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Student Perceptions of M.D.-Ph.D. Programs: A Qualitative Identification of Barriers Facing Prospective M.D.-Ph.D. Applicants

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Abstract

Phenomenon: Despite a high degree of interest in research among matriculating M.D. students, very few apply to combined M.D.-Ph.D. training programs. Even fewer of those applicants are female, leading to a gender disparity among M.D.-Ph.D. trainees. We used a qualitative approach to understand why students choose not to apply or matriculate to M.D.-Ph.D. programs.

Approach: We recruited recently matriculated medical students at a private research university with a self-reported interest in academic medicine and biomedical research to participate in focus groups, in which students discussed their career and life goals, general knowledge and sources of information for M.D.-Ph.D. programs, perceived benefits and downsides, and barriers to applying to such programs.

Findings: Twenty-two students participated in focus groups. Participants desired careers combining clinical work, research, and teaching. Students had knowledge of the structure and goals of M.D.-Ph.D. training and received information about dual-degree programs from research mentors, the Internet, and peers. Tuition remission and increased grant access were cited as benefits of M.D.-Ph.D. programs, whereas duration, perceived excessive research training, and early commitment were downsides. Perceived competitiveness, misconceptions about training, a lack of M.D.-Ph.D. program-specific advising, discouragement from applying, and duration of training all served as barriers preventing students from pursuing dual-degree training.

Insights: Through this qualitative study, we identified perceptions and misconceptions that recent medical school applicants have about M.D.-Ph.D. programs. These findings suggest targetable

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Disclosures

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Ethical Approval

This study was reviewed and approved by the Institutional Review Board at Johns Hopkins University (IRB # 00124975).

barriers to increase applications from interested students, such as improving awareness of programs, increased accessibility of advising and resources, and addressing concerns over training length, with the goal of improving training access for aspiring physician-scientists.

Keywords

M.D.-Ph.D.; medical school admissions; premedical experiences; premedical advising

Introduction

In the United States, combined M.D.-Ph.D. programs integrate medical and scientific training to prepare trainees for careers as physician-scientists. These dual-degree programs allow for completion of both M.D. and Ph.D. degrees within 7–9 years, with many programs providing tuition remission and/or stipends. Despite 41.1% of matriculating medical students indicating that they desire to be “significantly involved” with research in their career,¹ relatively few students apply to combined M.D.-Ph.D. programs. In 2017, only 3.6% of all applicants to medical school applied to M.D.-Ph.D. programs, with 1,858 applicants to M.D.-Ph.D. relative to 51,680 applicants to M.D. programs.^{2,3} Since 2008, applications to M.D. programs have increased more than 20%,⁴ but applications to M.D.-Ph.D. programs have remained stable at about 1,800 per year.⁵ More concerning, a gender disparity remains in enrollment among M.D.-Ph.D. programs despite near parity in enrollment in both M.D. and biomedical Ph.D. training programs for several years.^{5–7} In 2016, women accounted for only 38% of the total enrollment in M.D.-Ph.D. programs in the United States.⁸ This disparity results in part from fewer women applying to these programs. Indeed, only 41% of applicants to M.D.-Ph.D. programs were female in 2016,^{9,10} a proportion unchanged over the past 10 years.^{5,11} The reasons for low numbers of applications to combined training programs despite interest in biomedical research careers, as well as the persistent gender disparity, remain unknown.

Few studies explicitly explore this phenomenon. Involvement in laboratory research in high school and college, higher Medical College Admissions Test scores, and interest in biomedical research are predictive of M.D.-Ph.D. enrollment, but this does not explain a low application rate or a gender disparity, as many non-M.D.-Ph.D. enrollees also exhibited these credentials and interests.^{1,12} Editorial pieces have proposed several hypotheses for why fewer women apply to M.D.-Ph.D. programs, including the challenges combining M.D.-Ph.D. training and a physician-scientist career with family and childbearing, that women feel they have to be better than their male counterparts to be seen as equals, and that women are not being encouraged to become physician-scientists.¹³ Indeed, that M.D.-Ph.D. programs are more time-consuming and perceived to be more difficult than either degree alone may interact with gender differences in life goals (if such differences exist).¹⁴ However, many of these challenges are not specific to M.D.-Ph.D. trainees. They are adversities faced by women throughout academic medicine and biomedical research, and these may not necessarily independently drive the gender discrepancy in M.D.-Ph.D. programs.^{14–17}

Instead, individual advising, mentorship, and/or resources (or lack thereof) may be more predictive of future M.D.-Ph.D. enrollment, as identified by recent qualitative studies of

barriers faced by underrepresented students applying into the health professions.^{18,19} In addition, prior analysis of application trends suggests that one contributing factor may be a lack of confidence or encouragement specifically among female applicants to M.D.-Ph.D. programs.¹⁰ However, there are likely additional factors, experiences, or barriers impacting both male and female applicants that contribute to low application trends and gender disparity. Identifying and addressing the reasons for this disparity is particularly important because a diverse and representative scientific workforce is likely to improve the quality of our training environment, balance and broaden perspectives in setting research priorities, advance biomedical discovery, and improve our capacity to enhance the health of the public.

In this qualitative study, we sought to identify factors that may contribute to low application rates to M.D.-Ph.D. programs and a gender disparity among M.D.-Ph.D. applicants. We designed focus groups with recently matriculated M.D. students at a private research university who have a career goal of working in an academic medical setting but who chose to not apply to or matriculate in a combined degree program. To understand why they chose not to apply to M.D.-Ph.D. programs, we led a discussion on the participant's career and life goals; general knowledge about M.D.-Ph.D. programs; application preparation with advisors, mentors, and other information sources; personal experiences with medicine and research; and any barriers or experiences that prevented application to M.D.-Ph.D. programs. We stratified responses by gender to determine if differences emerged in goals, perceptions, or experiences between male and female participants. With this study, we hope to provide insights for increasing M.D.-Ph.D. program recruitment, as well as the national growth of a diverse physician-scientist workforce to advance biomedical knowledge.

Approach

Study design, setting, and participants

Based on our review of the secondary literature, we hypothesized that major limiting factors for M.D.-Ph.D. applications were the lack of knowledge of programs, applicants' perceptions that negatives outweighed benefits, that applicants were steered away by mentors or advisors, and that applicants felt they were uncompetitive for M.D.-Ph.D. programs. From prior work,^{10,13} we proposed that gender differences may exist among participants life goals, self-confidence, encouragement, or mentorship. Based on these initial hypotheses, our focus group guide was designed to highlight participants general knowledge of M.D.-Ph.D. programs; the perceived benefits and downsides of programs; premedical experiences that may have influenced how they applied; and how mentors, advisors, peers, and other information sources may have influenced their decisions.

First- and 2nd-year medical students at the Johns Hopkins University School of Medicine were recruited by an e-mail sent to classwide e-mail lists in the first week of classes in August 2017. Johns Hopkins University is a large private research institution located in the Mid-Atlantic region of the United States. Students who were interested in a future career in "Academic Medicine and Biomedical Research" were invited to participate in peer focus groups. Current M.D.-Ph.D. students were excluded from participating. All research procedures including recruitment e-mails, focus group guide, welcome script, and

participation consent forms were reviewed and approved by the Institutional Review Board at Johns Hopkins University (IRB # 00124975).

Data collection

Focus group sessions were organized with five to seven students per group, each scheduled for one hour in a quiet on-campus classroom setting. Oral consent was obtained at the start of each focus group, and participants self-identified their gender. A prepared script (Focus Group Guide; see the appendix) guided conversation toward students' career and life goals; general knowledge of M.D.-Ph.D. programs; benefits and downsides of these programs; role of advisors, mentors, peers, and family; and then finally why they chose not to apply to M.D.-Ph.D. programs. Participants were not informed at the outset of the discussion that assessing gender differences in factors affecting application to M.D.-Ph.D. programs was a goal of the study. Conversations were moderated by the authors who were peers but from class years distinct from those of the participants (A.G.D., C.J.B., or C.J.K.), digitally recorded, and subsequently deidentified and transcribed by a professional transcription company. To compensate students for their time, each student was given a \$10 Amazon gift card electronically at the conclusion of all focus groups.

Data analysis

Thematic analysis was performed on the interview transcripts to explore participants' perspectives on M.D.-Ph.D. training and careers.²⁰ After completion of all focus groups, broad domains were generated from the transcripts, such as "Career Goals" or "Downsides of M.D.-Ph.D. Programs" and themes within those domains were identified. Themes were defined as common ideas or beliefs expressed among multiple participants. Transcripts were then coded independently by the two authors who were not present for that particular focus group (A.G.D., C.J.B., or C.J.K.), and the results of the aggregation of themes were analyzed, with responses to individual themes broken down by gender of the participant. Any discrepancies among coding were discussed as a group (A.G.D., C.J.B., C.J.K., M.C.B) to reach a consensus prior to further analysis. However, we found 88.5% reliability between coders, suggesting that our themes were well defined. We determined that we had reached thematic saturation after the final focus group did not yield any new themes. Specific quotes were highlighted and used as representative examples of varying themes, with gender, group number, and participant number of the speaker noted.

Results

During the September 2017 focus group sessions, 26 first- and 2nd-year medical students responded to the initial recruitment email, 23 were scheduled for focus groups and enrolled, and 22 attended and completed the focus group sessions. Within these four groups, we had 11 female and 11 male participants, with 10 first-year and 12 second-year students. Every group had both training years and both genders represented.

Career and life goals

We first asked participants to share their career goals and life goals in order to gauge the importance of research in the participant's future careers and to elucidate important factors

when deciding to apply to medical school. Medical students of both genders identified a future career involving research in combination with medical care or teaching: “I guess my career goal is just to hold a position in some academic medical center with both research and clinical responsibilities. The split as to which is 80% which is 20 or whatever, not exactly sure” (M, G4-P1). Some participants envisioned a clinical or surgical focus with research and teaching as side endeavors, while others aspired to research-dominant careers: “I think I’d like to primarily do research, and then a part of it would be clinical medicine” (M, G3-P4). In addition, students identified an interest in public policy or global health work as important contributions to their career goals. Focus group participants also identified negative research experiences in the past that deterred them from a research career but had been increasingly considering a research career trajectory due to recent experiences in medical school:

I didn’t have good research experiences in undergrad so I thought I just wanted to be a clinician, and just practice and that’s it. But then after getting here I’ve been thinking about applying to or doing a Ph.D. or research year. (M, G4-P5)

For life goals, students emphasized their desire for career flexibility, in terms of work-life balance (having time to travel, self-care, pursue hobbies, etc.) and the ability to pursue their specific career interests, such as public policy or global health. Female participants noted the opportunities for career flexibility offered by the M.D.-Ph.D. degree:

Also, the flexibility with what you want to do with your career: that you can do a very, very heavy research [focus] and not practice clinical medicine in any way, shape or form. You can do purely teaching. You could do all clinical work. It’s probably the most flexibility of all. (F, G3-P1)

However, others proposed that M.D.-Ph.D. training may restrict medical specialty choice: “As an M.D.-Ph.D. you’re generally kind of limited in what kind of specialties you go into” (M, G2-P2). Participants did not raise concerns that an M.D.-Ph.D. career interfered with their ability to travel or pursue hobbies outside of work. Another important life goal for participants of both genders was having a family, being in close proximity to family, and ensuring time dedicated to their family.

I want to spend time with my children. I want to spend time with my wife. I want them to feel like they’re the first priority in my life, because they are. And I think in order to put that time in at home I would need to sacrifice a little of other things that I want to do. (M, G4-P7)

In fact, participants suggested that raising a family and having a research career may be in conflict at times: “Down the line, I see myself having a family and kids. And I would prioritize that over research in a lot of contexts” (M, G2-P2). A desire to raise a family was more prevalent among female participants. However, participants also shared contrasting viewpoints about raising a family: “I think having a family is like– I’m open to it, but it’s not really a priority” (F, G2-P4).

Knowledge of combined-degree programs

We asked students to identify their sources of information about M.D.-Ph.D. programs in order to understand how program information reached interested students. Participants had heard of and even considered applying to M.D.-Ph.D. programs, and reported sources of information that tended to be informal and social in nature, including research mentors, peers, and the Internet: “I think a lot of my exposure came during my gap years, when I did research for a couple years. I worked with a lot of fellows who had done an M.D.-Ph.D.” (M, G4-P6). Peers included fellow lab members, applicants, and undergraduate students: “Especially since I don’t have a formal advising committee ... it made more sense for me to talk to people who are already in med school or are going to it” (M, G1-P3). Participants used the Internet to gain general information and specifics about individual programs. Among males, information sources included more formal contact with M.D.-Ph.D. admissions committees and/or program directors. Participants described gathering pieces of information from different sources to assemble a general understanding of M.D.-Ph.D. programs:

I also don’t think I ever was sat down and given a full rundown. I think all the things I know about M.D.-Ph.D. programs came piecemeal, just through random conversations that I had with people. I think it would have been nice to sit down and be [given] everything about the M.D.-Ph.D. program. (M, G2-P2)

Students expressed that their preprofessional advisors did not provide sufficient information about M.D.-Ph.D. programs or personalized advice:

They gave me information, but I feel like when you talk to a pre-professional program or an admissions office, they’ll give you very neutral information. It’s things that you can just find on the website, so it wasn’t really helpful. (F, G1-P2)

Summer research programs for undergraduates also provided participants with an overview of M.D.-Ph.D. programs.

Students also described their general understanding of M.D.-Ph.D. programs, which was used to assess their level of knowledge and degree of prior investigation into combined degree programs. Their knowledge included that M.D.-Ph.D. programs are designed to train for research careers, with a general structure of completion of 2 years of medical school followed by Ph.D. work and culminating with the last 2 years of medical school, and the presence of Medical Scientist Training Program funding for some M.D.-Ph.D. programs. Participants stated that the Ph.D. portion of M.D.-Ph.D. training tends to be focused in the basic sciences and did not describe potential Ph.D. training in public health, medical humanities, or other social science fields:

I think the perception of having M.D.-Ph.D.—it’s like more basic science geared. And then a lot of people end up wanting to open labs and do basic science or clinic research as a majority of what they do when they go to an M.D.-Ph.D. program. (F, G1-P2)

In addition, participants incorrectly identified that no M.D.-Ph.D. programs offer funding for international students.

Student sense of pros and cons

Next, we identified the participant's perceptions of benefits and drawbacks to M.D.-Ph.D. training. We differentiated these from "Barriers" as described next, because these opinions were general and may or may not have had direct relevance to an individual participant's application decision. Participants saw the M.D.-Ph.D. program as a gateway to conducting research via facilitated access to funding, focused research training, release from debt, and professional network development. For example, students felt that M.D.-Ph.D. training increases the likelihood of receiving National Institutes of Health grants, such as an R01, in one's career as opposed to M.D.-only grant applicants: "I remember seeing some stats about a lot of funding going to M.D.-Ph.D.s versus M.D.s and that's sort of been shifting more towards M.D.-Ph.D.s. ... I guess just having that extra training can allow you to be, an independent investigator" (M, G4-P4). Participants emphasized that M.D.-Ph.D. completion also provides skills such as the ability to develop and answer important biomedical questions as an independent investigator: "I think the Ph.D. gives you training for if you really are serious about running a lab and coming up with your own research questions" (F, G2-P4). The lack of debt following medical school and stipend addition were major benefits to funded M.D.-Ph.D. training. In addition, participants believed that M.D.-Ph.D. training increases access to meaningful mentorship, which participants felt to be important for a research career.

In contrast, participants described several downsides of M.D.-Ph.D. training to be weighed against the perceived benefits, including the duration of training, a perceived mismatch between scientific training and career goals, and unwillingness to commit to the training pathway. The duration and relative value of M.D.-Ph.D. training was a concern among participants:

I've heard from some people that they don't think it's worth the time for what you're getting out of it. For example, his Ph.D. is probably going to take five years. And then he doesn't know if he wants to do residency, because that would be an additional three years beyond the last two years of his clinical years. So he's like, "Should I spend five more years of my life just to practice 20% of the time?" (M, G1-P5)

Lengthened training could also constrain one's geographical location, withhold financial benefits, and interfere with plans to raise a family: "You can't really raise a family on a resident's income or a Ph.D.'s salary" (M, G3-P5). In addition, the additional training may not be worthwhile, as participants mentioned that training in both medical and scientific realms may be superficial because of an accelerated program and the difficulty of excelling in both fields throughout one's career.

Although participants emphasized a desire to pursue a research career, they felt Ph.D. training was excessive for what they envisioned as their career goals:

I think also to echo some of the other opinions earlier you don't necessarily have to have a Ph.D. to do some of the things that you want you want to do. Lots of medical doctors will choose to do research on the side. (M, G3-P3)

Their reasoning included not desiring a majority-research career, the added burden of Ph.D. coursework, the ability to perform clinical research without a Ph.D., and that additional training time has decreasing returns. Instead, participants proposed that a research year during medical school, an MPH degree, or pursuing opportunities for training later in fellowship or residency would be sufficient for their careers. Finally, participants described that an early commitment in one's career trajectory is required for an M.D.-Ph.D. program, and that they did not have the maturity or the willingness to commit themselves to a location, research field, or research career in their early twenties.

Along with the fact that the M.D.-Ph.D. program was so long and I wasn't 100% positive about what I would do my Ph.D. in, and I didn't want to apply and then change my mind. And it just was such a long time period. I just couldn't see that far forward. (F, G1-P4)

Barriers to applying to M.D.-Ph.D. programs

Given the perceived benefits and pitfalls of M.D.-Ph.D. training, we next assessed the individual barriers that students faced when learning about, considering, or applying to M.D.-Ph.D. programs. Participants described a high degree of competitiveness of M.D.-Ph.D. program admissions, with students citing concerns about the extent of their prior research experience but not typical measures of competitiveness such as Medical College Admission Test scores or grade point averages.

I think the people that I knew that were applying to them were generally really good candidates that had really strong research backgrounds and multiple publications in basic science. ... And so I was worried about my competitiveness in those programs. (M, G2-P2)

Other participants felt that their research experience was not impactful or significant enough for M.D.-Ph.D. program admission: "I was coming through a small liberal arts school that was not going to be competitive enough to be an M.D.-Ph.D. candidate, like, wasn't real enough of research, probably, to get in" (F, G2-P4).

Students also received advice against applying to dual-degree programs either because their advisor or mentor felt they were not competitive or based on how they voiced their career goals, and these experiences were voiced particularly by female students:

My PI at my lab was a Ph.D., and he really wanted me to do the M.D.-Ph.D. And my pre-health advisor at my university was more hesitant. At first, she was like, "Yeah, like, you should, you know, consider it and think about it." And then as it got closer to the time I was applying, I only had one publication, and she was like, "Well, really, you should have two or three if you want to be competitive." (F, G2-P3)

In addition, participants identified pressure from family or partners that served as a barrier to their consideration of M.D.-Ph.D. programs: "My dad ... was always just super against me doing an M.D.-Ph.D., and so I had that in the background" (M, G2-P2). Even when mentors or family encouraged participants to apply to M.D.-Ph.D. programs, participant chose not to

because of perceived downsides, such a duration of training or a required early commitment to a research career.

I do plan to have a family at some point in my life, and I want to make sure that I'm done with residency. I'm done with fellowship, and I have an established job before I get moving on that aspect of my life ... and being an M.D.-Ph.D. there's also like this biological clock that I don't have a whole lot of time to try to do both of those. (F, G3-P2)

Training duration was a barrier voiced disproportionately by female students:

One of the biggest negatives for me was probably the time. And like I mentioned before, I have other goals in my life. I want to start a family. I want to be married and I felt like that long of schooling and that long-time commitment would probably further set back those goals. And those goals were more a priority for me than research in my career. So that was a very big setback for me. (F, G4-P2)

Another theme was a general superficial knowledge of M.D.-Ph.D. programs on the part of advisors or mentors and was a barrier highlighted particularly by female participants:

I was told from my undergrad institution if you do M.D.-Ph.D., you have to have, like, five or six publications. I don't know if that's true, but there's this nebulous cloud about what the expectations are for how strong an applicant you have to be when you apply for M.D.-Ph.D. (M, G1-P5)

Although some received incorrect information, other participants received little to no information about dual-degree programs: "I wish I would have known more about what M.D.-Ph.D. was and what the coursework was like, and I just didn't have that information, so it wasn't on my radar" (M, G4-P7). A lack of a knowledgeable peer network for the M.D.-Ph.D. application process was also a barrier:

My major adviser had mentioned some upperclassman who was doing M.D.-Ph.D. But I was just sitting here thinking, she's like the only person I know of in any class year around me who's doing M.D.-Ph.D. So, it wasn't a common path by any means from my college. (F, G2-P4)

The lengthier application required for M.D.-Ph.D. applicants, in terms of an additional essay and lengthened interview process, deterred prospective students:

I didn't have a formal advising committee and I didn't really seek a lot of advice pertaining to a [Medical Scientist Training] program, I didn't even know that there was a separate essay that you needed to do. So, by the time that I was going to submit, I found out that you had to do an extra essay and that just dissuaded me completely. (M, G1-P3)

Finally, international students highlighted a perceived lack of available training funding as a major barrier for their applications.

Insights

In this article we conducted a qualitative study of recent medical school matriculants with an interest in academic medicine and research but who did not apply to M.D.-Ph.D. programs. We found that participants had knowledge about the existence of M.D.-Ph.D. programs but had obtained knowledge primarily through informal networks and held misconceptions about M.D.-Ph.D. program admissions, graduate training, and outcomes. Although students were encouraged to apply to an M.D.-Ph.D. program, others reported being discouraged from applying by advisors, mentors, or family members. These findings, as well as the other barriers to M.D.-Ph.D. training that our participants identified, suggest several concrete solutions about how we might expand the pool of M.D.-Ph.D. applicants, perhaps with the effect of moving toward gender parity for dual degree candidates.

Participants in our study reported having knowledge of the structure and training goals of M.D.-Ph.D. programs, which resembled actual structure and outcomes.^{11,21} However, a recent study revealed that careers of M.D.-Ph.D. alumni vary widely in terms of employment in academia, degree of participation in research, and types of research performed, including research outside of the basic sciences.¹¹ Sources of information for participants were informal and included mentors, peers, and online forums. Students infrequently discussed M.D.-Ph.D. programs with premedical or preprofessional advisors, and generally felt that those individuals provided neutral or insufficient information when discussed. This suggests that students may not be raising their interest in M.D.-Ph.D. programs with advisors and instead resorting to informal networks to gain information and possible misinformation. These informal advising networks may contribute to disparities among applicants, such as between students from institutions with many M.D.-Ph.D. applicants and those at colleges where the M.D.-Ph.D. is an uncommon career path or that lack institutional access to M.D.-Ph.D. admissions committees. Informal advising may pass on misconceptions of the typical applicant, worsen notions of competitiveness, and contribute to barriers such as the failure to preemptively prepare additional components of the M.D.-Ph.D. application beyond the standard M.D. application, as raised by participants.

Highlighted benefits of the M.D.-Ph.D. training pathway included improved grant application success, focused research training, medical school tuition coverage, career flexibility, and mentorship. In contrast, downsides to M.D.-Ph.D. training included the duration and value of training, excessive training for clinical-dominant careers, a concern that accelerated training may be superficial, and the fact that an early commitment to a research career is required for M.D.-Ph.D. training. Barriers identified by participants included a perceived competitiveness of M.D.-Ph.D. admissions, advice discouraging interested students from pursuing an M.D.-Ph.D., time demands of training, and insufficient information about M.D.-Ph.D. programs prior to the application process. Along the lines of prior hypotheses, it appears that a lack of confidence and/or encouragement of applicants considering M.D.-Ph.D. programs is a major deterrent, and this may disproportionately dissuade female applicants from higher-ranked M.D.-Ph.D. programs.¹⁰ In addition, although the course of the two degrees are accelerated, the duration of training remains a critical barrier for students pursuing research careers.^{5,22–24} Nonuniform or reduced funding

for international students in various M.D.-Ph.D. programs may dissuade these students from this path of physician-scientist training as well.

In terms of the proposed hypothesis that fewer women apply to combined programs due to concerns about future childbearing and family responsibility,¹³ students identified family goals as a priority and noted that M.D.-Ph.D. training duration may directly (time) or indirectly (lost salary) interfere with these goals. Although female students were more likely to voice a desire for a family, male participants also identified family as a priority over one's career and an important influence on choosing a training and career path. In fact, both male and female students voiced that they may have to choose between having a family and a successful biomedical research career and that the duration of M.D.-Ph.D. training interferes with starting a family. In addition, students of both genders desired career flexibility and work-life balance, and M.D.-Ph.D. training was viewed to have positive impacts on future career flexibility by female participants but no effect on balancing a future career with travel or other hobbies. Additional trends in differential experiences by gender arose, including perceptions of training duration as a barrier, interactions with admissions committees, information availability from advisors, and discouragement from applying. These trends deserve additional study among larger cohorts of prospective applicants.

Based on these interviews, we propose several steps to break down barriers to application to M.D.-Ph.D. programs and to reduce the gender discrepancy in applications. Our data suggest the importance of increasing accessibility of advising, resources, and accurate online information for interested students, promoting representations of typical successful applicants to both applicants and advisors, improving awareness of M.D.-Ph.D. programs at smaller colleges, addressing applicant concerns about duration and value of training, and increasing awareness of the programs with available funding for international students and availability of training outside the biomedical sciences.^{25,26} Increased distribution of quality information sources, including the American Medical Colleges M.D.-Ph.D. website,²⁷ the resources of the National M.D.-Ph.D. Association,²⁸ and a recent National Institutes of Health career fair webcast on M.D.-Ph.D. training and applications,²⁹ could alter many barriers and misconceptions that applicants and advisors may have. Providing online live question-and-answer sessions for applicants with program directors, current students, and established physician-scientists could also address misconceptions. Having these resources linked through online forums and promoted by preprofessional advisors may increase their visibility. Increasing public awareness of M.D.-Ph.D. training and benefits may help reduce discouragement from family members. These proposals are supported by a growing body of literature suggesting that shortening of the M.D.-Ph.D. pathway to academic careers and increasing M.D.-Ph.D. diversity are critical components to success of future physician-scientist training.⁵ A recent report details successful interventions to increase minority application to and enrollment in M.D.-Ph.D. programs,³⁰ which could be employed to promote applicants from smaller, non-research-intensive institutions and to expose female applicants to successful female M.D.-Ph.D. mentors and advisors.

This qualitative study has a number of limitations. Conducted at a private research institution with a combined M.D.-Ph.D. program, this study may not adequately describe how potential applicants to other institutions view the meaning and pursuit of an M.D.-Ph.D. degree. Using

recently matriculated students as our study population is suboptimal, as recent experiences that followed matriculation may have influenced career goals, beliefs, and misconceptions held by students at the time of application. Some thoughts and opinions may have been influenced by current knowledge, peers, recall bias, or the focus group discussion and may not perfectly represent decision-making at the time of application. To develop a nationally representative understanding of potential M.D.-Ph.D. program applicants' perspectives, a larger multi-institutional survey of both prospective and matriculated students is needed.

In conclusion, we have highlighted several barriers and misconceptions of M.D.-Ph.D. programs held by recently matriculated medical students with career goals in academic medicine. We hope to use this preliminary knowledge of student perceptions of and barriers to M.D.-Ph.D. application to improve M.D.-Ph.D. recruitment efforts, with the goal of recruiting and retaining talented and diverse physician-scientists to advance biomedical knowledge. Based on our findings, our primary recommendations are to increase accessibility of advising and accurate information for interested students, promote representations of typical successful applicants to both advisors and students, accelerate the physician-scientist training pathway to retain prospective students, and improve awareness of M.D.-Ph.D. programs at smaller colleges and universities through increased outreach. With these steps, we hope to remove barriers and improve information distribution to ensure equal training opportunity for all future physician-scientists.

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Appendix:: Focus group guide

Study Background:

Thank you for agreeing to participate in this focus group. The purpose of this focus group is to understand your perspectives on MD/PhD programs and the application process. We know that you have very busy schedules and we appreciate your willingness to participate in today's discussion. This focus group is part of a larger study that we hope will provide much needed empirical work to inform policy. The specific goal of this focus group is to help us identify key issues that we will address in a broad survey of medical and graduate students nationwide on MD/PhD programs. We anticipate this conversation will last 30 minutes.

Introductions:

Each person here has important expertise and we hope that you will all actively participate in the discussion. We would like to take a few moments for introductions. Could you please introduce yourself by giving us your educational program?

Personal goals:

We will start the conversation by asking about your career and life goals, and how medical or graduate school will help you reach those goals.

Probes:

- What are your career goals?
- What are your life goals?
- How will medical school/graduate school help you reach those goals?
- What other experiences are important to you?

General Knowledge:

Next we want to ask about your general experiences or knowledge of MD-PhD programs.

Probes:

- What do you know about MD-PhD programs? This question is intentionally vague.
- What are some positive things you think about MD-PhD programs?
- What are some negative things you think about MD-PhD programs?

Personal Experience:

Next, we want to ask about your specific experiences with MD-PhD programs.

Probes:

- What did your academic or pre-professional advisors tell you about MD-PhD programs?
- Where did you get more information about MD-PhD programs?
- Why did you not enroll in an MD-PhD program?

Thank you for participating in this focus group. To reiterate, your comments will be anonymized in the transcription process. If you have any follow up questions regarding what we have discussed, please do not hesitate to contact us.

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