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Surviving or flourishing: how relationships with principal investigators influence science graduate students' wellness

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Abstract

Purpose – This study aims to focus on the experiences of biomedical science students nearing the end of their doctoral programs and the factors that influence their well-being. In addition to identifying general challenges, the study aims to expand understanding of how interactions with principal investigators (PIs) can influence students' well-being and engagement in wellness practices.

Design/methodology/approach – This qualitative study presents an analysis of interview data collected from 90 trainees five years after beginning their graduate programs. All were participants in a larger mixed-methods, longitudinal study. Emergent themes and a codebook were established after reviewing interview transcripts and completing memos. Codes were applied to data, and reports were generated to confirm and challenge early interpretations.

Findings – Participants described four key factors that influenced their well-being: perceived work/life balance; managing progress on research; program completion and job search; and overall faculty relationships. While relationships with PIs could be a source of stress, participants more often described how both interactions with, and observations of their PIs could amplify or mitigate their ability to manage other stressors and overall sense of well-being.

Originality/value – While researchers in the USA have increasingly considered the factors impacting graduate student mental health, there has been less of an emphasis on wellness and well-being. Furthermore, there has been less attention to how PIs contribute, in positive and negative ways, to these outcomes. This study offers insight into well-being at a specific timepoint, considering dynamics unique to wellness and well-being in the later stages of doctoral training.

Keywords Well-being, Graduate education, Principal investigator, Faculty, STEM, Mentoring

Paper type Research paper

While experiencing stress in graduate school is a common occurrence (Evans *et al.*, 2018; Offstein *et al.*, 2004), it can lead to significant mental health challenges, reflected in rates of distress, anxiety and depression among graduate students that often exceed levels found in the general population (Eisenberg *et al.*, 2007; Evans, *et al.*, 2018; Hyun *et al.*, 2006; Levecque *et al.*, 2017;

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Nagy *et al.*, 2019; Wyatt and Oswalt, 2013). Issues related to mental health and well-being may be particularly acute in biosciences graduate training programs, which rarely promote a healthy work–life balance (Evans *et al.*, 2018), require long hours spent in the lab (Ferreira, 2003; Nagy *et al.*, 2019),and foster competitive academic environments (Chakraverty, 2020; Ferreira, 2003; Jairam and Kahl, 2012; McGee and Bentley, 2017; Nagy *et al.*, 2019). Without support, biomedical science students may be particularly vulnerable to mental health issues and forced to leave their programs before they can engage in productive science (Tsai and Muindi, 2016).

The purpose of this study is to better understand how US biomedical science doctoral students nearing the end of their programs cope with stress and engage in wellness practices. While a growing literature addresses how various challenges impact graduate student mental health (Eisenberg *et al.*, 2007; Gardner, 2009a; Wyatt and Oswalt, 2013), our work intentionally centers student wellness and well-being. The National Academies of Sciences, Engineering, and Medicine (2021) defines well-being as "a holistic concept referring to both physical and mental health. Mental wellbeing includes a sense of personal safety and security, emotional support and connection, mechanisms to cope with stressors, and access to services [. . .]" (p. 24). Meyers and colleagues describe wellness as "a way of life oriented toward optimal health and well-being in which body, mind, and spirit are integrated by the individual to live more fully" (p. 252). Borrowing from both definitions, we define wellness as a process and the practice of balancing competing interests in the pursuit of well-being, which is one's state of physical, mental and emotional health.

In addition to broadly addressing well-being and wellness, this work focuses on students' relationships with their principal investigators (PIs). Despite the acknowledged centrality of faculty relationships in students' academic outcomes and quality of life (Austin, 2002; Eby *et al.*, 2010; Johnson, 2016; Kumar and Blake-Beard, 2012; O'Meara *et al.*, 2013; Tenenbaum *et al.*, 2001), whether and how faculty members influence graduate students' wellness and well-being has been relatively unexplored in qualitative research in the US graduate training context. While there are important similarities between graduate education in the USA and programs in Europe and Canada (Barnett *et al.*, 2017), work specifically focused on doctoral student well-being in the USA is important. Longer doctoral training programs, differences in cultural norms and the unique blend of mentorship and supervision (Barnett *et al.*, 2017) may translate to distinctions in how faculty and graduate students interact, and the subsequent impact of those interactions on student well-being. Thus, this study aims to expand the discourse by examining how relationships with PIs influence the wellness and well-being of US biomedical doctoral students.

Background

Literature review

Several researchers have addressed factors that contribute to graduate students' stress, which ultimately can have negative implications for their mental health and wellness (Martinez *et al.*, 2013; Nagy, *et al.*, 2019). The competitive nature of graduate school can exacerbate student stress and be challenging to navigate (Chakraverty, 2020; Ferreira, 2003; Jairam and Kahl, 2012; McGee and Bentley, 2017; Nagy *et al.*, 2019). This may be particularly relevant to the experiences of biomedical science graduate students given the culture of academic science, which is often described as alienating, unfriendly and taxing (Cabay *et al.*, 2018; Eleftheriades *et al.*, 2020; Hish *et al.*, 2019; Joseph, 2012). High expectations can create a competitive environment among graduate students and lead to toxic lab environments (Ferreira, 2003; Jairam and Kahl, 2012). These dynamics can contribute to feelings of stress and anxiety, having a negative impact on academic performance (Jairam and Kahl, 2012).

In addition, many graduate students have problems managing the demands of their academic programs with life roles and responsibilities. Researchers have increasingly addressed students' struggles to manage competing deadlines and demands (Martinez *et al.*, 2013; Offstein *et al.*, 2004; Schmidt and Hansson, 2018) and their inability to effectively balance work, school and life (El-Ghoroury *et al.*, 2012; Offstein *et al.*, 2004; Yusuf *et al.*, 2020). Graduate students who are managing competing deadlines and demands have repeatedly reported higher levels of stress and less enjoyment with their academic experience (Martinez *et al.*, 2013; Offstein *et al.*, 2004; Schmidt and Hansson, 2018).

While rarely addressed directly, there is research that suggests that students' relationships with faculty can influence how stress and mental health issues are managed. Positive interactions, emotional competency and demonstrations of care and concern from faculty are linked to graduate students' satisfaction and sense of belonging in graduate school and can translate to their ability to manage their academic programs (Burt *et al.*, 2021; O'Meara *et al.*, 2013; Tenenbaum *et al.*, 2001). Faculty support can enhance students' confidence (Curtin *et al.*, 2016; Griffin *et al.*, 2020) and mitigate emotional stress. For example, Hunter and Devine (2016) found that doctoral students who frequently met with their advisors and had faculty support were less likely to experience emotional exhaustion.

More often attention has been focused on documenting negative faculty relationships and their implications. Scholars, policymakers and institutional leaders have increasingly highlighted the need to address faculty that engage in harmful behaviors, including neglect, sabotage, emotional abuse and harassment (Eby and Allen, 2002; Eby *et al.*, 2010; Johnson, 2016; Kumar and Blake-Beard, 2012). Some faculty have been accused of stealing their students' work, sabotaging career opportunities or being manipulative and disingenuous (Eby and Allen, 2002; Eby *et al.*, 2010; Johnson, 2016; Kumar and Blake-Beard, 2012). While these behaviors often attract attention, acts of neglect are more pervasive (Castelló *et al.*, 2017; Gardner and Gopaul, 2012; Greene, 2015). Negative or dysfunctional advisor relationships can have long-term implications, including lower rates of productivity, increased levels of dissatisfaction and disengagement from one's research and work (Eby and Allen, 2002; Kumar and Blake-Beard, 2012); these can all heighten students' stress and anxiety and have negative implications for well-being.

Conceptual framework

We use the modified version of the Wheel of Wellness (Myers *et al.*, 2000) to understand graduate students' perceptions of and factors influencing their well-being during their graduate training. Mental health professionals have used the Wheel of Wellness in a clinical setting to help individuals understand how focusing on various dimensions of wellness (e.g. life tasks) can have a positive influence on overall well-being (Myers *et al.*, 2000). In our paper, we use the Wheel of Wellness to organize students' experiences in relation to their well-being and wellness, which allows us to connect training experiences to wellness strategies, as well as make recommendations on how this population can strive for a healthy overall well-being. While the Wheel of Wellness has less often been used to frame research, this framework has been used to explore counseling graduate students' well-being with direct attention to promoting wellness practices like self-awareness and self-care during their graduate programs (Wolf *et al.*, 2012).

The model consists of multiple interconnected components that can positively or negatively influence health, holistic living and well-being (Myers *et al.*, 2000). The model is a three-dimensional sphere comprising five core areas, which are referred to as life tasks (Myers *et al.*, 2000). The life tasks can interact with each other, as well as external forces, such as "family, community, religion, education, government, media, and business/industry"

(Myers *et al.*, 2000, p. 91). The five life tasks are spirituality, which is located at the center of the wheel, self-direction in the intermediate ring, and work and leisure, friendship and love on the outer ring of the model.

Given that extant literature documents how faculty and graduate students' engagement in laboratory research centers on the completion of work tasks, time management and the development of an independent scholarly identity (Gardner, 2007; Joseph, 2012; Joy *et al.*, 2015; Maher *et al.*, 2020; Weidman and Stein, 2003), we focus our attention on the self-direction and work and leisure life tasks. Self-direction captures how individuals manage life tasks in pursuit of short- and long-term goals and includes 12 specific subtasks: sense of worth, sense of control, realistic beliefs, emotional awareness and coping, problem solving and creativity, sense of humor, nutrition, exercise, self-care, stress management, gender identity and cultural identity. While these characteristics do not necessarily translate to an avoidance of stress, they can be used as tools to activate resilience and agency when stressful situations are encountered. The work and leisure life task addresses meaningful experiences and opportunities to thrive in and outside of the context of one's career, highlighting the importance of social, creative and physical outlets in addition to professional pursuits. This life task focuses on the importance of developing competence and experiencing satisfaction in one's work, coupled with finding a way to integrate and balance work and leisure activities (Myers *et al.*, 2000).

Using the Wheel of Wellness as a guiding framework, we examine how graduate students engage in wellness, managing their well-being and workload. We approach this work with the assumption that students' abilities to manage life tasks are influenced by their training environments and experiences, which has implications for their wellness and well-being. Notably, we examine how the challenges they encounter may influence how they manage their stress and engage in self-care practices (self-direction life task). In addition, we explore how students engage in their respective academic environments, particularly with faculty, and how this engagement could amplify or mitigate their stress (work and leisure life task).

Methodology

This study addresses two research questions:

RQ1. How do biomedical science doctoral students describe the factors and forces influencing their mental health and well-being during their graduate training?

RQ2. How do biomedical science doctoral students describe the nature and influence of their relationships with their principal investigators (PIs) on their sense of wellness and well-being?

The research is guided by a generic qualitative approach (Caelli *et al.*, 2003; Kahlke, 2014), which allows for the integration of multiple methodological strategies to understand distinctions in students' experiences in graduate training, well-being and efforts to engage in wellness. Our data collection and analysis are informed by a conceptual framework or theory (Caelli *et al.*, 2003) – in this case, the Wheel of Wellness. However, our interpretations of the data are largely inductive, and our approach allowed us to balance data-informed descriptions of students' graduate training experiences and interactions with their faculty with theory-based interpretations of how these experiences influenced their wellness and ultimately their well-being.

Data source and participants

Data for this study are drawn from a larger, longitudinal mixed methods project examining the skill development and career trajectories of 336 biomedical science graduate students. Participants started their degrees in the 2014–2015 academic year and were enrolled across 53 high research activity universities. Program recruitment began with outreach to program directors and department chairs of the 100 largest biological sciences doctoral programs in the USA. To diversify the prospective pool of participants, all public flagship universities (research intensive), minority serving institutions offering PhD programs in appropriate biology subfields were also contacted. Finally, emails describing the study and eligibility criteria were sent to several listservs, including those of the American Society for Cell Biology and the Center for the Integration of Research, Teaching, and Learning Network.

In addition to completing regular surveys, a subsample of respondents participated in annual in-depth interviews with a member of the research team. The larger project had an emphasis on inequities by first-generation status and race/ethnicity. The original interview sample included all first-generation and racially/ethnically minoritized students at institutions that had at least one student who identified as belonging to a racially/ethnically minoritized group. To develop a diverse sample, a similar number of students not belonging to those categories from each of the institutions were invited to participate.

Although the larger project had a focus on social identities, this study is not analyzed using a racial or critical lens. A preliminary review of the data revealed few distinctions in student wellness or well-being by race or sex, and there were few named incidents of identity-based marginalization directly related to the goals of this study named in participants' interviews. As such, we chose to focus on understanding the dynamics between PIs, doctoral students and doctoral student well-being without a direct examination of how these dynamics vary across identity groups represented in the sample.

This study focuses on qualitative data collected from trainees participating in both surveys and interviews in the 2018–2019 academic year (five years after starting their graduate training). Focusing on data collected five years after beginning graduate training allowed us to move beyond transitional stress associated with beginning graduate training to focus more on student wellness as they navigated their research projects and made decisions about their careers. Participants were at the final stage of their graduate training (independent research focused on completing their dissertations) or had recently completed their programs, which can be stressful as students in this stage are often simultaneously developing an independent academic identity, conducting research and are preparing to or engaging in a job search (Pifer and Baker, 2016; Gardner, 2009b).

Ninety trainees completed interviews during the summer of 2019. While our work focuses on well-being during graduate school, we chose to include data from seven participants who graduated because the interview protocol asked participants to reflect on their final year in the program. Consistent with research that states women are more likely to participate in research studies (Curtin *et al.*, 2000), most of our sample identified as women (62 women and 28 men). While almost half of doctoral students in biomedical science programs are women (National Center for Science and Engineering Statistics, 2021), we acknowledge that women are overrepresented in our sample. Twenty-six participants identified as first-generation college students and 25 indicated that they were either Asian (3), Latinx (4), black (10) or multiracial (8).

Data collection

All participants engaged in interviews that were approximately 45–60-min long. Participants were administered one of three semi-structured interview protocols based on

their degree progress: recent completers, continuing students and graduates in the workforce. While there were some unique questions based on degree progress, the majority of the protocol was composed of shared questions, followed by prompts to provide additional depth and context. Particularly relevant to this study, the protocol prompted participants to discuss experiences over the past year and their PhD training overall, interactions with PIs and how their relationships had evolved and forms of support they received. All interviews were recorded and transcribed verbatim, and all personal and identifying information was redacted prior to analysis.

Analysis

Data were analyzed based on methods used in team-based studies (MacQueen *et al.*, 1998 for details). Members of the research team were assigned a subset of interviews for an initial review. After reading and rereading the transcripts, each team member completed memos documenting how participants individually and collectively described their level of mental health (e.g. stress, anxiety, depression) and well-being, as well as any forces that may be impacting their well-being and efforts to sustain wellness. Memos were discussed to establish emergent themes, focusing on overall mental health and well-being, as well as how PIs could promote and diminish wellness.

The memos and team discussions were used by the lead author to develop a list of inductive codes. The lead author also composed a list of deductive codes reflecting key concepts from the Wheel of Wellness and extant literature on graduate student mental health and well-being. The codes were combined and compiled into a comprehensive codebook, and each code was assigned a definition and rules for usage (MacQueen *et al.*, 1998). After completing a training where codes were discussed and clarified, members of the research team applied them to participant interviews using the Dedoose data management system. Code reports were generated and reviewed to confirm emergent themes, which were discussed during multiple team meetings and revised to ensure accuracy and alignment with the data.

Scope and trustworthiness

While our focus on late-stage graduate students in biomedical science prevents us from extrapolating these findings to other disciplines or stages in student's graduate training, the work can certainly inform our fundamental understanding of the multidimensional nature of well-being, how PhD training can have implications for students' sense of well-being, and how faculty relationships can inform the ways students think about and manage their wellness. The laboratory-based training environment and culture of academic science may make these findings somewhat unique; however, the growing discourse problematizing the workload and the stresses of engaging in research in higher education more generally suggests that these findings may be transferrable to other disciplines. We also acknowledge that graduate education generally, and relationships between faculty and students more specifically, are often marked by racism, sexism and other forms of identity-based oppression (Cabay *et al.*, 2018; Joseph, 2012; McGee and Bentley, 2017). These dynamics are complex and critical to explore; however, this study's primary goal is to establish an exploratory understanding of student well-being and the potential ways it is shaped by interactions with PIs across a diverse sample; future work can more directly interrogate how the identities of the students and the PIs impact these phenomena.

We adopted multiple strategies to promote the trustworthiness of our analyses and interpretations of the data. The lead author is a black woman faculty member and administrator with responsibility for graduate studies in her college, and the members of the

research team are Black women currently working on doctoral degrees in education. We are not working or studying in a STEM discipline and do not have personal knowledge or experience with conducting laboratory-based research or completing a biosciences graduate degree. However, we have extensive experience with graduate training, which informs our perceptions of what can make it stressful and challenging, as well as how faculty can play a role in exacerbating and alleviating stress and well-being. To account for how our knowledge (or lack thereof) could inform our work, our team engaged in a rigorous process, challenging our assumptions and encouraging team members to support all assertions with multiple data points. The team met frequently to not only discuss the findings, but to identify evidence that both supported and challenged our initial interpretations, leading to more precise articulation of our themes and ideas.

Findings

Participants shared multiple dimensions of their academic programs that were stressful and challenging, which had implications for their well-being. Faculty relationships were particularly important in students' narratives, and interactions with and observations of their PIs could amplify or mitigate stress, relating to wellness practices and overall sense of well-being. While some students talked about their PIs as a source of stress themselves, we focus this section on how faculty relationships and interactions influenced management of other potentially challenging aspects of the later stages of graduate training.

Work–life balance and wellness

Participants often described the extensive time they spent in the lab as difficult and challenging to maintain, leading to exhaustion and stress that could have negative implications. Participant 79 reflected, "[. . .] I ended up doing 12 hours in the lab seven days a week and then another four hours at home on the computer [. . .]" Participant 58 described how a lack of boundaries and structured off-time in her graduate training translated to an unhealthy pace, explaining, "They don't have anything built for – you don't get two weeks of vacation or three weeks of vacation. You don't have off-time and holiday pay [. . .]. In grad school, it's just assumed that you're going to work always, all the time." In addition, participants' narratives acknowledged that time was finite, and that commitments to research created challenges for engaging in other activities that were important. For example, Participant 252 mentioned wanting to engage in other activities, but that would have meant time away from "all the other things I'm supposed to be doing [. . .]."

While the students expressed strong commitments to their programs, they recognized the need for more balance and engagement in life outside the lab. Participant 214 described prioritizing family over more immediate progress on lab work: "[. . .] it's like I could run this experiment but then I'll miss dinner, or I need to let the dogs out, or something like that. To me, those things are more important than the experiment, and always will be." A similar sentiment was expressed by Participant 178, "[. . .] science is very important, but there's also more to science, such as like my family and friends and stuff." Other participants prioritized time for exercise, connecting with friends, volunteer work and community outreach or engaging in student organizations. Participant 124 highlighted the importance of activities outside of the lab such as making time to "have a drink on Friday and just kind of vent about work or relax," and exercise, sharing "I also go to a gym here almost every day." Another student dedicated time for enjoyable activities, having "coached the men's and women's club [sports team] during my time [here]" (Participant 8**)**. These activities were described as important stress relievers and promoted well-being, and importantly, linked by one participant to being a better scientist. Participant 112 shared, "I can enjoy my weekends.

I can spend time with my significant others [. . .] you gotta take care of yourself if you wanna do good science, and you can do good science without spending 24/7 [. . .] in a lab."

As participants described their efforts to determine an appropriate workload and integrate engagement with family and in activities outside the lab, many described how faculty behaviors shaped their perspectives and decision-making. In some cases, PIs were supportive, offering advice or helping strategize about how to best manage time. Participant 53 explained how his dissertation committee and PI helped him re-allocate his workload to better manage his stress and make progress on his dissertation:

> I felt like last year I didn't get a whole lot done because I was stressed at tryin' [. . .] to get al.l the projects to work instead of really focusing on one. Then I had a committee meeting this last March, and my committee was like, "Okay, you really need to focus. You have to drop all your other projects." Finally, my boss was on board, so I dropped two of the projects and kept my main one.

Some PIs supported taking time off to de-stress. One student described his PI's ability to recognize his stress and encouragement to prioritize work–life balance. He explained, "He'll tell me, 'I think you need a day off [. . .] You probably should go relax', or 'You can leave early'" **(**Participant 68). Participant 178 described her PI's general support for her need to take breaks from lab, noting that the PI connected this balance to her potential success as a scientist. Her PI reminded her, "you need to take care of your body and your mind and all of this kind of stuff [. . .] she understands we have to take care of ourselves first to be good scientists." This advice helped her make better decisions and prioritize self-care as she aimed to make progress.

PIs also indirectly influenced students' thinking and behaviors about the integration of work and their personal lives by how they engaged in wellness practices, including leaving the lab at a reasonable time and taking vacations. Participant 96 noted that her PI "[. . .] works reasonable hours, and so, most of the time is out of the office by 5:30 or so, and takes vacations with her family," setting the tone for their expectations of work–life balance. Another student described her lab's environment and its positive influence upon her own life, saying "Everybody else is a mom, and it's completely normal to see babies and kids in offices at work" (Participant 265). This family-oriented culture within the lab enabled her to feel comfortable bringing her baby to the office for meetings.

Conversely, faculty could interrupt students' wellness and detract from their efforts to engage in activities and life outside of the lab. Some PIs tried to enforce unrealistic timelines for completing tasks, adding projects and responsibilities to students' already heavy workloads. According to Participant 60, their PI had expectations that ignored other life responsibilities and transitions: "[. . .] he wanted a quicker turnaround than I was able to give him with applying to jobs, networking, doing interviews, prepping for interviews, moving into a new house, taking care of animals, all that kind of stuff." Participant 124 described their PI's expectation that they would manage the lab and supervise multiple students as they finished their dissertation, sharing "it felt like I was almost working another job." Similarly, Participant 97 shared that their PI often had a sense of urgency around the completion of lab tasks and an expectation everyone would "drop everything and help," even in the face of other priorities.

Some PIs were more passive, discouraging breaks or expressing disappointment when their students spent time away from the lab. For example, one student explained, "[. . .] if I do share what I did with my weekend, I get the sense that he's [the PI] annoyed that I wasn't in lab working on stuff" (Participant 31). Another student noted that their PI implied breaks and time to connect with colleagues were unacceptable interruptions in the workday, sharing "[. . .] everyone in my cohort would go get coffee, but I wasn't allowed to do that [. . .]

I just never went and just had lunch with them because I would have gotten yelled at, you know, for taking more than a 20-minute lunch break" (Participant 178). These behaviors, whether active or passive, reinforced academic science norms and expectations that good science means working all the time and taking on multiple projects and tasks with little time for rest or renewal.

PIs who failed to model work–life balance shaped participants' impressions of how much time they should invest in laboratory work. Participant 178 may have been hesitant about taking longer lunch breaks partially because of her observations of her PI's own workload, and noted that her PI is "[. . .] one of those people that works every Saturday [. . .]" An additional student observed that his PI "sometimes, he just doesn't go home. He could just live there [. . .]" (Participant 148). While resisting patterns established by their PIs was challenging, observing faculty members' behavior and messages sent about balance often had implications for students' perceptions of the time and commitments academic science required. After observing her PI's lifestyle, Participant 151 concluded, "I don't want your job. I want to go home. I don't want to have a constant to-do list. I want working hours, and then I want to go."

Managing progress on research and wellness

Closely connected to participants' descriptions of the challenges associated with laboratory research's time demands were their perceptions of and the experiences with their progress on their projects. Participant 68 described experiencing "a bunch of highs and lows" after equipment in his lab broke, causing him to lose data for his dissertation. Participant 40's progress on his dissertation project was derailed when one of his committee members questioned his methods during a lab meeting. He had to reconsider his whole project and reported, "I was really pissed. I was really mad at that PI for a little bit" (Participant 40). Another participant described her year as "stressful" after data were stolen from her lab, which caused her to shift her dissertation focus (Participant 291). This setback was a challenging, and she shared "I felt like I lost my identity as a researcher when I lost that chapter and had to change my dissertation. I struggle with that a little bit." These challenges added to the overall stress that the participants experienced.

When experiencing setbacks, some faculty engaged with students in ways that increased morale, allowing participants to feel confident in their own abilities and diminishing the stress associated with their struggles. Participant 51 stated that their PI assisted with "[. . .] reinforcing and helping me obtain the right mindset, not just in terms of being able to overcome difficulties [. . .] and obstacles, but also the way to think about science [. . .] that mindset and the method to go about asking and answering questions." Participant 291 described her PI as "very supportive" when her data were stolen. Her PI kept her promise when she told her "This is not gonna delay you. We'll figure it out. You'll be fine". Participant 319 described shifting gears in her research unexpectedly. Even though her project took a new direction her PI was "honest in addition to being supportive" (Participant 319). Thus, some participants appreciated faculty, as they helped them deal with adversity and affirmed their independence, allowing them to normalize their challenges, as they engaged in the craft of research.

Faculty interactions around research progress could also be challenging and have negative implications for wellness and well-being, particularly when PIs had expectations that were not aligned with the students' goals. This misalignment of goals and expectations could ultimately have implications for students' progress and degree completion. Participant 151 discussed an anxiety-producing situation where her PI insulted her when work was not completed stating, "There's 24 hours in every day" and mocked her ability to graduate by

stating "if you can graduate" when things were not going well in the lab. Participant 219 explained that she experienced more "head-butting" moments with her PI because she was focused on graduating while her PI wanted her to engage in more bench science. She explained:

> I've noticed that my goals and my PI's goals were no longer aligning [. . .] When my PI now comes up to me with new ideas, and it's like, 'We should try this,' and it seems to come out of left field, I'm very hesitant. I started to learn how to use language basically saying no [. . .] I'm not gonna do that.

Similarly, Participant 18 explained that she had a "confrontational year" with her PI, because her goals did not align with her PIs priorities. More specifically, she was prioritizing her final project rather than her PI's projects. She stated, "the relationship is difficult because there's a very clear power dynamic where she has my graduation as a big incentive for me to do what she wants to do". In these cases, faculty behaviors and engagement around their students' research increased pressure and stress about both their work and their progress toward degree completion, making the difficulties of research more challenging to manage.

Program completion, job search and well-being

Students encountered stress and anxiety as they neared the end of their PhD programs and began their career decision-making and job search processes. As noted by Participant 244, "Really while I was finishing my PhD, I was really just overwhelmed and stressed and looking for what my next step would be." Participant 52 also reflected on leaving graduate school and entering the workforce, explaining that "the job hunt is so stressful." When thinking about the job search process, Participant 13 described it as "a little overwhelming and hard to think about where to start."

As students engaged in the sometimes stressful and overwhelming process of determining their steps postgraduation, PIs' behaviors could make this process more challenging. Interactions around final requirements and products for degree completion could be particularly contentious and difficult to navigate. Participant 123 reported that her PI was neglectful and refused to sign, read or give final approval to her dissertation. Her PI,

> [. . .] was making excuses, saying he was too busy. He hadn't had time. But, at the same time [. . .] we had a visiting student in our lab. . .and my mentor was reading [their work], providing edits, all of that sort of stuff. Our relationship was so bad that I think he just felt like he could refuse.

Participant 97 explained that they were frustrated and concerned about their ability to graduate when their PI did not provide guidance on a publication that was required for degree completion until almost a year after it was submitted. Similarly, Participant 181 explained that her advisor was unable to pay adequate attention to all her advisees, which caused her PI to ignore providing feedback on her paper that was required for degree completion.

Participants also described how their PI's support, or lack thereof, had implications for how they engaged and felt during their job search. For example, Participant 124 secured a postgraduate opportunity at her graduate institution to continue her work with her PI; however, she wanted to explore other potential opportunities. Her PI's "reaction was really negative, and he was actually pretty rude about it to me, so that was a bit difficult." Other participants described how their PIs did not offer any guidance or support in the job search process or connect them with people in their respective fields. Participant 79 shared: "My PI had a lot of those connections, and he didn't really utilize those too much to help his grad

students find positions. I mean we could put him on as a reference and everything like that, but I was responsible for finding my own job after graduating."

It is important to note that the participants who often felt a lack of job search support most often had chosen to pursue careers in industry and not academia. Participant 214 attributed the lack of support he received to his interest in industry stating, "You finish here and it's like turning 18 and your parents saying, 'All right, you're on your own [. . .]' There's not really any kind of that support or guidance." When discussing his PI providing career support or guidance, Participant 157 explained "I think maybe in terms of career-focused advice he's probably not the best resource. He doesn't know that much about job ops and options outside of academia really [. . .]" Another participant explained how her PI did not respect her decision to go into industry and instead of providing support for her chosen career path, he kept trying to convince her to change her mind and stay in academia. She explained "It was frustrating. I felt like he didn't listen to what I was saying [. . .] Because I told him that I don't wanna go into academia. I don't wanna be a PI. I don't wanna do a postdoc" (Participant 60). Thus, whether it was due to a lack of familiarity or lack of support for their decision, PIs' inability to offer advice or guidance in pursuing an industry career left participants on their own to navigate a challenging and unfamiliar process.

There were multiple ways PIs could support students' management of their well-being as they made progress toward degree completion and made decisions about their career paths. Participant 23 appreciated the ways that her PI supported her as she searched for a postdoc, sharing, "If I didn't have a supportive [. . .] advisor as I do, I'd probably be struggling a little bit." Support could come in the form of encouraging exploration of students' interests and passions. Participant 68 shared his PI created career opportunities for him that allowed him to continue his work at the same institution. Participant 145 was interested in a career in teaching, and explained, "I'm more interested in the teaching, and he's really supportive of allowing me to take time to gain those skills more [. . .]" Participant 173 explained "It doesn't matter where you go. If you wanna go to industry [. . .] if you wanna do a post-doc and go into academia [. . .] she always makes sure that you're a competitive person [. . .] and giving you opportunities that are unique and will build a strong scientist to be successful in the future."

More than half of participants in the study commented specifically on how their PI supported them in the job search process, which could help the management of the stress and challenges associated with the transition out of graduate school. For some, understanding the time and energy that the job search required was important. Participant 177 commented that she "was gone for weeks at a time doing interviews on the other coast, and whatnot, and [her PI] was supportive of that." More often PIs were described as reviewing CVs and application materials, writing letters of recommendation, and connecting students with scientists or professionals in their field. Participant 71 commented that her PI was "[. . .] very open and happy to connect me with people as far as looking at postdocs and suggest people to talk to." Thus, having understanding and space, as well as instrumental and guidance support from the PI during the job search process could help alleviate stress, allowing for better management of well-being and wellness during a challenging time.

Discussion

While there is a growing body of work focused on the factors impacting graduate student mental health and potential sources of support (El-Ghoroury *et al.*, 2012; Gardner, 2009a; Martinez *et al.*, 2013; Nagy, *et al.*, 2019; Offstein *et al.*, 2004; Yusuf *et al.*, 2020), a critical factor impacting graduate student wellness that has not been fully addressed is the impact of relationships with PIs or advisors on mental health and well-being (Hyun *et al.*, 2006; Tsai and Muindi, 2016). Doctoral advisors can support students in their academic journeys by

providing encouragement, emotional support and professional support (Jairam and Kahl, 2012); however, researchers have not fully examined how interactions with PIs can both help and challenge students as they manage domains of their lives that can be stressful and challenging. To address these issues, this study examined qualitative data collected from 90 graduate trainees in biomedical science five years after the start of their graduate programs.

While some participants did describe advisor dysfunction as a key challenge to their well-being, the impact that PIs had was often more indirect. Participants noted how their PIs positively and negatively impacted their navigation of their graduate training and preparation for the next steps in their careers. Participants most often and extensively described the implications of long work hours, unspecified timelines and unclear career paths with limited support on their well-being. Many of these themes are reminiscent of previous work on the nature of graduate education generally or academic science, specifically (Ferreira, 2003; Jairam and Kahl, 2012; Nagy *et al.*, 2019; Offstein *et al.*, 2004). However, this work makes a new and innovative contribution to the literature by linking these dynamics to student wellness and well-being, rather than career choice or graduate school attrition.

Using the Wheel of Wellness (Myers *et al.*, 2000) as a framework allowed us to focus on how graduate training is both part of and can intersect with various life tasks connected to student well-being. Participants' discussions of their efforts to attain and maintain work–life balance given the demands and pressures of academic science speak directly to management of the work and leisure life task, which focuses on thriving in and outside of one's career path and engagement in social outlets and activities (Myers *et al.*, 2000). While some participants established a schedule that included time for life outside of the laboratory, others struggled with making time for themselves and their interests given the demands of their programs and pace of academic science.

While work–life balance may generally be perceived as subject to an individual's decisions about their schedule and workload, it is important to acknowledge how contextual factors and expectations can influence individual decision-making about how much time to allocate to self-care, personal roles and relationships (Austin, 2002; El-Ghoroury *et al.*, 2012). Our study suggests that PIs can have a powerful influence on students' decision-making about how they allocate their time, impacting their management of the work and leisure life task. Faculty who expressed and modeled a commitment to boundaries and personal time outside the lab appeared to have a positive influence on how participants thought about their own efforts to manage work and life. However, PIs that implied or directly stated that they expected students to spend nights and weekends engaged in research, were unclear about vacation time, or made it clear that they did not approve of activities that took students outside the lab exacerbated challenges managing this life task.

Participants also noted how difficult it was to manage the pace and frustrations associated with making progress when engaged in academic research. Interestingly, the extent to which PIs were engaged in behaviors that supported students' development of the self-direction life task and subtasks seemed to be related to how they navigated challenges and maintained a sense of well-being. Faculty appeared to have influence on sense of control and problem solving and creativity, two sub-tasks within the larger self-direction life task. Managing research delays and failures appeared more manageable when PIs engaged their students in ways that cultivated their independence and ability to think creatively about the problems they were encountering, developing their identities and confidence and independence as scientists. Those who had PIs who were inconsistent, absent and delayed in the provision of feedback, seemed to feel less control and more frustration and stress.

Finally, while not directly addressed in the Wheel of Wellness framework, it is important to address how personal and professional transitions can be challenging and difficult to manage, ultimately having potential influence on student wellness. The self-direction life task generally, and sense of control, specifically, appeared to be relevant. As participants aimed to finish their dissertations and take steps beyond the lab, timely review of final products and help in finding potential post-graduate opportunities appeared linked to maintaining their well-being. Further, support from the PI extends beyond looking for jobs; it also appeared to include helping students manage and balance their lab responsibilities while job-searching.

Greater nuance in our understanding of the distinctions between good and problematic faculty relationships can lead to better student mental health, and faculty becoming more efficacious sources of support. Rather than focusing our attention solely on relationships that are clearly dysfunctional and abusive, education leaders and faculty must be more attentive to how specific interactions, expectations and role modeled behaviors can impact students' well-being. As institutional leaders assess student success, they must consider graduate student well-being as an important outcome to measure alongside retention and achievement of academic benchmarks. Further, many have recommended and instituted mentoring training as a strategy to foster better relationships and graduate student outcomes. We similarly recommend faculty participation in mentoring training, and it should be strongly encouraged and incentivized through connections to institutional rewards and advancement. In addition to general mentoring skill development, these trainings must encourage faculty to reflect on their explicit and implicit expectations regarding students' and their own productivity. Acknowledging these expectations and whether they are reasonable, sustainable and in the best interests of students' well-being will create opportunities to have more clear conversations about developing a work schedule that balances progress on important projects and time for other activities critical to wellness and well-being.

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