data in the study. This was most likely to occur during SLOR data collection, which was completed manually due to the lack of standardization in how the form is completed. Finally, we acknowledge the biases presented in this paper from converting race to a set of categorical variables and treating sex as a binary variable due to how the residency application structures demographic questions. Thus, nonbinary gender identities and multi-racial backgrounds are not included in the presented categories. Although this study did not identify evidence of racial bias in SLOR scores when comparing all applicants, we were not able to assess the extent of bias that may occur on a case-by-case basis. We also note that this study fails to identify other minority groups, such as first-generation students and LGBTQ+ applicants. LOR writers should continue to be cognizant of their own implicit biases both when completing SLORs and writing NLORs.

CONCLUSION

This study found that Question 6 of the ACAPS SLOR, "where would you rank this applicant. . .," correlated the most strongly with Match outcomes, with Step 1 scores and number of publications also significant when predicting Match outcomes. However, the substantial score inflation of remaining SLOR questions limits their use in evaluating applicants. Now that Step 1 is pass/fail and with increasing emphasis on research output, further work should be conducted to optimize the SLOR to better differentiate highly qualified applicants, while also remaining free of demographic biases.

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