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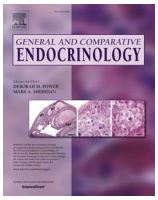

COVID-19 as a chronic stressor and the importance of individual identity: A data-driven look at academic productivity during the pandemic

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ABSTRACT

The COVID-19 pandemic impacted personal and professional life. For academics, research, teaching, and service tasks were upended and we all had to navigate the altered landscape. However, some individuals faced a disproportionate burden, particularly academics with minoritized identities or those who were early career, were caregivers, or had intersecting identities. As comparative endocrinologists, we determine how aspects of individual and species-level variation influence response to, recovery from, and resilience in the face of stressors. Here, we flip that framework and apply an integrative biological lens to the impact of the COVID-19 chronic stressor on our endocrine community. We address how the pandemic altered *impact factors of academia* (e.g., scholarly products) and relatedly, how *factors of impact* (e.g., sex, gender, race, career stage, caregiver status, etc.) altered the way in which individuals could respond. We predict the pandemic will have long-term impacts on the population dynamics, composition, and landscape of our academic ecosystem. Impact factors of research, namely journal submissions, were altered by COVID-19, and women authors saw a big dip. We discuss this broadly and then report *General and Comparative Endocrinology (GCE)* manuscript submission and acceptance status by gender and geographic region from 2019 to 2023. We also summarize how the pandemic impacted individuals with different axes of identity, how academic institutions have responded, compile proposed solutions, and conclude with a discussion on what we can all do to (re)build the academy in an equitable way. At *GCE*, the first author positions had gender parity, but men outnumbered women at the corresponding author position. Region of manuscript origin mattered for submission and acceptance rates, and women authors from Asia and the Middle East were the most heavily impacted by the pandemic. The number of manuscripts submitted dropped after year 1 of the pandemic and has not yet recovered. Thus, COVID-19 was a chronic stressor for the *GCE* community.

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1. Introduction

The COVID-19 pandemic was a global chronic stressor. In academia, labs shut down, research stopped, animals were culled, teaching pivoted to online learning, and we all adjusted to a new "normal". However, while we all weathered the same storm, some individuals had differential access to resources, support, and coping mechanisms. Particularly, those individuals with minoritized racial or ethnic identities, disabilities, minoritized sexual or gender identity and/or intersecting identities, and caregivers had increased burdens (Malisch et al., 2020a; Myers et al., 2020; Pineault and Rouzer, 2020; United Nations, 2020; Davis et al., 2022; National Academies of Sciences, Engineering, and Medicine, 2021; Staniscuaski et al., 2021; Wagner et al., 2022). Moreover, those individuals who were early career investigators or who were in non-tenure-track or contingent positions faced compounded challenges, especially when these individuals had intersecting identities (e.g., early career and a caregiver; Arnold and Woolston, 2020; Cardel et al., 2020a; Cohen Miller, 2020; Inouye et al., 2020; Krukowski et al., 2020; Fulweiler et al., 2021; López-Vergès et al., 2021; Schneider et al., 2021; Lokhtina et al., 2022; Staniscuaski et al., 2023). Disparities facing minority groups are well-documented in academia (Asplund and Welle, 2018; Cech and Blair-Loy, 2019; Asai, 2020; Cardel et al., 2020b; Malisch et al., 2020a; Cech and Waidzunas, 2021; Maas et al., 2021; Stevens et al., 2021; Valenzuela-Toro and Viglino, 2021; Yerbury and Yerbury, 2021; Berhe et al., 2022; Fox Tree and Vaid, 2022; Kozlowski et al., 2022; Mays et al., 2023), but the pandemic exacerbated differences.

In this manuscript, we apply an integrative biological lens to the impact of the COVID-19 chronic stressor on our endocrine community. We discuss the tradeoff between push and pause in research and scholarly output that academics navigated during the pandemic. Specifically, we address how COVID-19 altered *impact factors of academia* (e.g., scholarly products) and relatedly, how *factors of impact* (e.g., sex, gender, race, career stage, caregiver status, etc.) altered the way in which individuals could respond to COVID-19. Just as multiple biotic and abiotic factors influence life history and ecological tradeoffs in other organisms, multiple factors of impact altered the way in which individual academics were able to pursue productivity in the face of this global chronic stressor. Viewing this situation through ecological and evolutionary lenses allows us to see that these factors of impact are under selective pressure from the current academic environment, and they are driving the productivity of our current scientists. Using this lens, we predict that the COVID-19 pandemic will have long-term impacts on the population dynamics, composition, and landscape of our academic ecosystem.

2. Impact factors versus factors of impact

For aspiring, early-career, and continuing academics, especially those at research-intensive institutions, the mantra of publish or perish is always present. The three pillars of academia are teaching, research, and service, but in the current climate, academics thrive or whither based on their publications and research output. When we assess our academic peers, we determine the overall impact factor of their scholarly achievements. We define these *impact factors* to include publication number, citations and H-Index, journal prestige, grant money won, and international recognition. Combined, these impact factors are used to earn degrees and post-doctoral fellowships, and to award promotions, tenure, merit raises, and career advancement opportunities. Individual academics were differentially able to navigate the pursuit of academic impact factors during the pandemic; this reality will have long-term effects for our community. Compared to the past, the composition of a competitive curriculum vitae for today's job market is more expansive (Reinero, 2019) and the expectations for tenure and promotion have steadily escalated with increased reliance on research productivity (Schimanski and Alperin, 2018). Thus, COVID-19-related delays and disruptions have had, and will continue to have, large consequences on impact factors and career trajectories, especially for trainees and early-career individuals and particularly for those from minoritized groups (Malisch et al., 2020a; Cardel et al. 2020a,b; Gibson et al., 2020; Gonzales and Griffin, 2020).

2.1. Factors of impact - calls for equity

Despite the focus on impact factors for scholarly work, less attention is paid to the *factors of impact* that alter the way in which individual academics navigate the academic landscape (Fig. 1). Science is often thought of as a meritocracy, free from bias, outside input, or subjectivity. Thus, there is often the assumption that all members of the academy have equal opportunities and that all outcomes are (fairly) based on merit. This is not wholly accurate as axes of an academic's identity influence the ways in which we interpret our data, how we assess others' productivity, and how we move through this landscape (Hofstra, et al., 2020; Saini, 2020; Davies et al., 2021; Gosztyla et al., 2021; Heidt, 2023; Staniscuaski, 2023; Thorp, 2023). Therefore, the concepts of equality, equity, diversity, and inclusion add a necessary perspective to the discussion of academic achievement and the way in which axes of identity matter (**Box 1**).

Box 1

Equality: Having equal access to opportunities and resources; a focus on fairness and merit.

Equity: Having access to the opportunities and resources needed to ensure that everyone has the ability to reach the same outcome; a focus on justice and dismantling systemic obstacles.

Diversity: Having individuals with different characteristics and identities that enrich the group, output, or workplace. Diversity has many axes, including, but not limited to, race, skin color, place of origin, religion, immigration status, ethnicity, ability, sex, sexual orientation, gender identity, gender expression, and age.

Inclusion: Having one's voice, opinions, ideas, concerns, and identity respected and valued; allows one to reach one's full potential; a focus on belonging with diversity as the outcome.

From the beginning of the pandemic, academics highlighted diversity, equity, and inclusion concerns. Some of the earliest pandemic publications emphasized a) anti-Asian discrimination on campuses (Chang, 2020; Dill, 2020; Kwon, 2020), b) career impact concerns for contingent and minoritized faculty (Flaherty, 2020a; Gonzales and Griffin, 2020), c) impacts on diversity in science (Aviles, 2020; Woolston, 2020), d) education and access concerns for K-12 students (Southern Poverty Law Center, 2020; Strauss, 2020), e) equity concerns for higher education students (Harris et al., 2020; McMurtrie, 2020), f) accessibility and safety concerns for disabled students and faculty (Accessible Campus Action Alliance, 2020), g) gender equity for academics (Kreeger et al., 2020; Lewis, 2020; Malisch et al. 2020a; Minello, 2020), h) graduate student inequities (Flaherty, 2020b; 2020c Zahneis, 2020), i) productivity pressures (Ahmad, 2020; Lorenz, 2020; Pope-Ruark, 2020; Su, 2020), j) pandemic parenting (Cardel et al., 2020a; Cooney, 2020; Lloyd, 2020), k) tenure and promotion (Htun, 2020), l) field and animal work (Eschner, 2020; Grimm, 2020; Inouye et al., 2020; Pennisi, 2020; Pullium, 2020) and m) job market stalls and impacts on early career scientists (Chen, 2020; Gibson et al. 2020; Kelsky, 2020; Levine and Rathmell, 2020; Pain, 2020). Each of these topics has now been supported by multiple publications.

2.2. Impact factor - COVID-19 and journal article submission and publication

Research and scholarly productivity plummeted during the early pandemic, especially manuscript submission and publication. The abrupt falloff of journal submissions by women, combined with an increase in submission by men, was first voiced via social media and anecdotal analysis in early 2020 (Collins, 2020; Fazackerley, 2020; Flaherty, 2020d; 2020e; Kitchener, 2020; Viglione, 2020; Vincent-

Lamarre et al., 2020). Early hypotheses in the gendered impact on productivity focused on caregiving. Stay-at-home parenting roles were predominantly assumed by women, rendering working from home, writing, collaborating, submitting manuscripts, and starting new projects much more challenging to near impossible. Since then, several authors have investigated how COVID-19 impacted submission, review, and publication of articles by gender and across fields of study (Supplemental Table 1).

Our summary of 50 studies (Supplemental Table 1) corroborates early concerns about gender inequity in productivity as 36/50 reported decreased productivity by women academics. Overall, women submitted and published fewer manuscripts than men. Specifically, women, those who acted as caregivers, and especially the intersection of being a woman and a caregiver for children or elderly at home, were the groups most impacted by the pandemic. Also evident is that the persistent gender gap present across fields has grown even wider and will likely continue to grow. Analysis of 2,339 Elsevier journals and over 5 million authors and reviewers found that women, especially those with early career status, submitted proportionally fewer manuscripts than men during the pandemic (Squazzoni et al., 2021a); however, women were more likely than men to accept reviewer invitations. These results suggest a cumulative advantage for men authors (Squazzoni et al., 2021a). In addition to manuscript submission impacts, the pandemic resulted in a drop in new projects, particularly for women and parents of children under five (Gao et al., 2021; Madhusoodanan, 2021). These results suggest the impacts will be felt for years to come, as academic projects often take years to go from conception to published product. Fewer projects in the pipeline, especially for certain groups, can translate to widened productivity gaps in the future (Madhusoodanan, 2021). In summary, COVID-19-related impacts on productivity will have gender-biased impacts on the success, promotion, and representation of women across fields of science for years to come (Cardel et al., 2020a,b).

2.3. Impact factor – COVID-19 and journal submissions at general and comparative endocrinology

2.3.1. Data collection

We obtained data (date of submission, author names, corresponding author country, final decision, and publication date for accepted manuscripts) from Elsevier for all manuscripts submitted to *GCE* from 1 May 2019 through 30 April 2023. Data gathering and summary was approved by the TTU Institutional Review Board. We divided the data into three, 4-mo time periods that roughly correspond to summer, fall, and spring semester (in the Northern hemisphere). We anchored our timing with the onset of the pandemic campus shutdowns (April/May 2020) and had 4 yr of data (1 yr of pre-pandemic and 3 yrs of pandemic). For all 1,688 submissions, we searched Google, Google Scholar, Loop, ResearchGate, and/or ORCID to find an image of the first and

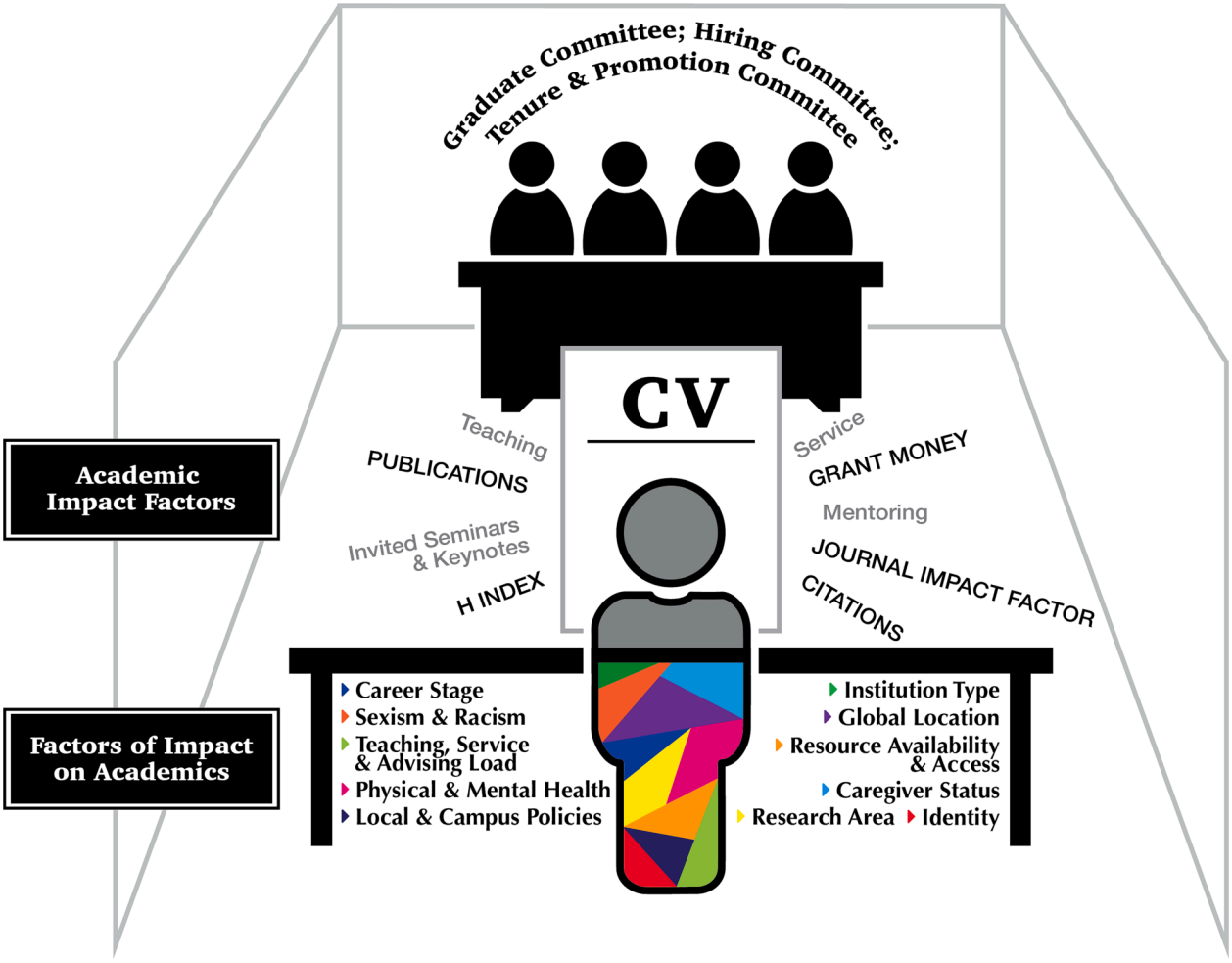

Fig. 1. The academic *impact factors* on which we are all evaluated are influenced by multiple *factors of impact* that affect individual academics and alter the way in which they can move through the academic landscape. These factors of impact can have compounding effects, as many aspects of identity (e.g., sex, race, gender, socioeconomic status, sexual orientation) intersect with one another to produce differing outcomes for individuals (e.g., women are more likely to be in contingent positions and/or have heavier teaching and advising loads; non-white individuals are more likely to experience racism which can impact mental and physical health; men and women experience the life history stage of parenting and caregiving differently).

corresponding author and/or a statement with gender pronouns. If that was not successful (which was the case in ~ 15 % of corresponding authors and ~ 30 % of first authors) we used the Gender API program to find the sex typically associated with the author's first name. If the program's estimation was 55 % or greater, we assumed a cisgender relationship (i.e., man for a male name, woman for a female name). Overall, an inferred gender identity was recorded for 98 % of authors.

Authors were coded as man, woman, or unknown, thus we have only binary categorization of gender. We know this is not a perfect method and that we had to make assumptions to generate the datasets. Additionally, there are important distinctions between sex and facets of gender (**Box 2**), but only gender can be inferred by collected author information (e.g., first names and/or presentation of gender expression in photos or pronoun use). In some instances, we had to make a binary gender distinction (see above), but otherwise in our writing, we use women as an inclusive term representative of all who identify as women. We also recognize that those with non-binary gender identities and those who are trans face additional challenges. Lastly, there are likely differences in submission based on intersectional aspects of identity (e.g., race, ethnicity, career status, position stability, etc.), but that information cannot be obtained from journal submission records. This is not a problem of *GCE* specifically, as this concern has been raised for multiple journals and publishing platforms (Wu, 2020).

Box 2

Sex: a combination of genetic, gonadal, gametic, hormonal, and other morphological characteristics used to categorize an individual along the male - female continuum.
Gender: a social construct incorporating psychological, social and cultural factors that shape attitudes, behaviors, and stereotypes.
Gender identity: a psychological sense of self; how individuals perceive themselves within specific cultures and contexts. Encompasses woman, man, and every option and combination in between, including agender.
Gender expression: how individuals present their gender, e.g., via clothes, actions or other outward appearance, within specific cultures and contexts. Encompasses masculine, feminine, and every option and combination in between.

2.3.2. Overall trends in publication metrics

The percentage of papers submitted that were accepted for publication decreased from the pre-pandemic level of 41 % to 36 % during year 1 and 32 % during year 2 (Table 1). The average time from submission to publication of accepted manuscripts rose slightly during years 1 and 2 of the pandemic, but increases were small, suggesting reviews and revisions were not taking longer to complete.

Overall, authors submitted fewer papers during the fall semesters (Sept 1 – Dec 31; except year 1 of the pandemic). The number of manuscripts submitted to *GCE* remained similar to pre-covid numbers during year 1 of the pandemic, but submission numbers dropped during each semester of years 2 and 3 of the pandemic (Fig. 2). We were unable to determine why submissions dropped, but we provide some hypotheses below. Authors that were able to submit during year 1 of the pandemic may have used the work-from-home and shutdown time to get in-progress papers finished. However, for many authors, the shutdowns also meant no new data collection. This was especially true for research teams that work at field sites, as travel and access to field sites, especially internationally, were heavily restricted by COVID-19 protocols. Additionally, for those working with animals on campuses, many colonies were terminated or extensively culled during shutdowns which translated to decreased ability to collect data. For all academics, the delay in reagents and lab supplies also stalled progress. This outcome is seemingly reflected in our dataset as the trend for increased submissions during year 1 was not sustained. Year 2 of the pandemic saw 70 % of pre-COVID manuscript numbers and Year 3 reached 65 %, suggesting that the impacts of COVID are not over.

Table 1
Total manuscript submissions (number for each 4-mo period in parentheses), overall acceptance percentage at *GCE*, and average days from submission to publication for accepted manuscripts before and during the COVID-19 pandemic. Note: data on percent accepted and average days until publication is not yet available for year 3 as some manuscripts were still in review and revision at the time of writing this paper.

	Pre-pandemic	Pandemic Yr. 1	Pandemic Yr. 2	Pandemic Yr. 3
May 1 - Aug 3 (Summer)	2019 (191)	2020 (158)	2021 (111)	2022 (116)
Sept 1 - Dec 31 (Fall)	2019 (152)	2020 (167)	2021 (107)	2022 (93)
Jan 1 - April 30 (Spring)	2020 (171)	2021 (177)	2022 (130)	2023 (116)
Total manuscript submissions	513	502	348	325
Percent accepted	41 %	36 %	32 %	*NA*
Mean days until publication	161	168	171	*NA*

2.4. Factors of impact – COVID-19 and journal submissions and acceptance at GCE by author gender

2.4.1. Submitted manuscripts

For the analysis below, we examined the sum total of all papers submitted and published during the timeframes described previously (Supplemental Table 2a,b). Men outnumbered women in first authorship positions (6 out of 12 time points; 2 points were roughly tied), but women outnumbered men in the summer before COVID-19 and notably at 2 of 3 time points during year 3 (Fig. 3). During all time periods investigated, men outnumbered women as corresponding author (Fig. 4). The gender difference in corresponding author was less pronounced during the summer semester pre-pandemic and during year 3, suggesting that laboratories headed by women submitted more manuscripts May through August.

Overall, it appears that first-author gender has more parity than corresponding-author gender. This could suggest a problem of retention of women in the field, or that senior women do not submit as readily to *GCE*. Most STEM fields are still heavily dominated by men, and this is especially true as one moves up the academic ladder. Data for tenured and tenure-track faculty from departments where authors from this manuscript work average 44.1 % women (range 28.6–68.2 %; Supplemental Table 3). As of 2021, over 50 % of biological and biomedical PhDs were awarded to women (National Academies and of Sciences, Engineering, and Medicine, 2021), however, we do not have the breakdown for endocrinology-focused degrees. But, despite the sexist past of the endocrine field (Purpura, 1998; Kistler, 2017; Baran, 2018; Tan and Bracha, 2019), the related field of behavioral neuroendocrinology is now dominated by women (see Baran, 2018). Dr. Cheryl McCormick tallied the gender breakdown of first and last author for manuscripts submitted to *Hormones & Behavior* pre-pandemic (17 Oct – 28 Dec 2019) and during the first months of the pandemic (1 Jan – 31 May 2020). She found a ~ 10 % dip in percentage of women first authors, but overall reported that women outnumbered men as first author and there was near gender parity for last author position (McCormick, 2020). Despite the overlap in topic, *Hormones & Behavior* appears to have more gender parity overall than does *GCE* as we did not see those same trends.

Our data indicate that gender was not a major factor driving submission of manuscripts to *GCE* during the pandemic. However, the number of submissions during years 2 and 3 were ~ 65 % of what had been submitted pre-pandemic and during year 1. Thus, overall, our data represent a survivor bias as fewer individuals were submitting (or were able to submit) manuscripts later in the pandemic and we lost ~ 35 % of authors. This loss was not driven by gender, but data to determine if other axes of identity could account for those who chose or were forced to pause during this time (e.g., parents or caregivers of all genders, research area [lab vs. field vs. computational], type of institution, collaboration network, etc.) were not collected by Elsevier.

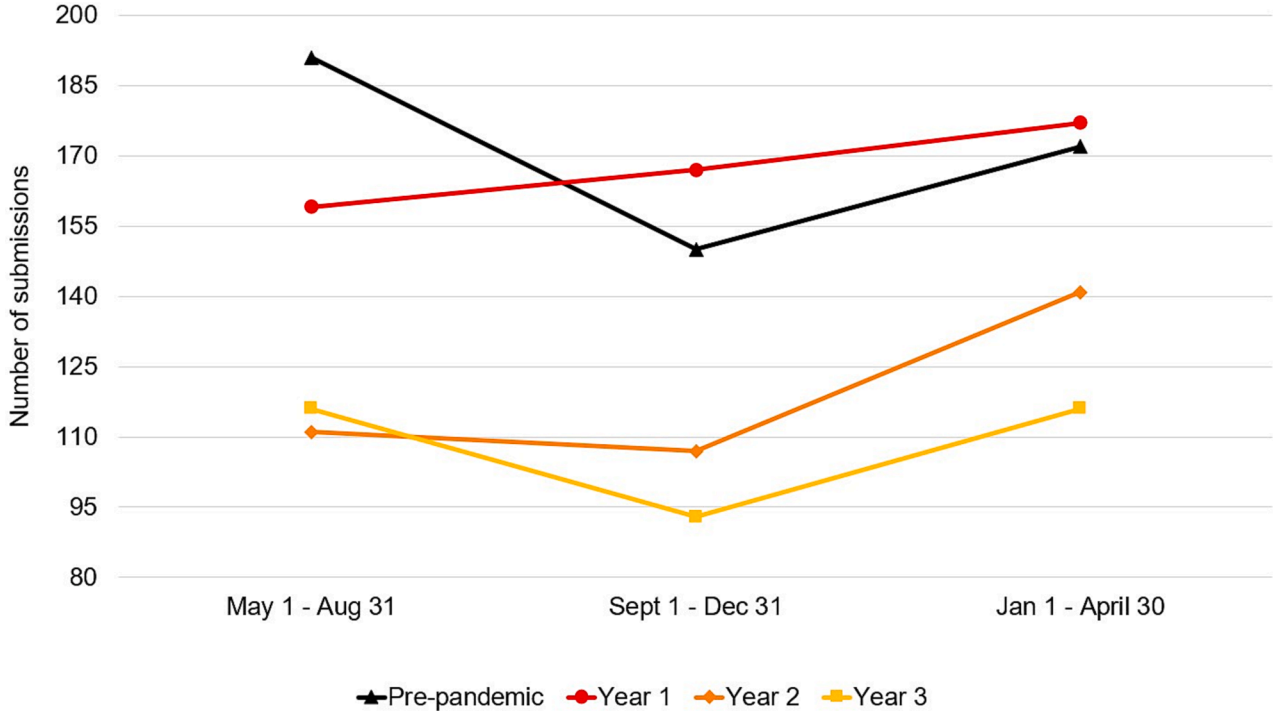

Fig. 2. Number of manuscripts submitted to *GCE* before and during the COVID-19 pandemic.

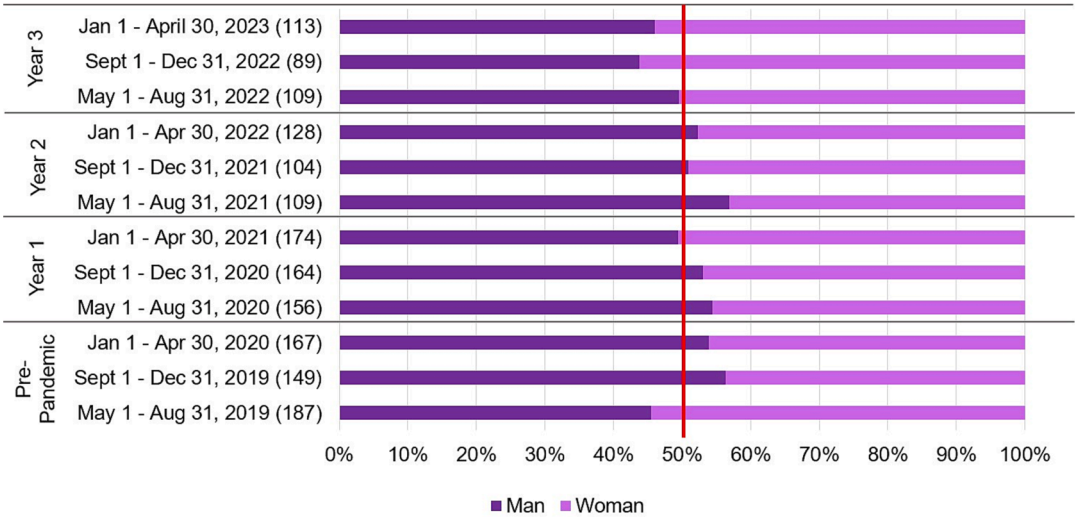

Fig. 3. Percentage of manuscripts submitted to *GCE* by first author inferred gender over time. Manuscripts where author gender could not be determined were removed from the denominator. Number in parentheses is the total number of submitted manuscripts during that time frame for which first-author gender could be recorded.

2.4.2. *Accepted manuscripts*

We also determined the gender breakdown of first and corresponding authors of accepted manuscripts over time (Supplemental Table 2c,d). Men narrowly outnumbered women as first author on accepted manuscripts (6 out of 12 time points, one point was tied; Fig. 5). When combined with submission data, however, papers with a woman first author were more likely to be accepted (women outnumbered men on submissions 3 out of 12 times, but outnumbered men on acceptance 5 out of 12 times), but this may represent random variation. For the corresponding author position, men outnumbered women on submissions at all time points and outnumbered women on acceptances at 10 out of 12 time points (Fig. 6).

We also determined the percentage of papers accepted out of papers submitted ("hit rate") for men and women first and corresponding authors. The percent accepted dropped for first and corresponding authors of both genders during COVID-19 compared to pre-COVID-19 (Supplemental Table 2e). The drop was greater for women authors: first author, −9% vs. −6% for men; corresponding author, −11 % vs. −5% for men. However, pre-COVID-19, a higher percentage of papers by women first (46 % vs. 38 % for men) and corresponding (47 % vs 39 % for men) authors were accepted. We do not have data to infer why this was the case. Other publications have noted a bias in journal acceptance when the first (Fox and Paine, 2019) or corresponding author (Hagan et al., 2020) is a woman, however, this result is not always found (Squazzoni et al., 2021b), and does not align with our data.

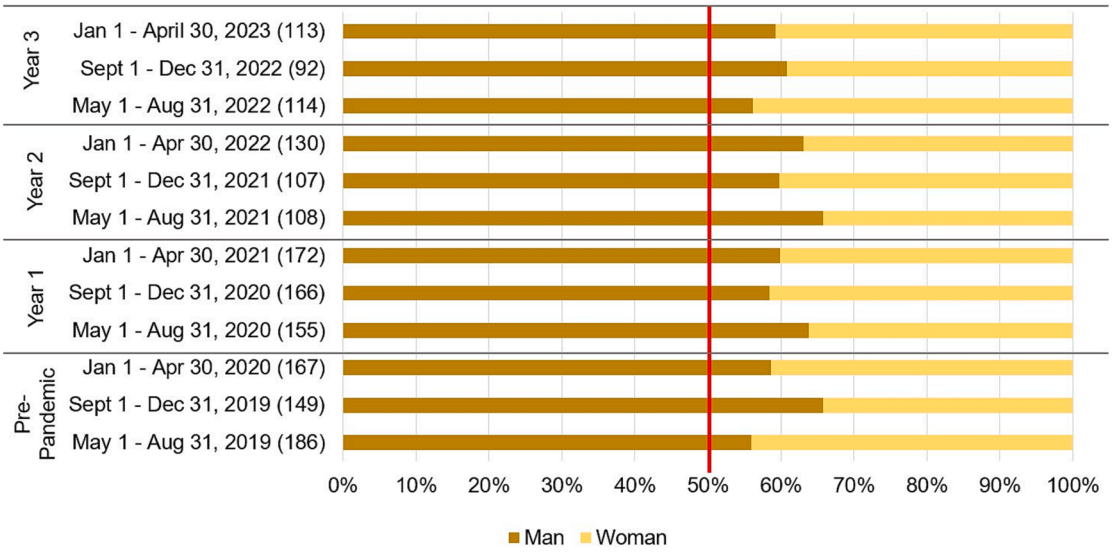

Fig. 4. Percentage of manuscripts submitted to *GCE* by corresponding author inferred gender over time. Manuscripts where author gender could not be determined were removed from the denominator. Number in parentheses is the total number of submitted manuscripts during that time frame for which corresponding-author gender could be recorded.

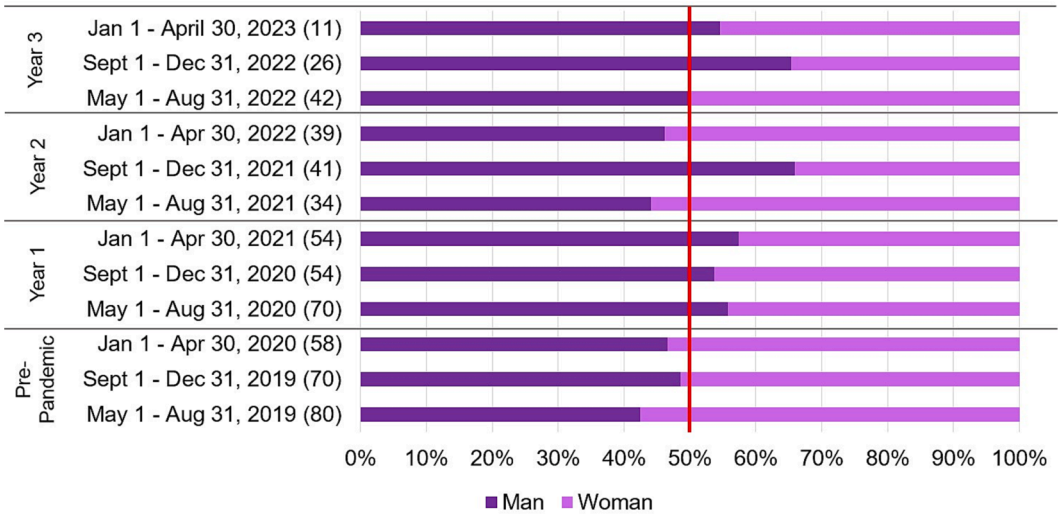

Fig. 5. Percentage of accepted manuscripts at *GCE* by first author inferred gender over time. Note, 1 Jan – 30 April 2023 data are incomplete as manuscripts were still in the review and revision stage at the time of writing this paper. Manuscripts where author gender could not be determined were removed from the denominator. Number in parentheses is the total number of accepted manuscripts during that time frame for which first-author gender could be recorded.

2.5. Factors of impact – COVID-19 and journal submissions and acceptance at GCE by geographical region

2.5.1. Geographical regions

Individuals who are not from wealthy or western nations face disproportionate research barriers (Maas et al., 2021; Valenzuela-Toro and Viglino, 2021; Khelifa & Mahdjoub, 2022), and thus location may influence pandemic-related impacts. We obtained the country of the corresponding author for all submissions and coded data into 9 regions: North America, Central America, South America, Caribbean, Europe, Middle East, Asia, and Australia & Oceania. The number of submitted and accepted manuscripts per region, the per region percentage of accepted out of submitted, the percentage of manuscripts submitted by women corresponding authors out of total submitted per region, and the percentage of accepted manuscripts per region authored by women were calculated.

Overall, manuscripts with the corresponding author in Asia represented the largest share of submitted papers (average of 45 %), whereas Central America and the Caribbean represented the smallest (0–1 % of papers submitted); other regions were in between (Asia [755 papers overall] > North America [330] > Europe [255] > Middle East [135] > South America [111] > Africa [72] > Australia & Oceania [28] > Caribbean [2] > Central America [0]; Supplemental Table 4a, 5a). The share of accepted papers rarely matched the share of submitted papers; on average papers from North American, South American, and European labs were overrepresented in percentage of accepted papers, and African, Middle Eastern, and Asian labs were underrepresented (Supplemental Table 4a**a**). None of these outcomes were not robustly influenced by COVID-19.

For acceptance per submission per region ("hit rate"), papers from North American labs had the highest value (average of 72 %) and hit rate improved slightly over the pandemic (67 % to 74 %, Supplemental Table 4**b**). Manuscripts from African labs also saw an increased hit rate during the pandemic (7 % vs. 19 %); all other locations saw a decrease

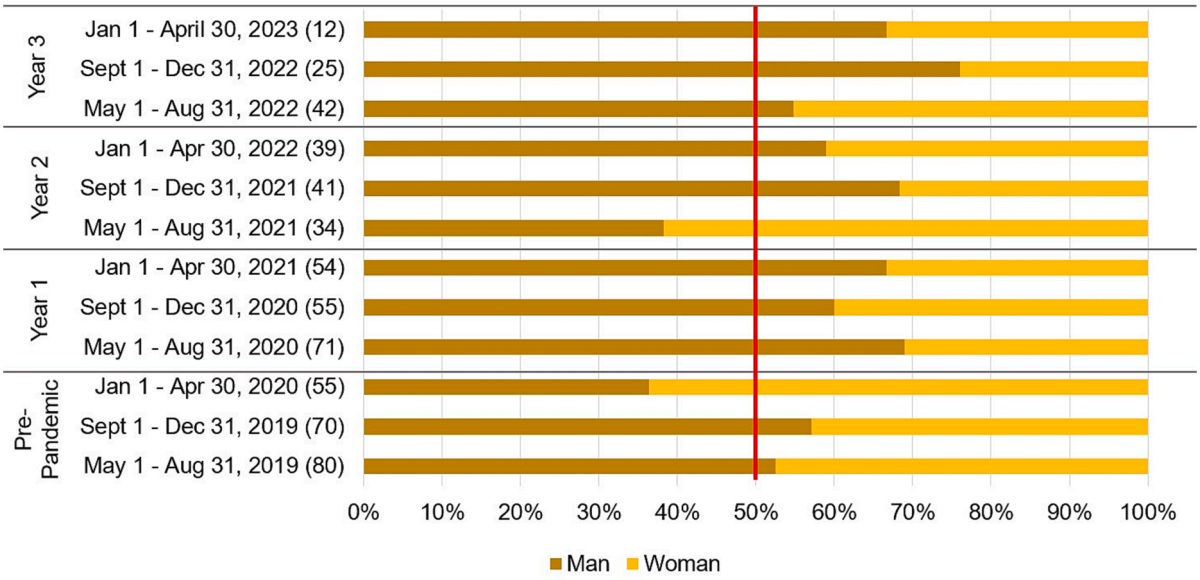

Fig. 6. Percentage of accepted manuscripts at *GCE* by corresponding author inferred gender over time. Note, 1 Jan – 30 April 2023 data are incomplete as manuscripts are still in the review and revision stage. Manuscripts where author gender could not be determined were removed from the denominator. Number in parentheses is the total number of accepted manuscripts during that time frame for which corresponding-author gender could be recorded.

(Supplemental Table 4**b**). Overall hit rate was lowest for papers from the Middle East (9 %), Africa (15 %), and Asia (26 %). We do not have data to investigate why these regional differences exist, but peer review can be particularly biased for non-white authors from regions that are not primarily English speaking (Silbiger and Stubler, 2019; Fox et al., 2023; Smith et al., 2023). The *GCE* data are like those from other outlets, as analysis of over 300,000 biological manuscripts found worse review outcomes and acceptance rates for authors from Asia, those from countries where English is not the primary language, and those from countries with lower scores on the Human Development Indices (Smith et al., 2023). In another study, disparities in reviewer scores were alleviated when the peer review was double blind (Fox et al., 2023). It may be beneficial for *GCE* to try double-blind peer review.

2.5.2. *Geographical region submissions by gender*

Submissions by women corresponding authors differed geographically. Over all time periods combined, over 60 % of submissions from Africa and Australia & Oceania had a woman as corresponding author (62 and 67 %, respectively; Supplemental Table 5**a–c**), North America, South America and Europe had roughly 50 % of submissions by women corresponding authors (average: 51–55 %;), whereas the Middle East, Asia, and Caribbean had the lowest overall percentage of women corresponding authors (33, 26 %, and 0 %, respectively).

During the first COVID-19 period (May 1 – August 31, 2020), manuscripts with women corresponding authors from North America, Africa, the Middle East, and Asia saw a roughly 20 % drop from the same time period pre-COVID-19. This pattern recovered by year 2 of the pandemic for North America, but not for the other regions. Thus, the pattern of decreased May 1 – August 31 submissions by women corresponding authors (section 2.4.1) is likely being driven by regional differences.

2.5.3. *Geographical regions acceptance by gender*

Out of all papers accepted by region, the average percentage with women corresponding authors ranged from 18 % (Asia) to 69 % (Australia & Oceania; Supplemental Table 5d,e). The percent of accepted papers with women corresponding authors was lower for papers from North America, the Middle East, and Asia for the first COVID-19 time period (May 1 – August 31, 2020) vs. that time pre-COVID-19; only acceptance percentage from North American labs rebounded by year 2 (Supplemental Table 5e).

The hit rate for papers submitted by women corresponding authors differed by region (Supplemental Table 5**f**). Women corresponding authors from North American had the greatest pre-COVID-19 acceptance success (65 %) and women corresponding authors from the Africa has the lowest (6 %). COVID-19 differentially impacted hit rate by region, the Middle East saw the biggest drop in hit rate for manuscripts with a women corresponding author (-26 %), followed by Europe and Asia (-8% each). Australia & Oceania, Africa, North America, and South America saw an increase in hit rate (27 %, 22 %, 12 %, 10 %, respectively; Supplemental Table 5**f**).

2.6. *Summary of COVID-19 impacts at GCE*

Within the *GCE* community, women and men were roughly equivalent in terms of first author on submitted articles, but men always outnumbered women as the corresponding author. Gender trends in authorship did not substantially change over the pandemic. Submission rate held steady during year 1, but then drastically decreased over the next two years of the pandemic; between year 1 and year 3 we lost ~ 35 % of our authors as submissions were at 65 % of those seen pre-pandemic. This trend may reflect a strategy where researchers used isolation time to publish data that had already been collected, but then ran out of material to publish. However, we do not have data on our authors to corroborate that hypothesis. For all articles, percent accepted dropped during COVID-19 compared to pre-COVID-19. The acceptance hit rate decreased more for women vs. men first and corresponding authors during COVID-19; pre-COVID-19 women authors had a higher hit rate. From a global perspective, region influenced submission numbers and the share of accepted papers rarely matched the share of submitted papers. Papers from North America, South America, and Europe were overrepresented in percentage of accepted papers, and those from Africa, the Middle East, and Asia were underrepresented. Manuscripts originating from Asia, Africa, and the Middle East had particularly low acceptance hit rates. Women corresponding authors from North America, the Middle East, and Asia saw a decline in submission and acceptance percentages during the first period of COVID-19; but only North American women recovered to pre-pandemic rates by pandemic yr 2. For women corresponding authors, COVID-19 differentially impacted hit rate by region, the Middle East saw the biggest drop followed by Europe and Asia. Overall, women corresponding authors

from Asia and the Middle East were the most heavily impacted by COVID-19. Data suggest trying a double-blind peer review process may be beneficial.

3. Factors of impact – From individual to community

3.1. The pandemic and the authors: Individual factors of impact

Organisms, including humans, use physiological and behavioral responses to cope with challenges. We know that individual and species-level variation alters the response to and recovery from stressors, with factors such as sex, age, life history stage, prior experiences, status, and condition, influencing outcomes. Additionally, multiple specific hypotheses to address how stressors influence tradeoffs, transitions, and health have been proposed (Harris, 2020). However, we often do not apply these hypotheses to the researchers conducting the work. Therefore, we sought to use our experiences and positionality as individuals to highlight how various *factors of impact* (individual variation) influenced our navigation of the push/pause tradeoff during a chronic stressor (COVID-19).

This section is not a comprehensive list of all the ways in which individual academics were impacted, but it does represent challenges faced by our authors. Additionally, the information presented here is not fully representative. As authors of this paper we have a degree of privilege, that is, we have weathered the COVID-19 storm and still hold our positions. Many of us are from the United States, thus, much of the pandemic and academic literature cited is US-biased. For example, the data for the start of pandemic, the delineation of spring vs. fall semester, and the policies mentioned are US-centric. Almost all of us are caregivers, to children, to adult family members, or to both. Many of us are white women and therefore our perspective cannot represent that of all women, or of individuals with non-binary gender identity. We recognize that non-white women as well as others with minoritized identities face additional challenges. None of our comments listed here are meant to disregard or downplay the challenges that others have faced.

3.1.1. Life history stage variation: Caregivers

Caregiving can take many forms, including, but not limited to, caring for young children, adolescents, aging family members, and family members with special (medical) needs. Depending on individual circumstances, substantial overlap in caregiving responsibilities both of young children and aging parents, can occur coincident with important career-advancement stages. Below, we describe a variety of ways in which caregivers, in this broad sense, were (and continue to be) impacted by the COVID-19 pandemic and its associated policies.

3.1.1.1. Academia and parenthood. The COVID-19 pandemic highlighted a long-standing trend in academia – the loss of women academics in tenure-track positions (Mason and Goulden, 2004; Cardel et al. 2020a,b). Even before the pandemic, the burden of bearing and rearing children during the most critical early career stages forced many parents from the workforce (Cardel et al., 2020b). Implicit biases against mothers have hindered their ability to obtain tenure-track positions (16 % less likely than a father, 21 % less likely than a woman without children under six) and gain tenure (27 % less likely than a similar man; Cech and Blair-Loy, 2019). The average age of the first-born child for a U.S. mother is 27, while an individual on the tenure-track has their first child at 34 years of age. The average age of the first faculty position is 33, indicating that the pre-tenure years are during a high-cost time of child raising. This timing disproportionately affects women, with 43 % of mothers leaving their careers after the birth of their first child compared to 23 % of fathers (Cech and Blair-Loy, 2019). However, the current policies are also detrimental to fathers (Leigh et al., 2023). The U.S. has no required paid maternity leave, let alone paternity leave, and many academics must rely on the unpaid six to twelve weeks of leave afforded by the Family and Medical Leave Act (FMLA). During the pandemic, FMLA could be used to care for loved ones affected by COVID-19, but it was also the only time given to many birthing mothers who then had to return to work afterwards. Many institutions have instituted a "stop-the-tenure-clock" option to account for loss of productivity, but this significantly decreases life-time earnings (Manchester et al., 2013; see section 3.2 below).

3.1.1.2. Giving birth. Pregnant people faced unique challenges during the pandemic: changes in physiology that affect breathing, drug metabolism, and immune status (Chen et al., 2020); unknown effects of COVID-19 viral infection and vaccination on unborn children; and changes to hospital policies and care for families that are COVID-19 positive at delivery. Pregnant people were considered high-risk for COVID-19 infection, but communicating this to colleagues could be a sensitive and stressful topic because many pregnant people prefer to wait until after the first trimester to announce pregnancy. Although in 2023 it is well-established that the mRNA COVID-19 vaccines are safe for pregnant people, in 2021 when vaccines were first available, the effects of the vaccine on pregnant people and unborn fetuses was not known, and doctors and midwives were sometimes reluctant to give advice on whether or not a pregnant person should be vaccinated. Children born in 2021 were the first people with possible *in utero* exposure to the vaccine and were studied retrospectively to determine safety for short- and long-term outcomes.

3.1.1.3. Caregivers of young children. Parents faced, and still face, additional burdens of lost childcare and reduced work time. In the U.S., children do not need to attend school until they turn 5. Thus, from birth until 5 years of age, working parents must find daily care for their offspring. Childcare is often expensive, and slots of attendance are competitive. Many parents were forced (due to shutdowns) or chose to pull their children from daycare during the pandemic. This often meant actively caring for a non-self-sufficient child (or children) while simultaneously attempting to work from home. Many parents also continued to pay daycare fees so as not to lose their spot when conditions improved. Several of our authors were without childcare for a year or more. The decision to keep children home was difficult, as many daycares did open back up after a few months of shutdown, but parents feared sending their children back, especially in locations where COVID-19 mitigations were not used (or were banned). Thus, parents felt they must choose between the opportunity for career advancement and their children's health.

Another major concern was the ability to mitigate infections. Many U.S. states and school districts dropped COVID-19 mitigation measures early in the pandemic (however there was massive variability by state and region), and vaccine rollout was based on age and risk status. In the U.S., the vaccine for those 12 yrs and older was authorized in December 2020, whereas the vaccine for children aged 5 – 11 yrs old was approved in October 2021, and the vaccine for those under 5 yrs of age was not approved until June 2022. In some locations, vaccines were in short supply. Moreover, even when vaccines did become available for younger kids, it did not alleviate lost childcare. For example, as of spring 2022 many parents had intermittent care due to COVID-positive shutdowns or exposure quarantines. For many locations, when a student in a class tested positive, exposed children had to quarantine, and this sometimes happened back-to-back such that parents did not have childcare for months at a time. There were factors of feeling safe and able to send children to their first year of or back to school (in some places with no COVID-19 mitigations at all) and once they were back, the frequent disruption from quarantines. Quarantine periods lasted from 5 to 10 d from exposure and often with no easy way to determine if infection had occurred. The ability to self-assess COVID-19 infection status easily and rapidly was not available until early 2022 and even then, testing kits were difficult to obtain initially. Thus, the burden related to childcare

lasted months or years for some parents as the pandemic started in the U. S. in March 2020. Although it has been declared "over", its ramifications are still ongoing.

3.1.1.4. Caregivers to older children. Caregivers with older children and adolescents in the home also faced unexpected pressures due to the impacts of school closures and social isolation during the height of the pandemic. Many also had to take on the role of assisting with or coordinating at-home schooling. Adolescence is a period in which social connection is particularly important for self-esteem, as well as academic and social adjustment (Ikiz and Cakar, 2010; Grant-Vallone et al. 2004). Unsurprisingly, multiple studies report that pandemic-related isolation and the associated worries that children and teens faced (e.g., about illness, family members, family dynamics, academic performance, and uncertainty about the future) resulted in increased anxiety and depression in children and adolescents (reviewed in Panda et al., 2021).

In June 2020, greater than 25 % of adolescents surveyed in the US reported declines in emotional and cognitive health, with disproportionately high levels of decline in Asian and Latinx youth (those with ethnic or cultural roots in Latin America), and in youth with parents born outside of the US (Margolius et al., 2020). Likewise, a 2020 survey of over 10,000 high school students in the U.S. also reported that in adolescents—and especially in women and students of color—perceived stress levels were especially high (with nearly 1/3 of respondents reporting mental health as a major source of stress); engagement with learning was low; and relationships with adults and peers were declining (Challenge Success, 2021). Thus, this dramatic increase in stress and declining mental health in adolescents that was associated with the pandemic brought with it additional demands for caregivers who were already stretched thin (see above). Given that parental support is a critical indicator of mental health outcomes in adolescents (Helsen et al. 2000), compounding effects of stressors associated with the pandemic on caregivers themselves may also have had indirect, negative effects on mental health outcomes for teens in need of greater support, with the potential for a cycle of continuing impacts on both adolescents and caregivers alike.

3.1.1.5. Caregivers of chronically ill or disabled children. Caregivers of chronically ill children or children with disabilities experienced magnified concerns of COVID-19 infection with often extended periods of social isolation, lost childcare and/or lost opportunities for in-person schooling and reduced social and family support to minimize the risk of exposure (Schneider et al., 2021). Particularly at the beginning of the pandemic, restricted visitation policies at hospitals and medical facilities reduced the ability of parents and siblings to attend appointments, procedures, or visit hospitalized children (McLoone et al., 2022). For immunocompromised children, a return to greater levels of social interaction was often contingent not only on the availability of vaccines, but also sufficient levels of herd immunity from vaccination or prior infection and continued masking.

3.1.1.6. Caregivers of elderly, and/or (chronically) ill family members. The circumstances of family caregiving situations can vary widely, including providing care for a family member who also lives in the same home, providing care for a family member residing in a separate home in the same community, and providing supportive care for a family member residing in a group care situation (e.g., assisted living homes, nursing homes, hospitals). Family caregivers provide assistance with emotional, social, and often physical support (e.g., assistance with grooming, dressing, and mealtimes). Balancing these tasks with other aspects of life and career can be a significant mental health challenge, with studies showing a greater risk of loneliness and social isolation in family caregivers compared to non-caregivers prior to the COVID-19 pandemic (Wasilewski et al., 2017; Wiegelmann et al. 2021; Phillips et al., 2023).

With the onset of the pandemic, these challenges increased. In most areas, public health protocols associated with COVID-19 resulted in caregivers providing in-home care increasing their caregiving duties, whereas those providing assistive care to individuals in group care situations were often excluded from providing care due to concerns of disease transmission (Anderson et al., 2021). In one study, more than half of family caregivers in a variety of settings reported declines in their mental health due to pandemic conditions. Specifically, self-reported levels of anxiety and loneliness showed steep increases over baseline levels for family caregivers during the pandemic (Anderson et al., 2021). Likewise, nearly half of family caregivers reported receiving less social support due to pandemic restrictions, though this was moderated to some extent for those who received assistance with care by siblings (Archer et al. 2021). In addition, in a study of women who worked and provided in-home care to elderly adult family members, participants reported increased caretaking burden as well as less time for self-care and greater fatigue in caregivers as a result of the pandemic (de Sousa 2022). Nearly 1/3 of family caregivers surveyed had multiple mental health problems related to caregiving stressors during the pandemic, with women having an increased risk of such compounding impacts on mental health (Li et al., 2021). Thus, academics who were faced with balancing caring for elderly or chronically ill family members during the pandemic with competing life demands (including academic career-associated demands such as teaching, research, and writing) faced additional challenges with the potential for long lasting effects on both mental health and career productivity.

Globally, hospitals and other medical facilities (e.g., assisted living, nursing homes) were faced with balancing the provision of medical care with the prevention of disease transmission throughout the COVID-19 pandemic. Although visitation policies differed across institutions, the overall result was tightening or limitation of visitations (Sudai, 2021). A presumably unwanted side-effect of these stricter visitation policies, however, was isolation of patients with sometimes severe non-COVID medical conditions from family members and loved ones. No-visitation policies likewise denied caregivers opportunities to provide in-person support to loved ones, or to benefit from providing such support (Siddiqi, 2020; Sudai 2021). Thus, these well-intended changes resulted in increased stress for patients (with potential for slower recovery from illness, or other negative health outcomes) and also increased stress on caregivers left at home without opportunities to support ailing loved ones. Therefore, faculty who found themselves invested in multiple caregiving roles, including caring for loved ones hospitalized during the pandemic, faced compounding stressors with the potential for personal and career impacts as a result of the pandemic.

3.1.2. Mental and physical health

Mental health decreased during the first year of the Covid-19 pandemic (Wu et al., 2020; Singu, 2022). Reasons for these declines in mental health were many, but included situations such as isolation, uncertainty, job loss, illness, loss of loved ones to COVID-19, concern over (lack of) government responses, and overall worry. Correspondingly, there was a rise in depression and anxiety diagnoses worldwide during the pandemic (World Health Organizations, 2022). Additionally, for individuals in the U.S., this viral, epidemiological chronic stressor co-occurred with significant social upheaval and trauma. The 2020 murder of George Floyd sparked a renewed racial reckoning in the U.S. In 2021, the Centers for Disease Control declared racism a public health threat in the U.S. (Centers for Disease Control and Prevention, 2021), and in 2022, a series of papers in the *Lancet* called racism a global health threat (Devakumar et al., 2022). For many individuals, the compounding effects of the public health threats of COVID-19 and racism led to further decreases in mental health.

Along with general racism, anti-Asian racism increased during the pandemic due to the identified origin of COVID-19, Wuhan, China. People of Asian descent faced, and continue to face, increased race-based experiences of microaggressions, physical violence, and

harassment (Gover et al., 2020; Wang and Santos, 2022). These experiences occurred in workplace/educational environments as well as in public spaces and online (He et al., 2022; Wang and Santos, 2022;). Further, reports of anti-Asian hate crimes (whether or not classified as such despite demographics of victims) sympathized with the aggressor and in one case, authorities claimed a shooter had a "really bad day" (Gee et al., 2022). Asian individuals experienced increased anxiety about their safety and belonging in the community while also trying to navigate the pandemic like everyone else.

In academia, there were reports of academic burnout (Gewin, 2021), the Great Faculty Disengagement (McClure and Fryar, 2022), quiet quitting (Forrester, 2023), institutional betrayal (Gilbert, 2020), and moral injury (a trauma which results when a person's core principles are violated; Svoboda, 2022). This moral injury was laid bare by the discrepancies between university mission or value statements, and the decisions made during the COVID-19 pandemic (and in the U.S., the racial reckoning described above). Many faculty became disillusioned with the academic system and began to see the academy as a neo-liberal enterprise. At least one of our authors sought therapy and medication, and seriously considered leaving academia due to COVID-19- and DEI-related institutional betrayal and moral injury.

Another source of stress was dealing with the death of loved ones. Millions of people lost family, friends, or loved ones to COVID-19. These losses were particularly pronounced for Black and Hispanic individuals, as due to social and structural factors, these communities suffered greater COVID-19 infection and deaths (Mude et al., 2021). All losses occurred within the framework of an ongoing pandemic and thus the typical process for grieving and to gain closure never occurred. And, depending on one's location, dealing with emotional challenges of COVID-19-denying family, friends, and politicians, made the grieving process more difficult.

Finally, COVID-19 had long lasting health impacts on individuals, with symptoms persisting for weeks or even years, with some symptoms expected to be lifelong (Davis et al., 2023). These symptoms could involve multiple organ systems, including the cardiovascular, immune, respiratory, digestive, reproductive and nervous systems, and lead to an inability to return to work. Alarmingly, a recent study (Subramanian et al., 2022) found women, individuals aged 18–30, and persons who were not white were more likely to develop long-COVID, further adding to disparities in COVID-19 impacts. Thus, contracting the virus had potentially chronic negative consequences on the productivity and both physical and mental health of individuals long after they tested negative. In many instances, institutions addressed COVID-19 policies as if it were not a pandemic, but instead a logistical constraint and mere inconvenience. Policies were not built to accommodate those who got very ill, but instead assumed individuals would be asymptomatic or have minor symptoms. It is unknown how institutions will deal with long-term illness associated with COVID-19.

3.1.3. Status: Career stage

3.1.3.1. Impacts on graduate students. Graduate students faced many challenges, including online teaching, difficulties in dissertation progress, research changes, preparing for future careers, and mental health, with these concerns having disproportionate effects on doctoral students of color, international students, and graduate students with marginalized identities (Levine et al., 2021; Walsh et al., 2021). Graduate students often found their exposure to COVID-19 and their academic progress affected by the whim of changing university and course policies. Graduate students are considered both employees and students by their institutions, which proved confusing regarding policies, restrictions, and expectations (Zahneis, 2020). There were differences in how well graduate students adapted to online learning and instruction (Bal et al., 2020). Many universities did not provide teaching assistants with training on how to adjust their teaching, course policies, and grading to be equitable to themselves and their students for an online platform during the pandemic. Authors in this special edition faced challenges in helping students find locations with internet access and desks suitable for online instruction and exams. They also faced mandatory in-person teaching assistant assignments, often under unsafe conditions (for example, no mandatory mask policies), because there were no protections from the university for students (i.e., paid leave).

Many graduate students faced derailments or delays in starting, continuing, or finishing projects for their thesis/dissertation with many students needing to make significant changes in order to stay on progress trajectories (Donohue et al 2021; Levine et al 2021). Research efforts were also limited due to restrictions and precautions of gathering in large groups (Flaherty, 2020b). Graduating graduate students feared the unexpected job market, contemplating and deferring graduation and feeling pressure to look for job opportunities outside of academia. While virtual networking opportunities did eventually arise, many graduate students suffered from the loss of professional development and networking at in-person conferences and workshops, fearing the negative consequences on their connections and communities for future employment prospects in a highly competitive academic job market (Donohue et al., 2021; Levine et al., 2021).

Self-reports of anxiety, depression, and isolation in graduate students were increased compared to pre-pandemic levels with students identifying as low-income, a person of color, woman, disabled, non-binary, or transgender, gay, lesbian, bisexual, queer, questioning, asexual, or pansexual or a caregiver being affected most (Chirikov and Soria, 2020; Donohue et al., 2021; Walsh et al., 2021; Liu et al., 2022). International graduate students and postdocs residing in the U.S. also faced additional immigration-related uncertainties, health care system-related uncertainties, and xenophobia concerns during the pandemic on top of already unique cultural, financial, and political challenges, elevating anxieties even more (Chirikov and Soria, 2020; Sustarsic and Zhang, 2022). In addition to the stressors discussed above, many graduate students faced anxiousness and concern over financial insecurity and losses reducing dissertation progress (Donohue et al., 2021). Graduate students at the beginning of their program often faced isolation in a new city, and graduates at the end of the program faced challenges with virtual postdoctoral interviews and tours.

3.1.3.2. Impacts on pre-tenure faculty. Newly independent scientists experienced unique challenges as the result of COVID-19, especially with respect to progressing towards tenure. Although the tenure process can be stressful and nebulous under the best of circumstances, it is generally accepted that publications and funding are the currency of tenure recommendations. In turn, publishing papers and securing grants are largely contingent on having people and supplies for your research program. Below, we outline how pandemic-related deficiencies in these factors disproportionately affected early-career faculty.

Pre-tenure faculty inevitably differ from their post-tenure counterparts in the time that they have had to establish a research laboratory and recruit people to their research program. People – technicians, graduate students, or postdoctoral associates – are essential for generating data that will ultimately be used for essential tenure milestones, that is manuscripts and grant proposals. The pandemic disrupted the processes of establishing lab infrastructure and of hiring personnel. Additionally, when everybody's in-person productivity came to a grinding halt, these new PIs were less likely than their colleagues to have existing data to use in manuscripts or grant proposals, and were thus less able to be productive during work-from-home or social distancing protocols.

Many laboratory supplies (e.g, gloves, pipette tips, reagents) were diverted towards COVID-19 response efforts (e.g., to personal health, testing, vaccine storage; Madhusoodanan, 2020). Although the sudden lack of consumable supplies was felt by all career stages, shortages of freezers, thermocyclers, and other equipment were most acutely felt by

individuals in the midst of setting up their lab spaces. In addition, the pandemic resulted in intense price increases and inflation when products were available, therefore, start-up funds for new PIs did not go as far as planned. In some cases, lab spaces themselves were not available to beginning PIs because renovations were delayed due to supply chain disruptions (Casadio and Simon, 2021). Thus, PIs who were hired and started their labs during the COVID-19 pandemic got off to a slow start.

Along with the delay in infrastructure, early-career faculty who had not yet recruited people to their research programs were disproportionately at a disadvantage when COVID-19 occurred. Networking to find new trainees was hampered by the cancellation of scientific meetings; student visas for international students were in limbo; in some cases, recruited students deferred admission or could not move initially. This lack of personnel was exacerbated in many cases by university-instituted staff hiring freezes for much of 2020 and beyond. Finally, when hiring was available, the pool of people to recruit was critically lower than pre-pandemic levels, consistent with a general trend across sectors (Langin, 2022). Additionally, if new PIs were able to recruit, they were spending start-up funds on personnel who were unable to devote the needed time or effort to research (Lowe-Power et al., 2021). Thus, as labs with existing personnel recovered from pandemic-related setbacks, this recovery was slower for early-career faculty.

What have been or will be the consequences of these factors for pre-tenure faculty? The lack of personnel and resources likely interacted to substantially delay the development of lab resources (e.g., assays, protocols, cell lines, animal strains) that would otherwise accrue in young labs. These delays account for a significant portion of the limited time given to assistant professors to gain momentum before they are considered for tenure. For this reason, some universities have adopted pandemic-related tenure extensions or modified tenure criteria (see 3.2, below). Still, such mitigation strategies cannot alter the loss of productivity in early-career scientists, which has effectively recalibrated their competitive abilities relative to more established scientists. Even before the pandemic, early-career faculty have been receiving progressively less funding worldwide (Daniels, 2015; de Winde et al., 2021); this pattern will likely be exacerbated in decades to come because of the disproportionate effects of the pandemic on early career investigators' productivity (Gibson et al., 2020).

3.1.3.3. Impacts on post-tenure faculty. Although the majority of research on the impacts of COVID-19 in academia and, therefore, research cited throughout this paper, focuses on early-career academics, some studies indicate that similar impacts were felt by mid-career faculty. For example, surveys including both early career and mid-career women in academic positions in health sciences research (i.e., ranging from research fellows to associate professors) demonstrated significant concern among respondents over issues related to childcare, finances, and job security (Bittar et al., 2022). Nearly one-third of respondents indicated high levels of concern regarding academic promotion and research productivity, and levels of stress and anxiety were self-reported to be "moderate to high" throughout the pandemic (Bittar et al., 2022). In a separate study, a latent class analysis demonstrated unequal COVID-19 pandemic impacts on faculty based on faculty rank and gender. Those most negatively affected by increased workload, high levels of stress, and decreased or deferred self-care as a result of the pandemic included both early and mid-career faculty, and particularly women. The class containing mostly mid-career faculty also reported a significant increase in administrative and clinical duties and decreased scholarly productivity coincident with the pandemic (Kotini-Shah et al. 2022).

Mid-career faculty are susceptible to high levels of burnout as a result of increasing service demands, compounded by unclear expectations for promotion and a general lack of support in the form of faculty development programs (Misra et al., 2011; Strange and Merdinger, 2015; Baker and Manning, 2021). For many post-tenure faculty, and particularly women, caregiving demands may intensify (e.g., with the onset of overlapping caregiving roles such as childcare and elder care), thereby increasing pressure for academic caregivers at later stages of their careers. For these reasons, independent of impacts from the pandemic, recent research has focused on increasing vitality in and sustaining professional growth for mid-career faculty, with a particular emphasis on women and faculty of color (Misra et al., 2011; Strange and Merdinger, 2015; DeFelippo and Dee, 2022; Kulp et al., 2022). Therefore, unsurprisingly, the COVID-19 pandemic also affected post-tenure faculty, and particularly those in caregiving roles, negatively. As these negative impacts can precede faculty burnout, further work to increase appropriate support for both early and mid-career faculty should be considered.

In summary, these intersecting chronic stressors made many faculty re-prioritize their work-life breakdown. Thus, traditional markers of success and impact factors seemed less important, and many shifted their efforts to pursue endeavors that had tangible, people-oriented impacts.

3.2. The scientists and the institutions - ecological interactions

During the pandemic, institutions influenced how academics both functioned and were evaluated, thereby defining both the ecological and selective regimes of individuals' careers. Institutions varied greatly in their responses to the pandemic and both institutional leadership and (local) government policy profoundly shaped the COVID-19 landscape in academia (see Blanco et al., 2022 and references therein). For example, some institutions had mask and vaccine mandates for returning to campus, others suggested these things, and in some locations, requiring these mitigations was banned. Additionally, some returned to (mandatory) in-person instruction almost immediately whereas others kept people off campus, out of labs, and online for extended periods of time. Below, we highlight variation in institutional modifications to tenure extensions, service and teaching workload, teaching evaluations, COVID-19 impact statements, and criteria for tenure or promotion during the pandemic. The experiences and perspectives of researchers who have published in this Special Issue were drawn from the data provided in **Supplemental File 1**. The results from our study of institutions represented in this issue are largely consistent with a study of 386 universities in the U.S. addressing similar, pandemic-related issues (Culpepper and Kilmer, 2022).

3.2.1. Tenure clock stoppages and workload release

Most universities approached pandemic-related impacts on research the same way they approach caregiver-related (e.g., parental leave or elder care) impacts on research: with a voluntary or automatic 1-year tenure extension. While "stopping the clock" makes sense in theory by allowing academics to reclaim the productivity lost during a pause, there is evidence that they at best fall short of their intended purpose, and at worst widen preexisting gender and racial disparities in salary (Manchester et al., 2013; Antecol et al., 2018; Fulweiler et al., 2021). One way in which some universities mitigated these differences was to retroactively award individuals pay raises that would have been issued with the original tenure date (e.g., the University of Massachusetts; McCarthy, 2020). While this approach is helpful in reducing financial discrepancies, it still delays an individual's access to status, job security, and ability to express their opinions on controversial matters, without fear of negative consequences on tenure votes. A more effective way to avert the negative consequences of delayed career advancement would be to require committees and administrators to only evaluate a select 4 years of the pre-tenure process (Htun, 2020), or simply reevaluate the bar for productivity under these unprecedented circumstances. The latter solution is akin to "achievement relative to opportunity" policies, such as those implemented at Monash University (Monash University, 2023). With such policies, equitable evaluation is given to individuals when personal circumstances have impacted their potential productivity.

Most institutions in our author survey offered opt-in or opt-out tenure extension policies for COVID-19 disruption. However, most individuals that were pre-tenure did not take these extensions; all individuals were concerned that taking an extension would look bad and/or that opting in posed too much additional work for an uncertain benefit. Further, for those that took an extension, none were offered back pay for the raise that they would have gotten in the previous year. Thus, even within this mesocosm of researchers, lasting disparities in salaries for minorities, women, and caregivers were exacerbated.

A common theme of the pandemic was losing research time. In parallel, service and teaching loads were increasing as faculty absorbed pandemic-related increases in administrative work and student mentoring (Cardel et al., 2020a). Because service and mentoring sometimes disproportionately fall to women and minority faculty members (Cardel et al., 2020b; Malisch et al., 2020a), one recommendation has been for institutions and departments to find ways to distribute service and course releases (Culpepper and Kilmer, 2022). Such releases could have been created by distributing administrative or course work to graduate students, thereby creating funding and training opportunities for budding scientists. However, in our survey of the researchers whose work is featured in this issue, no such teaching or service releases were offered.

3.2.2. Student evaluations of teaching (SETs)

The pandemic required academics to quickly pivot to online teaching which, in some cases, required completely re-engineering courses. Institutional responses to this change in teaching modality varied in at least two ways. First, some institutions provided additional software, training, and tutorials for how to effectively teach online. While such resources likely mitigated the effects of online teaching for the students, they increased the burden on faculty. The shift from doing research, or even reinventing research programs, to teaching ourselves (and others; Harris et al., 2020) how to be online teachers, needs to be acknowledged and incorporated in evaluations of an individual's research productivity. Second, some institutions suspended teaching evaluations, such as the University of Massachusetts (McCarthy, 2020), at least for the Spring 2020 semester, while other institutions did not. As the academic community pivoted to a completely unknown teaching modality, the inevitable consequence would be that many students (and their parents) were dissatisfied with their situation. This dissatisfaction could impact SETs – regardless of an instructor's ability to transition to and teach online courses – and thereby influence tenure, promotion, and merit review decisions. SETs do not measure learning and women and minorities are judged more harshly than their male and white peers (Sprague and Massoni 2005, Reid, 2010; Kreitzer and Sweet-Cushman, 2022), especially when their behaviors are not stereotypically gendered or racialized (El-Alayli et al., 2018; Docka-Filipek et al. 2023). Thus, pandemic-incurred negative SETs will likely increase disparities.

Half of the institutions from our author survey did nothing to modify their use of student evaluations during the pandemic, yet most educators (faculty and graduate students) saw or suspected that their evaluations suffered in the pandemic's wake. Just as institutions should re-examine researcher performance evaluation in the context of the pandemic, they should likewise re-examine student evaluations of teaching performance.

3.2.3. COVID-19 impact statements

Many institutions have attempted to document impacts of the pandemic by obtaining COVID-19 impact statements from current faculty and/or new hires (Htun, 2020; Malisch et al., 2020a see supplemental guide). In principle, statements should help faculty concretely document how productivity was impacted by the pandemic and thus contextualize C.V. content for merit and promotion review. Yet, clear communication about impact statement content and evaluation should be provided by administrators (see Malisch et al., 2020b). Without transparent guidance on what to include and exclude, faculty may over- or under-invest in preparing statements, taking time away from research. Without clear information on how statements will be used, some faculty may fear that such statements can be used as admission of inadequacy that might be used against them. Although impact statements requested by about half of the institutions in our author survey, communication about what should be included and their ultimate role in decisions was variable: half of the researchers indicated that their institution was vague or ambiguous about content and usage. Reasons for the impact statement varied from "analyzing stress on researchers" to "evaluation purposes" to "no explanation". Without clarity in COVID-19 impact statements, the majority of researchers were skeptical of statement usefulness.

In summary, faculty and graduate students featured in this Issue experienced variable shifts in institutional policy in some respects (tenure extension policies, teaching evaluations, and COVID-19 impact statements), and similar shifts in institutional policy in other respects (service and teaching releases). All of these aspects of institutional ecology can influence a researcher's relative fitness in their discipline, as well as their position within their own departments.

3.2.4. COVID-19 has disproportionately impacted some individuals in academia - what to do about it?

The scientific community has been vocal with suggestions for how to mitigate the disproportionate impacts of the pandemic. There are no clear, easy fixes — making academia more equitable will take investment, commitment, and intentional change from everyone involved in higher education and academic science. Solving these structural problems is beyond the scope of this paper (and any single paper), but we want to highlight that *individual behaviors are not solutions for structural problems* (Ahn et al., 2021; Fulweiler, 2021). While we can all individually do what we can, academia has ecosystem-level, structural problems that result in the disparities that we see in publishing, access to funding, etc. We need concerted, organized, and purposeful action from the entire system, including individuals, departments, institutions, journals, professional societies, funding agencies, and society. Some of the strategies and solutions previously proposed are highlighted in Table 2.

3.2.5. Moving forward – Shaping the landscape of our community

As good scientists, we would study the impacts of any major ecological and/or environmental stressors impacting our study organisms. Thus, we urge the *GCE* community to now assess the surface of the academic landscape during COVID-19 and how various factors of that landscape shaped the push/pause (publish/perish) tradeoff for academics.

In the 1930 s, Sewall Wright introduced the idea of evolution on adaptive landscapes (Wright, 1932) with genotypes occupying different parts of the landscape and associated with varying fitness peaks separated by valleys of low fitness. Over time, populations move across the landscape and the landscape itself can evolve (Hansen 2012).

If we use this concept from evolutionary biology as a metaphor for the distribution of the *GCE* community across the "academic landscape", we might position ourselves on the landscape on the basis of a composite research impact factor or variable (i.e., publications, grants, graduate students, etc.) and a composite personal impact factor or variable (i.e., intersectional identity, caregiver status, career stage, etc.). The varying heights of the landscape might reflect a compensation and recognition variable. Before the pandemic, each of us and our communities and departments might have existed in one small region of the academic landscape for an extended period of time, striving to reach greater heights of compensation and recognition, but confined to a relatively small area of the landscape. By dramatically shifting the balance between research and personal impacts for many in the *GCE* community, the pandemic fundamentally altered the academic landscape. Many of us now still find ourselves on new terrain. Rather than focusing on returning to the pre-pandemic academic landscape or distribution across

Table 2
Proposed strategies to reduce disparities in academic outcomes for disproportionately impacted groups, organized across levels of academic organization. The COVID-19 pandemic has disproportionately affected researchers and exacerbated inequities, thus, several of these strategies are tailored to the context of the pandemic.

Strategies for addressing academic inequities		
Level	Pandemic-Relevant Policies	References
Society	Acknowledge different people could be disproportionately impacted by the global pandemic	Ahn et al. 2021; Reardon 2021
Institutional	Promote gender balance and diverse faculty hires; incorporate DEI knowledge and actions into hiring Form an equity and pandemic faculty merit committee Listen to the faculty and staff collective concerns, ask for feedback and stay flexible Extend and flexibilize research awards, grants, and start-up funds Institute automatic extension of tenure probation periods (*note documented equity concerns with tenure clock extensions*) Provide transparency on institutional equity goals and action plans Provide safe and affordable childcare services located on campus Provide service relief by reducing administrative and teaching workloads Provide supplemental salary support for those most impacted Implement and/or increase family-friendly policies, such as lactation facilities and longer (or any) paid leave for mothers and fathers. Make inclusive language and behavior part of the scientific best practices Create emergency contingency plans that support the community (i.e., financial support, assistance for health and mental care services, remote teaching trainings, research resources for project adjustments, clear communication on travel policy for international researchers)	Cardel et al. 2020a,b; Ahn et al., 2021; Chirikov and Soria, 2020; Donohue et al., 2021; Fulweiler et al., 2021; Levine and Rathmell, 2020; Llorens et al., 2021; Maas et al., 2020; Malisch et al., 2020a; Sustarsic and Zhang, 2022
Department	Request a prescribed coronavirus impact statement as part of applications Recalibrate evaluations and focus on equity Plan an intervention to change gender-bias habits Identify challenges faced by faculty, especially early career and by graduate students Adjust performance expectations and stay flexible Lead honest conversations about teaching, research, and service Mentor and advocate for early career faculty/researchers, and graduate students from disproportionately impacted groups to lessen the burden for self-advocacy	Cardel et al. 2020a,b; Levine and Rathmell, 2020; Maas et al., 2020; Malisch et al., 2020a,b (Supplemental guide); Ahn et al. 2021; Fulweiler et al. 2021; Levine et al 2021; Llorens et al. 2021; Misra et al., 2011; Ruben 2021
Publishers	Promote gender balance and diversity by recruiting disproportionately impacted groups to editorial boards Invite disproportionately impacted groups to write review articles Prioritize women authored papers Extend deadlines	Cardel et al. 2020a,b; Ahn et al. 2021; Fulweiler et al. 2021
Funding Agencies	Reduce the administrative burden of grant proposal submission; provide more flexibility in award expenditures. Provide guidance and transparency on equity goals; make DEI knowledge and actions part of the application Request a pandemic impact statement as part of applications Check for gender-bias evaluations and promote a change of bias culture Enact policy proposals to eradicate bias in the grant evaluation process	Cardel et al. 2020a,b; Fulweiler et al. 2021; Llorens et al. 2021; Torres et al. 2023

the landscape, we should focus now on ensuring that the new distribution has not systemically resulted in lower compensation and recognition returns for some members of the *GCE* community.

We think the value of this metaphor lies in providing a framework through which we might quantify the impacts of the pandemic on members of our community and by guiding future research. For example, we might draw on additional ideas of evolution on adaptive landscapes to extend this metaphor and thinking to our communities. Consideration of local versus global adaptive landscapes might give us a framework for tackling both local (departmental/institutional) inequities in compensation and recognition, as well as national and international inequities based on the distribution of individuals across the landscape before and after the pandemic. Second, we might consider if our academic landscape includes density-dependent and/or frequency-dependent effects. Often, on density-dependent adaptive landscapes, specialization to reach a peak results in increased competition and causes fitness to decrease, ultimately reducing the height of the peak (Hendry et al., 2012). Do these same processes occur on the academic landscape? Third, how can we make directed changes to the landscape to promote further diversity in academia?

4. Summary

As we come out of pandemic mode, we urge our community to not fall back into the old ways with the same issues of inequity. The information presented in this manuscript and those cited within, combined with emerging concerns about lack of available reviewers, prolonged impacts of supply chain issues, shortage of postdocs to fill positions, burnout, and fears of a great resignation in academia, suggests a larger crisis for career advancement. We do not want to return to normal, as normal was not working for many of the members of our community. As stated by Gonzales and Griffin (2020), *"When evaluation committees allow cis-hetero men's inflated productivity to become the norm, everyone else suffers."* Let us take this opportunity to reset and start anew. We strongly believe that we must act, and we must act soon, or else we will lose a future generation of scientists (Cardel et al., 2020a; Gibson et al., 2020). We need collective buy-in from individuals up to institutions; we must transform our spaces (Lerback et al., 2022).

We need to move away from discrete and restricting measures of

success and embrace a more holistic, nuanced, and inclusive approach. There are proposed frameworks for doing this (e.g., see examples in Table 2 above). Corbera and colleagues (Corbera et al., 2020) recommend shifting to an ethics of care, including redefining excellence in teaching and research (see Table 1 in their paper). Davies and colleagues (Davies et al., 2021) outline a pathway for a paradigm shift and define inclusive metrics for evaluation (see their Fig. 1). Esposito and colleagues (Esposito et al., 2022) proposed a new framework for how to inclusively value broad academic contributions (see their Tables 1 and 2). Tiokhin and colleagues propose using the concept of multi-level selection to account for scientists' direct (individual-level) and indirect (community-level) impacts during assessment (Tiokhin et al., 2021). The Vitae Careers Research and Advisory Center produced the Research Development Framework, a graphical guide for building researcher expertise across domains (Vitae, 2011); this could be used to categorize academics' direct and indirect contributions. Additionally, there is no shortage of 10-simple-rules papers on how academics can tackle issues of inequity and bias across a range of axes (Maestre, 2019; Chaudhary and Berhe, 2020; Goh and Bourne, 2020; Kreeger et al., 2020; Arif et al., 2021; Gosztyla et al., 2021; Haelewaters et al., 2021; Guevara-Ramirez et al., 2022; Massey et al., 2022; Peña et al., 2022). Thus, we have the ideas and the tools. We just have to prove that we, collectively, want to work towards a more equitable and inclusive future. Importantly, this effort must be more than changes in individual behaviors - it must be a systemic, concerted effort with those in power (e.g., funding agencies, university presidents, deans, etc.) leading the charge. Recent anti-DEI legislation targeting institutions of higher education has appeared in many states (e.g., see Florida and Texas; Lu, 2023). These new legal policies will impact how, where, and who does this work, but the work must continue.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ygcen.2023.114394.

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