Abstract

Background

The COVID-19 pandemic caused graduate medical education (GME) programs to pivot to virtual interviews (VIs) for recruitment and selection. This systematic review synthesizes the rapidly expanding evidence base on VIs, providing insights into preferred formats, strengths and weaknesses.

Methods

PubMed/MEDLINE, Scopus, ERIC, PsycINFO, MedEdPublish and Google Scholar were searched from January 1, 2012 to February 21, 2022. Two authors independently screened titles, abstracts, full texts, performed data extraction and assessed risk of bias using the Medical Education Research Quality Instrument. Findings were reported according to Best Evidence in Medical Education guidance.

Results

One hundred ten studies were included. The majority (97%) were from North America. Fourteen were conducted before COVID-19 and 96 during the pandemic. Studies involved both medical students applying to residencies (61%) and residents applying to fellowships (39%). Surgical specialties were more represented than other specialties. Applicants preferred VI days that lasted

4-6 hours, with 3-5 individual interviews (15-20 minutes each), with virtual tours and opportunities to connect with current faculty and trainees. Satisfaction with VIs was high, though both applicants and programs found VIs inferior to in-person interviews for assessing “fit”. Confidence in ranking applicants and programs was decreased. Stakeholders universally noted significant cost and time savings with VIs, as well as equity gains and reduced carbon footprint due to eliminating travel.

Conclusions

The use of VIs for GME recruitment and selection has accelerated rapidly. The findings of this review offer early insights that can guide future practice, policy, and research.

Practice Points

- Applicants prefer virtual interview (VI) days lasting 4-6 hours, with 3-5 individual interviews lasting 15-20 minutes each, virtual tours, and informal opportunities to interact with current faculty and trainees.
- VIs save time and money, enhance equity, and minimize carbon footprint, though ability to assess fit and confidence in decisions are diminished.
- A hybrid future (e.g., VIs followed by limited in-person second looks) may optimize VI strengths and weaknesses.

- Research to date is largely quantitative, based on perspectives. Future studies should be longitudinal and focused on outcomes after arrival in programs. In-depth qualitative studies are also needed.

Keywords

Best evidence medical education, postgraduate, medicine, virtual interviews, recruitment and selection, COVID-19

Introduction

The COVID-19 pandemic has impacted all aspects of medical education. Across the globe, social distancing requirements and travel restrictions caused institutions to pivot to virtual interviews (VIs) for postgraduate recruitment and selection (Haas et al. 2020; Sternberg et al. 2020). As the world seeks a new normal, graduate medical education (GME) training programs are now faced with the challenging decision of whether to continue with VIs, to revert back to in-person interviews (IPIs), or to pursue a hybrid approach. Ideally, the decision will be driven by the best evidence, considering both educational and pragmatic factors for trainees and training programs.

IPIs have typically included multiple 1:1 or group interviews in unstructured, semi-structured, or structured formats. In part due to this heterogeneity, the predictive value of IPIs on training outcomes has been mixed. In a review by Stephenson-Famy et al. (2015), 17 out of 34 studies did not predict performance in residency, a finding more prevalent in studies using unstructured interview formats. Six studies showed inconsistent ability to predict attrition from programs and only 11 showed positive correlations with clinical evaluations, examinations, or residency composite scores. Nevertheless, prior to the COVID-19 pandemic, the practice of IPIs for GME recruitment and selection was common.

IPIs and VIs allow applicants opportunities to explore the institution and geographic area where they might train, as well as to interact with faculty, current trainees and co-applicants. IPIs and

VIs also allow programs opportunities to assess applicants' communication, interpersonal skills, and commitment to the specialty. During IPIs and VIs, stakeholders attempt to glean information beyond what is already known from applications, websites and reputations to inform the creation of rank lists (Downard et al. 2015). Rank lists are then submitted to national organizations such as the National Residency Match Program (NRMP) and the San Francisco Match in the United States (US), or the Canadian Resident Matching Service (CaRMS) in Canada to generate a "match".

During both VIs and IPIs, prospective trainees and programs engage in bi-directional assessments of "fit" or compatibility. The construct of "fit" is rarely defined or explained (Nuthalapaty et al. 2004), yet all who are involved in recruitment and selection are familiar with this term. Finding a good "fit" is often conceived as optimally aligning applicant characteristics with training environments so trainees will thrive both academically and emotionally (Shappell & Schnapp 2019). When the construct of "fit" is used to align research interests or academic areas of focus, it can add value. However, "fit" can be inappropriately used to assign value to similarities that may result in discrimination due to implicit or explicit bias, especially when gender, race, ethnicity, socioeconomic status, or other factors are considered (Shappell & Schnapp 2019). Indeed, the construct of "fit", in either VIs or IPIs, must be approached with caution, especially if institutions aim to enhance equity, diversity and inclusion (EDI) through selection decisions (Gallegos et al 2022).

The pivot to VIs highlighted some longstanding concerns related to IPIs (Edje et al. 2013; Melendez et al. 2012). The costs associated with IPIs for applicants in some countries are exorbitant. A study in the US found that fourth-year medical students spend between $1,000-$13,225 on the interview process, depending on the number and geographic distribution of programs to which they apply (Benson et al. 2015; Association of American Medical Colleges 2021). Costs associated with travel can drive applicants to decline interviews, which can have negative impacts on equity and diversity (Fogel et al. 2018). Training programs also spend a significant amount of money on IPIs. Gardner et al. (2018) estimated that programs spend $18,648 +/- $13,383 per position being filled, diverting money from other educational priorities.

Educational and personal opportunity costs are also associated with interviews. Residency applicants often disengage from their medical school curriculum in their final year of training, devoting 1-3 months to traveling for IPIs. Fellowship applicants similarly step away from clinical duties, creating service coverage gaps, as well as missed opportunities for learning at a critical stage in training.

The environmental impact of IPIs has also been highlighted. The carbon footprint of thousands of medical students flying across the country is significant (Bernstein & Beshar 2021, Liang et al. 2021). In the US alone, CO_2 emissions for residency interviews are estimated at 51,665 metric tons, equivalent to the amount of CO_2 produced by 11,162 passenger cars in one year (Donahue et al. 2021).

To address the fiscal, equity, educational, personal and environmental costs associated with IPIs, some authors have suggested that VIs should become a permanent fixture in GME (Carpinito et al. 2021; Frishman & Alpert 2021). However, others are concerned about the limitations of VIs related to fit assessment, which may have long-term impacts on educational outcomes and attrition from programs. Others worry VIs are exacerbating existing problems with application inflation, increasing the evaluation burden for programs (Carmody et al. 2021). These concerns have resulted in a desire by some to fully revert to the pre-pandemic practice of IPIs.

Educational bodies are calling for deeper study to determine if and how VIs should persist (Coalition for Physician Accountability 2021). The aim of this systematic review is to synthesize published reports on virtual interviewing for recruitment and selection into GME training programs to guide future practice, policy and research.

Methods

This review addresses the following:

- What studies were conducted on VIs prior to COVID-19?

- How have VIs been implemented for recruitment and selection since the outset of COVID-19 (i.e., description or ‘what was done’)?
    - How were interviews conducted? What formats were used, and what best practices emerged?
- What outcomes of VIs were evaluated during COVID-19 (i.e., justification or ‘did it work’)?
    - To what extent were different stakeholders (e.g., applicants, program directors, and interviewers) satisfied with VIs?
    - What did various stakeholders think about their ability to assess “fit” virtually?
    - To what extent did VIs impact stakeholder perceptions of confidence in decisions (i.e., ranking?)
    - To what extent were match outcomes impacted by VIs?
    - What was the impact on cost for applicants and programs?
    - What were the effects of VIs as it relates to equity, diversity, and inclusion?
    - What was the impact of VIs on the environment (i.e., carbon-footprint)?
    - How did VIs affect application inflation, interview acceptances, and interview hoarding?
    - What did stakeholders describe as the relative strengths and weaknesses of VIs?

    - What preferences were reported by different stakeholders for VIs, IPIs, or hybrid interviews in the future?

- What lessons were learned that should inform future practice, and what future research is needed (i.e., implications or ‘what’s next’)?

A study protocol was uploaded to the Best Evidence in Medical Education (BEME) website. Reporting was aligned with BEME guidance (Hammick et al. 2010) and the STORIES statement (STructured apprOach to the Reporting In healthcare education of Evidence Synthesis) (Gordon and Gibbs 2014).

Search strategy

An electronic search was performed on February 21, 2022 in PubMed/MEDLINE, Scopus, ERIC and PsycINFO. We decided to be pragmatic and use a date range restriction of 2012-current, as modern video-conferencing platforms were not available prior to this time. MedEdPublish was searched from its inception. To ensure we did not miss relevant articles, the first 200 references in Google Scholar were also searched according to the procedures outlined by Bramer et al. (2017). The lead authors developed the search strategy (**Appendix 1)** in consultation with a librarian (JW). Deduplication was conducted (Bramer et al. 2016) and citations uploaded into Covidence, a data management software (Veritas Health Innovation, Melbourne, Australia).

Definitions

Graduate medical education refers to training programs for residents, fellows or other postgraduate learners who have obtained a primary qualification in medicine, who are undergoing additional training, enabling them to practice independently. *Virtual interviews* refer to synchronous interviews conducted via video- or web-conferencing platforms (Davis et al. 2020).

Study selection

Inclusion criteria:

- Studies of VIs for recruitment or selection into GME training programs (e.g., residencies, fellowships, or their international equivalents).
- Studies with residency or fellowship applicants, and/or program directors (PDs) or interviewers.
- Any empirical study design (i.e., quantitative, qualitative) with data, in any language.

Exclusion criteria:

- Opinion pieces, commentaries, editorials, perspectives, or calls for change without empirical data.
- Studies that exclusively described other aspects of remote recruitment and selection (e.g., websites, social media) and not VIs.

- Studies of asynchronous video interviews or recordings (e.g., standardized video interviews).
- Studies focused on medical school admissions.
- Studies in health professions other than medicine.
- Studies about VI perceptions prior to VIs actually taking place (i.e., where the respondents had no actual lived experience with VIs).

Two authors (MD and JS) independently screened all titles and abstracts against the inclusion and exclusion criteria. Full texts were independently reviewed by another pair of authors (DW and MD). Disputes at all stages were resolved through discussion and involvement of a third author (MG) when necessary, until full consensus was reached. Inter-rater reliability was calculated using Cohen's Kappa.

Data extraction

A data extraction form was developed and uploaded into Google Sheets. The extraction form was piloted on two studies by all authors to ensure a shared understanding of content to be extracted. The form was modified based on a team meeting. Then, pairs of authors were assigned a group of studies to independently extract. After achieving consensus, the author pairs uploaded their extracted data into the shared document. Key items extracted are listed in **Appendix 2.**

Quality assessments

To assess the quality of study methodology, we used the Medical Education Research Quality Instrument (MERSQI) (Reed et al. 2007; Cook and Reed 2015) for studies with predominantly quantitative data. We reported MERSQI domain scores to highlight areas of relative strengths and weaknesses, such that readers may evaluate the quality of the evidence using a constructivist/interpretivist approach. We used the Critical Appraisal Skills Program (CASP) systematic review checklist for qualitative studies.

Synthesis of evidence

A descriptive approach was used to summarize the data from the extraction form into text and a visual infographic. Meta-analysis was considered, however the participants, VI formats and survey instruments were too heterogeneous. The major outcomes, strengths and weaknesses, and preferences for the future were summarized to develop implications for practice, policy and future research.

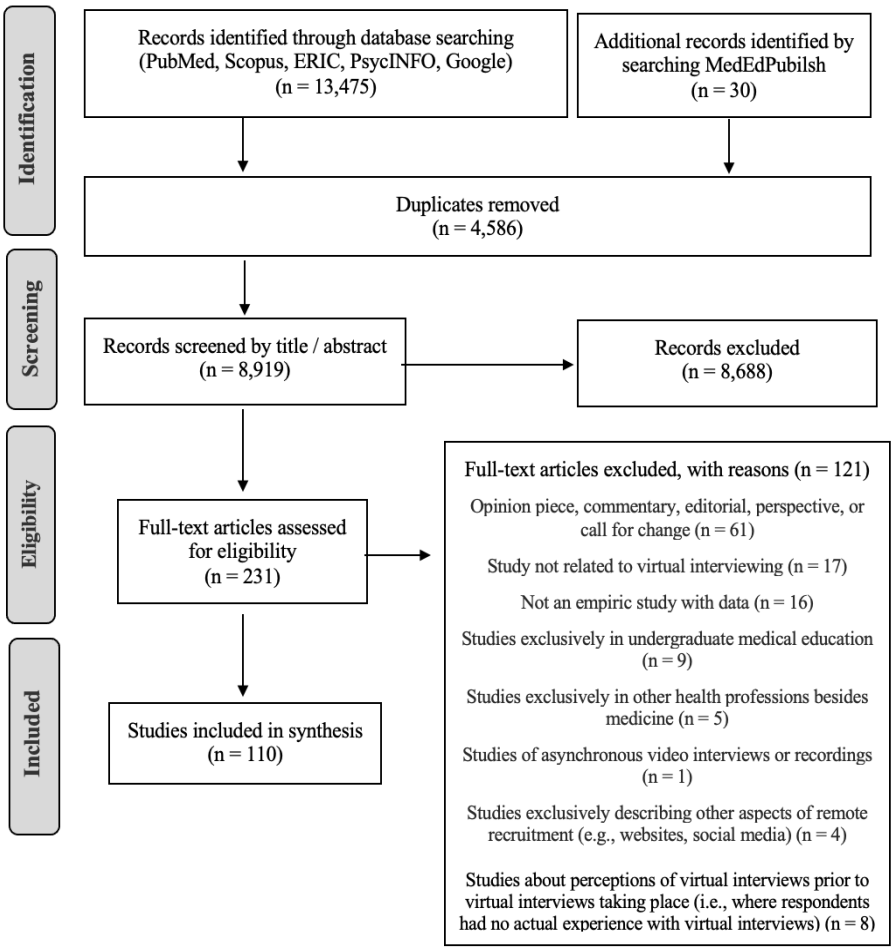
Results

Overview of studies included in the review

A total of 13,475 publications were identified through database searching and an additional 30 were identified in MedEdPublish. After duplicates were removed, 8,919 records remained, and

8,688 records were excluded after title and abstract screening. Inter-rater reliability was κ=0.88. Two hundred thirty-one records were moved to full text screening and excluded with reasons. The final data set contained 110 articles. Inter-rater reliability at this stage was κ=0.89. The PRISMA diagram is displayed in **Figure 1**.

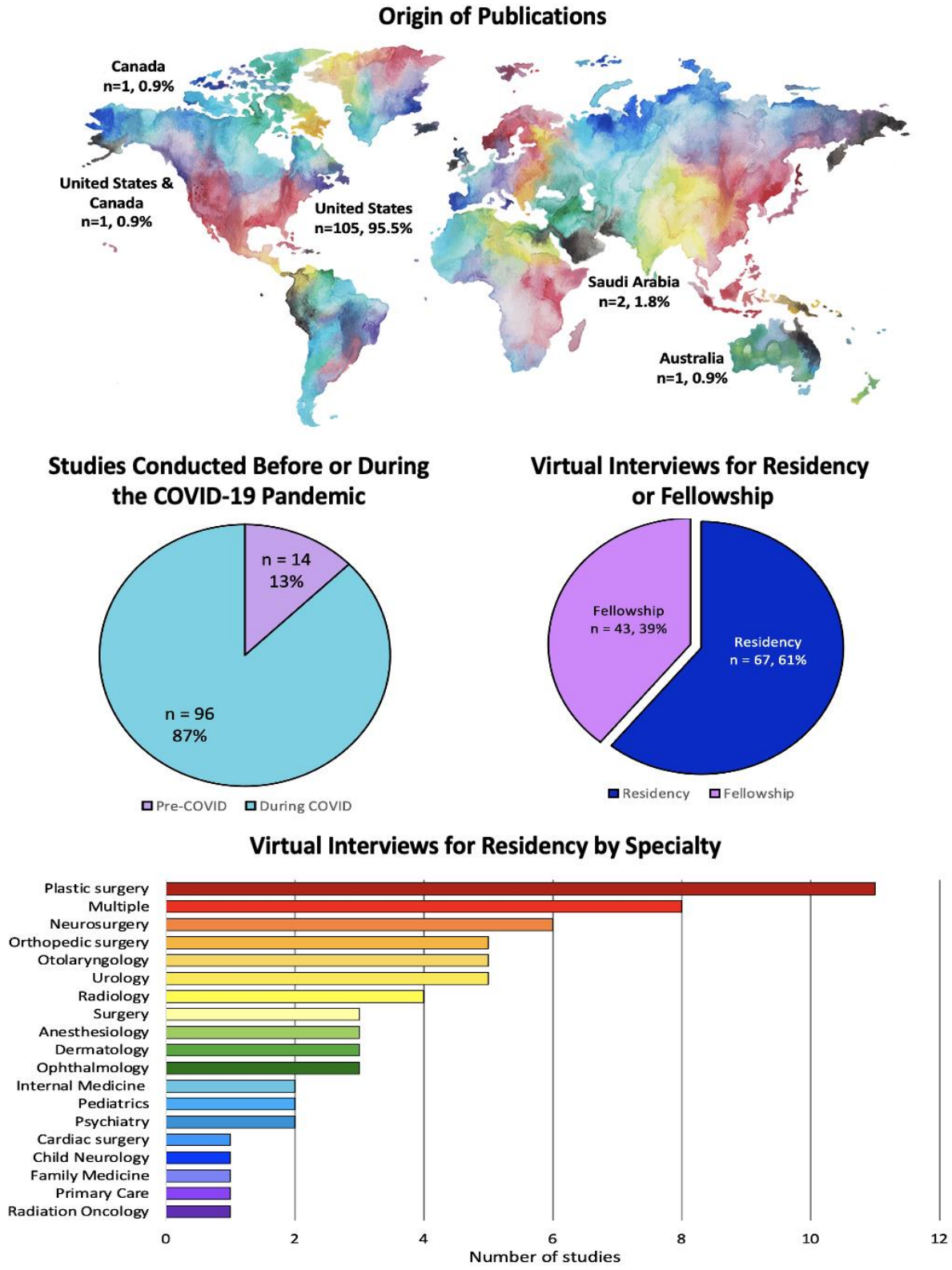
Figure 1: PRISMA flow diagram



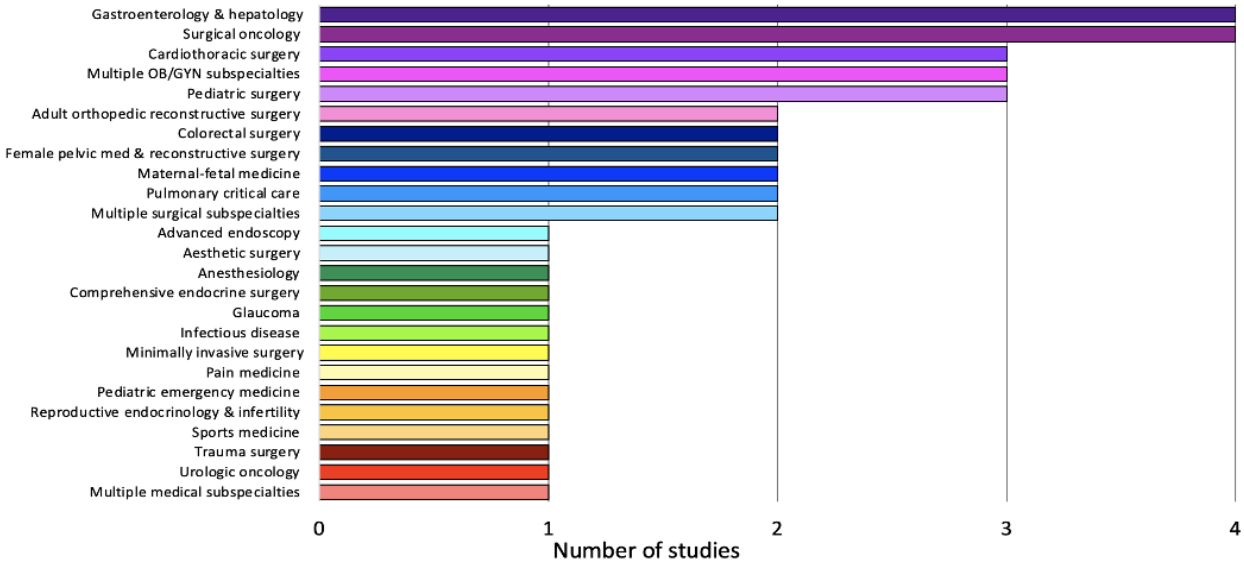
Most studies included in this review were from North America (n=107, 97.2%), with 105 from the US (95.4%), one from Canada (0.9%), and one jointly from the US and Canada (0.9%). Two were from Saudi Arabia (1.8%) and one from Australia (0.9%) (**Figure 2)**. Fourteen studies (13%) were conducted pre-COVID (**Appendix 3**), and 96 (87%) were conducted during the COVID-19 pandemic (**Appendix 4)**.

Sixty-seven studies (61%) involved medical students applying to residency programs, whereas 43 (39%) involved residents applying to fellowship programs (**Figure 2)**. The majority of studies focused on VIs for residency were from surgical specialties (n=42, 62%). Other specialties were less represented (n=17, 25%). However, due to the fact that a few of these papers (e.g., Simmons et al. (2022) in internal medicine and Frohna et al. (2021) in pediatrics) involved large numbers of program directors, a broad spectrum of GME perspectives was still represented in the data. Amongst the studies focused on VIs for fellowships, 30 (70%) were in surgical specialties and 13 (30%) in other specialties. Specialties in descending order are depicted in the VIs for residency and fellowship graphics in **Figure 2**.

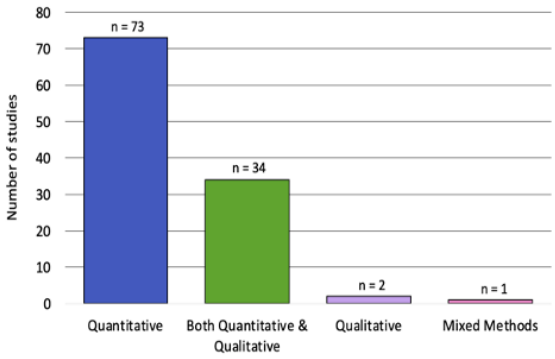
Figure 2: Infographic for Included Studies



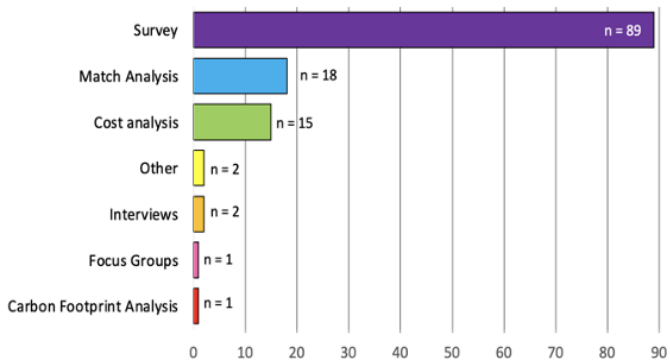
Virtual Interviews for Fellowship by Specialty



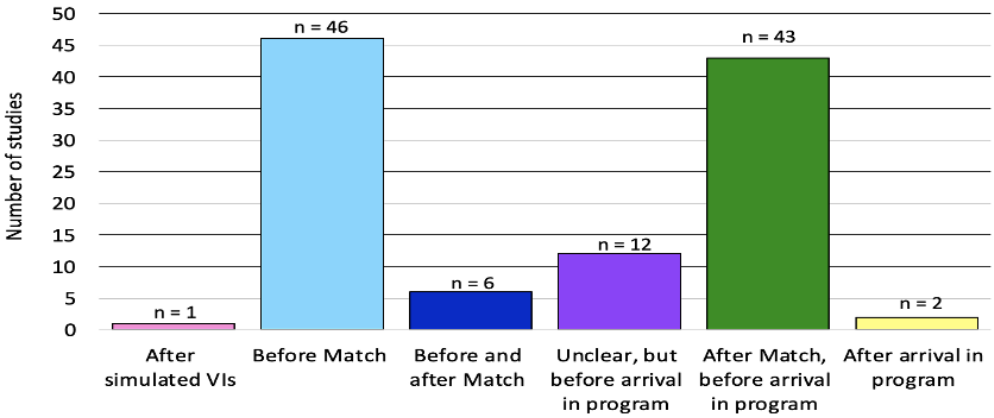
Type of Study



Study Methods



Timing of Data Collection for Virtual Interview Studies



In terms of study participants, the range of applicants (e.g., medical students or residents) in each study was 6 to 5,258 with a median of 71, and the range of interviewers (e.g., PDs, faculty, current chief residents, fellows, and program coordinators) was 3 to 365 with a median of 47. The majority of studies were exclusively quantitative (n=73, 66.4%), some were both quantitative and qualitative (n=34, 30.9%), two (1.8%) were exclusively qualitative, and only one (0.9%) was a true mixed methods study incorporating more than one study method (survey and focus groups). Most studies were surveys (n=89), containing both closed and open-ended questions. There were also several studies that used match analyses (n=18) to explore the geographic distribution of the match, as well as cost analyses (n=15) to examine costs for programs and applicants. Only two studies used interviews and one used focus groups. One study involved a carbon footprint analysis and two used other methodologies. Some studies included more than one study method (**Figure 2, Appendix 3, Appendix 4**).

In terms of timing of data collection, one study was after simulated VIs (0.9%), 46 studies were after VIs but before the match (42%), 43 were after the match but before arrival in the program (39.1%), and six were before and after (i.e., spanning) the match (5.5%). In 12 studies, the timing related to the match was unclear (10.9%). Almost all studies (n=108, 98.2%) were conducted before applicants arrived in their respective residency or fellowship programs. Only two studies (1.8%) were conducted after applicants arrived in their respective programs, such that on-the-ground experience informed perspectives (**Figure 2, Appendix 3, Appendix 4**).

Virtual interview studies conducted prior to the COVID-19 pandemic

Fourteen papers investigated VIs prior to the COVID-19 pandemic (**Figure 2, Appendix 3**). All were single institution studies in the US exploring the feasibility of VIs. Eight studies attempted to create direct comparisons between VIs and IPIs (Arthur et al. 2021; Davis et. al 2021; Healy et al. 2017; Melendez et al. 2012; Pasadhika et al. 2012; Pathak et al. 2021; Vadi et al. 2016; Williams et al. 2015). In these studies, applicants were either given a choice of interview modality or assigned randomly. Scheduling conflicts, travel constraints, and cost savings were the most common self-reported considerations for selecting VIs. Four papers used VIs as a screening tool prior to offering IPIs (Chandler et al. 2019; Edje et al. 2013; McAteer et al. 2020; Miotto et al. 2018). These papers found that using VIs for screening was time efficient and cost effective for applicants and programs. Two studies were randomized control trials that compared VIs to IPIs. Melendez et al. (2012) randomly selected applicants to participate in VIs or IPIs and compared performance on standardized interview questions. They found no differences in objective interview performance between the two formats. Shah et al. (2012) re-interviewed applicants with the opposite method in a cross-over design. In this study, preliminary and final rank lists showed a similar distribution for VI and IPI applicants, suggesting interview modality did not bias faculty ranking. Very few other studies assessed objective outcomes, but those that did showed no difference in programs' ranking of applicants or match outcomes based on interview modality (Arthur et al. 2021; Pasadhika et al. 2012; Valdi et al. 2016). However, one study reported VIs had a negative impact on applicants' ranking of a program (Healy et al. 2017).

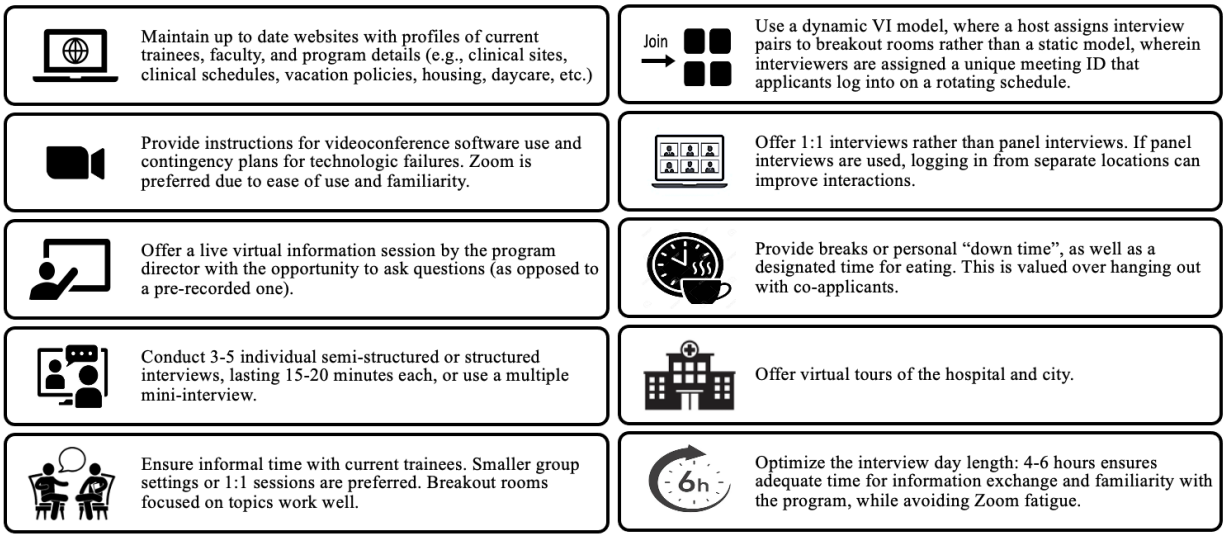
Overall, the stakeholders surveyed in these small studies were satisfied with VIs. Many studies reported significant cost benefits and time saved, with fewer days away from training and clinical responsibilities. However, both applicants and PDs were concerned about their ability to assess fit and culture. Most were uncomfortable making VIs the only means of interviewing in the future, though they embraced offering VIs as a choice or as a screening tool, prior to offering IPIs to a more select group of applicants. In summary, these early studies demonstrated the feasibility of VIs, while highlighting some of their strengths and weaknesses, as well as stakeholder hesitancy to fully replace IPIs.

Formats used and emerging best practices for virtual interviews during the pandemic

When the COVID-19 pandemic emerged in early 2020, a complete switch to VIs was necessitated. Most programs adopted Zoom as their VI platform. Other, less commonly used platforms included FaceTime, WebEx, Microsoft Teams, Bluejeans, Skype, Google Hangout, Thalamus, Vidrecruiter and E-Posterboards. Many programs offered informal social hours the night before in lieu of the in-person dinners held pre-COVID. The formal interview day typically began with a program overview (either live or pre-recorded) by the PD. This was followed by one or more VIs with faculty, program leadership and current trainees. Most programs used 1:1 interviews, though some used panel interviews. Panels consisted of two or more interviewers together in one room on a shared screen or logged in from separate locations interviewing one or more applicants. Interviews ranged from 10-60 minutes, with 15-20 minutes being the most common. A few studies (n=7) described the use of structured interview formats (McAteer et al. 2020; Melendez et al. 2012; Pathak et al. 2021), or multiple mini-interviews (MMIs) (Lund et al.

2021; Sabesan et al. 2022; Singh et al. 2021; Vasanthan et al. 2022), though the majority used semi-structured or unstructured formats. MMIs were typically coordinated by a host. Applicants rotated through 5-8 stations lasting 4-8 minutes each. Scenarios were presented, and applicants were given a few minutes to read the scenario then complete an assessment. Lund et al. (2021) went beyond interviewing to include assessment of technical and non-technical skills, combining a synchronous MMI with an asynchronous video review of applicants performing knot-tying and suturing tasks using a practice kit mailed to them by the program. Vasanthan et al. (2022) employed a virtual MMI, a written situational judgment test, and a panel interview. Some programs included breaks between interviews, either for "down time" or to allow applicants to talk with each other, current trainees, or faculty. Many programs offered a virtual tour of the clinical training sites and local community, though this practice was more common in larger residency programs than small fellowships. Several best practices based on applicant feedback are summarized in **Figure 3**.

Figure 3: Best Practices for VI Formats Based on Applicant Feedback



Satisfaction with virtual interviews during the COVID-19 pandemic

Forty-five out of the 96 studies conducted during the pandemic reported on satisfaction with VIs (**Appendix 4**). Applicant satisfaction was generally high with most studies reporting rates from 85% to 100%, with mean satisfaction scores of 8.6-10/10 (normalized to a 10-point scale). Among interviewers, satisfaction was more mixed, ranging from 43% to 100%, though mean satisfaction scores were still high at 8.3-10/10 (normalized to a 10-point scale). Despite overall high satisfaction, many studies reported that satisfaction was generally lower than with IPIs (e.g., Asad et al. 2022; Brueggeman et al. 2021; Elmorsi et al. 2021; Vasanthan et al. 2021), especially when both formats were experienced during the same interview season (Gorgy et al. 2022; Gupta et al. 2021). In some studies, however, stakeholders clearly preferred VIs (e.g., Temsah et al. 2021).

VIs allowed for high quality interactions amongst applicants and faculty (Kraft et al. 2022), however, opportunities for networking with co-applicants were more limited (Chen et al. 2021). VIs were organized (Temsah et al. 2021; Aljamaan et al. 2021) and stakeholders reported they could concentrate, stay engaged, and connect well in most cases (Yee et al. 2021). Technology was easy to use and technology failures were rare (Chandler et al. 2019; Hariton et al. 2021, Hill et al. 2021; Vining et al. 2020). VIs also scored highly on picture and voice quality, as well as time and place flexibility (Davis et al. 2021; Hill et al. 2021; Taylor, Freeman et al. 2021; Temsah et al. 2021). Interviewing in familiar environments also minimized the stress of travel and enhanced wellness (Moran et al. 2021).

Assessment of "fit" through virtual interviews during the COVID-19 pandemic

Sixty-one out of the 96 studies conducted during the COVID-19 pandemic queried stakeholders about their ability to assess one or more aspects of "fit" through VIs (**Appendix 4**). Overall, both applicants and PDs reported VIs made it more challenging to assess fit and VIs were inferior to IPIs in this regard (e.g., DiGiusto et al. 2021, Elmorsi et al. 2021; Frohna et al. 2021; Grova et al. 2021). However, these findings were not universal (e.g., Hariton et al. 2021; Huppert et al. 2021; Jones et al. 2022). Fit was rarely explicitly defined in the included studies and due to the variety of ways fit was conceptualized, calculating a mean score was not attempted.

PDs and interviewers noted certain aspects of "fit" were easier to assess virtually than others, though opinions were inconsistent across studies. For instance, some PDs found VIs sufficiently allowed for assessments of applicants' interpersonal and communication skills (Sarac et al. 2021), competence (Mohanty et al. 2021), and competitiveness for the program (Brueggeman et al. 2021). Other PDs found VIs inadequate to assess social skills, communication skills, clinical skills, surgical skills, and ability to function as a resident (Asaad et al. 2022; Brueggeman et al. 2021; Elmorsi et al. 2021; Rajesh et al. 2021). Some PDs also opined that it was difficult to gauge commitment to the specialty and genuine interest in the program virtually (Ho et al. 2021; Simmons et al. 2022). In the absence of having a good handle on fit, some programs relied more heavily on other aspects of the application, such as standardized test scores, letters of recommendation, and medical school reputation for ranking (Han et al. 2022).

When reflecting on their ability to convey their program's strengths and unique features, many PDs found the virtual environment more difficult (e.g., D'Angelo JD et al. 2021; Ream & Thompson-Stone 2022; Rhoades et al. 2021; Robinson et al. 2021; Rockney et al. 2021). While PDs reported they could adequately highlight their curriculum, clinical training, and research opportunities, they struggled to showcase their facilities, city, and interactions between current residents, faculty, and staff. These perceptions were shared by applicants, who could adequately assess clinical, research, and mentorship opportunities, rotation schedules, program salary, benefits, and academic prestige (e.g., Brueggeman et al. 2021; DiGiusto et al. 2021; Kamboj, Raffals et al. 2021), but struggled to get a feel for diversity of the patient population, quality of the facilities, location, city, and program culture through VIs (e.g., Barnes et al. 2021; Estevez et al. 2022; Majumder et al. 2020; Taparra et al. 2022.) Specifically, opportunities to detect some nuances or intangibles, often observed during casual in-person interactions, were missed in VIs, such as perceptions of resident camaraderie, resident-faculty and faculty-faculty relationships, support, morale, and well-being in programs. Interviewers and PDs likewise noted their inability to observe applicants casually interacting with current trainees, faculty, and staff, which left gaps in their impressions. Suggestions for ways to improve fit assessment for future VI cycles included creating more opportunities for informal interactions amongst applicants, current trainees, staff, and faculty, and enhancing virtual tours of the facilities and city.

Confidence in decisions after virtual interviews and impact on ranking

Fourteen out of the 96 studies addressed confidence in decisions and impact on ranking after VIs (**Appendix 4**). PDs and interviewers reported they were comfortable ranking applicants, with 50-86% of respondents across studies agreeing or strongly agreeing. Applicants also felt confident in creating rank lists, with 60-100% reporting they were comfortable or very comfortable. However, both applicants and interviewers generally felt less confident in their decisions based on VIs than IPIs. Chen et al. (2022) reported that the primary factors decreasing applicant confidence were diminished ability to assess fit and lack of away rotations. Barnes et al. (2021) noted that while it was easy to get a sense of definite "noes", it was much harder to get a deeper sense of programs to allow for differentiation, complicating decision making. Anteby et al. (2022) highlighted how VIs resulted in "data deficiency", and the loss of subjective "feel" resulting in programs "blending together" as applicants attempted to create their rank lists. Some applicants noted that more detailed notetaking was required during VIs to help mitigate these issues.

In terms of factors perceived to influence ranking during VIs versus IPIs, some studies reported a shift in emphasis, whereas others reported no change. Jones et al. (2022) found that the top three criteria (i.e., board scores, letters of reference, and the medical student performance evaluation) used by programs to rank candidates remained the same. Kamel et al. (2021) identified similar top factors, but found decreased emphasis on away rotations and grades, and increased emphasis on personal statements. No differences were observed in the perceived importance of interviews

on ranking when comparing virtual to in-person formats (Ream & Thompson-Stone 2022, Ho et al 2021).

One study reported that 40% of programs were concerned that VIs would affect the quality of applicants matched to their program (Clark et al, 2022). However, several studies showed no difference in programs' rank lists, and the applicants matched were the same or better than in prior years (Moran et al 2021, Simmons et al 2022, Romano et al 2022). Interestingly, among PDs who reported less favorable matches, 86% attributed the outcome to virtual recruitment, whereas only 28% of those with more favorable matches attributed the outcome to virtual recruitment (Simmons et al 2022).

Five studies showed that interview format did not influence applicants' rank lists (Geary et al. 2022; Hollins et al. 2021; Huppert et al. 2021; Moran et al. 2021; Robinson et al. 2021). Two studies reported a negative impact of VIs on ranking: Lewit & Gosain (2021) showed that among the top five programs on applicants' rank lists, the majority were at programs where they interviewed in-person; Yong et al. (2021) found VIs negatively impacted ranking of programs in 38% of cases. Of note, all of these studies were conducted during the hybrid interview season of 2020, wherein some interviews were conducted in-person and some virtually.

Impact of virtual recruitment on match outcomes

Sixteen papers examined the impact of VIs and canceled away rotations (i.e., rotations outside one's home institution) on match outcomes (**Appendix 4**). These studies exclusively focused on competitive surgical specialties in the US.

Based on objective match data, applicants from top 40 schools were more likely to match overall and to match at top 40 programs compared with prior years (Egan et al. 2022). International medical graduates were less likely to match (Jimenez et al. 2021). Studies varied on whether VIs impacted Doctor of Osteopathy (DO) match rates (Gabrielson et al 2021, Jimenez et al 2021).

Home match rates, defined as a match at the program affiliated with an applicant's medical school, increased in 12 studies - seven in plastic surgery (Asadourian et al. 2021; Egan et al. 2022; Faletsky et al. 2021A; Faletsky et al. 2021B; Hollins et al. 2021; Om & Losken 2021; Whisonant et al. 2021), two in dermatology (Abdelwahab et al. 2021; Ederle et al. 2021), two in otolaryngology (Faletsky et al. 2021A; Mulcahy et al. 2022), and one in ophthalmology (Rasendran et al. 2021). Study authors speculated that the loss of personal connections and ability to assess fit caused programs and applicants to select those with whom they were more familiar. Home match rates were unchanged in urology and neurosurgery (Faletsky et al. 2021A; Gabrielson et al. 2021). The authors speculated this may be the result of the relatively high proportions of international medical graduates and non-senior graduates in these specialties who complete research years at other programs, enhancing longitudinal fit assessment.

Cost and time savings with virtual interviews

Thirty-eight studies conducted objective cost analyses or asked subjective questions about cost and time savings within larger surveys (**Appendix 4**). VIs unequivocally saved applicants money. Across multiple US studies, individual applicants saved five thousand dollars in travel costs on average, with some saving more than $10,000. Applicants outside the US also saw cost-savings (Temsah et al. 2021); however, smaller country size and different match procedures meant the scale of savings was more modest. Some applicants reported spending money on technology, lighting, and clothing, though the amounts were generally small. Application fees were the main costs for applicants in the VI season. The amount applicants spent on application fees held steady (Lenze et al. 2022) or increased slightly (Moran et al. 2021), suggesting variability across specialties in application behaviors caused by VIs.

VIs also saved applicants time. Across studies, applicants reported spending less time away from their medical school curriculum (for residency applicants) and clinical duties (for fellowship applicants) (e.g., Gaigbe-Togbe et al. 2021; Geary et al. 2022; Kraft et al. 2022). Those with families and pets found it easier to meet obligations. Due to minimized travel and social events, interviews could be more efficiently scheduled (e.g., Frohna et al. 2021), with some applicants reporting interviewing at geographically distant places on successive or even the same day (e.g., Shah T. et al. 2022). Since historically students often declined interviews based on cost, multiple authors commented on the increased equity brought about by VIs for those of lower socioeconomic status and those underrepresented in medicine (URiM).

VIs also saved programs time and money, though some potential savings (e.g., reduced faculty time away from clinical care) were not easily "quantifiable". In one study, 83% of PDs reported spending less money on VIs (Brueggeman et al. 2021). Another study reported that PDs spent less than 10% of what they had on IPIs (Hariton et al. 2021). While many PDs spent money updating their technology and websites to support VIs, these investments were minor and offset by the significant cost savings related to hosting. Many programs reduced the length of VI days. In some programs, this time reduction was partially offset by offering more interviews. However, when comparing total person hours (days x faculty x hours), the requirements for VIs were less than for IPIs (Rosenbluth et al. 2022). PDs reported that faculty were more likely to participate in VIs due to the reduced time commitment, the ability to participate from anywhere, and the possibility of continuing some clinical duties (Simmons et al. 2022).

Impact of virtual interviews on the environment

Two studies reported on the environmental implications of VIs. Moran et al. (2021) surveyed radiology applicants and PDs, with most respondents feeling that VIs are an important mechanism to reduce climate change. Gallo et al. (2021) sought to quantify the impact and estimated that VIs reduced the carbon footprint by 6.26 metric tons per applicant, corresponding to 0.49 tons of CO_2 saved per interview. When applied to all applicants in the study, that resulted in a reduction of 3,011 metric tons of CO_2.

Application inflation / control measures / interview hoarding

Multiple studies reported objective evidence of application inflation, with programs receiving more applications per position than in prior years. When applicants were asked about the number of programs they applied to, only one-third believed they applied to "too many" programs. In contrast, 72% of PDs believed they received "too many" applications (Venincasa et al. 2022). Forty-seven to sixty-three percent of applicants interviewed at more programs with VIs than they would have in-person (DiGiusto et al. 2021; Hariton et al. 2021; Robinson et al. 2021; Yong et al. 2021). This led to a mean increase of 2.5 additional interviews per applicant (Robinson et al. 2021). Chen et al. (2022) reported that 73.9% of applicants felt VIs allowed students to "hoard" interviews or hold onto more than they needed. Historically, time and money limited interview hoarding, but during VIs, applicants tended not to decline invitations. Brueggeman et al. (2021) reported that top candidates were more likely to have more interviews, which led to lower tier applicants having fewer opportunities to interview. Romano et al. (2022) reported a decrease in the number of applicants interviewed off the waitlist compared with prior years. Simmons et al. (2022) reported that although PDs increased the number of interviews offered, the number of applicants declining or canceling interviews was so low, these efforts failed to improve interview availability for lower tier applicants.

Opinions were mixed regarding limiting applications, with 39% to 57% of applicants and 42% to 68% of programs favoring application limits (Chen et al. 2022; Kamel et al. 2021; Moran et al. 2021; Venincasa et al. 2022). Opinions on limiting interviews were also mixed, with 37.7% to 64.8% of applicants and 61% of programs favoring interview limits (Chen et al. 2022; Romano

et al. 2022; Snyder et al. 2021; Venincasa et al. 2022). Most applicants (71.3% to 88%) and programs (76% to 80%) favored a standardized interview release date and 68.9% of applicants favored a central scheduling portal (Moran et al. 2021; Snyder et al. 2021). Token or preference signaling was supported by 57.4% to 60% of applicants and 55% to 73% of programs (Chen et al. 2022; Kamel et al. 2021; Moran et al. 2021; Romano et al. 2022; Simmons et al. 2022; Snyder et al. 2021).

Effect of virtual interviews on equity, diversity and inclusion

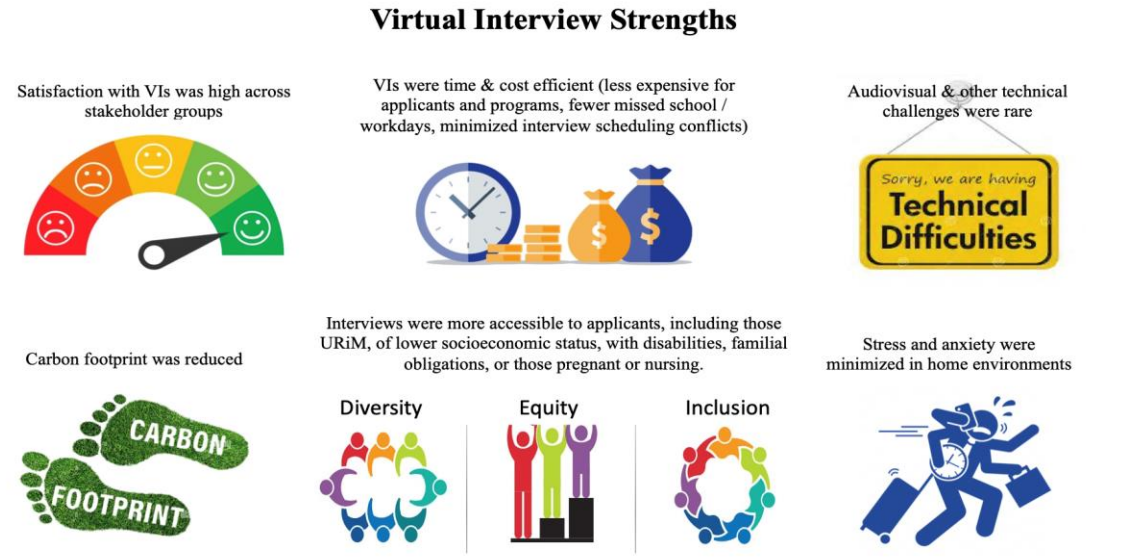
Multiple studies highlighted the reduced costs and time away associated with VIs as enhancers of equity. The elimination of travel made interviews more accessible for certain applicants, particularly those URiM, of lower socioeconomic status, with disabilities, familial obligations, or those pregnant or nursing (e.g., Chen et al. 2022; Frohna et al. 2021, Moran et al. 2021). Despite the reduction in barriers, the percentage of URiMs in the applicant pool, URiMs invited for interviews, and URiMs attending interviews did not change at one orthopedic residency program (Caldwell & Lawler 2021). Studies noted that it was more difficult for URiM applicants to assess fit or belonging and get a sense of support for diversity (e.g., Huppert et al. 2021). Holistic review has historically been shown to enhance EDI, and while one study (Frohna et al. 2021) noted that VIs may encourage holistic review, the application inflation documented across multiple studies may reduce programs' capacity to consider the "whole" applicant and cause programs to return to disproportionate weighting of certain factors (e.g., grades and exam scores). In a few studies, stakeholders raised concerns about digital inequities and the potential to introduce bias (e.g., Estevez et al. 2022). Proposed solutions to mitigate bias include

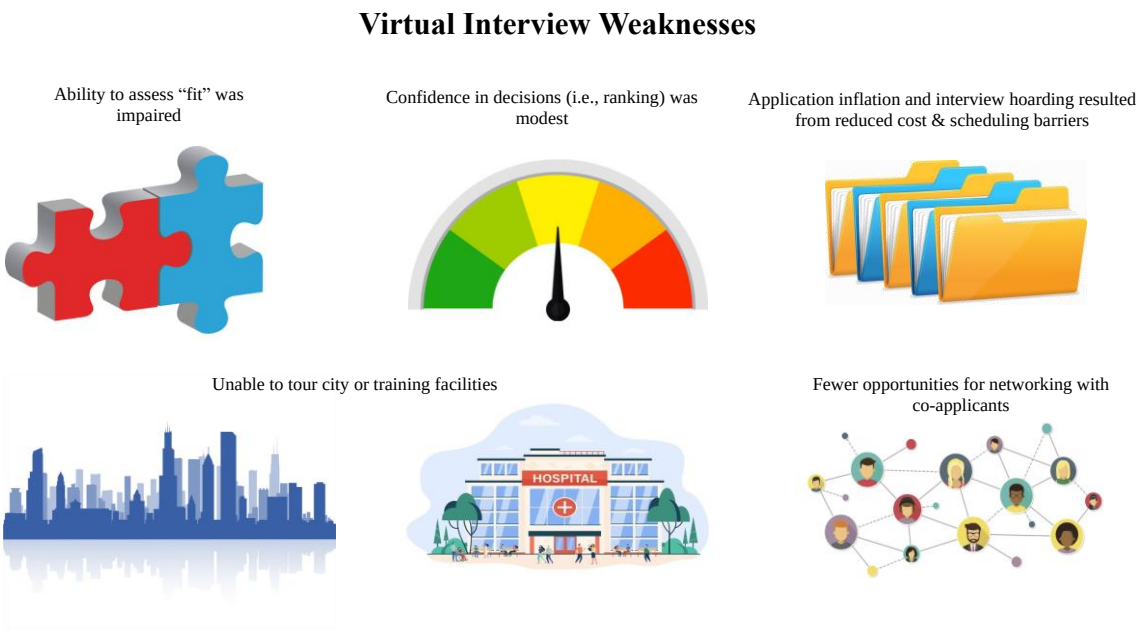
institutionally provided space, equipment, and WiFi connections, faculty training, and the use of standard virtual backgrounds. When considering preferences for the future, several studies noted that different hybrid models may introduce inequities (Allam et al. 2022; Clark et al. 2022; Hill et al. 2021; Kamboj, Chandrasekhara et al. 2021; Kamboj, Raffals et al. 2021, Yong et al. 2021). For instance, if applicants are offered a choice of VIs or IPIs, applicants choosing VIs may be perceived as "less interested", potentially impacting ranking, regardless of the applicant's rationale for choosing a particular interview format. If in-person second looks are offered, to ensure equity, these should be limited in number (to contain cost) and conducted after program rank list submission, so as not to bias outcomes.

Strengths and weaknesses of virtual interviews

The strengths and weaknesses of VIs have been enumerated above and are summarized in **Figure 4,** and **Appendices 3 and 4**.

Figure 4: Strengths and Weaknesses of Virtual Interviews





Preferences to Inform the Future

Preferences for VIs or IPIs in the future were nearly evenly split, and many preferred a hybrid model to optimize the best of both worlds. Several different hybrid models were proposed, including: 1) providing applicants a choice between VIs or IPIs; 2) using VIs for screening of all or some applicants, followed by a more limited number of IPIs; and 3) offering optional second looks at a limited or unlimited number of programs, before or after rank lists are submitted by PDs, to facilitate tours and in-person meetings with trainees and / or faculty to enhance "fit" assessment (e.g., Arthur et al. 2021; Geary et al. 2022; Kamboj, Chandrasekhara et al. 2021; Kraft et al. 2022). An interesting twist on the third option suggested in one paper was to allow PDs an option to move an applicant to "do not rank" in the event a concern was identified during the in-person visit (Gabrielson et al. 2021). Concerns about various hybrid options surfaced in some studies. If applicants are provided a choice, faculty may be favorably biased towards those that choose an IPI (Kamboj, Chandrasekhara et al. 2021). If screening VIs are used by all programs, ease of scheduling, time savings, and cost reductions will be diminished. If in-person second looks are offered, to be truly "optional", they must be conducted after program rank lists are submitted. Moreover, to make them feasible in a short time frame, they would need to be restricted in number (Gabrielson et al. 2021).

Quality Assessments / Risk of Bias

Based on the MERSQI scores, risk of bias in study methodology was low to moderate across all categories. Potential biases pertained to the predominant descriptive survey designs, representativeness of the samples (i.e., single institution), low response rates, and suboptimal

validity evidence of the survey instruments. An analysis of the MERSQI categories highlighted patterns in the data (**Table 1, Appendices 3 and 4**).

Table 1: MERSQI categories, response options, scoring and number of studies

Category / Response options	MERSQI Score	Number of Studies	Percent (n/108)
Study Design (SD)			
Single group cross-sectional or post-test only	1	86	80%
Single group pretest and posttest	1.5	1	1%
Nonrandomized, 2 group	2	19	17%
Randomized control trial	3	2	2%
Sampling Institutions (SI)			
1 institution	0.5	45	42%
2 institutions	1.0	0	0
3 or more institutions	1.5	63	58%
Sampling Response Rate (SRR)			
Not applicable	NA	1	1%
< 50% or not described	0.5	63	58%
50 – 74%	1	16	15%
≥ 75%	1.5	28	26%
Type of Data (D)			
Not described	0	2	2%
Assessment by study participant	1	89	82%
Objective	3	17	16%
Validity Evidence for Evaluation Instrument (VE)			
Not applicable	NA	18	16%
Not described	0	57	53%
Content	1	31	29%
Internal Structure	2	2	2%
Data Analysis Sophistication (DAS)			
Not described	0	4	4%
Descriptive analysis only	1	42	39%
Beyond descriptive analysis	2	62	57%
Data Analysis Appropriate (DAA)			
Not described	0	4	4%
Descriptive analysis only	1	104	96%
Outcome (O)			
Satisfaction, attitudes, perceptions	1	88	81%
Knowledge, skills	1.5	1	1%
Behaviors	2	15	14%
Patient / health care outcome	3	4	4%

If applicable to the study but not described a score of 0 was assigned. The Medical Education Research Quality Instrument (MERSQI) was not applied to the two qualitative studies in our sample, so the denominator for the percent is n=108. NA = not applicable. (Adapted from Reed et al. 2007).

Forty-five studies (42%) sampled one institution, whereas the remaining studies sampled three or more institutions. Slightly fewer than half of the included studies (41%) had sampling response

rates greater than 50%. Most studies did not provide validity evidence for the evaluation instruments (i.e., the surveys), compromising interpretation of the overall results. Thirty-one studies (29%) provided evidence of content validity (e.g., expert review, iterative processes for development, pre-testing or cognitive interviews used in survey item development). Only two studies (2%) provided internal structure validity evidence (e.g., Cronbach's alpha test of reliability). Outcomes in 88 studies (81%) described satisfaction/attitudes/perceptions. One study (1%) included results related to knowledge/skills, 15 studies (14%) described changes in behaviors (e.g., match analyses), four studies (4%) reported on program impact (e.g., objective cost analyses). Two studies with qualitative analyses were suboptimal in study design and methods, though one mixed methods study (Sabesan et al. 2022) was deemed to be rigorous according to the CASP checklist.

Discussion

A myriad of adaptations in medical education have occurred in response to COVID-19. The use of VIs for GME recruitment and selection accelerated overnight, and the findings of this review suggest VIs will persist in some form. Prior to the COVID-19 pandemic, a mere handful of studies on VIs had been conducted, and while they demonstrated feasibility, most envisioned the future use of VIs on a small scale, as a screening tool, or as a choice for a limited number of candidates with special circumstances. The mass adoption of VIs caused by the pandemic has opened new possibilities, and the rapid proliferation of work on this topic has offered insights into preferred formats for VIs, as well as strengths and weaknesses.

Overall, satisfaction with VIs was high for both applicants and programs, a commendable outcome given the rapid and unforeseen pivot necessitated by the pandemic. Although bidirectional assessment of 'fit' was perceived as particularly challenging and negatively impacted confidence in ranking, most applicants and programs support the continued use of VIs in the future due to the significant cost and time savings, the potential to enhance equity and the positive environmental impact. While several studies described a preference for a hybrid model in the future, the optimal design must still be delineated to ensure inequities are not recreated. Application inflation and interview hoarding emerged as concerns to be addressed.

Best practices for virtual interview implementation

Figure 3 summarizes best practices for VI formats based on applicant perceptions and may be used by programs to guide the next cycle. Programs should invest in their websites to facilitate virtual transmission of key information. The ideal VI day is limited in duration (4-6 hours long) and consists of a live program overview with an opportunity for questions, 3-5 individual interviews lasting 15-20 minutes each, opportunities for informal interactions with current faculty and trainees, virtual tours of the facilities / city and built-in down time. Surprisingly, standardized interview formats such as MMIs were rare, despite evidence showing higher validity and reliability evidence than unstructured formats (Ali et al. 2019; Jerant et al. 2017). Thus, broader adoption of virtual MMIs may be warranted in GME selection in the future.

Impact of virtual interviews on perceived assessment of fit

Fit is a difficult concept to define, making it challenging to assess. However, fit is one of the most important factors taken into consideration by applicants and faculty in ranking and selection decisions (Nuthalapaty et al. 2004, Schenker et al. 2016, Yaeger et al. 2021). This was reflected in the volume of studies attempting to understand how VIs impacted fit assessments.

Recently, there has been increased attention to how fit is defined and used (Bowe 2020; Shappell and Schnapp 2019). When ill-defined, fit has the potential to reinforce unconscious biases, but with intentional specificity, a focus on fit may help improve diversity efforts (Barceló et al. 2021; Coplan and Evans 2021; Marbin et al. 2021). With more training programs adopting holistic review practices, fit is likely to receive increased emphasis in future selection processes, as programs attempt to align their missions and goals with expanded selection criteria, to match workforce development to strategic priorities (Addams et al. 2010). Unfortunately, in the studies in this review, papers rarely defined "fit" and the term was often used colloquially, risking the introduction of bias. Any conclusions about the inability of VIs to assess fit, should be viewed through this lens.

One critical finding of this review was that 98% of studies were conducted prior to applicants arriving in their respective programs. Thus, the strong opinions expressed by various stakeholders about fit were not yet informed by applicants' and programs' perceptions of each other after arrival. As such, the concerns expressed to date largely represent challenges with

“first impressions” and may not reflect more informed feelings about fit and belonging, shaped over time. Longitudinal studies exploring fit will be critical, as first impressions may be powerful but misleading. Studies that explore whether challenges assessing fit translate practically into training outcomes or attrition from programs will also be imperative.

Given that challenges with fit are one of the strongest arguments put forth in the primary studies for returning to IPIs after the pandemic, consideration may be given to how to optimize fit assessment in the virtual environment. Several studies offered practical suggestions focused on creating more opportunities for casual interactions amongst applicants, current trainees, staff and faculty, and improving virtual visits of training facilities and the local community. Multiple studies proposed hybrid formats including limited in-person second looks, to allow for better fit assessment, while continuing to contain costs and enhance equity. Strategies to improve fit assessment may increase stakeholder confidence in decisions when determining rank lists in future cycles. Of course, caution should be used to ensure the focus is on how programs and trainees might academically “add value” to one another, while avoiding the pitfalls of implicit and explicit bias.

Impact on geographic diversity

Of studies evaluating the impact of VIs on home match rates, the majority showed an increase in the number of applicants staying at their home institution, although this was less common in top-ranked institutions. By affecting the composition of matched applicants, VIs may negatively

impact the geographical diversity of some programs. However, the impact of VIs is difficult to tease out from the impact of cancelled of away rotations, particularly in highly competitive surgical subspecialties where away rotations are most prevalent. The return of away rotations, as well as hybrid models that allow applicants to experience programs in-person prior to ranking, may combat this potential downside of VIs.

Impact of cost and time savings, enhanced equity, and reduced carbon footprint

Cost savings are a significant benefit of VIs, which is particularly important considering the high price of medical education. In the US, the average cost of public versus private medical school is $243,902 and $322,767 respectively, with median medical student debt exceeding $200,000 (Association of American Medical Colleges 2021). Medical students spend on average $4,992 - $8,312 on applications and interviews for residency (Blackshaw et al. 2017; Kuhn et al. 2019; Polacco et al. 2017; Ramkumar et al. 2018; Van Dermark et al. 2017), and residents incur additional costs for fellowship interviews, potentially furthering indebtedness. The cost to programs for hosting interviews is similarly large ($18,648 +/- $13,383 per position being filled), when considering faculty salaries, administrative costs, and time invested (Brummond et al., 2013; Gardner et al. 2018; Van Dermark et al., 2017). When these numbers are extrapolated to the total applicant pool for residents and fellows, this equates to ~$300,000,000 in potential savings for applicants and up to ~$1 billion in potential savings for programs in the US alone. These cost savings represent an immediate and tangible positive outcome of VIs. Longer term costs may emerge that are difficult to quantify, such as the impact of a resident withdrawing

from training or switching specialties due to matching at a program at which they ultimately realize they are a poor fit, though these costs will likely be small in comparison.

Another positive outcome of VIs mentioned across studies is enhanced equity. Socioeconomic privilege, as well as gendered and ableist perspectives on ease of travel, create advantages for certain applicants when interviews are conducted in-person. Historically, URiM applicants were more likely to decline interviews due to costs or personal difficulties with travel (Fogel et al. 2018). If applicants are offered a choice of VIs or IPIs in the future, there is concern the choice to interview in-person could favorably bias interviewers. Thus, a VI "option" may not actually be perceived as optional by applicants. While VIs may increase equity for interviewing by eliminating travel expenses, URiM applicants found it harder to assess fit and commitment to diversity in the virtual environment (Huppert et al. 2021). Thus, having no in-person component to the recruitment process may be a drawback. A hybrid option of VIs followed by a limited number of in-person second looks may help URiM applicants better understand fit.

Another benefit noted for VIs was the environmental impact. The medical education community has recently embraced the need to educate medical students on the health impacts of climate change and must therefore explore its own contributions to the problem. The reduction in CO_2 emissions brought about by VIs was enormous (Donahue et al. 2021) and any plan to re-introduce travel should take carbon footprint into account.

Cost, equity, and environmental impact were key factors in the Association of American Medical Colleges decision to recommend continuation of VIs for the 2022-23 season (Association of American Medical Colleges 2022). Considered in balance with the negative impact on fit assessment, the findings of this review largely support that recommendation.

Application inflation and interview hoarding

With regards to VIs, programs and applicants alike shared concerns about over-application and interview hoarding, though this is largely a US problem. VIs exacerbated the existing "application fever" that started in the 1990s with the introduction of the Electronic Residency Application System and simultaneous relative reduction of available residency positions per applicant. Yet, supply and demand alone do not explain this complicated phenomenon, and game theory appears to influence applicant behaviors to apply to more programs in order to confer individual benefits without improving overall match rates (Berger & Cioletti 2016; Carmody et al. 2021; Morgan et al. 2021; Weissbart et al. 2015). The AAMC has published data available to students demonstrating that applying to additional residency programs beyond a certain number results in diminishing returns (Association of American Medical Colleges 2020a). Nonetheless, the number of applications per individual has doubled over the past decade (Aagaard & Abaza 2016; Association of American Medical Colleges 2020b).

Some have argued that interventions such as preference signaling, application/interview caps, or an early match may benefit applicants and programs alike by saving time and money, more

equitably distributing interviews beyond the top cohort of candidates and enhancing program bandwidth for holistic review (Hopson et al. 2020; Hammoud et al. 2020; Villwock et al. 2020). Accordingly, some highly competitive specialties have recently implemented preference signaling and interview caps (Pletcher et al. 2022; Quillen et al. 2021). As VIs increase the number of interview opportunities, while removing barriers of travel and cost, it will be important to identify interventions to curtail excessive interviewing and ensure more equitable distribution of interviews across candidates.

The ideal future

Given both the advantages and disadvantages of in-person and virtual recruitment, a hybrid approach might best harness the strengths and minimize weaknesses. However, the ideal breakdown of VIs and in-person components remains unknown, and national organizations have put out conflicting recommendations. The American Association of Colleges of Osteopathic Medicine recommended a hybrid approach due to concerns that exclusively virtual interviews disadvantage DO students (American Association of Colleges of Osteopathic Medicine 2022.). In contrast, the AAMC has advised that programs should conduct VIs for all applicants, and that hybrid interviews within the same program should not currently be offered (Association of American Medical Colleges 2022). This recommendation is based on research demonstrating that interviewee performance tends to be lower for VIs (Melchers et al. 2021), as well as concerns about potential bias against those who choose VIs that might exacerbate inequities for financially constrained applicants (Association of American Medical Colleges 2022). Of the potential models described, the use of VIs initially followed by optional in-person second looks

at a limited number of programs after PDs rank applicants, may allow for the best of both worlds. Consensus recommendations from national organizations would help facilitate the implementation of such a model.

Strengths

The author group included a large, international group of key stakeholders including deans, PDs, clerkship directors, faculty, fellows, and residents. While this review was conducted on a rapid timeline in order to generate results that could be utilized in the upcoming interview season, the review did not sacrifice methodological rigor. Heterogeneity between studies precluded the ability to perform meta-analysis of the collated data; however, we were able to include a large number of studies with shared constructs (e.g., satisfaction, fit) and consistent findings. Although the precision of our findings may be limited by this heterogeneity, the results suggest that our findings adequately and accurately reflect general opinions across the GME continuum.

Limitations

The findings were largely subjective, based on perspectives, though cost analyses and match analyses offered more objective data. Most studies occurred in the US, limiting the generalizability of findings to other nations. For instance, the purported equity gains are largely contextual and based on the large cost savings associated with eliminating travel in a geographically dispersed nation. Most studies were quantitative and primarily involved surveys,

generating response bias and potentially resulting in a loss of nuance in responses. The survey response rates in many studies were also suboptimal, potentially introducing nonresponse bias. Additionally, the largest proportion of studies were conducted before the match, and it is possible that attitudes toward VIs may change as applicants and programs assess one another more longitudinally and in-person. Lack of away rotations represented a significant confounder, and as away rotations resume, applicants may not rely so heavily on VIs alone to assess fit.

Implications for future research

Future research should incorporate qualitative methodologies (e.g., interviews and focus groups) to more thoroughly explore perspectives and achieve a more nuanced understanding of impacts on EDI. Most studies were completed prior to the start of the academic year following VIs. Additional studies conducted after applicant arrival in their programs, as well as longitudinally thereafter, are critical to investigate whether fit was adequately assessed. The upcoming academic year will provide a natural experiment to tease out the impacts of the temporary loss of away rotations from the switch to VIs alone. Additional research assessing long-term outcomes, including program attrition or rates of changing specialties, is needed to better understand what might be lost from in-person interactions that may not be readily apparent in the short-term. Future research is also warranted regarding hybrid models and their ideal structure. Additionally, innovative methods to limit overapplication and interview hoarding should be implemented and studied.

Implications for policy and practice

- A hybrid model that involves a standard approach to VIs across all programs but allows for the possibility of a limited number of in-person second looks following the submission of rank lists may allow for assessment of aspects of fit that are otherwise difficult to convey.
- Leaders from national groups should conduct multi-site research on VIs, the findings of which may allow stakeholders to optimize the strengths of VIs (e.g., reductions in cost, environmental impact, scheduling flexibility) while addressing weaknesses (e.g., technical difficulties, loss of spontaneous social interactions, ability to experience the feel of physical locations such as the surrounding geographic area and program facilities).
- Multi-site research on mechanisms to limit application inflation, such as preference signaling and caps on the number of applications and/or interviews should be conducted. National organizations representing key stakeholders should also come to consensus on these measures based on data.

Conclusions

The COVID-19 pandemic caused GME programs to shift to VIs for recruitment and selection. This review synthesized data on VIs, providing insights for optimizing the format. Overall satisfaction was high, and important benefits were reported regarding cost, time savings, equity, and environmental impact. However, applicants and programs alike perceived an inferior ability to assess fit and expressed decreased confidence in ranking decisions. This review may inform

future VI formats, and policies regarding virtual versus in-person interviews for GME recruitment and selection.

Acknowledgments

The authors would like to express their appreciation to Touba Warsi for her assistance with developing the graphs and figures.

Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the article.

Notes on contributors

Michelle Daniel, MD, MHPE, is Chair of the BEME Review Committee, Associate Editor for Medical Teacher, and Vice Dean for Medical Education and Clinical Professor of Emergency Medicine at the University of California, San Diego School of Medicine, La Jolla, California, USA.

Michael Gottlieb, MD, is the Director of the Emergency Ultrasound Division, Program Director for the Clinical Ultrasound Fellowship, and Associate Professor of Emergency Medicine at Rush University Medical Center, Chicago, Illinois, USA.

Darcy Wooten, MD, MS is an Associate Professor of Medicine in the Division of Infectious Diseases and Global Public Health, and the Program Director for the Infectious Disease Fellowship at the University of California, San Diego School of Medicine, La Jolla, California, USA.

Jennifer N. Stojan, MD, MHPE, is a Professor of Internal Medicine at the University of Michigan Medical School in Ann Arbor, Michigan, USA.

Mary R. C. Haas, MD, MHPE is Assistant Residency Program Director and Assistant Professor, Department of Emergency Medicine, University of Michigan Medical School, Ann Arbor, Michigan, USA.

Jacob Bailey, MD, MA is a Pulmonary Critical Care Fellow in the Department of Medicine, and Assistant Director of the Program in Medical Education - Health Equity at the University of California, San Diego School of Medicine, La Jolla, California, USA.

Sean J. Evans, MD is a Clinical Professor of Neurosciences and Associate Dean for Undergraduate Medical Education at the University of California, San Diego, School of Medicine, La Jolla, California, USA.

Daniel Lee, MD is Assistant Dean for Graduate Medical Education and a Clinical Professor of Anesthesiology at the University of California, San Diego, School of Medicine, La Jolla, California, USA.

Charles Goldberg, MD is Associate Dean for Graduate Medical Education and Clinical Professor of Medicine at the University of California, San Diego, School of Medicine and an Academic Hospitalist at the Veterans Association San Diego Healthcare System, La Jolla, California, USA.

Jorge Fernandez, MD is an Associate Clinical Professor and the Medical Student Program Director within the Department of Emergency Medicine, and an Academic Community Director at the University of California, San Diego, School of Medicine, La Jolla, California, USA.

Simerjot K. Jassal, MD, MAS is Clinical Professor of Medicine and Program Director of the Internal Medicine Residency Program at the University of California, San Diego School of Medicine, La Jolla, California, USA.

Frances Rudolf, MD is Assistant Residency Program Director and Assistant Clinical Professor of Emergency Medicine at the University of California, San Diego School of Medicine, La Jolla, California, USA.

Kama Guluma, MD is a Clinical Professor of Emergency Medicine and Associate Dean for Admissions and Student Affairs at the University of California, San Diego, School of Medicine, La Jolla, California, USA.

Lina Lander, ScD is an Associate Professor, Family Medicine and Public Health and Associate Dean, Education Technology, Innovation and Assessment at the University of California, San Diego, School of Medicine, La Jolla, California, USA.

Emily Pott, MD, is Chief Resident in the Emergency Medicine Residency Program at the University of California, San Diego, La Jolla, California, USA.

Nicole H. Goldhaber, MD, MA is a Surgery Resident and Perioperative Quality, Informatics and Education Research Fellow at the University of California, San Diego School of Medicine, San Diego, California, USA.

Satid Thammasitboon, MD, MHPE is Director of the Center for Research, Innovation and Scholarship in Health Professions Education, Co-Director of the BEME International Collaborating Center, Texas Children's Hospital and Baylor College of Medicine, Houston, Texas, USA.

Hussein Uraiby, MBChB, MMedEd, FHEA is a Specialty Trainee in Histopathology and an Honorary Clinical Education Fellow at the University Hospitals of Leicester NHS Trust, Leicester, UK.

Ciaran Grafton-Clarke, MBChB is a Clinical Education Fellow at University Hospitals of Leicester, UK, and Honorary Fellow at the University of Leicester, UK.

Morris Gordon, MBChB, PHD, MMed, is Chair of the BEME Executive, Coordinating Editor of the Cochrane Gut Group, Professor of Evidence Synthesis and Systematic Review and a Consultant Pediatrician in the North West of the UK.

Teresa Pawlikowska, MB BS, PhD FRCPI is Foundation Director of The Health Professions Education Centre (HPEC) which is also a BEME International Collaborating Center, RCSI University of Medicine and Health Sciences, Dublin, Ireland.

Janet Corral, MD is Professor of Medicine and Associate Dean of Medical Education at the University of Nevada School of Medicine, Reno, Nevada, USA.

Indu Partha, MD, FACP is Clinical Associate Professor of Medicine and Associate Program Director, Primary Care Track and Ambulatory Medicine at the at the University of Arizona College of Medicine, Tucson, Arizona, USA.

Karyn B. Kolman, MD is Associate Professor, Vice Chair for Education and Program Director in the Department of Family and Community Medicine, at the University of Arizona College of Medicine, Tucson, Arizona, USA.

Jennifer Westrick, MSLIS AHIP is a Library Research Information Specialist at Rush University Medical Center in Chicago, Illinois, USA.

Diana H. J. M. Dolmans, PhD is Professor and Chair of the Department of Educational Development & Research, staff member of the School of Health Professions Education, Faculty of Health, Medicine and Life Sciences, Maastricht University, Maastricht, NL.

References

Aagaard EM, Abaza M. 2016. The residency application process--burden and consequences. N Engl J Med. 374(4):303-5.

Abdelwahab R, Antezana LA, Xie KZ, Abdelwahab M, Tollefson M. 2021. Cross-sectional study of dermatology residency home match incidence during the COVID-19 pandemic. J Am Acad Dermatol. [E-pub ahead of print]

Addams A, Bletzinger RB, Sondheimer HM, White SE, Johnson LM. 2010. Roadmap to diversity: integrating holistic review practices into medical school admissions processes. Association of American Medical Colleges. [accessed 2022 July 9.] https://store.aamc.org/downloadable/download/sample/sample_id/195/

Ali S, Hashmi MS, Umair M, Beg MA, Huda N. 2019. Multiple mini-interviews: current perspectives on utility and limitations. Adv Med Educ Pract. 10:1031.

Aljamaan F, Alkhattabi F, Al-Eyadhy A, Alhaboob A, Alharbi NS, Alherbish A, Almosned B, Alobaylan M, Alabdulkarim H, Jamal A, et al. 2021. Faculty members' perspective on virtual interviews for medical residency matching during the COVID-19 crisis: A National Survey. Healthcare (Basel). 10(1):1-16.

Allam JS, Burkart KM, Çoruh B, Lee M, Hinkle L, Kreider M, Tatem G, Witt C, Ashton RW, Huie T, et al. 2022. The virtual interview experience: perspectives of pulmonary and critical care fellowship applicants. ATS Scholar. 3(1):76-86.

Allen KA. 2020. The Psychology of Belonging. Melbourne AU: Routledge.

Al Saiegh F, Ghosh R, Stefanelli A, Khanna O, Hattar-Medina E, Hoffman M, Hafazalla K, Sabourin V, Farrell C, Tjoumakaris S, et al. 2020. Letter to the Editor: Virtual residency training interviews in the age of COVID-19 and beyond. World Neurosurg. 143:641-43.

American Association of Colleges of Osteopathic Medicine. 2022. AACOM strongly recommends hybrid residency interviews for 2022-23 cycle. [accessed 2022 July 9]. https://www.aacom.org/news-and-events/news-detail/2022/05/13/aacom-strongly-recommends-hybrid-residency-interviews-for-2022-23-cycle

Anteby R, Sinyard RD, Jogerst KM, McKinley SK, Coe TM, Petrusa E, Phitayakorn R, Scott DJ, Brunt LM, Gee DW. 2022. Challenges of virtual interviewing for surgical fellowships: a qualitative analysis of applicant experiences. Surg Endosc. 36(6):3763-71.

Armstrong A, Kroener L, Cohen J, Han CS, Nitti V, Rible R, Brennan K. 2021. The influence of virtual interviews on the fellowship match in obstetrics and gynecology (OBGYN). Fertil Steril. 116(3):e75.

Arthur ME, Aggarwal N, Lewis S, Odo N. 2021. Rank and match outcomes of in-person and virtual anesthesiology residency interviews. J Educ Perioper Med. 23(3):E664.

Asaad M, Elmorsi R, Ferry AM, Rajesh A, Maricevich RS. 2022. The experience of virtual interviews in resident selection: a survey of program directors in surgery. J Surg Res. 270:208-13.

Asadourian PA, Murphy AI, Marano AA, Rohde CH, Wu JK. 2021. Home field advantage: assessing the geographic trends of the plastic surgery residency match during the COVID-19 pandemic. J Surg Educ. 78(6):1923-29.

Association of American Medical Colleges. 2020a. Apply smart: data to consider when applying to residency. [accessed 2022 July 9].

https://students-residents.aamc.org/applying-residency/filteredresult/apply-smart-data-consider-when-applying-residency/

Association of American Medical Colleges. 2020b. ERAS data. [accessed 2022 July 9]. https://www.aamc.org/data-reports/interactive-data/eras-statistics-data

Association of American Medical Colleges. 2021. The cost of interviewing for residency. [accessed 2022 July 9]. https://students-residents.aamc.org/financial-aid-resources/cost-interviewing-residency.

Association of American Medical Colleges. 2022. AAMC interview guidance for the 2022-2023 residency cycle. [accessed 2022 July 9]. https://www.aamc.org/about-us/mission-areas/medical-education/aamc-interview-guidance-2022-2023-residency-cycle#

Bamba R, Bhagat N, Tran PC, Westrick E, Hassanein AH, Wooden WA. 2021. Virtual interviews for the independent plastic surgery match: a modern convenience or a modern misrepresentation? J Surg Educ. 78(2):612-21.

Barceló NE, Shadravan S, Wells CR, Goodsmith N, Tarrant B, Shaddox T, Yang Y, Bath E, DeBonis K. 2021. Reimagining merit and representation: promoting equity and reducing bias in GME through holistic review. Acad Psychiatry. 45(1):34-42.

Barnes EL, Grimm-Vavlitis JL, Long MD. 2021. Impact of virtual interviews on gastroenterology and hepatology fellowship recruitment. Dig Dis Sci. 1-2.

Benson NM, Stickle TR, Raszka WV. 2015. Going "Fourth" From Medical School: Fourth-Year Medical Students' Perspectives on the Fourth Year of Medical School. Acad Med. 90(10):1386-93.

Berger JS, Cioletti A. 2016. Viewpoint from 2 graduate medical education deans: application overload in the residency Match process. J Grad Med Educ. 8(3):317–21.

Bernstein D, Beshar I. 2021. The carbon footprint of residency interviews. Acad Med. 96(7):932.

Blackshaw A, Watson S, Bush, J. 2017. The cost and burden of the residency match in emergency medicine. West J Emerg Med. 18(1), 169–73.

Bramer WM, Giustini D, de Jonge GB, Holland L, Bekhuis T. 2016. De-duplication of database search results for systematic reviews in EndNote. J Med Libr Assoc. 104(3):240-43.

Bramer WM, Rethlefsen ML, Kleijnen J, Franco OH. 2017. Optimal database combinations for literature searches in systematic reviews: a prospective exploratory study. Syst Rev. 6(1):245.

Brueggeman DA, Via GG, Froehle AW, Krishnamurthy AB. 2021. Virtual interviews in the era of COVID-19: expectations and perceptions of orthopaedic surgery residency candidates and program directors. JBJS OA. 6(3).

Brummond A, Sefcik S, Halvorsen AJ, Chaudhry S, Arora V, Adams M, Lucarelli M, McDonald FS, Reed DA. 2013. Resident recruitment costs: a national survey of internal medicine program directors. Amer J Med. 126(7):646–653.

Carmody JB, Rosman IS, Carlson JC. 2021. Application fever: reviewing the causes, costs, and cures for residency application inflation. Cureus. 13(3):e13804.

Critical Appraisal Skills Programme. 2022. CASP systematic review checklist. Available at: https://casp-uk.net/wp-content/uploads/2018/01/CASP-Systematic-Review-Checklist_2018.pdf Accessed: May 27, 2022.

Caldwell LS, Lawler EA. 2021. Orthopedic surgery residency application process in 2020 - has diversity been affected? Iowa Orthop J. 41(1):1-4.

Carpinito GP, Khouri RK, Jr., Kenigsberg AP, Ganesan V, Kuprasertkul A, Caldwell KM, Hudak SJ, Lemack GE. 2021. The virtual urology residency match process: moving beyond the pandemic. Urology. 158:33-38.

Chandler NM, Litz CN, Chang HL, Danielson PD. 2019. Efficacy of videoconference interviews in the pediatric surgery match. J Surg Educ. 76(2):420-426.

Chang TC, Hodapp EA, Parrish RK, Grajewski AL, Gedde SJ, Lee RK, Wellik SR, Junk AK, Vazquez L, Swaminathan SS, et al. 2021. Virtual versus in-person surgical fellowship interviews and ranking variability: the COVID-19 experience. Res Sq. 1-11.

Chen S, Schroeder M, Pak TK, Zaworski E, Topolski N, Anishchenko K, Bae E, Stuard W, Zhu C, Quach S, et al. 2022. A match made in cyberspace: applicant perspectives on virtual residency interviews. Available at: https://www.medrxiv.org/content/10.1101/2022.02.07.22270645v1.full. Accessed: June 1, 2022.

Clark SC, Kraeutler MJ, McCarty EC, Mulcahey MK. 2022. Virtual interviews for sports medicine fellowship positions save time and money but don't replace in-person meetings. Arthrosc Sports Med Rehabil. 4(2):e607-15.

Coalition for Physician Accountability. 2021. Coalition for Physician Accountability Releases Recommendations On 2021-22 Residency Season Interviewing. National Resident Matching Program website. [accessed 2021 July 9]. https://www.nrmp.org/coalition-recommendations-2021-22-interviewing/.

Cook DA, Reed DA. 2015. Appraising the quality of medical education research methods: the medical education research study quality instrument and the Newcastle–Ottawa scale-education. Acad Med. 90(8):1067-76.

Coplan B, Evans BC. 2021. How organizational culture influences holistic review: a qualitative multiple case study. Adv Health Sci Educ Theory Pract. 26(5):1491-1517.

Cotner CE, Mercadante SF, Shea JA. 2022. Assessing the impact of the COVID-19 pandemic on geographic residency placement relative to medical school location. J Grad Med Educ. 14(1):108-11.

D'Angelo A-LD, D'Angelo JD, Beaty JS, Cleary RK, Hoedema RE, Mathis KL, Dozois EJ, Kelley SR. 2021. Virtual interviews – utilizing technological affordances as a predictor of applicant confidence. Am J Surg. 222(6):1085-92.

D'Angelo JD, D'Angelo AD, Mathis KL, Dozois EJ, Kelley SR. 2021. Program director opinions of virtual interviews: whatever makes my partners happy. J Surg Educ. 78(6):e12-18.

Davis ME, Jafari A, Crawford K, MacDonald BV, Watson D. 2021. Novel implementation of virtual interviews for otolaryngology resident selection: reflections relevant to the COVID-19 era. OTO Open. 5(1):1-4.

Day RW, Taylor BM, Bednarski BK, Tzeng CD, Gershenwald JE, Lee JE, Grubbs EG. 2020. Virtual interviews for surgical training program applicants during COVID-19: lessons learned and recommendations. Ann Surg. 272(2):e144-47.

DeAtkine AB, Chisolm PF, Singh NP, Koch CG, King TW, Greene BJ, Buczek EP. 2021. Interviewing otolaryngology applicants in a virtual setting: a perspective after 2020 to 2021 match. Ear Nose Throat J. [E-pub ahead of print]

DiGiusto M, Lupa MC, Corridore M, Sivak EL, Lockman JL. 2021. The impact of the COVID-19 pandemic on the 2020 pediatric anesthesiology fellowship application cycle: A survey of applicants. Paediatr Anaesth. 31(9):968-76.

Ding JJ, Has P, Hampton BS, Burrell D. 2022. Obstetrics and gynecology resident perception of virtual fellowship interviews. BMC Med Educ. 22(1):58.

Donahue LM, Morgan HK, Peterson WJ, Williams JA. 2021. The carbon footprint of residency interview travel. JGME. 13(1):89-94.

Downard CD, Goldin A, Garrison MM, Waldhausen J, Langham M, Hirschl R. 2015. Utility of onsite interviews in the pediatric surgery match. J Pediatr Surg. 50(6):1042-5.

Ederle A, Shahriari S, Whisonant C, Stewart S, Roberson P, Valdes-Rodriguez R. 2021. The impact of COVID-19 on the dermatology match: an increase in the number of students matching at home programs. Dermatol Online J. 27(9).

Edje L, Miller C, Kiefer J, Oram D. 2013. Using skype as an alternative for residency selection interviews. J Grad Med Educ. 5(3):503-05.

Egan KG, Nauta A, Butterworth JA. 2022. Effect of COVID-19 restrictions on 2021 integrated plastic surgery match outcomes. J Surg Educ. 79(1):249-52.

Elmorsi R, Asaad M, Ferry AM, Rajesh A, Maricevich RS. 2021. How real is a virtual interview? Perspectives of orthopaedic surgery residency directors. Eur Rev Med Pharmacol Sci. 25(24):7829-32.

Estevez TP, Casasnovas CE, Safin DS. 2022. Structuring the future residency recruitment seasons: applicants' perspective on the virtual experience during the 2020-2021 interview season. Acad Psychiatry. 46(1):140-41.

Faletsky A, Zitkovsky H, Guo L. 2022. Disparate responses in match outcome across competitive surgical subspecialties to pandemic era constraints: an analysis of impacts of minimal auditions. J Surg Educ. 79(1):243-48.

Faletsky A, Zitkovsky H, Guo L. 2022. The impact of COVID-19 on plastic surgery home program match rates. Ann Plast Surg. 88(1):4-6.

Fogel HA, Liskutin TE, Wu K, Nystrom L, Martin B, Schiff A. 2018. The Economic Burden of Residency Interviews on Applicants. Iowa Orthop J. 38:9-15.

Frishman WH, Alpert JS. 2021. Virtual Interviews During Internal Medicine Recruitments: An Unexpected Favorable Outcome of the COVID-19 Pandemic? Am J Med. 134(8):935-36.

Frohna JG, Waggoner-Fountain LA, Edwards J, Fussell JJ, Wueste B, Gigante J, Vinci RJ, Heitkamp NM, Neelakantan MK, Degnon LE, et al. 2021. National pediatric experience with virtual interviews: lessons learned and future recommendations. Pediatrics. 148(4).

Gabrielson AT, Meilchen CK, Kohn JR, Kohn TP. 2021. The COVID-19 residency application cycle did not affect geographic dispersal patterns among applicants entering the urology match: a quantitative mapping study. Urology. 158:26-32.

Gaigbe-Togbe BHA, Menhaji K, Tran AD, Bui AH, Ascher-Walsh C, Dabney L, Hardart A. 2021. Virtual interviews during COVID-19 pandemic: a survey of applicants to fellowships in female pelvic medicine and reconstructive surgery. Female Pelvic Med Reconstr Surg. 27(9):e626-29.

Gallegos M, Landry A, Davenport D, Caldwell MT, Parsons M, Gottlieb M, Natesan S. 2022. Holistic review, mitigating bias, and other strategies in residency recruitment for diversity, equity, and inclusion: an evidence-based guide to best practices from the Council of Residency Directors in Emergency Medicine. West J Emerg Med. 23(3):345-52.

Gallo K, Becker R, Borin J, Loeb S, Patel S. 2021. Virtual residency interviews reduce cost and carbon emissions. J Urol. 206(6):1353-55.

Gardner AK, Smink DS, Scott BG, Korndorffer Jr JR, Harrington D, Ritter EM. 2018. How much are we spending on resident selection? J Surg Educ. 75(6):e85-90.

Geary AD, Wang TS, Lindeman B, Kuo JH, Lyden ML, Shen WT, Morris-Wiseman LF, Carty SE, Drake FT. 2022. Perspectives on virtual interviews - a follow-up study of the comprehensive endocrine surgery fellowship interview process. Surgery. 171(1):259-64.

Gordon AM, Conway CA, Sheth BK, Magruder ML, Vakharia RM, Levine WN, Razi AE. 2022. How did coronavirus-19 impact the expenses for medical students applying to an orthopaedic surgery residency in 2020 to 2021? Clin Orthop Relat Res. 480(3):443-51.

Gordon M, Gibbs T. 2014. STORIES statement: publication standards for healthcare education evidence synthesis. BMC Med. 12(1):1-9.

Gore JL, Porten SP, Montgomery JS, Hamilton RJ, Meng MV, Sexton WJ, Psutka SP. 2021. Applicant perceptions of virtual interviews for society of urologic oncology fellowships during the COVID-19 pandemic. Urol Oncol. [E-pub ahead of print]

Gorgy M, Shah S, Arbuiso S, Cline A, Russo M. 2022. Comparison of cost changes due to the COVID-19 pandemic for dermatology residency applications in the USA. Clin Exp Dermatol. 47(3):600-02.

Grova MM, Donohue SJ, Meyers MO, Kim HJ, Ollila DW. 2021. Direct comparison of in-person versus virtual interviews for complex general surgical oncology fellowship in the COVID-19 era. Ann Surg Oncol. 28(4):1908-15.

Gupta S, Grier Arthur L, Chandler N, Danielson P, Downard C, Ehrlich P, Gaines B, Gray B, Javid P, Lallier M, et al. 2021. Is the changing landscape of fellowship recruitment during COVID-19 here to stay? J Pediatr Surg. 13(41).

Haas M, He S, Sternberg K, Jordan J, Deiorio N, Chan T, Yarris L. 2020. Reimagining residency selection: Part 1 – a practical guide to recruitment in the post-COVID-19 era. JGME. 12(5): 539-544.

Halse C. 2018. Theories and theorising of belonging. In *Interrogating belonging for young people in schools*. Palgrave Macmillan, Cham.

Hamade N, Bhavsar-Burke I, Jansson-Knodell C, Wani S, Patel SG, Ehrlich AC, Paine E, Hosseini-Carroll P, Menard-Katcher P, Fayad N. 2021. Virtual gastroenterology fellowship recruitment during COVID-19 and its implications for the future. Dig Dis Sci. 1-10.

Hammick M, Dornan T, Steinert Y. 2010. Conducting a best evidence systematic review. Part 1: from idea to data coding. BEME Guide No. 13. Med Teach. 32(1):3-15.

Hammoud MM, Andrews J, Skochelak SE. 2020. Improving the residency application and selection process: An optional early result acceptance program. JAMA. 323(6):503–04.

Han AY, Obiri-Yeboah D, French JC, Lipman JM. 2022. The virtual recruitment onion: peeling back the layers of the interview season during the COVID-era. J Surg Educ. 79(1):77-85.

Hariton E, Raker CA, Frishman GN, Feinberg EC. 2021. Perceptions and lessons from web-based interviews for the reproductive endocrinology and infertility fellowship application cycle. Fertil Steril. 116(3):872-81.

Healy WL, Bedair H. 2017. Videoconference interviews for an adult reconstruction fellowship: lessons learned. J Bone Joint Surg Am. 99(21):e114.

Hemal K, Sarac BA, Boyd CJ, Runyan CM, Gosman AA, Janis JE. 2021. Applicant preferences for virtual interviews: insights from the 2020-21 integrated plastic surgery application cycle. Plast Reconstr Surg Glob Open. 9(7):e3732.

Hill MV, Ross EA, Crawford D, Lai L, Turaga K, Grubbs EG, Mullen J, Dineen S, D'Angelica M, Reddy S, et al. 2021. Program and candidate experience with virtual interviews for the 2020 complex general surgical oncology interview season during the COVID pandemic. Am J Surg. 222(1):99-103.

Ho G, Davis J, Hindle AK, Heinz E. 2021. Virtual residency interviews: a survey of anesthesiology program director perspectives amidst the COVID-19 pandemic. J Educ Perioper Med. 23(4):E674.

Hollins AW, Zhang GX, Stoehr JR, Atia A, Sergesketter AR, Wickenheisser VA, Ko JH, Phillips BT. 2021. Staying Close to Home: The effects of COVID-19 on the plastic surgery residency match. Plast Reconstr Surg Glob Open. 9(9):e3864.

Hopson LR, Edens MA, Goodrich M, Kiemeney M, Werley EB, Kellogg A, Franzen D. 2020. Calming troubled waters: a narrative review of challenges and potential solutions in the residency interview offer process. West J Emerg Med. 22(1):1–6.

Huppert LA, Hsu G, Elnachef N, Flint L, Frank JA, Gensler LS, Hsiao EC, Khanna RR, Qasim A, Schwartz BS, et al. 2021. A single center evaluation of applicant experiences in virtual interviews across eight internal medicine subspecialty fellowship programs. Med Educ Online. 26(1):1-9.

Iwai Y, Lenze NR, Mihalic AP, Becnel CM, Stitzenberg KB. 2022. Effect of the COVID-19 pandemic on the residency match among surgical specialties. Surgery. 171(6):1512-18.

Jerant A, Henderson MC, Griffin E, Rainwater JA, Hall TR, Kelly CJ, Peterson EM, Wofsy D, Franks P. 2017. Reliability of multiple mini-interviews and traditional interviews within and between institutions: a study of five California medical schools. BMC Med Educ. 17(1):1-6.

Jimenez AE, Khalafallah AM, Romano RM, Chambless LB, Wolfe SQ, Witham TF, Huang J, Mukherjee D. 2021. Perceptions of the virtual neurosurgery application cycle during the Coronavirus Disease 2019 (COVID-19) pandemic: a program director survey. World Neurosurg. 154:e590-604.

Jones HM, Ankem A, Seroogy EA, Kalantar A, Goldsmith DC, Rizenbergs KC, Van Meter TL. 2022. Impact of COVID-19 on radiology residency selection process: a survey of radiology residency programs in the US. Acad Radiol. 29(5):779-85.

Kamboj AK, Chandrasekhara V, Simonetto DA, Raffals LE. 2021. How we did it: virtual interviews with an eye toward the future. Am J Gastroenterol. 116(10):1972-75.

Kamboj AK, Raffals LE, Martin JA, Chandrasekhara V. 2021. Virtual interviews during the COVID-19 pandemic: a survey of advanced endoscopy fellowship applicants and programs. Tech Innov Gastrointest Endosc. 23(2):159-68.

Kamel S, Wang MX, Guccione J, Zhang X, Taher A, Sanhaji L, Hsieh P, Ferguson E, Elsayes KM. 2021. Analyzing the landscape of the 2021 virtual match: a nationwide survey of radiology programs' stakeholders. Acad Radiol. [E-pub ahead of print]

Kraft DO, Bowers EMR, Smith BT, Jabbour N, Schaitkin BM, O'Leary MA, Groblewski JC, Young VN, Sridharan S. 2022. Applicant perspectives on virtual otolaryngology residency interviews. Ann Otol Rhinol Laryngol. [E-pub ahead of print]

Kuhn AW, Jarrett RT, Scudder DR, Pereira DE, Fleming AE, Drolet BC. 2019. The costs of applying to residency: one institution's efforts to increase transparency. South Med J. 112(7):376–81.

Lenze NR, Mihalic AP, Kovatch KJ, Thorne MC, Kupfer RA. 2022. Impact of the COVID-19 pandemic on the 2021 otolaryngology residency match: analysis of the Texas STAR database. Laryngoscope. 132(6):1177-83.

Lewit R, Gosain A. 2021. Virtual interviews may fall short for pediatric surgery fellowships: lessons learned from COVID-19/SARS-CoV-2. J Surg Res. 259:326-31.

Lewkowitz AK, Ramsey PS, Burrell D, Metz TD, Rhoades JS. 2021. Effect of virtual interviewing on applicant approach to and perspective of the maternal-fetal medicine subspecialty fellowship match. Am J Obstet Gynecol MFM. 3(3).

Liang KE, Dawson JQ, Stoian MD, Clark DG, Wynes S, Donner SD. 2021. A carbon footprint study of the Canadian medical residency interview tour. Med Teach. 43(11):1302-8.

Lund S, Shaikh N, Yeh VJ, Baloul M, de Azevedo R, Pena A, Becknell M, Que F, Stulak J, Rivera M. 2021. Conducting virtual simulated skills multiple mini-interviews for general surgery residency interviews. J Surg Educ. 78(6):1786-90.

Majumder A, Eckhouse SR, Brunt LM, Awad MM, Dimou FM, Eagon JC, Holden S, Fone H, Blatnik JA. 2020. Initial experience with a virtual platform for advanced gastrointestinal minimally invasive surgery fellowship interviews. J Am Coll Surg. 231(6):670-78.

Marbin J, Rosenbluth G, Brim R, Cruz E, Martinez A, McNamara M. 2021. Improving diversity in pediatric residency selection: using an equity framework to implement holistic review. J Grad Med Educ. 13(2):195-200.

McAteer R, Sundaram S, Harkisoon S, Miller J. 2020. Videoconference interviews: a timely primary care residency selection approach. J Grad Med Educ. 12(6):737-44.

Melchers KG, Petrig A, Basch JM, Sauer J. 2021. A comparison of conventional and technology-mediated selection interviews with regard to interviewees' performance, perceptions, strain, and anxiety. Front Psychol. 11:603632.

Melendez MM, Dobryansky M, Alizadeh K. 2012. Live online video interviews dramatically improve the plastic surgery residency application process. Plast Reconstr Surg. 130(1):240e-41e.

Menhaji K, Gaigbe-Togbe BH, Hardart A, Bui AH, Andiman SE, Ascher-Walsh CJ, Dabney L, Do Tran A. 2021. Virtual interviews during COVID-19: perspectives of female pelvic medicine and reconstructive surgery program directors. Female Pelvic Med Reconstr Surg 27(9):575-80.

Miotto GC. 2018. Tele-interview in the aesthetic fellowship selection process. Aesthet Surg J. 38(11):NP175-77.

Mohanty A, Caldwell DJ, Hadley CC, Gibson A, Ravanpay A, Patel AJ. 2021. Virtual interviews in neurosurgery resident selection - a work in progress. World Neurosurg. 155:e412-17.

Moran SK, Nguyen JK, Grimm LJ, Yee JM, Maxfield CM, Shah N, Heitkamp DE, Chapman T. 2021. Should radiology residency interviews remain virtual? Results of a multi-institutional survey inform the debate. Acad Radiol. [E-pub ahead of print]

Morgan HK, Winkel AF, Standiford T, Muñoz R, Strand EA, Marzano DA, Ogburn T, Major CA, Cox S, Hammoud MM. 2021. The case for capping residency interviews. J Surg Educ. 78(3):755–62.

Mulcahy CF, Terhaar SJ, Boulos S, Lee E, Zapanta PE. 2022. Did more otolaryngology residency applicants match at their home institutions in 2021? Investigating the impact of the COVID-19 pandemic. Ann Otol Rhinol Laryngol. [E-pub ahead of print]

Mulligan KM, Pan X, Gerges C, Rabah NM, Selden NR, Wolfe SQ, Wright CH, Wright JM, 3rd. 2021. The 2021 neurosurgery match: an analysis of the impact of virtual interviewing and other COVID-19-related changes. World Neurosurg. [E-pub ahead of print]

Nuthalapaty FS, Jackson JR, Owen J. 2004. The influence of quality-of-life, academic, and workplace factors on residency program selection. Acad Med. 79(5):417–425

Om A, Losken A. 2021. Effect of COVID-19 on geographic distribution of the integrated plastic surgery match. Plast Reconstr Surg Glob Open. 9(6):e3676.

Pasadhika S, Altenbernd T, Ober RR, Harvey EM, Miller JM. 2012. Residency interview video conferencing. Ophthalmology. 119(2):426e5.

Pathak N, Schneble CA, Petit LM, Kahan JB, Arsoy D, Rubin LE. 2021. Adult reconstruction fellowship interviewee perceptions of virtual vs in-person interview formats. Arthroplast Today. 10:154-59.

Peyser A, Gulersen M, Nimaroff M, Mullin C, Goldman RH. 2021. Virtual obstetrics and gynecology fellowship interviews during the coronavirus disease 2019 (COVID-19) pandemic: a survey study. BMC Med Educ. 21(1):449.

Pletcher SD, Chang CWD, Thorne MC, Malekzadeh S. 2022. The otolaryngology residency program preference signaling experience. Acad Med. 97(5):664-68.

Polacco MA, Lally J, Walls A, Harrold LR, Malekzadeh S, Chen EY. 2017. Digging into debt: the financial burden associated with the otolaryngology match. Otolaryngol Head Neck Surg. 156(6):1091–96.

Quillen DA, Siatkowski RM, Feldon S. 2021. COVID-19 and the ophthalmology match. Ophthalmology. 128(2):181-4.

Rajesh A, Asaad M, Elmorsi R, Ferry AM, Maricevich RS. 2021. The virtual interview experience for MATCH 2021: a pilot survey of general surgery residency program directors. Am Surg. [E-pub ahead of print]

Ramkumar PN, Navarro SM, Chughtai M, Haeberle HS, Taylor SA, Mont MA. 2018. The orthopaedic surgery residency application process: an analysis of the applicant experience. J Amer Acad Orthop Surg. 26(15):537–44.

Rasendran C, Rahman S, Younis U, Wadhwa R, Kapadia M, Lass JH, Ohsie-Bajor LH. 2021. The impact of virtual interviews on the geographic distribution of ophthalmology match results in the 2020–2021 cycle. J Acad Ophthal. 13(02):e242-46.

Ream MA, Thompson-Stone R. 2022. Virtual residency interview experience: the child neurology residency program perspective. Pediatr Neurol. 126:3-8.

Reed DA, Cooke DA, Beckman TJ, Levine RB, Kern DE, Wright SM. 2007. Association between funding and quality of published medical education research. JAMA. 298(9):1002–9.

Rhoades JS, Ramsey PS, Metz TD, Lewkowitz AK. 2021. Maternal-fetal medicine program director experience of exclusive virtual interviewing during the coronavirus disease 2019 pandemic. Am J Obstet Gynecol MFM. 3(4):100344.

Robinson KA, Shin B, Gangadharan SP. 2021. A comparison between in-person and virtual fellowship interviews during the COVID-19 pandemic. J Surg Educ. 78(4):1175-81.

Rockney D, Benson CA, Blackburn BG, Chirch LM, Konold VJL, Luther VP, Razonable RR, Tackett S, Melia MT. 2021. Virtual recruitment is here to stay: a survey of ID fellowship program directors and matched applicants regarding their 2020 virtual recruitment experiences. Open Forum Infect Dis. 8(8).

Romano R, Mukherjee D, Michael LM, Huang J, Snyder MH, Reddy VP, Guzman K, Lane P, Johnson JN, Selden NR, et al. 2022. Optimizing the residency application process: insights from neurological surgery during the pandemic virtual application cycle. J Neurosurg. 1-9.

Rosenbluth AL, Nagaraj MB, Brunt LM, Scott DJ. 2022. Survey of the 2020 fellowship council application and match process and the impact of COVID-19. Surg Endosc. 1-8.

Sabesan V, Kapur N, Zemanek K, Levitt D, Vu T, Van Erp A. 2022. Implementation and evaluation of virtual multiple mini interviews as a selection tool for entry into paediatric postgraduate training: a Queensland experience. Med Teach. 44(1):87-94.

Sarac BA, Shen AH, Nassar AH, Maselli AM, Shiah E, Lin SJ, Janis JE. 2021. Virtual interviews for the integrated plastic surgery residency match: the program director perspective. Plast Reconstr Surg Glob Open. 9(7):e3707.

Schenker ML, Baldwin KD, Israelite CL, Levin LS, Mehta S, Ahn J. 2016. Selecting the best and brightest: a structured approach to orthopedic resident selection. J Surg Educ. 73(5):879-85.

Shah SK, Arora S, Skipper B, Kalishman S, Timm TC, Smith AY. 2012. Randomized evaluation of a web based interview process for urology resident selection. J Urol. 187(4):1380-84.

Shah T, Werner K, Morreale M, Arfken C. 2022. Medical students' perspectives of remote residency interviews. Acad Psychiatry. 1-2.

Shappell E, Schnapp B. 2019. The F Word: How ‘‘Fit’’ Threatens the Validity of Resident Recruitment. JGME. 11(6):635-6.

Simmons RP, Ortiz J, Kisielewski M, Zaas A, Finn KM. 2022. Virtual recruitment: experiences and perspectives of internal medicine program directors. Am J Med. 135(2):258-63.

Singh N, DeMesa C, Pritzlaff S, Jung M, Green C. 2021. Implementation of virtual multiple mini-interviews for fellowship recruitment. Pain Med. 22(8):1717-21.

Snyder MH, Reddy VP, Iyer AM, Ganju A, Selden NR, Johnson JN, Wolfe SQ, Society of Neurological S, American Association of Neurological Surgeons Young Neurosurgeons C. 2021. Applying to residency: survey of neurosurgical residency applicants on virtual recruitment during COVID-19. J Neurosurg.1-10.

Spencer E, Ambinder D, Christiano C, Phillips J, Choudhury M, Matthews G, Fullerton S, Dyer L, Zelkovic P, Eshghi M, et al. 2021. Finding the next resident physicians in the COVID-19 global pandemic: an applicant survey on the 2020 virtual urology residency match. Urology. 157:44-50.

Stephenson-Famy A, Houmard BS, Oberoi S, Manyak A, Chiang S, Kim S. 2015. Use of the interview in resident candidate selection: a review of the literature. JGME. 7(4):539-48e.

Sternberg K, Jordan J, Haas M, He S, Deiorio N, Yarris L, Chan T. 2020. Reimagining residency selection: Part 2 – a practical guide to interviewing in the post-COVID-19 era. JGME. 12(5):545-9.

Strumpf Z, Miller C, Livingston D, Shaman Z, Matta M. 2021. Virtual interviews: challenges and opportunities for pulmonary disease and critical care medicine fellowship programs. ATS Sch. 2(4):535-43.

Taparra K, Ebner DK, Cruz DDL, Holliday EB. 2022. The impact of COVID-19 on radiation oncology residency applicant away rotations, interviews, and rank lists: a comparison between the 2020 match and 2021 match. Adv Radiat Oncol. 7(1).

Tawfik AM, Imbergamo C, Chen V, Filtes P, Butler A, Gatt C, Katt BM. 2021. Perspectives on the orthopaedic surgery residency application process during the COVID-19 pandemic. J Am Acad Orthop Surg Glob Res Rev. 5(10).

Taylor M, Freeman K, Mehaffey JH, Wallen T, Okereke IC. 2021. Applicant perception of virtual interviews in cardiothoracic surgery: a Thoracic Education Cooperative Group study. J Thorac Cardiovasc Surg. [E-pub ahead of print]

Taylor M, Wallen T, Mehaffey JH, Shirafkan A, Brescia AA, Freeman K, Louis C, Watson J, Okereke I. 2022. Interviews during the pandemic: a thoracic education cooperative group and surgery residents project. Ann Thorac Surg. 113(2):663-68.

Temsah MH, Alkhattabi F, Aljamaan F, Alhasan K, Alherbish A, Philby M, Alsohime F, Alobaylan M, Alabdulkarim H, Almosned B, et al. 2021. Remote interviews for medical residency selection during the initial COVID-19 crisis: a national survey. BMC Med Educ. 21(1):462.

Vadi MG, Malkin MR, Lenart J, Stier GR, Gatling JW, Applegate RL, 2nd. 2016. Comparison of web-based and face-to-face interviews for application to an anesthesiology training program: a pilot study. Int J Med Educ. 7:102-8.

Vallejo MC, Price SS, Vanek TW, Fuller KA, Nield LS, Cottrell SA, Ferrari ND. 2022. Virtual interviewing in the COVID-19 era: A survey of graduate program directors. J Dent Educ. 86(5):535-42.

Van der Laan L, George R, Nesiama JA, Nagler J, Langhan ML, Yen K, Ngo TL, Rose JA, Caglar D, Kant S, et al. 2022. Virtual interviewing for pediatric emergency medicine fellowship - a national survey. Pediatr Emerg Care. 38(4):e1207-12.

Van Dermark JT, Wald DA, Corker JR, Reid DG. 2017. Financial implications of the emergency medicine interview process. AEM Educ Train. 1(1):60–9.

Van Der Vleuten CP. 1996. The assessment of professional competence: developments, research and practical implications. Adv Health Sci Educ. (1):41-67.

Vasanthan V, Brown A, Spooner A, Kent WDT, Holloway D, Maitland A. 2021. Virtual adaptation of multimodal cardiac surgery residency interview: for the pandemic and the future. Ann Thorac Surg. [E-pub ahead of print]

Venincasa MJ, Steren B, Young BK, Parikh A, Ahmed B, Sridhar J, Kombo N. 2022. ophthalmology residency match in the Covid-19 era: applicant and program director perceptions of the 2020-2021 application cycle. Semin Ophthalmol. 37(1):36-41.

Villwock JA, Bowe SN, Dunleavy D, Overton BR, Sharma S, Abaza MM. 2020. Adding long-term value to the residency selection and assessment process. Laryngoscope. 130(1):65–68.

Vining CC, Eng OS, Hogg ME, Schuitevoerder D, Silverman RS, Yao KA, Winchester DJ, Roggin KK, Talamonti MS, Posner MC, et al. 2020. Virtual surgical fellowship recruitment during COVID-19 and its implications for resident/fellow recruitment in the future. Ann Surg Oncol. 27(Suppl 3):911-15.

Weissbart SJ, Kim SJ, Feinn RS, Stock JA. 2015. Relationship between the number of residency applications and the yearly Match rate: time to start thinking about an application limit? J Grad Med Educ. 7(1):81–5.

Whisonant CT, Shahriari SR, Harrison J, Ederle A, Marley SJ, Dowdy-Sue HE, Borah G. 2021. Evaluating the integrated plastic surgery residency match during the novel Coronavirus pandemic. Cureus. 13(8):e16988.

Williams K, Kling JM, Labonte HR, Blair JE. 2015. Videoconference interviewing: tips for success. J Grad Med Educ. 7(3):331-33.

Yaeger KA, Schupper AJ, Gilligan JT, Germano IM. 2021. Making a match: trends in the application, interview, and ranking process for the neurological surgery residency programs. J Neurosurg. [E-pub ahead of print.]

Yee JM, Moran S, Chapman T. 2021. From Beginning to End: A single radiology residency program's experience with web-based resident recruitment during COVID-19 and a review of the literature. Acad Radiol. 28(8):1159-68.

Yong TM, Davis ME, Coe MP, Perdue AM, Obremskey WT, Gitajn IL. 2021. Recommendations on the use of virtual interviews in the orthopaedic trauma fellowship match: a survey of applicant and fellowship director perspectives. OTA International. 4(2).

Zarate Rodriguez JG, Gan CY, Williams GA, Drake TO, Ciesielski T, Sanford DE, Awad MM. 2022. Applicants' perception of fit to residency programmes in the video-interview era: a large multidisciplinary survey. Med Educ. 56(6):641-50.

Zhang R, Schappe A, Salyapongse N, Bentz M. 2022. To Zoom or not to Zoom: weighing the pros and cons of the virtual plastic surgery residency interview. Plast Reconstr Surg. 149(2):365e-66e.