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Research Article

State of the Practice of Team Science in Speech-Language Pathology and Audiology

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Purpose: The purpose of this study was to investigate engagement in collaborative research (team science) and perceptions of related knowledge and skills to inform personnel preparation and workforce development efforts.
Method: A questionnaire was used to solicit information about the team science–related experiences of 220 doctoral students, faculty, and research scientists in speech-pathology and audiology. Additionally, the questionnaire surveyed participants' perceptions of readiness, benefits, and challenges to team science.
Results: Results demonstrated low percentages of respondents had received training in collaborative research (17%), and those with training were more likely to engage in cross-disciplinary collaborative research. Group differences were found with female researchers reporting lower psychological safety than male researchers. The most frequently cited advantages of team science included diverse perspectives, collective expertise, innovative ideas, and productivity. Conversely, common challenges included time constraints, finding collaborators, and differing expectations.
Implications: Because this study yielded group difference in psychological safety between groups that differed in gender and position, results suggest additional efforts may be necessary to ensure that imbalances in the power structure of members are not allowed to dissuade members from actively contributing to team activities. Additional training opportunities in team science could support the degree to which professionals in communication science and disorders engage in collaborative research.
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Speech-language pathologists and audiologists are expected to collaborate on interprofessional teams in clinical practice across a variety of settings (American Speech-Language-Hearing Association, 2017; Goldberg, 2015), yet the emphasis on teaming in clinical translational research in communication disorders has been studied to a lesser extent. Although programs in communication science and disorders (CSD) are required to provide interprofessional education (IPE), less is known about training and preparation for collaborative research in communication disorders. The purpose of this study, therefore, was to examine researchers' experiences in team-based science or collaborative research in CSD programs.

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The notion of "team science" has gained momentum in recent years. The term refers to "scientific collaboration by more than one individual in an interdependent fashion, including research conducted by small teams and larger groups" (National Research Council, 2015, p. 2). We use the term to focus on the practice of team science, not the "science of team science" or the study of teams. Although collaboration occurs within individual disciplines, the rationale for team science is conveyed in the seminal work of Popper (1963), who urged researchers to consider themselves students of complex problems that often cut across the boundaries of any one subject matter or discipline. Since that time, there has been more recognition in clinical practice that multifaceted problems may benefit from multiple perspectives and interprofessional collaborations (e.g., Ogletree et al., 2017; Sylvester et al., 2017). Similarly, in applied research, scholars have reportedly engaged in more frequent collaborative research over the last three decades with other scientists and extended collaborations across discipline and institutional boundaries (Frickel & Jacobs, 2009; Porter & Rafols, 2009). Evidence for the increasing shift toward

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teamwork in research and science is demonstrated by the growing number of co-authors and co-authored publications (as opposed to single-authored publications) reported by many disciplines over the last three decades (Wuchty et al., 2007). The increase in co-authored work is further motivated by the fact the publications with co-authors from multiple disciplines are cited more than single-authored publications (Larivière et al., 2015; Stipelman et al., 2015) and are more likely to appear in high-impact journals (Campbell et al., 2014).

We therefore use the term *team science* in this article to refer to collaboration across multiple disciplines. We note that except when referring to the work of others who used a more specific term, we use the overarching term *cross-disciplinary* in this report to describe any collaboration across disciplines. The team science literature defines important differences among the terms *multidisciplinary*, *interdisciplinary*, and *transdisciplinary*, which are often used interchangeably. The differences are related to a continuum of levels of integration among the disciplines in a collaboration: "Multidisciplinary" research is additive, with lines of research in parallel or consecutively staying within disciplinary boundaries; "interdisciplinary" research involves more interactive or integrated experimental approaches; and "transdisciplinary" research involves a more holistic integration of disciplines, often transcending traditional boundaries and sometimes creating new disciplines (Choi & Pak, 2006).

The growing interest and expectation for engagement in team science is well aligned with the recent prioritization of collaborative practice, interprofessional practice (IPP), with professionals from different disciplines working together in person-centered service provision to address the needs of individuals with complex communication needs (McNaughton, 2018; White et al., 2018; World Health Organization, 2016). Prior literature has established that successful implementation of IPP relies on complex teaming skills, including communication, trust, collaboration, role clarification, and conflict resolution (Karasinsksi & Schmedding-Bartley, 2018; McNaughton, 2018; White et al., 2018). Furthermore, the need to consider preparing individuals to develop teaming skills is evidenced in the adoption of IPE by training programs in CSD programs (McNaughton, 2018). Despite the focus on IPP and IPE in CSD practices, the extent to which cross-disciplinary teaming has been applied or adopted in research practices in CSD has been studied to a lesser extent.

Increased Engagement in Team Science

A growing emphasis on teaming in translational research is apparent in many areas of study. This emphasis is illustrated by a statement of the National Institutes of Health (NIH) National Center for Advancing Translational Sciences, which reads, "team science promises to drive major improvements in translational efficiency and effectiveness, since what is difficult or impossible for one member of the team may be easy for a teammate with a different skill set" (NIH, 2018). More recently, an emphasis on collaborative research for translational science is also apparent in reading research (e.g., Petscher et al., 2020; Solari et al., 2020). To illustrate, in a recent article by Solari et al. (2020), the authors urge multidisciplinary scholars and basic and applied reading and literacy researchers to coalesce around the complex challenges involved with moving the basic science of reading to efficacy studies in authentic classroom settings. Similarly, in Petscher et al. (2020), the authors advocate for a translational team approach to leverage collective expertise and combine complementary traits and roles needed to conduct translational research. The desired traits and roles are based on a model by Gilliland et al. (2019) that identifies essential characteristics needed for translational science that different individuals contribute to the collective body, including team members who possess innovative ideas, networking skills, research design expertise, and advanced statistical knowledge.

With increasing recognition of the value and need for teaming to address complex problems, team science has gained impetus within institutes of higher education (IHE). The emphasis on team science in IHE can be seen in several ways. First and foremost, many institutions have integrated professional development opportunities and training in transdisciplinary teaming at multiple levels (e.g., undergraduate, graduate, and early career faculty) through coursework and workshops to prepare personnel and the next generation of scientists to engage in collaborative research teams (e.g., Khuri & Wuchty, 2015; Spring et al., 2011; Vogel et al., 2012). Leaders in translational science have called for IHE to offer increased access to team science training at multiple levels (e.g., Shah, 2018) to provide preservice supports and professional development to assist physicians and scientists at every career stage. Additionally, emphasis on team science in IHE can be evidenced by the expansion of the infrastructure to facilitate collaborative intersections between early career scientists in team-based collaborative research.

Moreover, beyond activities within IHE, growth in team science is evidenced by the formation of national institutes and organizations focused on team science (e.g., International Network for the Science of Team Science and NIH National Center for Advancing Translational Sciences) and the creation and distribution of guides to team science as exemplified by the National Cancer Institute (e.g., Bennett et al., 2018). The NIH roadmap, for example, stresses the development of interdisciplinary programs, centers, and conferences (Morrisey, 2003). The Clinical Translational Science Award (CTSA) Program, for example, offers resources and expertise in team science and translational research. Furthermore, the adoption of team science practices is incentivized by several federal funding agencies, such as the National Science Foundation, in response to data that transdisciplinary center grants results in overall higher publication rates with more co-authors per publication compared to investigator-initiated grants such as R01 grants (Hall et al., 2012). Similarly, funding agencies implicitly support team science by placing favorable point distributions on publication histories that demonstrate productivity with established collaborators and through the requirement of collaboration plans in grant proposals.

Variability in Team Science Engagement

Although team science has been embraced and incentivized by funding agencies and centers of excellence, team science preparation and implementation may not be as well adopted by various disciplines and institutions that differ in resources, size, private/public, and other potential influencing factors. Research suggests the highest shift to collaborative research has occurred in the medical science and engineering fields (Wuchty, et al., 2007). In contrast, the fields of speech-language pathology and audiology in CSD have been understudied with regard to team science adoption and collaborative research practices. Few if any researchers have examined the inclusion of team science training in personnel preparation and professional development in CSD programs. It is equally plausible that collaborative research is widely adopted or that silo-based research practices persist widely, considering that the implementation of team science practices by researchers in CSD has not been sufficiently studied.

Given that teaming in clinical and translational research may foster innovation in addressing the complex needs of individuals with communication disorders, additional research is warranted on collaborative research practices by researchers in CSD, training experiences, knowledge and skills related to collaborative research, influencing factors, and perceptions of potential benefits and challenges. Specifically, we hypothesize that researchers who embrace team science experience numerous benefits such as increased funding success from aligning their resources across research networks. Among other potential advantages, researchers may perceive benefits that increase the likelihood of achieving desired outcomes in advocacy, increasing knowledge, innovation, and dissemination.

Potential Influencing Factors

The extent to which research faculty in speech-language and audiology engage in cross-disciplinary collaborations may partially depend on a number of factors, including but not limited to training, perceived psychological risk, gender, and position/rank. To provide background, we review the related literature on influencing factors highlighted in the previous research on team science.

Training and Preparedness

Programs that have adopted team science training workshops or coursework may be expected to be largely dominated by biomedical sciences, behavior sciences and social medicine, nursing, and engineering disciplines. Research indicates that training in team science and collaboration is related to researchers' participation in transdisciplinary research teams and scholarly productivity (Vogel et al., 2012). Exemplary formal training mechanisms are sometimes associated with CTSA grant awards (Vogel et al., 2012). It is possible that less emphasis or adoption has occurred in CSD programs. Alternatively, faculty in speech-language pathology and audiology may be ideally situated to embrace and engage in team science considering their training in communication and their expertise with low-incidence, complex conditions that necessitate IPP.

Variability in training and preparation may be reflected in variability in researchers' perceptions of their skills related to collaborative research teaming. A multitude of skills are associated with effective team science practices. The NIH field guide (Bennett et al., 2018) highlights core skills, knowledge, and approaches for effective cross-disciplinary collaborations. Among a long list of team science–related knowledge and skills, the field guide highlights the importance of team-building skills, establishing shared goals and expectations, clearly articulating a vision, effectively communicating with team members, assigning roles and responsibilities, modeling a collaborative process, agreeing on a process for sharing data, supporting team members, establishing and sharing credit, resolving conflict, and managing authorship.

Perceived Psychological Risk and Safety

Numerous researchers have suggested that trust and psychological safety have an essential role in research team collaborations (e.g., Bennett & Gadlin, 2012; Edmondson, 1999; Stanley, 2014). Psychological safety, in relation to teaming, has been defined as "a shared belief held by members of a team that the team is safe for interpersonal risk taking" (Edmondson, 1999, p. 354). Psychological safety influences the way in which team members share ideas and opinions, voice concerns, offer innovations, engage in problem solving, and offer constructive criticism and feedback to the team (Newman et al., 2017). Psychological safety has been explored as a mediator, moderator, and outcome in the literature and is often viewed as an important predictor of team-level outcomes (Kostopoulos & Bozionelos, 2011; Newman et al., 2017). Several studies suggest that low levels of psychological safety may inhibit and reduce the likelihood of a researcher engaging in research team collaborations (e.g., Stanley, 2014). Specifically, team members tend to act in ways that inhibit information exchange when they perceive the potential for threat or embarrassment (Edmondson, 1999). Conversely, teams whose members have higher levels of psychological safety may be more inclined to take risks and to engage in *exploratory learning*, in which team members experiment and challenge ideas (Kostopoulos & Bozionelos, 2011). By nature, research teams engage in exploratory learning as a part of scientific inquiry, so the relationship between psychological safety and team outcomes is critical. Examining levels of psychological safety among researchers in speech-language pathology and audiology could offer data relative to our field and whether psychological safety is related to engagement in team science activities within CSD and if safety varies across groups of researchers in CSD.

Gender

A few studies have examined gender stereotypes in CSD academic leaders (e.g., Rogus-Pulia et al., 2018) and potential influences of gender on academic careers in CSD. Among potential effects of implicit gender bias, authors point out that assumed authority effect may subtly socialize

men toward leadership roles. Following the authors' argument of how implicit gender bias can influence academic careers in CSD, it is possible that women perceive more psychological risk in engaging in self-promoting or initiating teaming within networks of researchers due to stereotype threat (Rogus-Pulia et al., 2018). Furthermore, women may be discouraged from taking risks on teams due to perceived role congruity (or how their gender identity matches or does not match the "gender typing" roles of one's chosen roles and field).

However, wider research on gender in academia indicates that women are often more likely to engage in collaborative teams than men, particularly outside their own discipline (Bozeman & Gaughan, 2011; Hall et al., 2018). However, there are nuances to these findings, such that women are less likely to engage in international collaborations and they are less likely to form collaborations with business and industry than their male counterparts (Hall et al., 2018). Other sources suggest female researchers may be less likely seek out reciprocity of effort during collaborations (Pfirman & Balsam, 2005) and less likely to offer ideas or share differing perspectives due to the perceived risk of negative consequences (Rhoten & Pfirman, 2007).

Rank/Position

Among influencing factors, it is possible that faculty in tenure track and non–tenure track positions differ in the amount of perceived risk or safety in pursuing collaborative research. There is a general dearth of previous research in this area; however, given that translational research often involves clinically relevant applied research, it would seem important to assess if faculty in clinical, nonacademic, and/or non–tenure track positions report similar or different experiences and psychological safety in teaming. It is possible that researchers with different ranks may embrace teaming to greater or lesser extents. As Stanley (2014) pointed out, researchers may feel varying degrees of responsibility for ensuring the soundness of all aspects of the research process and have difficulty relinquishing roles to other researchers.

Although influencing factors have not been widely studied, other potential influencing factors may account for variability in engagement in collaborative research, such as the area of research focus, access to collaborators, and/or institutional incentives or disincentives related to promotion and tenure. It is possible, although not empirically tested, that participation in cross-disciplinary collaborative research varies by characteristics of the researcher, including age group of focus (e.g., children vs. adults) and type of institution (e.g., private or public).

Additional information is needed on the current practices and perceptions of benefits and challenges to team science preparation and implementation by speech-language pathologists and audiologists. Although studies have examined interprofessional collaborative practice broadly (e.g., American Speech-Language-Hearing Association, 2017; Pfeiffer et al., 2019), the state of the practice of team science has been less studied. Teaming in translational research may or may not be widely adopted by CSD programs in IHE. Additional studies are needed that offer insights into how we can forge team science forward in translational research. To our knowledge, the practice of team science in speech-language pathology and audiology research programs has not been empirically studied.

Research Questions

In response to the dearth of inquiry on team science in speech-language pathology and audiology, this study aimed to address the following research questions.

1. To what extent do speech-language pathology and audiology researchers engage in team science?
2. How do faculty and research scientists in speech-language pathology and audiology perceive their preparedness and skills in team science?
3. Are there group differences in perceptions of psychological safety between groups who differ in demographic characteristics (e.g., level of training, gender, position type, area of research, and public/private institutions)?
4. What are perceived benefits and challenges to team science preparation and implementation in speech-language pathology and audiology?

Method

This study was reviewed and approved by the institutional review board of the Human Subjects Committee at Florida State University (#00001395). Using Qualtrics, the investigators invited doctoral students, postdoctoral fellows, faculty, and research scientists in speech-language pathology and audiology to participate in a self-assessment of team science readiness, knowledge, and skills. The investigators sent an e-mail invitation to instructors, faculty, and research personnel listed on the websites of 180 speech-language pathology and audiology programs based on faculty at Council of Academic Programs in Communication Sciences and Disorders (CAPCSD) member programs. All potential participants were invited to share their thoughts and opinions about how they use teams in their research by voluntarily completing a survey. They were also encouraged to share the survey link with doctoral students or other colleagues in their programs.

Participants

A total of 220 individuals responded to the survey invitation. Of the respondents, 11 (5%) were doctoral students, four (2%) were employed in postdoctoral positions, 38 (17%) were in non–tenure track positions, and 149 (22%) were in tenure track faculty positions. Of the total participants, 149 (66%) worked in public universities, with 59 in private universities (29%) and 15 unreported. The precise number of different institutions represented could not be determined since there was an anonymous response option; however, the e-mail addresses of the respondents who voluntarily

entered contact information indicated that the sample included participants from at least 116 different institutions in 38 different states. Respondents reported a variety of areas of specializations as displayed in Table 1 and focused on a wide range of age groups, including early intervention (18%), school age children (23%), adults (37%), and across the life span (16%).

Instrument

A 29-item survey (with multiple subquestions) was developed for research personnel in speech-language pathology and audiology to assess engagement in collaborative research and their self-perception of readiness, knowledge, and skills related to team science (refer to survey in Supplemental Material S1). The existing surveys selected for inclusion (e.g., Research Orientation Scale and the Cross-Disciplinary Collaborative Activities survey) were nominated by investigators involved in team science trainings across five institutions. The final items, divided into nine subsections, were informed by theory and previous research on influencing factors on research team collaborations (e.g., Bennett & Gadlin, 2012) and adopted from existing surveys (e.g., Edmondson, 1999; Hall et al., 2008). Subsections of the survey are described in detail below, including demographics, engagement in collaborative research, research orientation, psychological safety, and cross-disciplinary activities and orientation.

Table 1. Demographic characteristics of respondents.

Respondent characteristics	*n*	%
Gender		
Female	176	80.00
Male	28	12.70
Did not respond	16	7.30
Race/ethnicity		
African American/Black	8	3.63
Asian/Pacific Islander	8	3.63
Hispanic	11	5.00
White	172	78.18
Other	4	1.81
Did not respond	17	7.72
Current position		
Predoctal/graduate student	11	5.00
Postdoctoral fellow	4	1.80
Instructor (non–tenture track)	15	6.80
Clinical faculty	22	10.00
Assistant professor (tenure track)	64	29.10
Associate professor (tenured)	49	22.30
Full professor (tenured)	36	16.40
Research faculty	1	0.04
Did not respond	18	8.20
Type of institution		
Public	146	66.40
Private	59	28.80
Did not respond	15	6.80
Highest degree offered		
Master's	80	36.40
Clinical doctorate/AuD	12	5.50
PhD	113	51.40
Did not respond	15	6.80
Area of focus—Big 9		
Speech/articulation	18	8.20
Fluency	4	1.80
Cognitive communication	25	11.40
Social communication	14	6.40
Expressive and receptive language	75	34.10
Voice and resonance	17	7.80
Feeding and swallowing	7	3.20
Auditory habilitation/rehabilitation	28	12.70
Augmentative and alternative communication	13	5.90
Did not respond	19	8.60
Primary age group		
Early intervention/preschool	39	17.80
School age	51	23.20
Adult	81	36.80
Life span	34	15.50
Did not respond	15	6.80

Demographic Questions

The survey included questions intended to solicit information about the characteristics of respondents. These included questions about participants' rank (e.g., predoctoral, assistant professor, and associate professor), type of position (e.g., tenure track or nonacademic) gender, race, and ethnicity, and work setting (e.g., public or private universities and highest degree offered in the program). Demographic questions also requested information about the respondents' primary area of research interest and the age group that best reflects their primary area of research (e.g., early intervention, school age, adults, and life span).

Engagement in Collaborative Research

Five questions were used to examine participants' engagement in collaborative research. Participants were asked if they consider themselves part of an interdisciplinary research team, who the teams include, and how many co-authors they typically have per publication. The question pertaining to the number of co-authors ("On average, how many co-authors would you estimate you typically have per publication?") was presented with an open-text numeric value entry rather than choices or ranges. The free response was designed to prevent restriction of the range of responses or an artificial ceiling. The question did not specify publications that were products of collaborative research but instead asked participants about the number of co-authors per publications on average. This allowed respondents to also consider sole-authored publications (i.e., zero co-authors), assuming some respondents may not engage in collaborative dissemination activities. One question pertained to access to other researchers for collaboration. Additionally, two questions inquired about the ways collaborative research has been advantageous and challenging based on their experiences. Lastly, two questions solicited information about respondents' training experiences and the type of training received (e.g., coursework, webinars, workshops, and conferences).

Research Orientation

Ten items were adopted from the Research Orientation Scale (Hall et al., 2008). These items assessed the extent to which researchers embraced a uni-, multi-, or interdisciplinary orientation using a 1–7 scale (*strongly disagree, disagree,*

somewhat disagree, neutral, somewhat agree, agree, and strongly agree). Survey items asked participants to self-assess the extent to which they believe they are more productive alone than working as a collaborative team, see the value in seeking perspectives of other disciplines, and see the value of integrating research methods from different disciplines in their collaborations.

Psychological Safety and Trust

Based on literature suggesting that trust plays a critical role in team collaborations (e.g., Bennett & Gadlin, 2012), seven items were adopted from a survey of safety (Edmondson, 1999), which assessed trust and perception of risk. Among items in this subset were questions that asked about effectiveness in promoting a climate of collaboration and trust. Specific examples of items include questions that ask respondents to assess their agreement with the notion that if they make a mistake, it is held against them, or whether it is safe to take risks in the research team. Response choices were presented on a 1–7 scale of agreement from *strongly disagree* to *strongly agree*.

Cross-Disciplinary Activities and Cross-Disciplinary Orientation

Six items measured the frequency of cross-disciplinary behaviors, for example, reading journals or publications outside primary field or obtaining new insights into own work through discussion with colleagues who come from different fields or disciplinary orientations. Response options were presented on a 1–7 scale of frequency, including *never, rarely, once a year, twice a year, quarterly, monthly*, and *weekly*. Finally, three items were adopted from the Cross-Disciplinary Collaborative Activities survey (Hall et al., 2008), which pertained to assessing research orientation toward teaming. Questions asked respondents to consider the value they assign to teamwork and collaboration.

Open-Ended Questions

The survey included several open-ended questions to elicit additional input, insights, and comments. Open-ended questions were designed to provide opportunities for participants to self-identify potential benefits and challenges to team science preparation and implementation. Specifically, participants were asked, "In what ways has collaborative research been advantageous to you? What benefits have you experienced?" and "What barriers or challenges have you experienced in collaborative research?" Comments about benefits and challenges of collaborative research were provided by 152 and 156 participants, respectively. Additionally, open-ended questions provided opportunities for participants to self-identify topics they deemed important or related to team science, allowing participants to guide the domain area and depth of responses.

Procedure and Analyses

The investigators distributed invitations to potential participants through Qualtrics. Research assistants entered individual e-mails for faculty members in the distribution list using listings in CAPCSD and CSD program websites. The investigators sent a reminder invitation 1 week later and a final reminder 2 weeks later in an effort to increase the response rate (Dillman, 2000). The survey was open and available for respondents for a total of 2 months.

Descriptive analyses were conducted to address Research Questions 1 and 2, which aimed to describe the extent to which researchers in CSD engage in collaborative research, as well as their perceptions of readiness and the quality of teaming skills. To examine potential group differences in responses, we conducted an analysis of variance to examine mean differences in responses by groups that differed in age group of focus, position, and type of institution. We also conducted independent-samples t tests to assess differences in research orientations, engagement and orientation toward cross-disciplinary collaborative activities, and psychological safety based on membership in interdisciplinary teams, prior team science training, and gender. A chi-square test of independence was performed to examine the relation between team science training and membership in cross-disciplinary teams.

Finally, we conducted a content and natural language processing analyses of open-ended responses to identify the major themes in collaboration research challenges and strengths that were nominated by respondents. First, free-text comments containing participant responses for advantages and challenges of team science and collaboration were analyzed using a Leximancer v4.5, a natural language software tool. An exploratory topic modeling analysis was conducted on the free-text comments using latent Dirichlet allocation. This approach allows for the identification of probabilistic vectors (lists) of words relevant to topic clusters. These probabilistic word vectors indicate relative relevance of specific words to a topic cluster within the text corpus. Previously reported comparisons of software-aided thematic analysis and manual concept and theme coding revealed usability of Leximancer for the identification of themes (Harwood et al., 2015). Specifically, the use of software reduces coder bias in identifying recurrent and repeated constructs, and advanced text-analytic methods allow for the identification of themes that goes beyond word counting and explicit content analysis. However, the use of software retains the active role of the researchers in analyzing findings and thematic interpretation. Next, we reviewed text excerpts associated with each exploratory topic cluster to identify themes based on the repetition, recurrence, and forcefulness of presented constructs (Owen, 1984). We also applied elaborative coding, a "top-down" coding approach that starts with previously identified constructs and refines them by identifying relevant text (Auerbach & Silverstein, 2003; Saldaña, 2021).

Results

To answer the first research question, which sought to describe the extent to which researchers engage in team science, we report descriptive statistics highlighting the distribution of responses on survey items that related to

engagement in collaborative research activities. Of the 220 respondents, 106 (48%) reported that they currently considered themselves part of an interdisciplinary research team, while 61 (28%) did not consider themselves part of an interdisciplinary team and 14 (6%) reported being uncertain. When asked about what members they currently engaged with in their research group or team, respondents identified a range of different research partners. As displayed in Figure 1, research team members reported by respondents included individuals within their internal labs, community partners, and unidisciplinary collaborators within their institution and at other institutions. Participants also reported co-authoring manuscripts with zero to 10 co-authors, with an average of 2.63 co-authors (SD = 1.48). When provided an open-field response to estimate the average number of co-authors on their publications, the majority of respondents (132 or 57%) reported relatively few co-authors (zero to three), while 45 (20%) reported publishing with larger co-authorship teams (four to 10; see Figure 2). Likewise, the majority of respondents (166 or 76%) indicated that they had not participated in any training about team science in their doctoral training or as part of their current position, while 38 (17%) had engaged in team science training. Approximately half of the participants indicated team-based research was somewhat encouraged or rewarded (109 or 50%), and 15 (7%) responded that team-based research was not encouraged or rewarded (e.g., emphasis placed on single-authored publications).

To answer the second research question, means and standard deviations are reported in tables to describe participants' perceptions of readiness for teaming and the quality of their teaming skills. Table 2 displays the distribution of responses on questions related to research orientation. Responses on items related to psychological safety are provided in Table 3. Responses related to research orientation show positive beliefs and perceptions toward cross-disciplinary orientation and activities. Specifically, respondents indicated general consensus that seeking input from other fields is important (e.g., 83% somewhat agree, agree, or strongly agree) and that they find teamwork to be personally and professionally valuable. Furthermore, 86% of respondents somewhat agreed, agreed, or strongly agreed that teaming has improved their research productivity. Conversely, 19% of respondents agree that focusing on their own field is important because there is so much work to be done within the discipline.

Group Differences

In response to Research Aim 3, which considered potential group differences in team science engagement, we tested for group differences in responses based on type of university (e.g., public/private), age group of focus (e.g., early intervention or adults), and area of specialty (e.g., language and dysphagia). Results of analyses of variance, indicated no significant group differences in the composite for the 10 questions related to research orientation based on type of university (p = .058), age group of focus (p = .475), and area of specialty (p = .409).

In addition to differences in engagement, we examined group differences in perceived psychological safety or risks involved in engaging in collaborative research. We considered gender, position type, and type of institution as potential factors associated with group differences in psychological safety. Gender and position type were associated with differences in psychological safety. Specifically, respondents who were women indicated significantly lower perceived psychological safety on collaborative teams (M = 5.64, SD = 0.79) compared to men (M = 6.08, SD = 0.78), with a mean difference of 0.44. A Welch two-sample t test showed that the difference was statistically significant, $t(19.13)$ = 4.367, p = .05. Additionally, faculty in nonacademic or

Figure 1. Frequency of reported research team members by type.

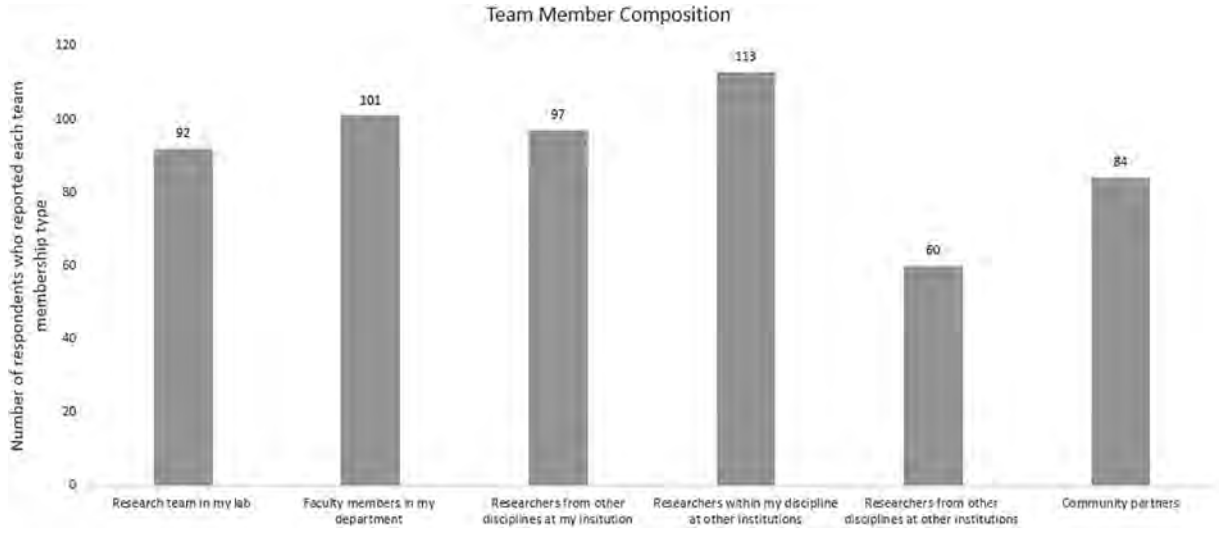
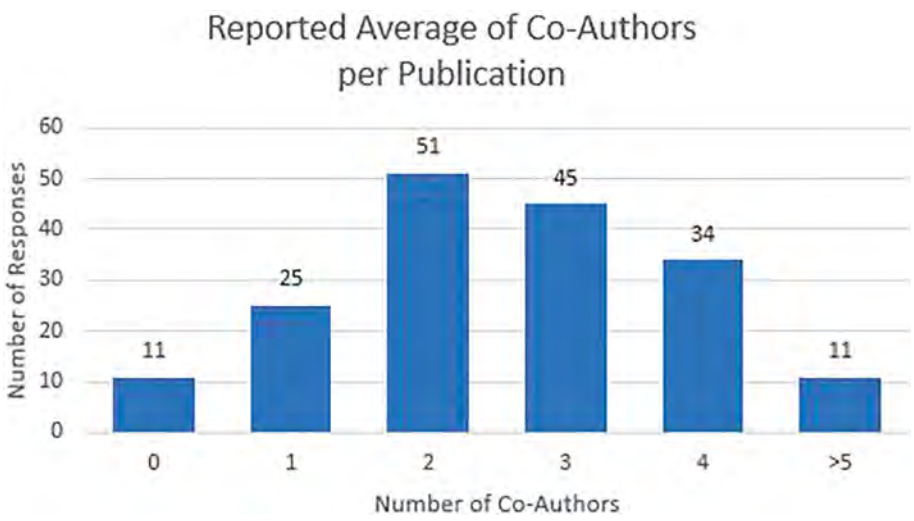


Figure 2. Distribution of responses reporting average number of co-authors per publication.



non–tenure track positions reported significantly lower psychological safety ($M = 5.26$, $SD = 0.95$) compared to faculty in academic tenure track positions ($M = 5.82$, $SD = 0.71$), with a mean difference of 0.56, $t(36.98) = 8.591$, $p = .006$.

Additionally, we assessed the effects of membership in cross-disciplinary teams on research orientation and collaboration. The 105 participants who reported membership in cross-disciplinary teams compared to 70 participants who were not reported had lower unidisciplinary research orientation scores, $t(173) = 4.08$, $p < .001$, but higher multidisciplinary orientation scores, $t(173) = -5.48$, $p < .001$, and higher interdisciplinary orientation scores, $t(171) = -4.83$, $p < .001$. Similarly, participants in cross-disciplinary teams reported higher engagement in cross-disciplinary collaborative activities, $t(165) = -5.87$, $p < .001$, and stronger cross-disciplinary collaborative orientation, $t(168) = -2.87$, $p < .05$. Psychological safety scores for participants in cross-disciplinary teams appeared numerically higher but did not reach significance, $t(133) = -1.894$, $p = .073$. Table 4 presents mean and standard deviation data.

Next, we assessed the effects of prior team science training on the outcome variables of interest. No significant differences were observed for research orientation, cross-disciplinary collaborative orientation, or psychological safety. However, the rate of engagement in cross-disciplinarily collaborative activities was higher for participants with prior team science training ($M = 5.52$, $SD = 1.56$) than for those without team science training ($M = 4.54$, $SD = 1.48$), $t(165) = -3.28$, $p < .001$.

We also assessed the differences in the outcome variable based on gender. No significant differences were observed for research orientation or cross-disciplinary collaborative orientation. The rate of engagement in cross-disciplinary collaborative activities was higher for women ($M = 4.84$, $SD = 1.54$) than for men ($M = 3.95$, $SD = 1.38$), $t(165) = -2.58$, $p = .011$. Conversely, perceived psychological safety was lower for women ($M = 5.64$, $SD = 0.79$) than for men ($M = 6.08$, $SD = 0.78$), $t(133) = 2.09$, $p = .05$.

A chi-square test of independence was performed to examine the relation between team science training and membership in cross-disciplinary teams. The relation between these variables was significant, $\chi^2(1, N = 181) = 4.92$, $p = .020$. The review of standardized residuals showed that those with team science training are more likely to participate in cross-disciplinary teams than those without the training.

To address the final research question that examined the perceived advantages and barriers to team science, we examined responses to open-ended questions. As visually shown in Figure 3, comments about the advantages and disadvantages of collaboration and participation in team science revealed three overarching themes with in vivo labels of "Perspectives," "Research," and "Collaborators." Respondents identified numerous advantages, including diverse perspectives, collective expertise, innovative ideas, and higher research quality and productivity. In contrast, challenges mentioned by participants included difficulty finding and connecting with collaborators, time/scheduling, and different expectations between team members.

Comments about the advantages of collaboration were closely associated with the "Perspectives" theme, for example, opportunities for perspective and expertise sharing, exchange of ideas, and exposure to knowledge across disciplines. Overall, this theme was representative of the intrapersonal mechanisms that affect faculty view of collaborative research and motivate action. One participant noted that collaboration "grows my expertise in related areas, strengthens the research design and applicability of outcomes, increases opportunities for research grant funding, access to instrumentation and equipment not available at my home institution." Participants also identified facilitating factors and motivations for collaborative research, for example, "Working with a team

Table 2. Distribution of responses on questions related to research orientation and cross-disciplinary research.

Item	*n*	*M*	*SD*	Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
I tend to be more productive working on my own research projects than working as a member of a collaborative research team.	175	3.04	1.5	14%	30%	22%	14%	14%	6%	1%
There is so much work to be done within my field that it is important to focus my research efforts with others in my own discipline.	175	3.67	1.7	12%	18%	17%	17%	16%	19%	1%
The research questions I am often interested in generally do not warrant collaboration from other disciplines.	175	2.34	1.1	29%	38%	15%	7%	19%	1%	0%
While working on a research project within my discipline, I sometimes feel it is important to seek the perspective of other disciplines when trying to answer particular parts of my research question.	175	5.31	1.1	1%	2%	5%	8%	34%	43%	7%
Although I rely primarily on knowledge from my primary field of interest, I usually work interactively with colleagues from other disciplines to address a research problem.	175	4.58	1.4	3%	7%	8%	20%	39%	18%	5%
The benefits of collaboration among scientists from different disciplines usually outweigh the inconveniences and costs of such work.	175	5.43	1.1	1%	2%	2%	10%	33%	42%	11%
In my collaborations with others, I integrate research methods from different disciplines.	175	5.13	1.2	2%	2%	4%	15%	37%	35%	6%
In my own work, I typically incorporate perspectives from disciplinary orientations that are different from my own.	175	4.87	1.2	1%	3%	12%	16%	38%	27%	5%
Although I was trained in a particular discipline, I devote much of my time to understanding other disciplines in order to inform my research.	175	7.72	1.4	2%	9%	19%	11%	36%	26%	6%
In my collaborations with others, I integrate theories and models from different disciplines.	175	5.05	1.2	1%	4%	5%	15%	37%	29%	8%
I find teamwork to be personally valuable.	170	5.81	1.1	0%	2%	0%	2%	44%	17%	35%
I find teamwork to be professionally valuable.	170	5.92	1.0	0%	0%	0%	2%	45%	13%	40%
Collaboration has improved my research productivity.	170	5.47	1.1	0%	1%	4%	9%	45%	17%	24%

Table 3. Distribution of responses on items related to psychological safety.

Item	*n*	*M*	*SD*	Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
If I make a mistake in my research team, it is held against me.	139	2.00	1.1	36%	45%	10%	5%	2%	1%	1%
Members of my research team are able to bring up problems and tough issues.	137	5.22	1.1	0%	2%	4%	18%	40%	21%	15%
People on my research team reject others for being different.	137	1.58	1.0	65%	25%	2%	4%	3%	1%	0%
It is safe to take risks in my research team.	137	5.16	1.2	1%	3%	3%	17%	39%	23%	14%
It is difficult to ask other members of my research team for help.	136	2.03	1.2	42%	34%	12%	6%	4%	1%	1%
No one on my research team would deliberately act in a way that undermines my efforts.	136	5.47	1.6	4%	4%	1%	8%	32%	15%	36%
Working with members of my research team, my unique skills and talents are valued and utilized.	136	5.65	1.0	0%	1%	0%	7%	40%	27%	25%

Table 4. Means and standard deviations based on cross-disciplinary (CD) team membership.

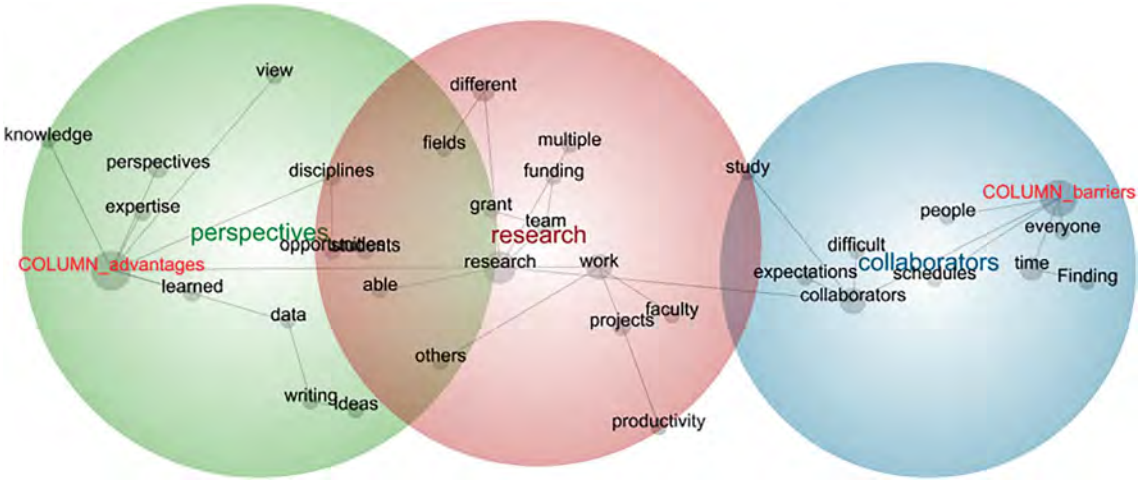
Teaming dimension	CD team membership	*n*	*M*	*SD*
Unidisciplinary orientation	Yes	70	3.41	1.14
	No	105	2.76	0.97
Multidisciplinary orientation	Yes	70	4.47	0.98
	No	105	5.26	0.90
Inter-/transdisciplinary orientation	Yes	69	4.64	0.98
	No	104	5.30	0.81
Cross-disciplinary collaborative activities	Yes	66	3.93	1.41
	No	101	5.24	1.41
Cross-disciplinary collaborative orientation	Yes	67	5.55	0.99
	No	103	5.85	0.91
Psychological safety	Yes	53	5.54	0.88
	No	82	5.80	0.72

is helpful in creating and implementing ideas, our team rotates in who takes the lead on different projects which allows for flexibility and a maximum use of skills and resources, my overall productivity is much higher than it would be if I worked on my own."

Comments about the disadvantages of collaboration were more strongly associated with the "Collaborators" theme. This theme addresses preexisting differences in worldviews, academic working styles, and competing demands for collaborators' time imposed externally. Overwhelmingly, the comments focused on the infrastructure of research collaboration, the logistics of meetings and scheduling, and availability of collaborators to make consistent contributions to joint projects. "Scheduling and expectations amongst authors can serve also as a barrier, as it is difficult to find the time to discuss progress, timelines, and review each other's work." In addition, the differences in expectations for collaborative workflow were identified as factors that create a barrier for collaborative work, for example, "Team coordination, responsibilities, different writing styles, different willingness to do the work, not knowing each other's strengths and weaknesses."

Finally, the theme of "Research" included discussions of both the advantages of and barriers to collaboration. This theme focused on the outcomes of collaborative research, and its key lexical terms included grants, funding, projects, and distribution of work. On the one hand, participants recognized that "grant funding requires teams and it is ideal for diverse perspectives for publication and mentorship." However, they also commented that this possible, desired outcome does not always represent reality: "Although I am working with collaborators, I have not benefited directly (grant submission/acceptance or papers published)." Participants also assessed collaboration as a mediating factor for faculty outputs, noting that, through collaboration, "I have been able to get more work done/more projects," but that collaboration may contribute to "delayed submission timeline of grants/publications due to multiple approvals." Finally, this theme also included the discussion about the overall expectations for research outcomes. Engagement in collaborative

Figure 3. Thematic analysis of free-text responses. The circles depict themes in responses related to advantages and barriers to team-based research. Each word, depicted alongside a shaded circle, indicates a word that frequently occurred in free-text responses. The size of the circle reflects the frequency of occurrence with larger circles indicating more frequently occurring words or concepts than smaller circles.



research may be misaligned with the expectations for individual faculty productivity when "it is difficult as a clinical faculty member to continue to actively participate in research and it is not necessarily expected or rewarded."

Discussion

This study aimed to examine and describe perceptions of knowledge, skills, and approaches to team science by doctoral scholars, postdoctoral early career faculty, and faculty in CSD programs. Key findings include relatively low engagement in cross-disciplinary research and preparation with less than half of participants considering themselves part of an interdisciplinary research team and few respondents (17%) receiving training in team science. Despite low engagement, the majority of respondents showed positive perceptions toward cross-disciplinary orientation and activities with consensus that seeking input from other fields is important and that teaming improves research productivity. Among group differences, female scientists indicated significantly lower psychological safety compared to male scientists. Additionally, faculty in nonacademic and non–tenure tract positions reported lower psychological safety than faculty in tenure track positions. Finally, the rate of engagement in cross-disciplinary collaborative activities was higher for participants with prior team science training than for those without training. Respondents identified numerous advantages, including diverse perspectives, collective expertise, innovative ideas, and higher research quality and productivity. Lastly, frequent challenges mentioned by participants included difficulty finding and connecting with collaborators, timing and scheduling, and different expectations between team members.

Engagement in Team Science

The finding that those with team science training are more likely to participate in cross-disciplinary teams than those without the training is consistent with reports in the literature (Vogel et al., 2012) and substantiates the important role of team science training. However, the current findings suggest that slightly less than half (48%) of respondents considered themselves part of a cross-disciplinary research team suggests that cross-disciplinary collaborative research teaming remains underutilized by researchers in CSD. The fact that participants most often reported that members of their research teams were from same-discipline backgrounds or within the same institution suggests that cross-disciplinary research teams that include members at other institutions are underutilized. The finding that only 17% of respondents had engaged in training about team science was concerning in light of the finding that respondents who receive training are more likely to participate in cross-disciplinary research teams. Similarly, the average number of co-authors (2.63) was surprisingly low compared to the upward trend in number of co-authors reported in science, technology, and translational health sciences research (Wuchty et al., 2007). This finding is somewhat concerning in light of research that suggests publications with more co-authors and co-authors from cross-disciplinary backgrounds are more highly cited and impactful (Larivière et al., 2015) and are more likely to appear in high-impact journals (Campbell et al., 2014).

Although there was broad consensus across respondents regarding the high value of cross-disciplinary collaborative teaming in research (e.g., importance of seeking input from other disciplines, positive impact on productivity), respondents reported rather low levels of participation or engagement in training and/or cross-disciplinary research activities. Taken together, the current findings suggest more research is needed to identify ways to improve the execution of cross-disciplinary research practices in CSD and further vetting the underlying causes of the disconnect between what we value and what we do (i.e., how we engage in cross-disciplinary research). Given the descriptive design, causal relations cannot be derived, but the open-ended responses in the current findings point to factors that warrant further exploration, including but not limited to importance placed on first or sole author work, team coordination challenges, differing expectations, and time or scheduling difficulties.

Group Differences in Team Science Practices

The group differences based on gender are consistent with other findings in the literature based on team science in other fields. Specifically, the finding that female faculty are more likely to engage in cross-disciplinary collaborative activities is consistent with other literature, suggesting that women engage in more collaborations than men (Abramo et al., 2013; Bozeman & Gaughan, 2011; Zeng et al., 2016). The current finding substantiates other literature, suggesting that women are more likely than men to collaborate outside their discipline (Abramo et al., 2013; van Rijnsoever & Hessels, 2011). Although factors that contribute to women's higher likelihood of engaging in cross-disciplinary collaborations cannot be deduced from this study, previous studies have attempted to identify these specific factors. The extant literature highlights discipline-specific (Zeng et al., 2016) and structural (Abramo et al., 2013; Bozeman & Corley, 2004; Bozeman & Gaughan, 2011) factors at play. For example, Zeng et al. (2016) attribute women's superior collaboration skills combined with their lower representation in science, technology, engineering and mathematics (STEM) disciplines to their increased collaborations. However, other studies concluded that structural inequities for women in academia (e.g., lack of social capital, isolation, less social support and recognition, limited mentorship, and gender bias) push women to seek cross-disciplinary collaborative opportunities (Abramo et al., 2013; Bozeman & Gaughan, 2011).

The finding in this study that women's psychological safety scores were lower than those for men is considered a key finding. Specifically, female faculty responded differently on items that related to difficulty asking other team members for help, belief that their unique skills and talents are valued, and belief that members on research team reject

others for being different. This finding is concerning, considering the previous research that suggests that psychological risk influences information exchange and learning between and among team members (Edmondson, 1999; Kostopoulos & Bozionelos, 2011; Newman et al., 2017). Taken together with the finding that female researchers in this study were more likely than men to engage in cross-disciplinary collaborations, it does not appear that psychological risk inhibited female respondents from engaging in team science overall. This finding contradicts prior research suggesting that a low level of psychological safety is associated with decreased likelihood of a researcher engaging in research collaborations (e.g., Stanley, 2014).

Although the cause of group differences in psychological safety scores cannot be determined from this study, the finding may be partially attributed to the fact that a higher percentage of male respondents in this study were tenured faculty members. Prior research has considered the potential influence of rank on psychological safety (De Houwer & Beckers, 2002; Pfirman & Balsam, 2005). Accordingly, when collaborators are more established, others must overcome "blocking" and "overshadowing" effects that unintentionally connect their individual ideas to their senior colleagues (De Houwer & Beckers, 2002). Given that historically women remain a minority in many scientific fields, it is possible this negative male–female collaborative effect may contribute to lower psychological safety scores observed in female respondents (Rhoten & Pfirman, 2007).

The current findings related to differences between men and women in cross-disciplinary teaming practices should be interpreted cautiously, recognizing that male researchers were underrepresented in the current sample of respondents, although the percentage of female respondents in this study (74%) was somewhat aligned with recent proportions of women (72%) compared to men (28%) receiving doctoral degrees in doctoral programs in CSD (Rogus-Pulia et al., 2018). Moreover, women historically have comprised more than half, 67%, of faculty in speech-language pathology and audiology (Boswell, 2001). Nevertheless, the unequal number of male–female respondents and other unrelated differences between gender groups presents challenges for interpreting the complexities of gender differences in collaborative research patterns. Such challenges are consistent with limitations noted in other previous studies of team science (Benenson et al., 2014; Zeng et al., 2016).

Advantages and Barriers of Team Science

Participants' responses on the open-ended questions affirm the perceived value of team science and offer insights into challenges to advancing team science forward in our field. The current findings illuminate the perceived benefits and advantages to collaborative research. The themes that emerged suggest collaborative research efforts have a high pay off with much to offer scientists in speech-language pathology and audiology. Based on participants' comments on benefits of teaming, it seems likely that the perceived value of multiple, diverse perspectives and ideas contribute to a mindset of teaming in the workplace.

The challenges to team science that were frequently identified (e.g., time for collaboration) echo those reported by speech-language pathologists in research on barriers to IPP (Pfeiffer et al., 2019) and challenges reported by other disciplines regarding team science (e.g., Cummings et al., 2013; Trochim et al., 2008). Based on the themes in barriers identified by participants, institutional and departmental infrastructure (time and scheduling) and cultures of research may be influential on the likelihood of engaging in teaming. The fact that time was identified as a benefit of teaming, from the standpoint of distributing the workload and also as a barrier or challenge, may suggest that the strategic management of time plays a critical role in executing team science. Although not empirically studied, it seems reasonable that innovative tools to increase efficiency of teaming (e.g., task managers, remote networking opportunities, and virtual schedulers) may offer beneficial supports as having adequate time and/or guarded research effort may influence feasibility, likelihood, and outcomes of collaborative research.

Limitations

Several limitations should be considered when interpreting the current findings. First, the respondents were predominantly White women, and therefore, it cannot be assumed that the findings represent collaborative research experiences and perceptions of underrepresented groups from diverse backgrounds. Additionally, the limited statistical power should be noted as a limitation. Specifically, the modest sample size in this study may have played a role in limiting the significance of some of the statistical comparisons conducted. It should also be noted that the current results capture self-reported skills and perceptions related to team science. Self-report may vary for individuals depending on the individual's criteria used to judge ratings, such as perceptions of psychological risk. Furthermore, the items on the questionnaire were notably decontextualized given that they were presented without scenarios or vignettes. As such, individual respondents may have considered teams with vastly different dimensions when responding to questions such as differences in team size, team goals (e.g., scientific discovery, training, clinical, translational, public health, and policy-related), and disciplinary scope (e.g., unidisciplinary or cross-disciplinary). Accordingly, it would be interesting in a future study to compare responses when teaming vignettes are given to provide additional context. Moreover, it would be beneficial to observe team science skills given simulations or through other innovative venues that could allow for interactive exchanges between researchers. Such limitations noted in this study are similar to those reportedly experienced in team science research in other fields, since the study of team science has relied almost exclusively on retrospective studies rather than prospective observational, experimental, or quasi-experimental studies of research teams (Hall et al., 2018; Stokols et al., 2008).

Implications

Given the low percentage of respondents who had engaged in training about team science taken together with the fact that those who receive training are more likely to engage in interdisciplinary research, additional programs and supports may be necessary to facilitate wider implementation of training and preparation in collaborative CSD research. Additional research is needed to further explore the potential effects of training in team science on productivity and outcomes. In addition, the potential relation between psychological safety and academic rank would be interesting to investigate in a future study with larger numbers of participants at each academic rank. Further research on the infrastructure needed for programs to adopt team science training may be beneficial as programs strive to prepare CSD researchers to gain skills for research teaming. Future research findings could inform how training programs in team science improve how participants organize, communicate, and conduct research across disciplinary, professional, and institutional boundaries.

Considering the presence of group differences in perceived psychological safety, additional supports may need to be considered to lower the potential risks of engaging in interdisciplinary collaborations to "level the playing field." Specifically, the finding that women and clinical faculty indicated they perceive higher risks associated with interdisciplinary collaborations may suggest additional assurances, incentives, and supports may be needed to foster equity of voice and dissuade overshadowing by male, tenured, and/or higher ranked faculty. Although causal inferences cannot be drawn from the current data, it is possible that multicomponent support such as increasing awareness of the importance of equity of voice, the value of perspectives of clinical faculty for translational research, and awareness of the harmful effects of overshadowing may bolster psychological safety. Although not empirically studied, highlighting and emphasizing the additive value of clinical faculty members' unique perspectives, knowledge, and skills may lower perceived safety and increase likelihood of collaboration in translational research efforts. Because this study yielded group difference in psychological safety between groups that differed in gender and position, additional efforts may be necessary to ensure that imbalances in the power structure of members are not allowed to dissuade members from actively contributing to team activities.

In summary, this study contributes to what we know about the state of team science in CSD research. While teaming is highly valued, responses indicate room for growth in cross-disciplinary teaming activities and in the provision of trainings related to team science. Although this study aimed to provide a glimpse of the state of the practice of team science, additional iterative development efforts are needed to design, refine, and further develop scales of team science practices to better inform preservice training and professional development activities. Additionally, further research is needed to further vet underlying barriers to executing team science and to develop and test innovative approaches to move the practice forward with increased implementation of cross-disciplinary collaborative research.

Author Contributions

Carla Wood: Conceptualization (Lead), Data curation (Lead), Investigation (Supporting), Formal analysis (Lead), Writing – original draft (Lead), Writing – review & editing (Lead). **Mollie Romano:** Conceptualization (Supporting), Data curation (Supporting), Investigation (Supporting), Writing – original draft (Supporting), Writing – review & editing(Supporting). **Yulia A. Levites Strekalova:** Data curation (Supporting), Formal analysis (Supporting), Methodology (Supporting), Software (Lead), Visualization (Supporting), Writing – original draft (Supporting). **Victor A. Lugo:** Data curation (Supporting), Formal analysis (Supporting), Project administration (Supporting), Writing – original draft (Supporting). **Wayne T. McCormack:** Conceptualization (Supporting), Funding acquisition (Lead), Methodology (Supporting).

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