



Volume 15, 2020

## THE IMPOSTOR PHENOMENON AMONG POSTDOCTORAL TRAINEES IN STEM: A US-BASED MIXED-METHODS STUDY

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### ABSTRACT

Aim/Purpose	This mixed-methods research study examined impostor phenomenon during postdoctoral training in science, technology, engineering and mathematics (STEM) through the following research question: “What are the manifestations of the impostor phenomenon experienced during postdoctoral training in STEM?”
Background	The impostor phenomenon occurs when competent, high-achieving students and professionals believe that they are fraud and will be exposed eventually. It involves fear of failure, lack of authenticity, feeling fake or fraud-like, denial of one’s competence, and is linked to lower self-esteem, mental health consequences, and lack of belonging.
Methodology	This study was conducted with US-based postdoctoral trainees (or post-docs) using mixed-methods approach. The study examined aspects of impostor phenomenon among 43 postdocs by converging survey data using Clance Impostor Phenomenon Scale (CIPS) and qualitative data from semi-structured interviews from the same participants. Both convenience and snowball sampling were used. Majority of the participants were White, female, and from science disciplines. Interview findings were organized into themes using constant comparative method and analytic induction.
Contribution	Findings pointed to the need for better designing professional development programs for postdocs that would: 1) address fears and insecurities due to impostor-feelings, 2) normalize conversations around perceived failure, judgment, and one’s lack of belonging, and 3) provide support with networking, mentoring, academic communication, and mental health challenges.
Findings	Survey results indicated moderate to intense impostor-feelings; interviews found six triggers of the impostor phenomenon during postdoctoral

Accepting Editor Wing Shui Ng | Received: February 27, 2020 | Revised: May 9, June 20, 2020 |  
Accepted: June 22, 2020.

Cite as: Chakraverty, D. (2020). The impostor phenomenon among postdoctoral trainees in STEM: A US-based mixed-methods study. *International Journal of Doctoral Studies*, 15, 329-352. <https://doi.org/10.28945/4589>

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	training: 1. not pursuing new things, 2. not making social connections, 3. impaired academic communication, 4. not applying, 5. procrastination and mental health, and 6. feeling undeserving and unqualified. Current findings were compared with prior findings of impostor-triggers among PhD students who also experienced the first three of these challenges during doctoral training: challenges to applying newly learnt knowledge in other domains, reaching out for help, and developing skills in academic communication verbally and through academic writing.
Recommendations for Practitioners	The office of postdoctoral affairs could design professional development programs and individual development plans for those experiencing the impostor phenomenon, focusing on strengthening skills (e.g., academic writing) in particular. There was an environmental and systemic dimension to the impostor phenomenon, perhaps more prevalent among women in STEM. The academy could devise ways to better support scholars who experience this phenomenon.
Recommendations for Researchers	Research characterizing the qualitative characteristics of the impostor phenomenon across the STEM pipeline (undergrads, PhD students, postdocs, and faculty) would help understand if the reasons and manifestations of this phenomenon vary among differing demographics of students and professionals.
Impact on Society	Organizations could focus on the training, development, mental health, and stressors among postdocs in STEM, particularly by focusing on career transition points (e.g., PhD to postdoc transition, postdoc to faculty transition), especially for those at-risk of experiencing this phenomenon and therefore dropping out.
Future Research	Future research could examine how to manage or overcome the impostor phenomenon for students and professionals, focus on disciplines outside STEM, and investigate how socialization opportunities may be compromised due to this phenomenon. Longitudinal studies might characterize the phenomenon better than those that focused on the impostor phenomenon at a single time-point.
Keywords	impostor phenomenon, impostor syndrome, higher education, postdoctoral training, socialization, STEM, STEM postdocs, transition

## INTRODUCTION

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The term “impostor phenomenon” was first coined by Clance and Imes (1978) to describe certain experiences of some successful and accomplished women who labelled themselves as intellectual frauds or phonies, crediting their achievements to luck, pretense, and other’s misjudgment or overestimation of one’s ability. Over the last four decades, this research extended across genders and racial minorities (Austin et al., 2009; Burt et al., 2017; Cokley et al., 2015; Ewing et al., 1996). Eminent figures like Michelle Obama, Sheryl Sandberg, and the late Maya Angelou have publicly voiced their experiences with an internalized experience of fraudulence. Although better known as “impostor syndrome” in popular media, the word “phenomenon” describes the process better than “syndrome” that can create the stigma of a medical condition (email communication with Dr. Pauline Rose Clance in 2017, cited in Chakraverty, 2019).

The topic of impostor phenomenon (other names: impostor syndrome, impostorism, impostor feelings) among students and professionals has gained particular attention recently (e.g., Cohen & McConnell, 2019; Jaremka et al., 2019; Vaughn et al., 2019). It is a recurrent belief of intellectual

fraudulence experienced by those who attribute their success and achievements to reasons such as luck, favors, and error of judgement by others rather than one's hard work, perseverance, and ability (Clance & Imes, 1978; Harvey & Katz, 1985; Hawley, 2019). Not everyone successful feels like an impostor, however, for those who do, these are not standalone beliefs. Such self-handicapping beliefs are correlated with impaired motivation (Vaughn et al., 2019) and fear of discovery as fraud (Neureiter & Traut-Mattausch, 2016). It could be related to student under-preparedness in academia (Cisco, 2020).

Experiencing the impostor phenomenon can affect how one experiences doctoral training and preparation to enter the workforce. Doctoral education can be strengthened by examining challenges for early career researchers, including current PhD students and postdoctoral scholars (or postdocs) who completed their PhD recently. In fact, the challenges experienced by doctoral and postdoctoral scholars due to the impostor phenomenon may or may not be entirely different. The rationale of the current study is to extend findings from prior research examining triggers of the impostor phenomenon in PhD students (Chakraverty, 2020) and to develop a holistic understanding of how to improve postdoctoral (and by extension, doctoral) education by examining the manifestations of this phenomenon during postdoctoral training. This would help one to adopt a fine-grained approach by looking at the two training phases (doctoral and postdoctoral) individually, and in relation to the overall science, technology, engineering, and mathematics (STEM) pipeline.

The current study examined postdoctoral phase as an academic transition to characterize behaviors due to impostor phenomenon and understand how it could potentially affect postdoctoral socialization. It aimed to address a research gap by examining the challenges of postdocs in STEM who feel like impostors. More specifically, this research study addressed the following question through a mixed-method examination: "What are the manifestations of the impostor phenomenon experienced during postdoctoral training in STEM?" Although prior research has extensively examined this phenomenon among other populations, it is largely underexplored among postdocs.

## LITERATURE REVIEW

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Research on the impostor phenomenon has been conducted in several countries and with several populations. It has been conducted in countries like Korea (Chae et al., 1995), Israel (Kuna, 2019), Australia (Thompson et al., 1998; Want & Kleitman, 2006), Belgium (Vergauwe et al., 2015), and Germany (Brauer & Proyer, 2017; Brauer & Proyer, 2019; Brauer & Wolf, 2016), among others. Additionally, it has been investigated among undergraduates (Blondeau & Awad, 2018) and graduate students in STEM (e.g., Chakraverty, 2019; Craddock et al., 2011; Jöstl et al., 2015). However, it has not been adequately investigated among postdocs despite the transitory nature of their training that could make one vulnerable to experiencing the impostor phenomenon along with anxiety, lack of preparation for the next stage, and mental health consequences.

Postdoctoral training is the period following PhD where trainees focus on advancing scientific research and gaining additional experience with publishing, grant writing, teaching, and professional networking (National Academy of Sciences [NAS], 2014). It is best viewed as a temporary, transition period (~1-10 years) before one starts pursuing research independently, typically as faculty (NAS, 2014). Other than advanced research experience obtained under a mentor or supervisor, postdoctoral training could also involve teaching and mentoring responsibilities for undergraduates and PhD students (Association of American Medical Colleges, 2006). In 2012, there were between 60,000-100,000 postdoctoral researchers in the US alone, the top five fields of training including life sciences (65%), physical sciences (13%), engineering (11%), geosciences (3%), and math and computer sciences (3%) according to the Graduate Students and Postdoctorates in Science and Engineering Survey (National Science Foundation [NSF], 2017). Postdoctoral training is considered the default option and even mandatory in many biological fields (Sauermaann & Roach, 2016) and has a positive impact on future faculty aspirations, fostering increased research productivity and output through publications (Horta, 2009).

While not everyone in postdoctoral training experiences the impostor phenomenon, we do not know how prevalent it is other than anecdotal evidence. Scientific training is a lengthy journey; those successfully pursuing science careers have, at times, been interested in the field since childhood due to various school-based and family experiences (Chakraverty et al., 2020; Chakraverty & Tai, 2013; Dabney et al., 2013). Yet, those already in the field but vulnerable to impostor-feelings might experience their training differently despite their passion in science. Manifestations of the impostor phenomenon specifically among STEM postdocs, to the researcher's knowledge, have not been documented before.

Academic transition experiences have been studied under various contexts in higher education such as university transition (Briggs et al., 2012; Gale & Parker, 2014), doctoral student transition (Dabney et al., 2016; Laudel & Gläser, 2008; Roulston et al., 2013), and even transition in between the different phases of MD-PhD dual-degree program (Chakraverty et al., 2018). The current study includes participants in a transition phase with expectations of high-quality scholarly output (Horta, 2009), an undefined length of training, a hypercompetitive environment with fewer full-time faculty positions available thereafter than the number of postdocs (Alberts et al., 2014), yet, no significant impact on earning potential (Yang & Webber, 2015). The impermanence or the transitory nature of postdoctoral training brings its own challenges not limited to a decline in interest in faculty careers (Gibbs et al., 2015; Martinez et al., 2007), long work hours, low salaries, compromised work-life balance (Price et al., 2018), and mental health consequences (Arnold, 2014; Gloria & Steinhardt, 2016).

Academic socialization is a process by which individuals are socialized into an academic role, and the postdoctoral period plays a crucial role in this process. In fact, postdoctoral socialization could be viewed as an extension of doctoral socialization where PhD aspirants not only gain content knowledge and develop research and teaching skills, but also form academic networks, including peer networks (Gardner, 2007; Gardner & Barnes, 2007; Kim, 2018), with the intended outcome of becoming independent researchers and developing a long-term research agenda. Postdoctoral training and socialization should focus additionally on funding management, time management, and forming networks crucial to one's long-term career development such as collaborations and partnerships (Feldon et al., 2019; Horta, 2009; Kong et al., 2013; Müller, 2014).

Transition points are important in understanding how novice researchers integrate psychologically and socially in an academic culture and environment to transform into independent researchers (Chakraverty et al., 2018). This takes time, training, and skill-development that are rather complex, and many fields that require mandatory laboratory training may require additional training post-PhD to acquire those skills (Feldon et al., 2019). PhD training may not fully prepare students for academia, hence additional post-doctoral training could enhance research skills and provide more time for research output required for faculty positions (NAS, 2014). Fewer tenure-track faculty positions, complex tenure processes, heavy research expectations, decreasing funding, and other challenges might discourage PhDs, especially women, to strive for faculty positions (Sheltzer & Smith, 2014), especially if they also experience impostor phenomenon.

Prior research among PhD students in STEM showed five triggers of the impostor phenomenon in doctoral training: due to progress and public recognition, when comparing oneself with peers and colleagues, while developing oral communication and academic writing skills, while applying new knowledge in other domains, and while asking for help (Chakraverty, 2020). Impostor phenomenon could be predicted by academic self-concept and school environment during PhD training (Ewing et al., 1996) and is related to feeling inadequate, stressed, fear of failure, academic under-preparedness (Craddock et al., 2011), and lack of belonging due to racial underrepresentation for Blacks (Burt et al., 2017), predominantly at White institutions as doctoral students (Stone et al., 2018).

Research on impostor phenomenon among doctoral students has used a combination of methodologies such as surveys (Chakraverty, 2019; Cohen & McConnell, 2019; Ewing et al., 1996; Vaughn et al., 2019), semi-structured interviews (Burt et al., 2017; Chakraverty, 2020), and focus groups

(Craddock et al., 2011; Stone et al., 2018). While surveys were more predominant and leveraged on a larger sample size, qualitative investigations provided an in-depth understanding of the phenomenon through personal narratives. Given the paucity of research examining the perspectives and life experiences of postdocs experiencing impostor phenomenon, there was no precedent to guide the choice of a particular method in the current study. With an objective to expand understanding of impostor phenomenon among postdocs by expanding on prior findings from PhD students, a mixed-methods approach seemed appropriate to be able to collect and analyze data using multiple methods.

## METHODS

This research study emerged from a larger, US-based study focusing on multiple understudied areas of the impostor phenomenon in various STEM fields. Data for the larger study were collected in 2017-2018 using online surveys and one-on-one, phone interviews after getting IRB approval from a large public university in northwestern US. The current study specifically focused on aspects of the impostor phenomenon experienced by postdocs in STEM, 43 of whom completed both, a survey followed by an interview. Each of these instruments of data collection are described in detail below.

### *DATA COLLECTION AND ANALYSIS*

#### **Study sample and eligibility**

This study used a convergent mixed-methods design (Creswell & Clark, 2017; Creswell et al., 2003; Ivankova et al., 2006) whereby cross-sectional surveys and semi-structured interviews were conducted independently and compared from the same sample (Table 1). The rationale behind this was to integrate quantitative and qualitative data for a less-understood phenomenon among postdocs. Following IRB approval, a webpage for the study with a link to an online survey was hosted to share among potential participants through email and social media. The webpage indicated that a study was being conducted to understand attributes of impostor phenomenon in STEM; only those who experienced this phenomenon were eligible to participate. The website provided an operational definition of the impostor phenomenon provided by Clance and Imes (1978) where successful people sometimes were not able to internalize success and accomplishments, fearing being exposed as frauds or impostors.

**Table 1: Participant demographics**

TOTAL	N=43
Field	Science: 38 Engineering: 2 Mathematics: 3
Sex	Male: 6 Female: 37
Race/ethnicity	White: 37 Hispanic: 2 Asian: 2 Multi-racial: 1 American Indian or Alaska Native: 1
Age range (years)	20-29: 11 30-39: 29 40-49: 3
Clance Impostor Phenomenon Scale (CIPS) scores (0-100)	Moderate (41-60): 5 High (61-80): 23 Intense (81-100): 15 Mean: 74.65; Std. dev.: 11.24

To be eligible for the study, participants had to meet the following criteria (verified from the survey and interview questions): 1. Should be currently working as a postdoc at a US institution in a STEM field, and, 2. Should have experienced the impostor phenomenon and be able to articulate it in English. STEM postdocs of all backgrounds (with respect to gender, racial/ethnic background, age, current location in the US, generational status, and country of origin) could participate provided that they were situated in the US at the time of the study and were conversant in English. This was to ensure that when describing academic/environmental factors and life experiences, these references were grounded in the US-context.

The researcher used convenience sampling as well as snowball sampling to recruit participants (Sadler et al., 2010). Data were collected in 2018. Participants were recruited by contacting professional networks at research universities and other professional societies (requesting to share information about the study by emailing members). These included various postdoctoral affairs offices, 500 Women Scientists, various women in science/women in STEM groups, the Future PI Slack group, the Science Teaching Experience for Postdocs at a research university (and other such groups at other universities), listserv for professional societies (e.g., Society for the Advancement of Biology Education Research), conferences (e.g., Understanding Interventions that Broaden Participation in Science Careers), and social media (relevant groups on Facebook and Twitter).

### Surveys

Following the principles of convergent mixed-methods design (Creswell & Clark, 2017), the surveys and interviews were conducted with the same individuals independently (survey results did not influence the interviews). The researcher did not individually solicit participation; interested individuals with a link to the survey participated. The online survey (7-8 minutes) consisted of demographic questions (e.g., name of institution and field, year in postdoctoral training, age range in 10-year increments, sex, and racial/ethnic background) and open-ended free-text responses (without word limits) to how did they learn about the study and if they had recently experienced the impostor phenomenon. The purpose of the open-ended survey question was for participants to articulate an impostor-experience to ensure that they understood what impostor phenomenon meant. At the end of the survey, participants indicated if they wanted to be contacted for a one-on-one phone interview to expand on their experiences of impostor phenomenon. Further, the Clance Impostor Phenomenon Scale (CIPS; Clance, 1985) were used with permission. It is a validated scale to measure to what extent impostor phenomenon occurred. The CIPS consists of 20 Likert-scale items (1 = not at all, 2 = rarely, 3 = sometimes, 4 = often, 5 = very true) where scores were interpreted as <40 = low, 41-60 = moderate, 61-80 = high, and 81-100 = intense impostor phenomenon. A higher score indicated a greater intensity of impostor phenomenon.

### Semi-structured interviews

The researcher interviewed all those who completed the survey, consented to be contacted in the future, and provided evidence of some familiarity and experience with the impostor phenomenon. Those who said that they have not experienced the phenomenon were not contacted. Further, to ensure that participants understood the topic, there were probes in the interview asking them to explain their understanding of the phenomenon. Following a semi-structured format, the interview expanded on a list of questions asked to every interviewee in relation to their postdoctoral training:

1. What was your motivation to participate in the study?
2. What did it mean personally to feel like an impostor?
3. How did your current research group, department, field, or academia, in general, contribute to your impostor experiences?
4. Was your impostor experience self-handicapping in terms of your short-terms or long-term professional goals? How?

Follow-up questions were asked when required. Due to a semi-structured design, other experiences about family, undergraduate training, or PhD training came up during the conversation, although this study specifically focused on factors directly related to one's postdoctoral training (e.g., mentorship).

The researcher developed these interview questions based on her understanding of the topic, limitations in the current literature, and specific domains she was interested in (e.g., the role of institutional climate in triggering the impostor phenomenon). Each interview lasted ~45 minutes and was transcribed using professional transcription services. Transcripts were shared with participants who could add more information or delete responses that they did not want to be included in the analysis and to verify the overall accuracy of transcription. Participants were also requested to share information about the study in their professional networks to recruit people from a widely distributed network through snowball sampling (Sadler et al., 2010).

### **Analytic strategy**

The researcher calculated CIPS scores for participants, classifying them as those with low, medium, high, and intense impostor phenomenon (Clance, 1985). A participant could score a maximum of 100 points, computed as low (<40), moderate (41-60), high (61-80), or intense (81-100) impostor phenomenon. The researcher also analyzed the interviews using a combination of codes developed in prior research with PhD students (Chakraverty, 2020) as well as through open coding of the current interviews to create a codebook of the combined codes. For example, some of the codes related to postdoctoral experiences were: “grant,” “teaching,” “future goals,” “faculty career,” “conference,” “professional development,” “mentor,” “challenges,” and “risks.” Similarly, codes related to impostor phenomenon included “fear,” “procrastination,” “mental health,” “undeserving,” “unqualified,” “self-evaluation,” “peer-evaluation,” “judgment,” and “belonging.”

The interviews were coded using constant comparative method and analytic induction; following coding, emergent themes related to the manifestations of the impostor phenomenon were developed (Boeije, 2002; Glaser & Strauss, 2017; Miles & Huberman, 1994; Thomas, 2006), specifically focusing on postdoctoral training. Data saturation had occurred by the time the researcher completed analyzing all the interviews and no new codes emerged thereof. The researcher was mindful that her worldviews could differ from that of the participants that could influence data collection and analysis (Antin et al., 2015). The researcher maintained a reflective journal acknowledging any disconfirming evidence as well as her prior background in STEM, professional experiences, and how that may have influenced how the study was conducted and managed.

An integrated mixed-methods approach ensured that those interviewed indeed experienced some level of impostor phenomenon as indicated by CIPS score. Additionally, starting the interview asking what it meant to feel like an impostor helped verify that the interviewee indeed clearly understood and experienced the phenomenon which is characterized by the fear of being found out as fraud and attributing success to luck rather than competence or ability. While the study followed a constructivist approach (Creswell & Clark, 2017), the CIPS scores indicated how intensely one experienced the phenomenon. Emergent themes from the qualitative phase are enlisted with representative quotes; the study benefitted from perspectives of participants from a variety of STEM fields.

## **FINDINGS**

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Data were collected using both, surveys and interviews with the same 43 participants (Table 1). Survey results are displayed followed by the interview findings. Interviews were the primary source of data for this study while the surveys augmented the interviews by enhancing our understanding of participant demographics, helping quantify the phenomenon using CIPS (Clance, 1985), and excluding those who did not experience the phenomenon and were thus not eligible for the study.

### ***QUANTITATIVE: SAMPLE CHARACTERISTICS***

Fifty-two participants originally completed the survey out of which, nine declined to be interviewed (their surveys were not included for further analysis). The rest of the 43 participants were mostly from science (33 out of 38 were from life sciences), predominantly female and White, between ages 21-39 years, representing 30 different research-focused (R1) universities and labs from across the US

(The Carnegie Classification of Institutions of Higher Education, n.d.). Most of them scored highly in CIPS, with a mean of  $74.65 \pm 11.24$ . CIPS scores confirmed that none of the participants interviewed had low scores (Table 1).

### ***QUALITATIVE: INTERVIEW THEMES***

Six themes related to how impostor phenomenon manifested during postdoctoral training emerged from interview analysis. Each theme is discussed in detail and supporting quotes provided in the discussion as well as presented in Table 2.

**Table 2: Manifestations of the impostor phenomenon during postdoctoral training**

THEMES	QUOTES
Not pursuing new things	Contributing to my impostor syndrome is the fact that every time I present or submit an article or analysis or teach a class, I feel like it's like shoddy workmanship because I haven't had the time that I need with all these different things. (Biology postdoc)
Not making social connections	I feel like I might ask something that I should know or that I didn't read up on enough. When I'm asking a question, all of a sudden, people are listening to me, and that's terrifying because I'm scared that I'm just gonna say something really dumb and that everybody's gonna be like, 'Oh, what's she doing here? Why is she asking this question that makes no sense?' (Biochemistry postdoc)
Impaired academic communication	Oral communication: I'm close to getting exposed as an impostor [at conferences]. When I'm presenting, the risk is high because there's a lot of people thinking about what I've been thinking about for years. They're gonna see something that I haven't seen in my years of working on it. Then it's all gonna be over. It's gonna be like, 'Well, you didn't see this, so you're clearly not good enough to be here.' (Biology postdoc)  Academic writing: People will think it's [the manuscript is] dumb. It's not as good as this other article. I would get really anxious, and I wouldn't write. I just would sit there and look at the screen. I know it's valuable, but I still have those feelings of inadequacy with it [the manuscript], so it's definitely slowed that [the writing] down. (Engineering postdoc)
Not applying	I am not qualified for my aspirations. I could not possibly be a successful professor, though I have the same qualification, better even than many of my peers. (Molecular Biology postdoc)
Procrastination and mental health	If they really knew what was going on in my head, they would reject me from the lab, I'd lose my job. That type of thing has made it difficult to get up in the morning. There's definitely a combination between anxiety and some depression that's mixed in with this anxiety over this impostor feeling. That's made it challenging to come into work every day. (Cell Biology postdoc)



THEMES	QUOTES
Feeling undeserving and unqualified	I feel like an imposter every time I attend our lab meeting. My colleagues all are better versed in their scientific literature, and methods, present and interpret more interesting findings, and worked harder than me. I scrape to put together a full lab meeting presentation and feel like I don't understand or present as well as any of my peers. (Immunology postdoc)

### Not pursuing new things

Those who felt like impostors hesitated to pursue anything new, for example, volunteer for new roles and responsibilities, experiment with new research ideas, explore new lab protocols, or take risks. They feared failing or doing something wrong and in turn, being judged. Academic excellence required one to be constantly learning, yet there was fear of not knowing or understanding certain concepts, ideas, teaching techniques, research areas, or other's research. While graduate school provided more time to learn something new, postdoc positions were result-oriented, leaving less time for learning new things. One was sometimes required to learn new, unfamiliar techniques of data analyses. Hesitating to pursue something new affected how one was perceived. A fisheries and wildlife postdoc shared that when asked by the adviser to "take on a new, highly complex task, I emailed him a list of reasons why I can't do that, all related to my inexperience, lack of knowledge, etc., and almost got myself fired." Anything that was new or not routine was perceived as challenging, for example, as shared by an environmental science postdoc, "A new project, a new method in the lab, or even something I have done a million times before but I am gonna use a new protocol."

### Not making social connections

Those who felt like impostors had a difficult time networking, asking for help, or asking questions despite recognizing its value. They found it difficult to walk up to peers or faculty, introduce themselves, and talk about their work. They feared wasting other's time, not being recognized, or being rendered invisible. The thought of networking was draining, inducing anxiety, feelings of incompetence, and a sense of not belonging. A medicine postdoc feared, "I don't have anything to say. I don't know how to talk. Whatever I say will not be interesting to them [colleagues]. Maybe these people won't even remember who I am."

Although postdocs knew the value of networking and seeking feedback in one's professional development, they felt anxiety, judgment, and inferiority. A biology postdoc shared that her mentor had recently made a career change, and although she wanted to reach out and learn about his transition experience, she did not contact him due to anxiety and impostor-feelings. A genetics postdoc feared: "I don't want to waste their time and so I have a hard time initiating networking conversations, even though they'd be good for me." A cell biology/molecular genetics postdoc faced difficulty reaching out to other professionals and networking because "I feel like an imposter, like I'm not sure I can hold my own in this conversation and I don't want them to think I'm stupid and under-trained." The impostor phenomenon impacted one's confidence, coping skills, and openness to seek research feedback. A psychology postdoc remarked:

I'm so worried about not being smart enough. That delayed some progress I could have made in the first few months. I'm nervous that if I don't think about every single crack in my argument, or every single poorly written paragraph, I shouldn't send it yet because they're gonna see that it's flawed.

Postdocs who did not reach out did not get timely feedback. A cognitive psychology postdoc shared, "I hold onto things and ideas in order to try and make them perfect where, probably, it would be more productive to have the conversation and work through the trouble areas together as a group."

Postdocs further feared asking questions publicly, at seminars and conferences. Instead of seeking opportunities to learn more about a topic, network, and make their voices heard, they worried if theirs was a good question and if they would be judged as stupid, less serious, or incompetent. A bio-physics postdoc felt like an impostor:

When I'm not understanding something that everybody else is understanding or I missed something in the presentation, especially during the question session because I hear questions that others are asking, and they sound like they really put together all the information that they were getting from the talk.

Asking questions was viewed as risk-taking activity that could expose one's ignorance, leading to fear and impostor-feelings and stymying learning opportunities. Participants felt like they did not have good questions and were not able to connect ideas like the others. A mathematics postdoc felt:

uncomfortable asking questions often because I am afraid that it will give away that I am an impostor. When it's constantly happening that people can come up with interesting questions that ask about different connections between ideas, and I don't think of those questions or those connections, that's really what solidifies it.

Postdocs felt like they could not match others' competence who asked better, more intelligent questions they could not have thought of. They blamed themselves for not paying attention during talks or not being smart enough to synthesize a talk. Regarding anxiety around asking questions, a bio-chemistry postdoc wondered "if this is a good question to ask, if I'm gonna sound really stupid, if somebody already asked this question or if they covered it already in the seminar and I just missed it and wasn't paying attention."

### **Impaired academic communication**

Participants shared lacking the confidence in both, pursuing oral communication and academic writing, as discussed below:

**Oral communication:** Those who felt like impostors were intimidated by large conferences and thought of themselves as poor communicators lacking social skills. A biochemistry postdoc did not "understand the culture of talking [at conferences]. I feel like I don't fit in and I'm probably not good enough." Some struggled to speak with authority and confidence about their research, worrying about how others would perceive them. During conference talks, an environmental health postdoc felt, "this is all nonsense, why would anyone listen to this? It's really hard to get past that perception. Everyone's staring at you, judging you. That's a pretty large trigger for anxiety."

A biology postdoc often interrupted herself while speaking, that affected the way she taught in class. "Because I am self-conscious about it, I end up doing it more." She shared that in lab settings, "I can hide and just do my work. The risk of exposure there is low."

Many felt a lack of confidence in speaking, assuming that their research was not interesting or important enough or they were not performing well enough. A biology postdoc talked about "a disconnect between the work I produce and the intellect that's in my head. By having this disconnect, it makes me feel a lot of insecurity." Lack of confidence came partly from not knowing who the audience would be, especially at large conferences. Many worried about how much prior knowledge the audience had and how people would react if they said something that was factually wrong. A pathology postdoc shared, "I say something incorrect about the mitochondria, then all the people in the audience who know about mitochondria are going to know that and assume that the rest of my talk is bad and I'm not a good scientist." Many felt self-conscious about how they would be perceived, that their knowledge was being tested whenever they spoke, and other established scientists were waiting to catch one wrong answer and expose them. The thought of being asked questions was terrifying. Not being able to answer a question made a life science postdoc wonder, "Is this person, who I am portraying, who is really competent and good at their work, actually real, or is everyone else actually

better?” A psychology postdoc reasoned that impostor phenomenon was due to the pressure she put on herself to look perfect and the uncertainty of what questions she would be asked and how quickly she would be able to answer them. There was no structured audience feedback at the end of a talk, because of which, a biochemistry postdoc reasoned that she would not know “how I did and whether or not they [the audience] think I completely messed everything up and that I’m worthy of the position I’m in and worthy of moving forward in this career trajectory.” Many equated saying something wrong to not deserving the label of being an expert in the field. There was a cost to such self-deprecating thoughts. A molecular biophysics postdoc shared,

It’s hard to go into a meeting worried that I’m gonna be discovered as a fraud and kicked out of the lab. It’s not very conducive to confidence. Little things like this on a day-to-day basis in terms of confidence in talking at meetings or confidence when I’m designing experiments ultimately can have long-term effects.

Postdocs who taught worried that their students will figure out gaps in knowledge and perceive them as poor teachers. One felt the pressure to be the expert in the room. Once again, one feared not knowing the answers to a question that would be asked (like in conferences), which equated to not being a subject-matter expert and not having the ability to explain concepts convincingly. An engineering postdoc, while teaching, “was just antsy and nervous all day. I was like, ‘I’m gonna be standing up there, and they’re gonna know that I don’t know how to do this’ [use MATLAB].”

**Academic writing:** Postdocs who felt like impostors questioned their contribution to research manuscripts as authors, feeling exposed and overwhelmed about writing that others would read and judge. They feared inadvertently writing something in a research paper that could be false, utterly foolish, or overlooking something major. A biology postdoc shared, “Publishing is permanent record. When you put something down on paper, it’s there forever. It’s hard to go back and say, ‘Oops, I made a mistake.’”

Participants feared judgment from readers. Self-paralyzing fear not only delayed publication, but also impacted the quality of journal one chose to publish in. Many admitted to publishing in less prestigious journals due to the fear that the reviewers would find a mistake and discover that the experiments were not done correctly. Postdocs hesitated to ask for feedback or submit a manuscript for review timely. Many admitted to procrastinating and rewriting for months instead of seeking timely feedback. The anxiety affected one’s productivity, which had a counter-productive effect. A biology postdoc shared, “The less productive you are, the less qualified you might be viewed for positions, promotions, or for the next grant you’re trying to get. It slows me down because I’m questioning myself rather than just pushing through.” Advanced postdocs shared similar fears. A fifth-year postdoc worried while submitting research manuscripts, “Did I think of everything? Am I crazy? Will the reviewers think I’m stupid? Will people think the reviewers were wrong when it comes out?”

### Not applying

Those feeling like impostors felt reluctant to apply for career opportunities or accept competitive positions and were unable to visualize themselves as future faculty members. A psychology postdoc feared, “I don’t have what it takes [to apply] because I don’t have the real or right training.” The fears persisted despite knowing that not applying can hurt one’s career. Those who questioned their research ability were less inclined to apply for research positions. A biology postdoc did not accept a second postdoctoral offer because she feared:

If I were to transition to a research-intensive university and really strong department, I would just flop. I don’t have the same training that the other people in their labs do. I wouldn’t be as productive as the other postdocs, wouldn’t be able to compete. It’s prevented me from leaving. Being where I am right now is detrimental to my long-term career success, yet I’m afraid to take that next step. Because I just don’t necessarily feel like I belong there.

Many did not apply for new positions, fellowships, grants, and other career opportunities they could have, assuming that they were not qualified or competent enough and would not be good at their job even if they got the position. There was a mismatch in true ability and the perception of one's ability. A chemistry postdoc admitted to not applying for faculty positions at community colleges because "I don't think I would be good at it even though I was a pretty good teaching assistant and won an award for it." Similarly, a postdoc in astronomy and astrophysics shared, "Because of all the impostor syndrome, it was really hard to convince myself that I should apply. ... I think it can have really long-term and short-term effects on local productivity and the whole career path."

The thought of being scrutinized by a selection committee made participants anxious. They struggled to understand if they were good enough to even apply for an opportunity. A postdoc in genomic medicine shared, "I under-shoot my capabilities. People constantly tell me how smart I am, but I don't believe that. ... Why spend all this time on this [application] if I know I'm not gonna get it, 'cause I don't deserve it?" Insecurity and self-doubt persisted long into postdoc training. For example, a sixth-year postdoc felt that she was fooling people by doing research that was not important. "I avoided applying for some grants because I thought my research projects and my abilities were not worthy. And then I feel bad that I'm not self-motivated."

The purpose of postdoctoral training is to help postdocs transition into faculty positions. However, those with impostor-feelings hesitated to visualize themselves as future faculty "because I don't think I could do it," a genetics postdoc shared. They felt that they had less knowledge, were inferior compared to current faculty and could never get the success that others did. "How can I ever produce something that looks like what these other people are producing, at the rate that I need to, to become a faculty member?" a biology postdoc mused. Another biology postdoc who recently applied for a faculty position at an R02 school wondered:

If I had more confidence, if I didn't have this impostor syndrome, would I try for something bigger? Am I self-limiting? Is it a horrible cycle of impostor syndrome where I choose lower things? Then choosing lower things makes me feel more like an impostor?

True to the definition of impostor phenomenon, such fears persisted although postdocs were qualified to apply for faculty positions. A mathematics postdoc shared, "I have many publications for my age and several prestigious awards, but I still worry that I am somehow behind others and that I will not be able to find a permanent job." The impostor phenomenon got in the way of career progress because many thought that they were not capable of becoming faculty. A chemistry postdoc shared, "I've always wanted to run a research lab and be a faculty at a big school. But I almost decided not even to fight for it because I didn't think I was gonna be good enough to do it."

### **Procrastination and mental health**

Those with impostor-feelings tended to procrastinate or spend their time trying to be perfect. They also experienced mental health conditions with anxiety and lower work efficiency. Some tried to over-prepare and overcompensate for their lack of confidence. An astronomy postdoc shared:

If you're busy feeling like an impostor about giving a talk, you might spend too much time preparing for the talk and overcompensating. Which means you're not working on what you should be working on, or avoid working on whatever is making me anxious for long enough that then I have to do a really rushed job. It's, therefore, probably not my best work.

Those who procrastinated found it hard to be focused, excited about their work, and put energy into something they worried they would fail at. A marine science postdoc found herself "more prone to wandering off to get a snack or checking my e-mail while I'm trying to work." Procrastination could impact starting or finishing an experiment on time. An immunology postdoc shared:

If you think of an impostor as also potentially thinking that my [research] questions may not be the correct questions or that the experiment might not show a difference, those feelings

lend toward a tendency to procrastinate in starting an experiment if I think that it's not going to come out positively or that I'm not very excited about what the results might show.

Those who procrastinated usually completed a deadline, but were not satisfied with the quality of work. "I sit and look at things for hours and I think, I don't even know where to start because I clearly am not good enough to write or to think about this. It makes me slower," a biology postdoc shared, adding that she got into "loops of procrastination or putting aside the most important thing because it's hard. Then it triggers my anxiety and I feel like I can't rise to that challenge."

Many postdocs procrastinated and delayed looking and applying for positions, thinking that their application was not strong enough or they were not ready to pursue a new position. Those with mental health conditions due to impostor phenomenon suffered from unwanted consequences. A microbiology postdoc shared that "it definitely fed into procrastination, depression, and avoiding things that you didn't wanna do or were hard for you." Some struggled on a daily basis. A pulmonary health postdoc shared:

This is almost every day for me [experiencing impostor phenomenon]. I sit at my desk and spend the first 20-30 minutes of everyday giving myself a pep talk and usually end up crying in the bathroom at least once a week because I feel like such a joke.

An immunology postdoc, on certain days, found it challenging to be even:

getting up, taking a shower, getting dressed, leaving to go into the lab, that's very anxiety filled for me. I get stuck on a thought, and I look at it from every single angle, and I circle back around about it. When I have this idea that I'm not good enough, I don't work enough hours, I don't work hard enough, I keep coming back to it. I try to rationalize and I definitely self-handicap as I try to navigate my way around those issues.

### **Feeling undeserving and unqualified**

Those experiencing impostor phenomenon doubted their achievements and wondered if they could be called field experts based on their knowledge, convinced that their advisers and others overestimated their ability. Some had to overcome personal hardships (including health problems) to excel in their field. A medicine postdoc didn't think he deserved his postdoc position that "felt like charity" and his employer felt sorry for him, despite completing a PhD and authoring publications "after two years of medical leave due to a brain injury that severely affected my language and cognitive skills." An environmental sciences postdoc who "fought and beat breast cancer while continuing to move forward on my research" did not feel deserving of her position.

Some felt anxious that their lack of knowledge in the field would be exposed during lab meetings and they would be asked to leave the lab. On receiving competitive grants, a biology postdoc felt like her lack of productivity made her less deserving and her peers were better at completing research projects and publishing. Many had an eroded sense of belonging in the field. A genomic medicine postdoc shared that at large conferences, "I start feeling like an imposter, like I don't belong there. You start comparing yourself to what they're [the experts are] doing. You think you're never gonna get there. You're not good enough." Due to self-doubt, an environmental health postdoc spent a lot of time verifying what she spoke, doubting herself.

I might spend an hour researching some comment that I made to make sure that it was correct, when I clearly already knew the answer because I said it, but I don't believe that it could have been right kind of thing.

One tended to diminish one's achievements and worth despite external validation. A genetics postdoc who was invited to chair a session at a conference "assumed that it was not because I could do a good job, give a good talk, and had good research, but because they needed a young woman for the quotas and the funding." Others felt that their skills were overestimated, they would disappoint their adviser, and would not win the same award a second time. Some hesitated to review other's work in

fear that they were unqualified to do so. “I have to be sure that I’m saying the right things. You’re asked to be an expert on something, and it’s not always the case,” a biology postdoc shared.

## DISCUSSION

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In this mixed-methods study, 43 postdocs in STEM took a short, online survey and participated in a semi-structured phone interview to share manifestations of the impostor phenomenon experienced during postdoctoral training. Overall, six themes were uncovered, namely, 1. not pursuing new things, 2. not making social connections, 3. impaired academic communication, 4. not applying, 5. procrastination and mental health, and 6. feeling undeserving and unqualified. The sample in this study was primarily White women in various science fields in their thirties who experienced high to intense levels of impostor phenomenon.

This study focused on a sample (postdocs in STEM) among whom, the impostor phenomenon has presumably not been deeply examined. Understanding experiences during postdoctoral training could help design interventions and personalized professional development programs not only for postdocs (Omary et al., 2019), but also doctoral trainees (Sharmini & Spronken-Smith, 2019). In fact, earlier research shows that PhD students in STEM have experienced first three of the six themes uncovered in this study, i.e., not applying new knowledge, not asking for help, and fear of developing public speaking and scientific writing skills (Chakraverty, 2020). The challenges of both PhD students and postdocs may possibly have enough commonalities that understanding the experiences of both the groups in a holistic way would be essential. In STEM, many PhDs and postdocs aspire for a faculty career (Bennett et al., 2020; Main & Wang, 2019), and adopting a fine-grained approach by examining the challenges of doctoral and postdoctoral training individually would allow better understanding of how doctoral education and training can be tailored and improved for those who experience the impostor phenomenon (Chakraverty, 2020). Understanding behaviors related to impostor phenomenon could help design specific interventions for professional development for PhDs/postdocs to mitigate fears and self-handicapping patterns of thoughts (Want & Kleitman, 2006). Structured training in public speaking is an example (Chakraverty, 2020). Emergent narratives in the current study indicated that the impostor phenomenon is not just a passive voice in the head. When unacknowledged, it can affect the way a person behaves either privately or in a professional setting and takes certain career decisions (for example, not applying for grants or faculty positions). This study sought to learn more about such self-sabotaging behaviors linked to the impostor phenomenon.

The first and second themes found that postdocs hesitated to pursue anything new and faced difficulty networking, asking for help, or asking questions. Professional networking and relationship-building are among the desirable goals of a successful postdoctoral experience (NAS, 2014). Formulating individual development plans (IDPs) annually would facilitate career development, allowing postdocs to self-evaluate strengths and improvement areas along with their mentors and manage their career goals based on individual needs and progress (NAS, 2014). Many institutions now mandate postdocs to develop and maintain IDPs (Ferguson et al., 2014). The role of a supportive mentor and quality supervision in postdoctoral training is imperative (Scaffidi & Berman, 2011). Structured training programs can help in professional identity development and providing a rich learning environment (Faupel-Badger et al., 2015).

The third theme found that due to the impostor phenomenon, postdocs lacked confidence in oral communication and academic writing. Similar findings among post-graduate students indicated under-preparedness in academic communication in terms of reading, writing, and presenting research (Cisco, 2020). Developing effective communication skills is listed as one of the six core competencies of postdoctoral training, stipulated by the National Postdoctoral Association (NAS, 2014). Ideally, mentors should help postdocs develop required skills during their training such as scientific writing and communication, leadership and management of a laboratory, publishing research in peer-reviewed journals, etc. Training programs such as the Seeding Postdoctoral Innovators in Research and

Education have been very effective in providing postdocs (especially women and persons of color) with the skills required for transition into academic careers in STEM such as increased number of publications, independent teaching experience, and other professional development programs (Rybarczyk et al., 2016).

The fourth theme found that due to the impostor phenomenon, postdocs did not apply for career opportunities and faculty positions, being unable to visualize themselves as future faculty members. They chose less research-intensive universities due to the fear of being exposed as frauds not belonging in academia or unqualified to pursue research. In life sciences especially, the underrepresentation of women is a challenge at the principal investigator or faculty level at research institutions despite more women than men earning PhDs (Gibbs et al., 2014). Low pay and long training time before getting established are other challenges (Stephan, 2013); PhDs often pursue multiple postdocs before becoming faculty (Kaplan, 2012). Transition between a PhD and the first faculty position typically took 5-6 years in life sciences (Stephan, 2012); less than 15% of the life-science PhDs actually made this transition (Martinez et al., 2007; National Research Council [NRC], 2011; National Science Board [NSB], 2012). Improving diversity in graduate and postdoctoral training is key to keep up with the increasing diversity of the US population and ensure a culturally competent workforce (Chakraverty, 2013). Possibly, those with impostor phenomenon were vulnerable to not achieving their full potential and restrained themselves in the fear of being found out as frauds despite being accomplished and high-achieving.

The fifth and sixth themes found that postdocs tended to procrastinate and experienced mental health conditions, often feeling undeserving and unqualified. Impostor phenomenon is linked to psychological distress and interpersonal shame due to being perceived negatively by others, lower self-compassion (Wei et al., 2020), and perfectionism (Pannhausen et al., 2020). It is also related to lower self-esteem (Neureiter & Traut-Mattausch, 2016; Schubert & Bowker, 2017; Sonnak & Towell, 2001; Yaffe, 2020), increased self-doubt (Stone et al., 2018), feelings of inadequacy (Cope-Watson & Betts, 2010), lower self-efficacy (Blondeau & Awad, 2017), anxiety, depression (Fraenza, 2016; McGregor et al., 2008), and mental health consequences (Cokley et al., 2017). Such manifestations have mostly been studied among undergraduate/graduate students and professionals, but not postdocs. Given the transitory nature of postdoctoral training, it would be valuable to study these constructs specifically among postdocs.

It was particularly revealing that participants faced challenges in key aspects of training including professional networking, asking for help, taking risks, pursuing new lines of research, asking relevant questions, communicating research to an audience, and teaching. Many delayed finishing work on time and were less inclined to ask questions because they did not want to be noticed or heard. This could be self-limiting for everyone (not only those aspiring to become faculty), with challenges to thriving in an academic environment where people from different backgrounds collaborate and share ideas as well as experience a competitive environment in scientific research where failures are commonplace (Schwartz, 2008). Postdocs also experienced mental health consequences, fears and anxieties, procrastinated, and felt undeserving and unqualified, all traits linked to impostor phenomenon. However, there might be other manifestations of this phenomenon not uncovered in this study. Those facing the phenomenon could be avoiding risk by not pursuing new lines of research in fear of failure or rejection. These manifestations could negatively impact postdoctoral socialization experiences as well. Postdocs could be collaborating, communicating, and networking less than others who do not feel like impostors, not utilizing their socialization opportunities to the fullest.

Socialization is “the process by which persons acquire the knowledge, skills, and dispositions that make them more or less able members of their society” (Brim & Wheeler, 1966, p3). It includes engaging in related activities to develop a holistic understanding about one’s profession (Gardner & Barnes, 2007; Kim, 2018; Weidman, 2003). Individual experiences of impostor phenomenon could very well be shaped by academic culture, interactions, and socializing experiences. Research on newly hired faculty indicated that developing collegiality and receiving mentor support and encouragement

could ease the process of academic socialization and integration into their new roles, with new faculty feeling more connected to their environment (Schrodt et al., 2003). Similar practices with postdocs could help them get situated and integrated in an academic environment by visualizing the numerous roles they would play in the future in academia.

One major, though unintended limitation of the current study is a predominantly White sample pool. Thirty-seven out of 43 postdocs in this study identified as White, while the rest identified as Hispanic, Asian, American Indian or Alaska Native, or multi-racial. It is possible that underrepresented minorities in STEM fields experience the impostor phenomenon differently, their experiences more contextually aligned with their background and life experiences. To address this limitation, future research could examine impostor phenomenon specifically among the underrepresented groups in STEM based on race/ethnicity, focusing on similarities and differences of experiences between and across the groups.

In order to strengthen the US-STEM workforce, the President's Council of Advisors on Science and Technology (PCAST, 2012) made several recommendations on improving student interest, matriculation, and graduation rates in STEM fields, including improved teaching practices to enhance classroom learning (Baker et al., 2014; Lund et al., 2015; Stains et al., 2015). STEM training is often characterized by a hypercompetitive environment and long training time (Kaplan, 2012; Stephan, 2013) along with field-specific challenges such as the number of life science PhDs far exceeding the number of academic positions available (NRC, 2011; NSB, 2012). Other challenges include lack of demographic diversity and male-dominance in fields such as physics (Chakraverty, 2013; Chakraverty et al., 2020). The PCAST Report (2012) emphasized the importance of providing more competitive training in STEM to meet the demands of a technologically advanced nation. One of the many ways of building a globally competitive STEM workforce would be by strengthening doctoral and postdoctoral training. Some people in STEM (including PhDs and postdocs) may be facing mental health challenges due to their demographic underrepresentation, stereotyping, lack of belonging, alienation, and the impostor phenomenon. Additionally, there could be a cost to experiencing mental health challenges in terms of people not pursuing career advancement opportunities in fear of being found out as fraud (Chakraverty, 2020; Clance & Imes, 1978).

Based on the understanding gained from this study, it would be prudent to consider that the impostor phenomenon is not as much categorical as triggered or heightened by certain circumstances or activities. For someone, impostor-feelings could be triggered during academic writing, but not during public speaking at conferences. Therefore, some of the ways of addressing the phenomenon among postdocs could include helping them recognize what activities heighten impostor-feelings and design targeted workshops to provide tools for those who grapple with the phenomenon. Being able to recognize early signs and create safe spaces where those experiencing stress can share their fears and insecurities would be useful. In fact, having more conversations about this phenomenon could normalize such experiences, especially when those more successful and accomplished also admit to experiencing it if they did. The impostor phenomenon is perhaps as incapacitating as one makes it to be; while the fears associated with it are real and need to be acknowledged, providing specific tools and exercises timely to address such fears could help mitigate these self-handicapping beliefs.

### ***LIMITATIONS AND STRENGTHS***

The study sample is not representative of the US postdoc population, and interview themes should not be generalized to all STEM postdocs. The sample was predominantly White and female, with the largest representation of 33 participants from life sciences. Understanding whether impostor phenomenon disproportionately affects certain groups of postdocs is beyond the scope of the current study. However, future research could examine if it occurs less or is more difficult to investigate among certain demography of people, for example, among men. Only one interview was conducted per participant. The sample was self-selected that could bias the selection of those already familiar



with impostor phenomenon. Additionally, this study did not interview participants who left their postdoctoral training or academia altogether due to impostor phenomenon.

Despite these limitations, it was valuable to learn about the experiences of STEM postdocs, a population prior studies have not focused much on. The transitory nature of postdoctoral training could induce anxiety, which motivated this study. Examining the phenomenon using a constructivist approach from participants' personal experiences helped develop a deeper understanding while also leveraging on quantitative data from the CIPS scores. While prior research has unraveled many variables correlated with the phenomenon, this study was able to enhance our understanding from multiple perspectives by participants (Creswell & Clark, 2017). Postdoc training was shaped by social interactions (Feldon et al., 2019) and personal experiences; experiencing impostor phenomenon could mean different things for different people based on their life experiences. Through semi-structured interviews, this study could leverage on the diversity of these life experiences.

### ***FUTURE DIRECTIONS***

Future research could focus on examining how to better support PhD students, postdocs, and others experiencing the impostor phenomenon. It could address the knowledge gap through surveys studying how academic socialization opportunities could be compromised due to impostor phenomenon. Future research could also examine the prevalence and the characteristics of the impostor phenomenon outside STEM disciplines, characterize the phenomenon through longitudinal studies rather than measuring and examining impostor phenomenon at a single time-point, and examine how the phenomenon affects marginalized doctoral students in STEM.

### **CONCLUSION**

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The current research study examined behavioral manifestations of the impostor phenomenon among 43 STEM postdocs in the US using a mixed-methods approach. Surveys revealed moderate to intense impostor phenomenon among most participants based on scores from the CIPS (Clance, 1985). The participants were a self-selected group of mostly White women in their twenties and thirties. Interviews with those who completed the survey revealed that postdocs experiencing the impostor phenomenon hesitated to pursue newer lines of research, faced challenges to networking, asking for help, or asking questions, lacked confidence in oral communication and academic writing, did not apply for career development opportunities and faculty jobs, procrastinated and experienced mental health consequences, and felt undeserving and unqualified. Some of these themes were also reported among PhD students in STEM, such as the application of newly learnt knowledge in other domains, reaching out for help, and developing communication skills verbally and through academic writing. These could have implications on the quality and frequency of networking in the field, risk-taking in terms of pursuing newer lines of research, collaboration, mentoring or receiving mentoring from others in fear that one's weaknesses would be exposed, and fearing failure and judgment.

### ***RECOMMENDATIONS***

There are a number of ways to address impostor phenomenon, like, giving and seeking social support from peers outside one's program and consciously changing one's reference group for comparison in order to recalibrate standards of success (Gardner et al., 2019). The traits of impostor phenomenon are malleable and trigger-induced; thus, developing tools to cope with the phenomenon could potentially help address it (Gardner et al., 2019). More experienced faculty could share their impostor-experiences to normalize such conversations and reduce one's fear of being exposed as fraud (Hutchins, 2015). The current study found that developing awareness and recognizing particular activities that triggered impostor-feelings could help develop personalized coping strategies. This would alleviate discomfort and anxiety around the impostor phenomenon. As one engaged more in activities one excelled at, it developed self-confidence through positive reinforcement. For example, if one's impostor-feelings revolve around academic writing, consciously practicing writing regularly and

purposefully while being mindful of the triggers may be productive and reduce anxiety. For those who fear public speaking, advisers could proactively encourage them to present at conferences. Additionally, recognizing one's strengths and spending time everyday pursuing those activities could reduce anxiety, provide validation when recognized by others, and make one feel productive. Overall, understanding and accepting one's limitations might make one learn to ask for help, work in teams, or allocate work to reduce anxiety. External validation in terms of praise, awards, and timely feedback about one's work could also play a role, although according to the classical definition of impostor phenomenon, it is these very achievements, awards, and positive reinforcements that trigger impostor-feelings.

Finally, this study underscores the need to view doctoral and postdoctoral training holistically, especially since the internalized feelings of fraudulence characteristic of the impostor phenomenon might be based on environmental factors such as a bad mentor-mentee relationship, an excessively competitive work environment, and lack of critical mass for women and underrepresented minorities. The office of postdoctoral affairs could offer professional development programs and IDPs focusing on strengthening skills. In particular, focusing on the stressors during transition points (PhD to postdoc transition, postdoc to faculty transition) would be important.

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