Habits and attitudes toward writing affect the publication output of environmental biology trainees

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Abstract

Publications are the mainstay of academic success, yet scientific writing requires consistent feedback and practice to build and maintain skills. In this study, we surveyed 342 environmental biology trainees (i.e., graduate students and postdoctoral scholars) about their writing habits. Our objective was to explore whether trainee writing habits align with suggestions from scientific writing guide books and articles, and how individual habits and attitudes may impact writing output. We found that the majority of respondents (>65%) felt negatively about writing and publishing, and few adhered to established advice such as scheduling writing time, setting attainable goals, or joining a writing accountability group. Our results show that trainees who dedicated more hours to writing each week and individually tracked their writing progress had more first-author publications. In particular, graduate students who regularly scheduled writing time during the week and participated in writing groups also had more first-author publications. Conversely, trainees who felt negatively about writing, wrote mainly before deadlines, and relied on "check-ins" with advisors or writing groups to monitor writing progress had fewer first-author publications. We describe ways that individuals, advisors, and institutions could improve trainee writing habits and assist them in developing more positive attitudes toward writing to ultimately help trainees achieve their writing goals.

KEYWORDS
graduate student, postdoctoral scholar, publishing, scientific writing, survey, trainees, writing groups, writing habits, writing schedule

INTRODUCTION

Writing is a discipline that requires consistent upkeep. Like athletes, writers require training, coaching, and practice to gain, build, and maintain their skills (Martin, 2012). Trainees (i.e., graduate students and postdoctoral scholars) are at a career stage in which they are learning how to write academic manuscripts and developing writing habits and perspectives toward writing. However, this training period comes with high

pressure to publish early and often; trainees who seek academic tenure-track positions were often those who produced the highest number of publications before entering the job market (Fox, 2020; Pinheiro et al., 2014). Furthermore, the number of publications prior to obtaining a Ph.D. has been increasing among graduate students (Mendoza-Denton et al., 2017). Even though writing is an essential skill for research career paths, the focus on output instead of the process may impact how trainees approach and feel about scientific writing.

While trainees are well aware of the importance of writing "better" and writing "more," many continue to struggle with writing and its many internal and external challenges. Writing anxiety, apprehension, and generalized negative feelings toward writing can create serious internal roadblocks and hinder improvement and productivity. The external challenges of navigating revisions during peer review can be arduous for early-career trainees (Ellwanger & Bogo Chies, 2020). Advice such as "you need to grow tougher skin" does not help with the feelings of inadequacy and the perception of Sisyphean revision processes.

Experts agree that writers can increase their success by implementing certain habits such as setting goals and scheduling writing time (Gray, 2005; Heard, 2016; Lamott, 1995; Peterson et al., 2018; Silvia, 2007). The general knowledge from these writing guides is that writing is a skill that can be learned, yet requires deliberate practice. However, it is still unclear what writing habits trainees implement and what support systems trainees have access to at their institutions, and how these habits and support systems may impact their publication records.

Developing effective writing habits is especially important for early-career researchers who are building their foundational writing expertise. Participating in writing accountability groups has been shown to be effective at bolstering writing potential, writing productivity, camaraderie, and solidarity among the group members (Eckstein et al., 2017; Gardner et al., 2018; Rickard et al., 2009; Thorpe et al., 2020). Trainees who participated in writing programs reported feeling more confident and less anxious about their writing (Gardner et al., 2018; Rickard et al., 2009). Furthermore, writing accountability groups can maintain or increase the frequency or duration of writing (Eckstein et al., 2017; Thorpe et al., 2020). While these studies provide a foundation of knowledge, they were typically self-reported and carried out on small group sizes. Thus, we still lack larger scale information on whether these types of writing support groups are accessible to trainees at their institutions and whether they impact writing output.

In this study, we surveyed environmental biology trainees to ask whether various writing habits and attitudes were related to first-author publications. We assess at a broad scale whether the writing best practices recommended by many authors (e.g., regular daily writing sessions, tracking writing time, accountability; Gray, 2005; Heard, 2016; Peterson et al., 2018; Silvia, 2007) are currently used by trainees. We also investigate how sentiment toward writing and peer review may impact writing productivity. We predict that trainees who dedicate more hours to writing each week, who regularly plan writing time, and who track their writing in some way will have more first-author publications. We also predict that trainees who participate in writing groups and those who have positive sentiment toward writing and peer review will similarly have more first-author publications, and that participation in writing groups would relate to positive sentiment toward writings and peer review.

MATERIALS AND METHODS

Survey and data collection

We used an anonymous Qualtrics survey targeting graduate students and postdoctoral scholars. There can be major differences in publishing practices among STEM fields (Mendoza-Denton et al., 2017); therefore, we limited our sampling to participants studying a subfield under the broader environmental biology umbrella. We chose to focus on environmental biology because we have a thorough understanding of the publishing practices in this field. We advertised the survey during March and April 2021 via social media (i.e., Twitter, Reddit, Instagram), targeted emails to colleagues and 98 department chairs or graduate coordinators at major R1 universities in the United States and Canada, and posted twice on the ECOLOG-L listserv hosted by the Ecological Society of America. Most respondents (92%) were previously or are currently at a university in the United States or Canada. Consequently, our results focus on academic training in North America. We were approved for IRB exemption under 45CFR46.104 (2)(ii) and no answers could be linked to individuals or geographic locations. The survey, therefore, did not track any personal identifying information. We offered respondents the option of entering an unlinked gift card drawing after completing the survey. The voluntary response makes our survey results a convenience sample and may not be fully representative of the larger trainee population or may have a self-selection bias. Nonetheless, we had a large sample (>300) for inference.

The survey asked questions about (1) publication records, (2) challenges to writing, (3) planning and scheduling writing, (4) writing tracking methods, (5) laboratory group (i.e., peers and advisor) involvement in their writing process, and (6) participation in writing

accountability groups (hereafter, writing groups) based on a set of questions for those six clusters (the complete survey available from Dryad [https://doi.org/10.5061/dryad.fqz612jwn]). We also asked respondents to use one word to describe how they feel about scientific writing and one word for peer review. We did not require respondents to answer all questions and therefore some fields were left blank, which we categorized as "NA."

Statistical analyses

For the purpose of statistical analyses, we grouped some responses as follows: With regard to writing planning, we grouped responses into "no writing schedule" if the respondent indicated they do not schedule any writing time; "write before deadlines" if they said they write on weekends, breaks, or before deadlines; and "regularly schedule writing" if they set aside times or days every week for writing. Similarly, we grouped writing tracking into "no tracking" if they selected they did not track, and "individual tracking" if the person selected electronic or physical notebooks. The responses "writing group check-ins" and "advisor check-ins" were not grouped. Survey respondents were allowed to check all options that applied, and responses were coded as 1 if they chose any option and 0 if they did not select any. To assess the sentiment of the words respondents used to describe the writing process and the peer review process, we initially performed a traditional sentiment analysis using three different lexicons: AFINN lexicon (Nielsen, 2011), BING lexicon (Hu & Liu, 2004), and NRC lexicon (Mohammad & Turney, 2013). However, all three methods reduced our sample size, from $n = 277$ to 90, 189, 230, respectively, because many of the words respondents entered were not included in the list of words associated with each lexicon. Therefore, we coded the responses as either "positive," "negative," or "neutral" based on definitions and unanimous agreement among five authors. In our analyses, we considered first-author publication count instead of co-authored publications because first-authored manuscripts typically involve significant writing by the first author. Co-authored manuscripts normally imply collaboration on other aspects of publishing (e.g., data collection or data analysis) and not necessarily major writing contributions.

All statistical models were fit in R version 4.1.2 (R Core Team, 2021). We used Bayesian linear regressions in "rstanarm" (Goodrich et al., 2020) to examine whether first-author publication totals were related to: (1) total hours per week devoted to writing; (2) to planning writing (see categories above); and (3) tracking writing (see categories above). We also explored (4) whether sentiment toward scientific writing and peer review (negative, neutral, positive) was related to total hours per week devoted to writing, and (5) whether sentiment affected first-author publication totals. Additionally, we assessed (6) whether participation in writing groups influenced the number of first-author publications. We used weakly informative normal priors with a mean of zero and SD of 2.5. We allowed "rstanarm" to scale and center predictors and adjust priors. Each model ran four chains of 10,000 iterations, and we discarded the first 5000 iterations as warm-up to end up with 20,000 model estimates for analysis. We confirmed convergence and checked for influential outliers by confirming that Rhat < 1.01, examining diagnostic trace plots, and performing leave-one-out cross-validation using the ("loo") function in the "rstan" package (Stan Development Team, 2020). For models 2–5, we set the intercept to 0 to allow for an easier interpretation of the effect. Lastly, we performed a Bayesian χ^2 test with a Poisson distribution using package "BayesFactor" v. 0.9.12-4.3 (Rouder & Morey, 2021) to examine (7) whether participation in writing groups had any effect on sentiment toward scientific writing and peer review. We were curious about the confounding effect of career stage (graduate student vs. postdoctoral scholar) on the results; therefore, we repeated the above analyses separated by career stage. We report estimated model coefficients using the notation β_{hat} (see Appendix S1 for a brief overview on Bayesian statistics and the key differences between Bayesian and frequentist statistics).

RESULTS

Sample frame

Overall, 342 respondents accessed our survey, with 85% ($n = 292$) fully completing it; they reported 149 subfields of environmental biology (e.g., ecology, biology, evolution, and plant sciences). About three quarters of the trainee respondents were graduate students (74%, $n = 231/311$), with their time spent as graduate students ranging from 0 to 15 years (avg = 4.7 years, SD = 2.7). In addition, 26% ($n = 80/311$) were postdoctoral scholars, with experience ranging from 0 to 9 years spent as postdoctoral scholars (avg = 1.9, SD = 1.9). We report demographic details in depth in a separate study (Rowland et al., 2022). Briefly, the majority of respondents identified as female (69%, $n = 187/270$), about a third identified as male (28%, $n = 75/270$), and a small number identified as nonbinary (3%, $n = 7/270$). Additionally, 20% ($n = 54/268$) identified as BIPOC (Black, Indigenous, or as a Person of Color).

There were very little differences in the results by career stage (Appendix S2); therefore, the data we present

correspond to the pooled data of all trainees. We explicitly address the few cases where results differed and note the career stage.

Hours spent writing, planning, and tracking writing

More hours devoted weekly to writing each week was positively related to first-author publications for trainees ($\beta_{hat} = 0.09$, 95% credible intervals [CRIs] = [0.03, 0.16]; Figure 1, Table 1) and trainees reported, on average, 7.5 h per week writing. While about a third of trainees did not plan their writing time (29%, $n = 131/456$), 27% set aside blocks of time during the week or specific days to write ($n = 122/456$). About 18% of trainees set time during the weekends or breaks to write ($n = 81/456$), and 27% ($n = 122/456$) set aside large blocks of time to write before deadlines (Figure 2A). Those who wrote mainly before deadlines had fewer first-authored publications ($\beta_{hat} = 0.20$, 95% CRI = [−0.18, 0.55]) than those who planned writing time regularly ($\beta_{hat} = 0.57$, 95% CRI = [0.18, 0.89]). However, those who had no writing schedule had the most positive association with first-authored publications ($\beta_{hat} = 0.85$, 95% CRI = [0.52, 1.14]) (Figure 2B, Table 1). When analyzed by career stage, results for postdoctoral scholars showed a similar trend; however, for graduate students, those who planned writing time regularly had the most positive association with first-authored publications ($\beta_{hat} = 0.48$, 95% CRI = [0.17, 0.76]), followed by those who wrote mainly before deadlines ($\beta_{hat} = 0.31$, 95% CRI = [0.01, 0.58]), and those who had no writing schedule ($\beta_{hat} = 0.27$, 95% CRI = [−0.07, 0.55]) (Appendix S2: Figure S2).

Approximately a quarter of trainees (24%, $n = 106/446$) did not track their writing progress (Figure 2C). Trainees who tracked their writing progress did so using various methods including self-records (notebooks, spreadsheets, or applications [26%, $n = 114/446$]), or checking in with a designated person/group. The most commonly reported tracking method was a check-in with an advisor or mentor (36%, $n = 160/446$) or with a writing accountability/support group (11%, $n = 48/446$). Tracking writing progress using check-ins with an advisor ($\beta_{hat} = 0.05$, 95% CRI = [−0.34, 0.37]) or writing group check-in ($\beta_{hat} = -0.21$, 95% CRI = [−1.25, 0.37]) had little effect on first-authored publications (Figure 2D). However, individual tracking in electronic or physical notebooks increased publications by 0.7 ($\beta_{hat} = 0.74$, 95% CRI = [0.29, 1.08]). Oddly, not tracking progress at all was most positively related to first-authored publication totals ($\beta_{hat} = 1.25$, 95% CRI = [1.03, 1.43]; Figure 2D, Table 1).

Sentiment toward writing and output

In general, the sentiment analysis indicated that the majority of trainees felt negatively about the scientific

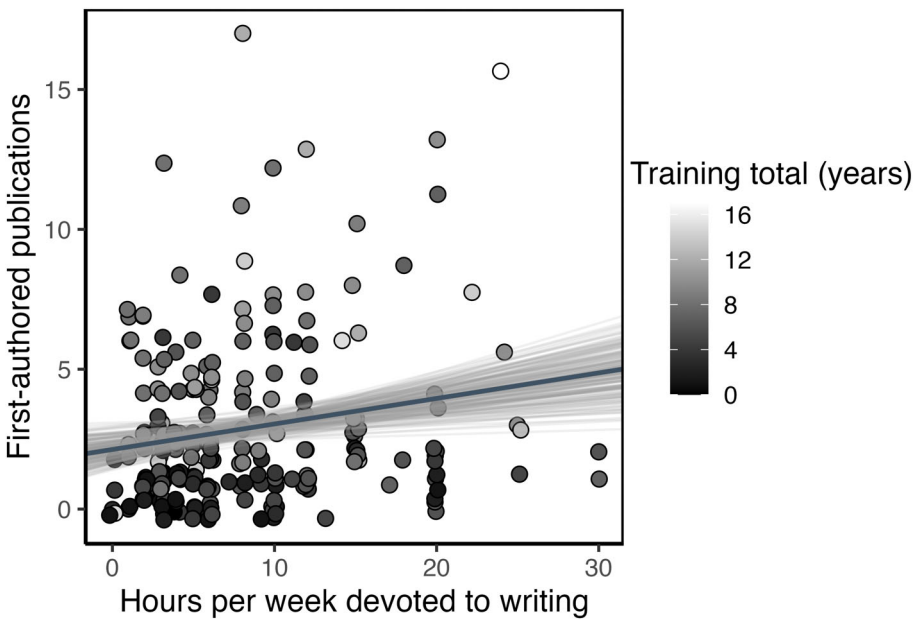

FIGURE 1 Relationship between hours per week devoted to writing and first-authored publications. More hours devoted weekly to writing each week was positively related to first-author publications in early-career trainees ($\beta_{hat} = 0.09$, 95% CRI = [0.03, 0.16]). Points are jittered for easier interpretation and darker fill colors indicate later stages in training. The dark line shows the model median, and 200 posterior draws are plotted behind as light gray lines to show uncertainty of model estimates.

TABLE 1 Summary of variables, categories, questions, and results for all statistical analyses.

Variable	Categories	Question	Results
First author publications; total hours per week devoted to writing	NA (numerical)	Is there a relationship between total hours per week devoted to writing and first-author publications?	More hours devoted weekly to writing was positively related to first-author publications (Figure 1).
Planning writing	No writing schedule; write before deadlines; regularly schedule writing	Is there a relationship between first-author publications and planning writing?	Those who wrote mainly before deadlines had fewer first-authored publications than those who planned writing time regularly. Not scheduling writing was most positively related to first-authored publications (Figure 2B); graduate students who planned writing time regularly had the most positive association with first-authored publications.
Tracking writing	Individual tracking; writing group check-ins; advisor check-ins; no tracking	Is there a relationship between first-author publications and tracking writing?	Tracking writing using check-ins with an advisor or writing group had little effect on first-authored publications; whereas individual tracking increased first-author publications. Not tracking writing was most positively related to first-authored publication totals (Figure 2D).
Sentiment toward scientific writing	Negative; neutral; positive	Is sentiment toward scientific writing related to total hours per week devoted to writing?	No relationship
		Is sentiment toward scientific writing related to first-author publications?	Having a positive sentiment toward scientific writing was positively related to first-author publications (Figure 3C).
Sentiment toward peer review	Negative; neutral; positive	Is sentiment toward peer review related to total hours per week devoted to writing?	Having a neutral sentiment was associated with less hours per week devoted to writing, compared with positive or negative sentiment; no relationship for postdoctoral scholars.
		Is sentiment toward peer review related to first-author publications?	No relationship
Participation in writing groups	Yes; no	Does participation in writing groups influence the no. first-author publications?	No relationship for all trainees; graduate students who participated in writing groups had more first-author publications.
		Does participation in writing groups influence sentiment toward scientific writing?	No relationship
		Does participation in writing groups influence sentiment toward peer review?	No relationship

Note: Results correspond to "all trainees" unless the career stage is explicitly noted.

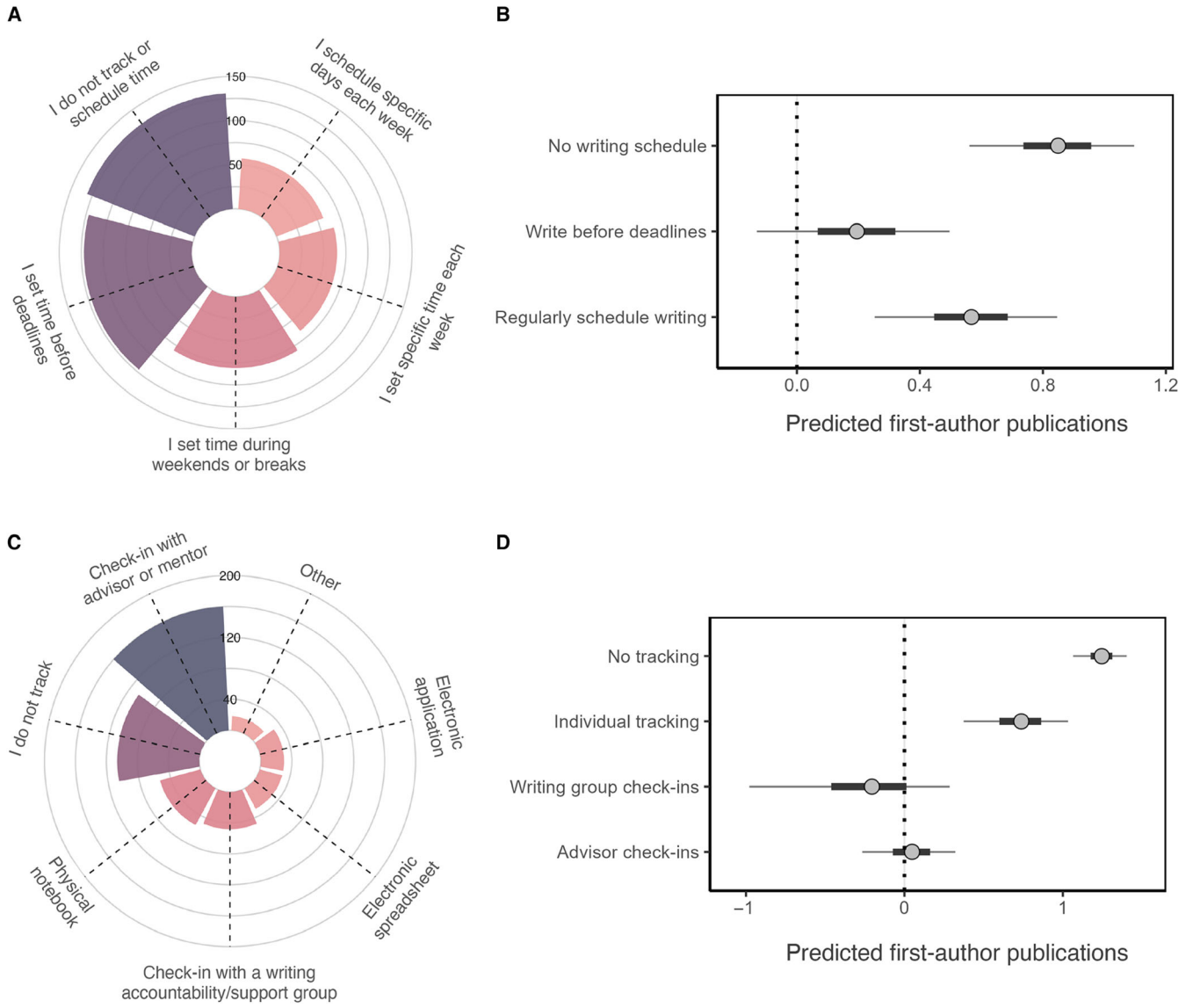

FIGURE 2 Circular bar plots summarizing the various ways participants (A) planned their writing, and (B) model results of how planning writing affects the number of first-authored publications in trainees. (C) Circular plot summarizing the various ways participants tracked their writing and (D) model results of how tracking writing affects the number of first-authored publications in trainees. For circular plots, the number of respondents is displayed on the panel grid lines and the corresponding percentages are labeled according to the color scale bar. For model plots, results are shown as medians (point), 50% credible intervals (thick lines), and 95% credible intervals (thin lines). Tracking writing progress using check-ins with an advisor ($\beta_{hat} = 0.05$, 95% CRI = [−0.34, 0.37]) or writing group check-in ($\beta_{hat} = -0.21$, 95% CRI = [−1.25, 0.37]) had little effect on first-authored publications, individual tracking in electronic or physical notebooks increased publications by 0.7 ($\beta_{hat} = 0.74$, 95% CRI = [0.29, 1.08]), and not tracking progress at all was most positively related to first-authored publication totals ($\beta_{hat} = 1.25$, 95% CRI = [1.03, 1.43]).

writing process (Figure 3A); the three most common words provided were all classified as negative: challenging ($n = 16$), difficult ($n = 13$), and tedious ($n = 13$). Among the words provided, 68% were negative ($n = 187$, e.g., slow, long, crushing), 17% were neutral ($n = 48$; e.g., revision, time, tolerable), and only 15% were positive ($n = 42$; e.g., fun, satisfying, rewarding; Figure 3A). Trainees also felt similarly about the peer review process: 67% of the open-answer words were negative ($n = 182$; e.g., daunting, tiring, boring), 17% were neutral ($n = 46$; e.g., iterative, okay), and 16% were positive ($n = 45$; e.g., fun, constructive, good; Figure 3B). The most commonly used words to describe the peer review process included one positive word (helpful [$n = 18$]), one neutral word (necessary [$n = 11$]), and two negative words (long [$n = 13$] and tedious [$n = 12$]) (Figure 3B).

There were no differences in total hours per week devoted to writing and attitude toward scientific writing

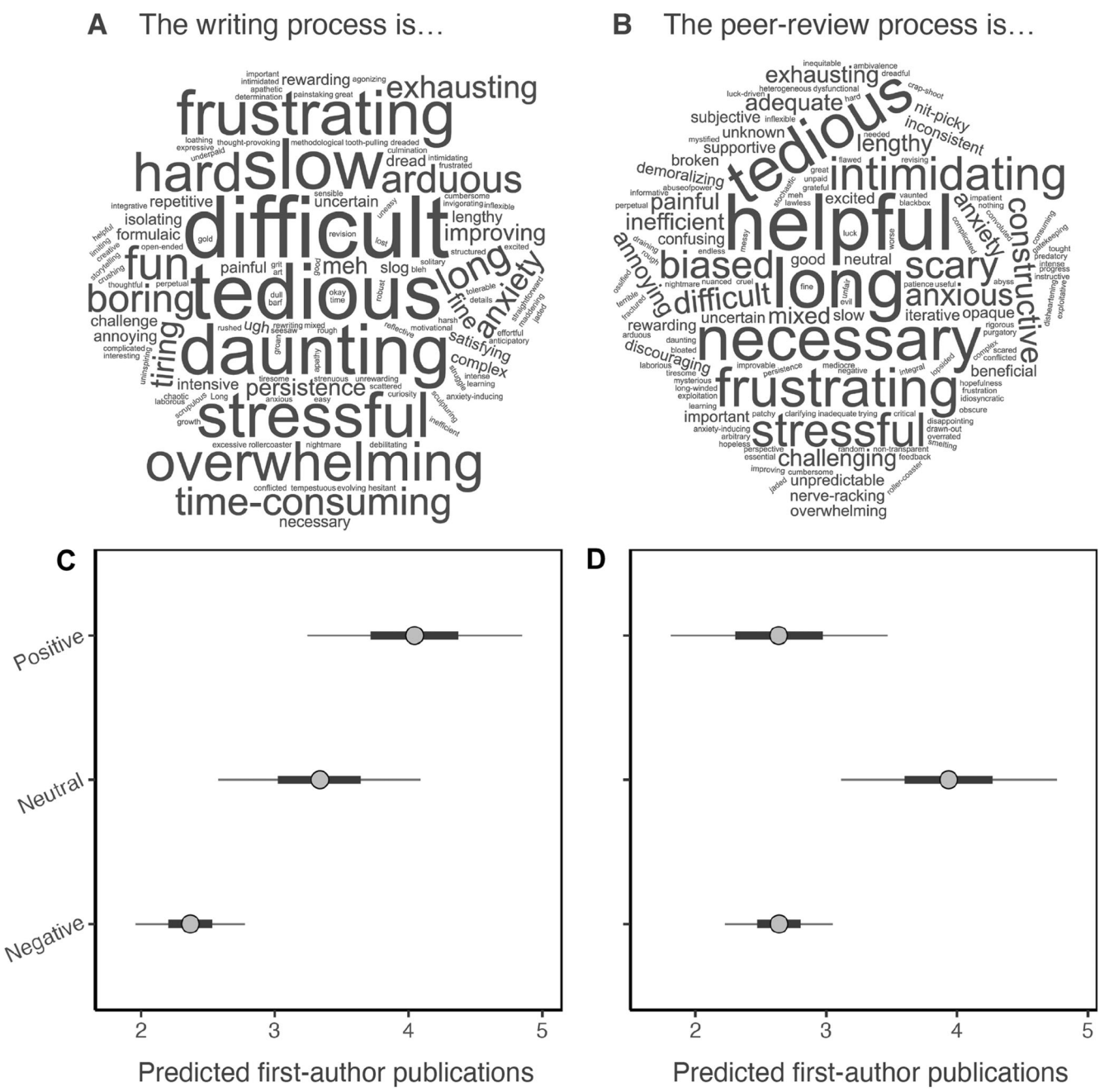

FIGURE 3 Word cloud summarizing the sentiment (negative, neutral, or positive) that trainees had toward (A) the scientific writing process and (B) the peer review process. Respondents were asked to use one word to describe each process. Words used more often are larger in size. Bayesian model parameter estimates as medians (point), 50% credible intervals (thick lines), and 95% credible intervals (thin lines) of how (C) sentiment toward the scientific writing process and (D) sentiment toward the peer review process affect the number of first-authored publications in trainees. Having a positive sentiment toward scientific writing as shown in (C) was positively related to first-author publications ($\beta_{hat} = 4.05$, 95% CRI = [3.09, 5.01]) compared with having a negative sentiment ($\beta_{hat} = 2.37$, 95% CRI = [1.89, 2.85]). While having a neutral sentiment ($\beta_{hat} = 3.34$, 95% CRI = [2.43, 4.25]) did not relate to first-author publications when compared with negative or positive sentiment. Sentiment toward the peer review process as shown in (D) did not relate to first-author publications regardless of whether sentiment was negative ($\beta_{hat} = 2.64$, 95% CRI = [2.15, 3.13]), neutral ($\beta_{hat} = 3.94$, 95% CRI = [2.95, 4.93]), or positive ($\beta_{hat} = 2.64$, 95% CRI = [1.65, 3.63].

between neutral sentiment ($\beta_{hat} = 8.12$, 95% CRI = [6.36, 9.89]), negative sentiment ($\beta_{hat} = 7.32$, 95% CRI = [6.41, 8.21]), and positive sentiment ($\beta_{hat} = 7.34$, 95% CRI = [5.44, 9.21]). However, neutral sentiment toward peer review ($\beta_{hat} = 5.63$, 95% CRI = [3.77, 7.49]) was associated with less hours per week devoted to writing

compared with negative ($\beta_{hat} = 7.99$, 95% CRI = [7.08, 8.90]) or positive sentiment ($\beta_{hat} = 7.41$, 95% CRI = [5.56, 9.25]) (Table 1). This trend was similar for graduate students, but for postdoctoral scholars, there were no differences in total hours per week devoted to writing among those who had a negative ($\beta_{hat} = 9.30$, 95% CRI = [7.21, 11.37]), neutral ($\beta_{hat} = 7.68$, 95% CRI = [3.70, 11.48]), or positive sentiment ($\beta_{hat} = 7.98$, 95% CRI = [3.96, 11.81]) toward the peer review process (Appendix S2: Figure S5).

Interestingly, a positive sentiment toward the scientific writing process resulted in more first-author publications ($\beta_{hat} = 4.05$, 95% CRI = [3.09, 5.01]) compared with a negative sentiment ($\beta_{hat} = 2.37$, 95% CRI = [1.89, 2.85]). Those reporting a neutral sentiment toward writing ($\beta_{hat} = 3.34$, 95% CRI = [2.43, 4.25]) had statistically equal first-author publications to those with negative or positive sentiments (Figure 3C). In contrast, sentiment toward the peer review process did not change the number of estimated first-authored publications regardless of whether sentiment was negative ($\beta_{hat} = 2.64$, 95% CRI = [2.15, 3.13]), neutral ($\beta_{hat} = 3.94$, 95% CRI = [2.95, 4.93]), or positive ($\beta_{hat} = 2.64$, 95% CRI = [1.65, 3.63]; Figure 3D, Table 1).

Challenges, feedback, and writing groups

The most commonly reported challenge to writing was feeling easily distracted (25%, $n = 190/774$), closely followed by difficulty starting a writing project (19%, $n = 147/774$), and feeling perfectionism hindered writing progress (19%, $n = 144/774$; Figure 4). Trainees also reported feeling like they had too many other obligations apart from their writing projects (17%, $n = 134/774$) or had trouble fitting writing time into their schedules (15%, $n = 114/774$; Figure 4). The least reported barrier to writing was a lack of adequate feedback (6%, $n = 45/774$; Figure 4). Laboratory group involvement in the writing process was common: 63% ($n = 189/299$) of respondents had a collaborative grant or paper with their laboratory group, and 69% ($n = 210/302$) received feedback from their laboratory group on their manuscript (Figure 5A). Among the participants who received feedback from their laboratory group, 95% ($n = 196/208$) reported that it was helpful (Figure 5A). Advisors' participation in the writing process was mostly through giving major revisions (31%, $n = 225/812$; Figure 5B), and this engagement with trainees could be mirrored through the multiple rounds of manuscript revision—34% ($n = 103/295$) of trainees reported their manuscripts went through more than five rounds of revision with advisors before submission (Figure 5C).

While most trainees had participated in writing groups (57%, $n = 163/287$), the ones who had not (43%, $n = 124/287$; Figure 6A) equally reported either lack of interest (32%, $n = 66/206$) or that they did not know writing groups existed (30%, $n = 62/206$; Figure 6B). Peer groups were the most common type of writing group that trainees participated in (37%, $n = 80/217$), followed by formal writing courses (20%, $n = 44/217$), formal writing workshops (20%, $n = 43/217$), writing retreats/study halls (20%, $n = 43/217$), and lastly mentoring programs (3%, $n = 7/217$) (Figure 6C).

Trainees reported that writing group participation improved: camaraderie (75%), goal setting (70%), writing output (67%), giving and receiving feedback (64%),

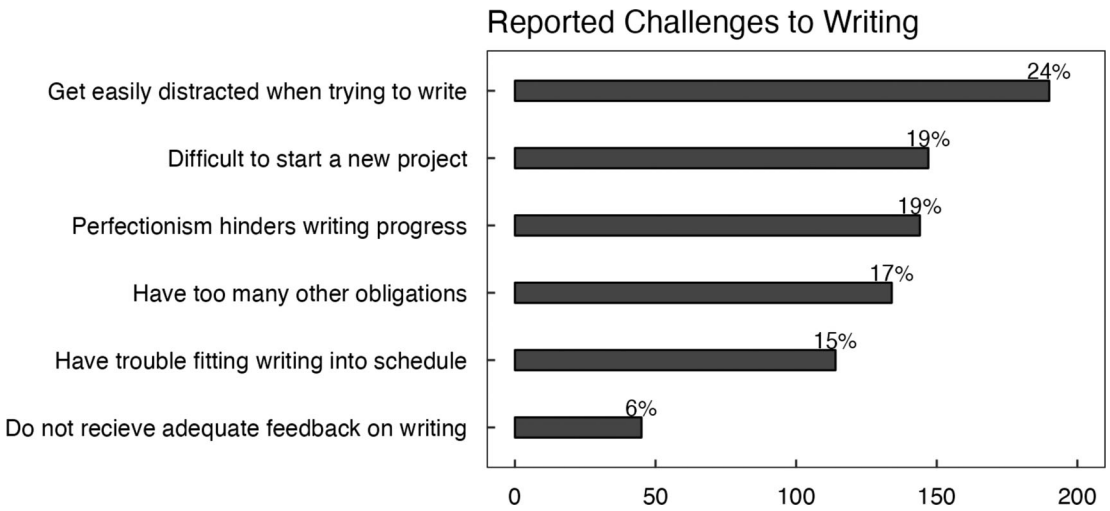

FIGURE 4 Trainees reported many challenges to writing, with the most commonly reported challenge to writing being "feeling easily distracted when trying to write." Participants were invited to select all that apply, which gave rise to high count numbers and suggests that many trainees felt multiple writing challenges were applicable.

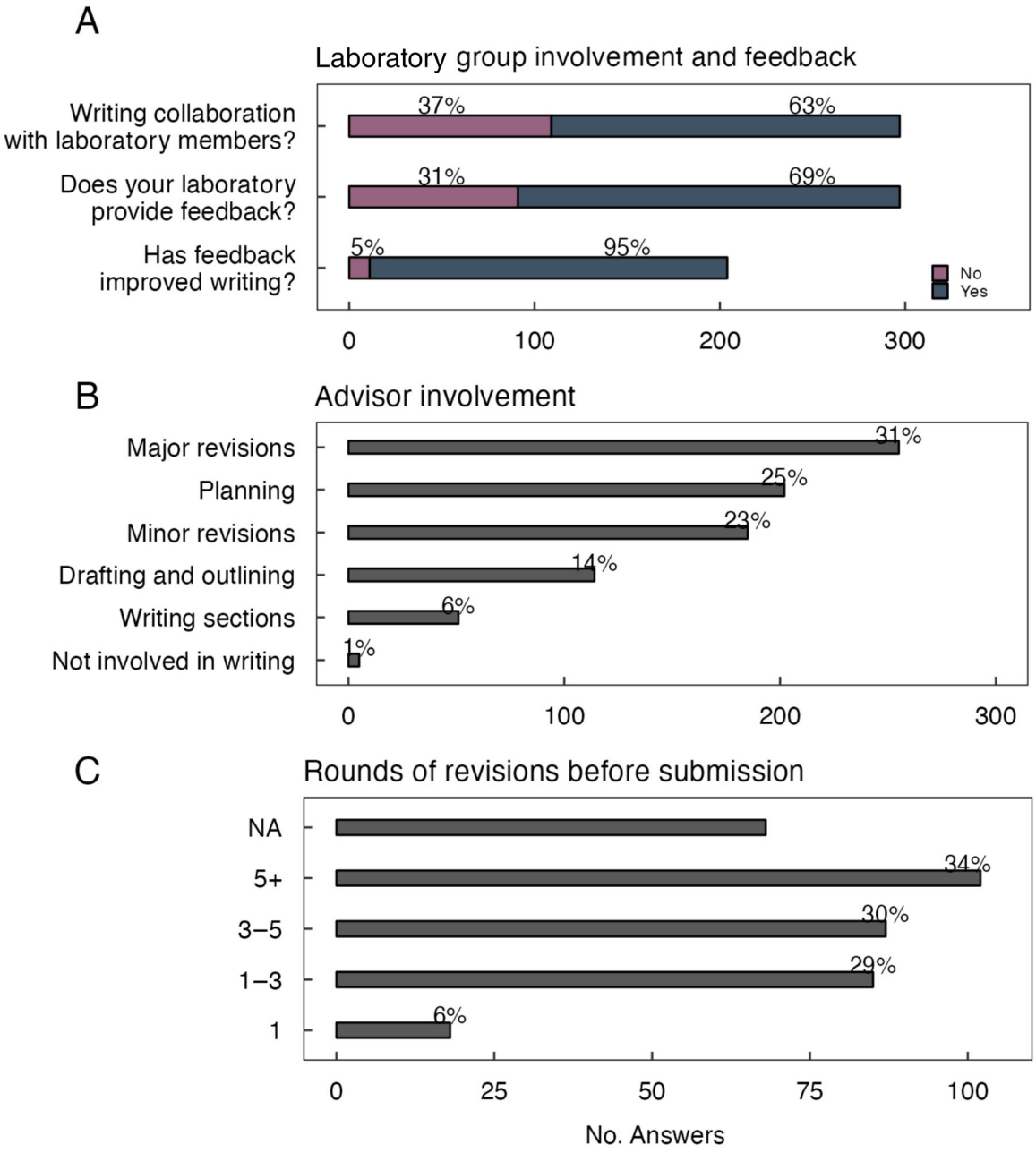

FIGURE 5 (A) Laboratory group involvement in the writing process (e.g., laboratory group collaboration on writing grants or manuscripts), laboratory group feedback on the writing, and whether the feedback has improved respondents' writing. (B) Different ways advisors engage in writing projects. (C) Number of revisions with co-authors a typical manuscript goes through prior to submission to a journal.

writing quality (59%), overcoming writing anxiety (56%), and overcoming perfectionism paralysis (55%; Figure 6D). Trainees were equally likely to report improvement or neutral effect of writing groups on technical writing skills (improved:neutral; $n = 51{:}48\%$), ability to start a writing project (improved:neutral; $n = 49{:}49\%$), and time management (improved:neutral; 49:49%; Figure 6D). Despite these positive attitudes, participating in writing groups did not affect the number of first-author publications for all trainees ($\beta_{hat} = 0.52$, 95% CRI = [−0.25, 1.29]). Although analyzed by career stage, participating in writing groups positively affected the number of first-author publications for graduate students ($\beta_{hat} = 0.71$, 95% CRI = [0.11, 1.33]). Lastly, there was no relationship between participation in writing groups and sentiment toward scientific writing, nor sentiment toward peer review (both Bayes factors of 0.18:1; Table 1).

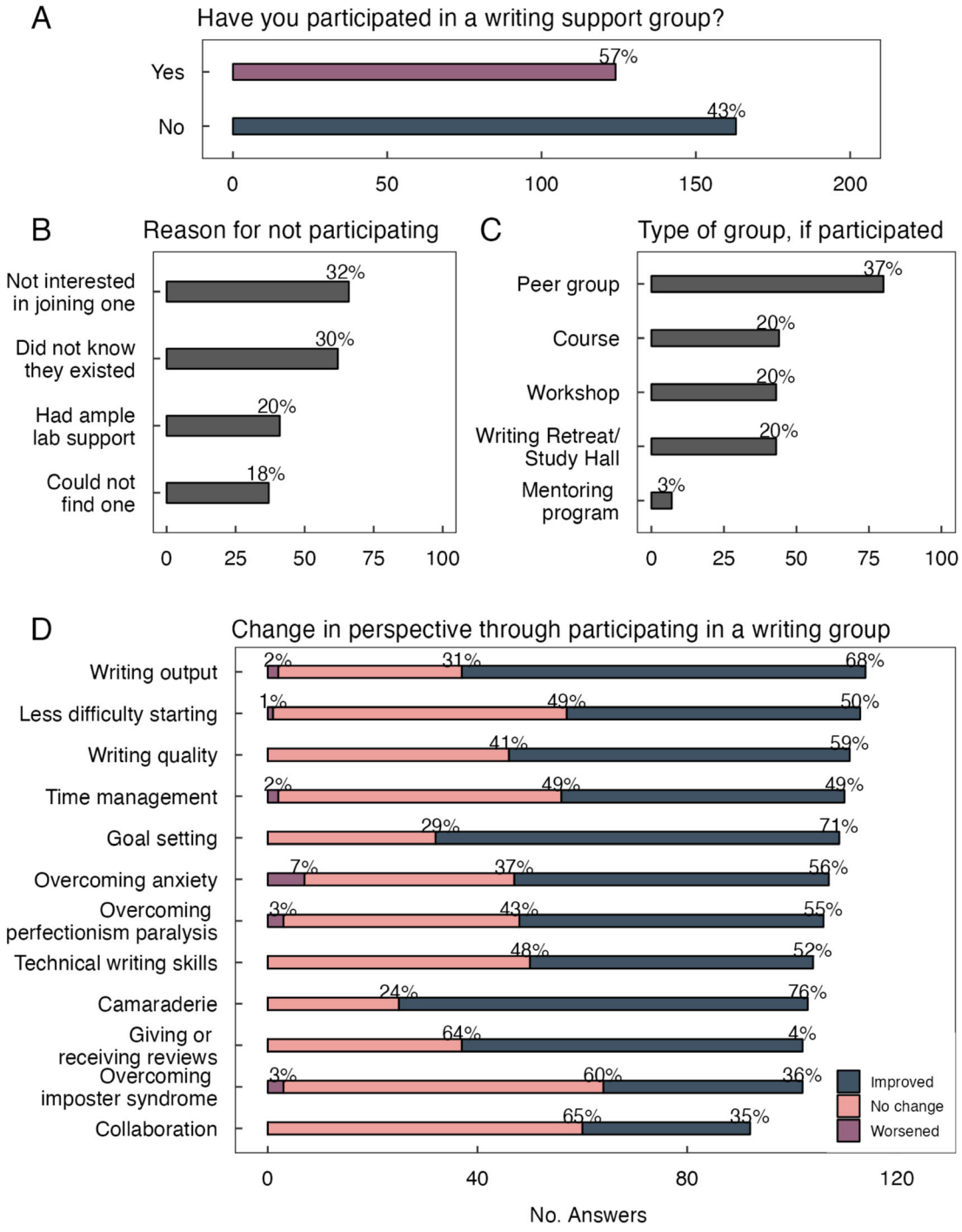

FIGURE 6 Responses about writing group (A) participation; (B) if no, reason for not participating in a writing group; (C) if yes, types of writing groups respondents used; (D) reported changes in aspects of writing with writing group participation. Participants were invited to select all that apply for panels (B)–(D).

DISCUSSION

Academic writing is a well-known challenge for trainees (Gardner et al., 2018), so it is unsurprising that our respondents reported facing many writing barriers and the majority (>65%) of trainees felt negatively about writing and publishing. However discouraging those results are, our findings offer some hope. Our data show that trainees who dedicated more hours to writing each week, regularly scheduled writing time during the week, and individually tracked their writing progress had a higher first-author output. While we recognize and support the need for academia to consider new and different metrics for professional success and potential beyond publication

totals (Montgomery, 2021; Montgomery et al., 2014; Rowland et al., 2022; Schell et al., 2020), early-career researchers in any sector (e.g., industry, not-for-profit, government) must write for their jobs.

There are many detailed books and articles on academic writing (Gray, 2005; Heard, 2016; Silvia, 2007; Strunk & White, 1999; Sword, 2018; Turbek et al., 2016; Williams, 2005), which are useful guides for early-career academics to develop good writing habits. Overall, our results suggest that some trainees are not currently using these recommendations. Graduate programs and faculty tend to assume that graduate students already know how to write, or will learn writing on their own (Sullivan, 1991). By shedding light on how attitudes and habits toward writing can correlate with first-author publications, we hope trainees will seek out resources to improve their writing habits and institutions offer adequate writing skill development training.

Across our participants, more time dedicated to writing each week was positively correlated with first-author publications (Figure 1); on average, trainees reported spending 7.5 h per week writing and our results suggest that even small increases in consistent writing time could result in higher publication totals. Graduate students who planned writing time regularly had more first-authored publications (Appendix S2: Figure S2). This indicates that trainees in the very early stages of their career may benefit the most from setting regular writing time. Interestingly, postdoctoral scholars who do not plan writing time had more first-authored publications. This curious result could be due to their advanced career stage, where they may already incorporate regular writing time in their routines and do not explicitly plan it. Ultimately, those with more structured and limited free time may benefit most from scheduling specific time blocks for writing. It would be interesting to compare our trainee results with a survey of faculty writing habits, which is an understudied topic (Wells & Söderlund, 2018).

It was surprising that across all trainees, those who did not track their writing had more publications than those who tracked their progress in some way. A possible reason for this counterintuitive result could be that our survey options were too limited in scope. We asked whether trainees use explicit tracking methods such as writing in notebooks or verbally checking in with an advisor or writing group; perhaps some of those who selected "no tracking" do in fact track writing, but not within the framework we laid out. For example, they may track their writing with nonspecific, general goals such as "I'm going to finish the introduction this week." Those trainees who already regularly and frequently write as part of their routine may not think to track their writing since they already view writing as a routine component of their days.

Advisor or writing group check-ins had no effect on first-author publications—this lack of effect is crucial to note for trainees who may think advisor check-ins are sufficient to achieve productivity in their writing. Compared with those verbal or informal check-in methods, individually tracking writing progress such as tracking in a notebook or spreadsheet was related to more first-author publications. This strategy could be helpful not only for trainee writing productivity but also to develop a writing routine.

Given the most reported challenges were distraction and difficulty starting writing, trainees could benefit greatly from employing commonly suggested practices in the literature (Gray, 2005; Lamott, 1995; Peterson et al., 2018; Silvia, 2007) to strengthen their writing practices. Building these writing habits is not an easy task, and trainees may still find difficulty in incorporating writing into their routine:

> I really enjoy writing, but have to be in a sharp frame of mind (i.e., my morning brain) and it is easy to let other tasks get in the way of writing.
>
> (Graduate student)

Findings from psychology research could be applied here on an individual level. For example, habit bundling and habit stacking (Quartuccio, 2017; Scott, 2014) are two methods that could help trainees build better writing habits and eventually make writing more enjoyable.

How trainees feel about writing matters and can impact writing output. Negative sentiments toward writing and inadequate feedback can be a barrier to writing. Here we show that trainees who had a negative sentiment toward the scientific writing process had fewer first-author publications (Figure 3C). Graduate students spent more hours writing when they had either positive or negative sentiment toward peer review. It is surprising that these opposite sentiments both influenced graduate students to write more compared with feeling neutral—disentangling the complex feelings trainees may hold toward peer review is worthy of more research. This trend did not exist for postdoctoral scholars; perhaps as trainees in a later career stage, they have developed "tougher skin" toward peer review compared with graduate students and their feelings toward peer review no longer influence their output. While responses indicated advisors provided adequate feedback and engaged through multiple rounds of manuscript revision (Figure 5B,C), some trainees reported that they felt negatively about how feedback was given:

> The type of feedback received is the area I find most frustrating. Heavy edits completed just before deadlines do not help me improve my writing. I understand everyone is strapped for time but how are graduate students to improve their writing without a more iterative process. I'm frustrated because I don't want someone to do it for me but that's what happens anyway.
>
> (Graduate student)

> The most frustrating part not included in this survey is waiting for my PI to be ready to submit a paper. I have two manuscripts ready and have had them ready for 6 months now, but my PI does not make time for my manuscripts since I am an early years graduate student.
>
> (Graduate student)

An academic advisor or mentor who thoroughly plans how to address reviews together with their trainees or shares experiences with peer review can normalize the experience and give trainees context for how successful scientists approach revision. This is best summarized by this respondent's comment, "learning how to filter feedback is essential" (Postdoctoral scholar), since many trainees expressed discouragement and disappointment with the peer review:

> Harsh and unnecessary peer review comments have delayed some writing projects for over a year because of the emotional baggage.
>
> (Graduate student)

> Writing is easy for me. It is the endless criticism confronted once you submit that is exhausting and discouraging.
>
> (Postdoctoral scholar)

Adequate feedback, constructive criticism, and providing tangible suggestions for writing improvement could build trainee confidence and help reduce the negative sentiments toward the peer review process (Figure 3B). Trainees with English as their second language (ESL) similarly provided qualitative descriptions of difficulties with the review process, citing frequent negative feedback as a hindrance to morale (Rowland et al., 2022).

Joining writing groups also has potential to improve sentiment toward writing. While our model showed that participation in writing groups did not influence trainee sentiment toward scientific writing or the peer review process, our qualitative data suggested that writing groups did have some positive benefits. Specifically, respondents reported improvement in the social aspects of writing: building camaraderie, overcoming anxiety, and feeling easily distracted (Figure 6D). The social aspects of writing are often overlooked, but are an essential component of academic writing (Sword, 2018), and writing groups are a natural way to enhance this social connection as stated:

> Writing buddies are the only way I could finish my dissertation.
>
> (Graduate student)

Graduate students who participated in a writing group had more first-author publications, and a large subset of respondents (68%) expressed that their writing output improved through participation in a writing group. Writing groups have been shown to bolster writing potential, writing productivity, and solidarity among members (Bodenberg & Nichols, 2019; Dwyer et al., 2012; Maher et al., 2013; Rickard et al., 2009; Thorpe et al., 2020), creating a supportive atmosphere that can help to diminish the feelings of anxiety and pressure to publish (Dwyer et al., 2012). Previous research strongly suggests participating in writing groups accelerates dissertation completion (Maher et al., 2013) and has the potential to maintain or increase the frequency or duration of writing via scheduling and accountability (Eckstein et al., 2017; Thorpe et al., 2020). Future work would benefit from comparing the effects of different writing group types on trainee writing output.

It is worth noting that almost half (48%, $n = 99/206$) of our respondents who had not participated in writing groups either did not know writing groups existed or could not find one (Figure 6B). Writing books suggest that those who cannot find a group to join can create their own peer writing groups (Silvia, 2007), and that even having more than one writing accountability group can be beneficial. Institutional-level support such as requiring writing groups (Tyndall et al., 2019), adding formal academic writing courses to graduate curricula, creating study halls and writing retreats, and having graduate writing laboratories on campus all build a base of social and technical support for trainees. Writing groups that facilitate peer review between participants is another way to increase trainee writing confidence when it comes to giving and receiving feedback, which ultimately improves writing skills (Cunningham, 2019).

There can certainly be differences in the academic lifestyle and productivity demands between a graduate student and a postdoctoral scholar. Our findings indicated a few areas where graduate students may benefit most from writing habits and writing groups. The lack of greater differentiation in our findings between the two career stages could be due to the wide range in experience of the trainees we surveyed. Our graduate student pool included students pursuing masters and doctoral degrees, ranging between 0 and 15 years in their studies. Similarly, our postdoc pool included a wide range of experience (0–9 years). Different degree types, institutions, and years of study and experience can all play a role in a trainee's development of writing habits. We could deduce that even graduate students with poor writing habits can secure postdoctoral positions; however, it is unclear whether they can progress successfully beyond that career stage. Follow-up studies comparing graduate students with good writing habits who transition into postdoctoral positions and current postdoctoral scholars with poor writing habits would shed light on how building writing habits early in one's career may influence productivity and career outcomes.

CONCLUSION

Writing is a discipline that requires consistent practice, yet current trainees in environmental biology reported inconsistent writing habits and negative attitudes about the writing and peer review process. Early-career scientists can benefit from support at different levels: (1) individuals could improve their own writing habits (e.g., scheduling writing, tracking goals, engaging with or forming a writing group); (2) advisors could coach trainees by using laboratory meetings for friendly review, teaching how to handle criticism and navigate the peer review process, and working closely on co-writing manuscripts; and (3) institutions could offer graduate writing laboratories, formal study halls, and academic writing courses to graduate students. Our study adds to previous work on scientific writing by exploring how hundreds of trainees are approaching their writing. By adopting positive individual writing habits and encouraging advisors and institutions to develop their writing resources, we hope that scientific writing will become less onerous for trainees, and dare we say, enjoyable.

AUTHOR CONTRIBUTIONS

Yara A. Alshwairikh, Ana Clara Fanton, Kyra A. Prats, Mary K. Burak, Marlyse C. Duguid, and Freya E. Rowland designed the study and distributed the survey. Yara A. Alshwairikh and Freya E. Rowland conducted the statistical analyses. Yara A. Alshwairikh, Ana Clara Fanton, Kyra A. Prats, Mary K. Burak, Marlyse C. Duguid, and Freya E. Rowland interpreted the results. Yara A. Alshwairikh, Ana Clara Fanton, Kyra A. Prats, Mary K. Burak, and Freya E. Rowland wrote the manuscript. All authors contributed to the editing and the final draft. Yara A. Alshwairikh and Ana Clara Fanton are co-first authors. Middle authors are in alphabetical order.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Raw data and the full survey used for the analyses (Alshwairikh, Rowland, Prats, et al., 2023) are available from Dryad: https://doi.org/10.5061/dryad.fqz612jwn. Code (Alshwairikh, Rowland, & Fanton, 2023) is available from Zenodo: https://doi.org/10.5281/zenodo.8200163.

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REFERENCES

Alshwairikh, Y., F. Rowland, and A. C. Fanton. 2023. "YaraAlshw/TraineeWritingHabits (v1.0.0)." Zenodo. https://doi.org/10.5281/zenodo.8200163.

Alshwairikh, Y., F. Rowland, K. Prats, M. Burak, A. C. Fanton, and M. Duguid. 2023. "Survey: Trainee Attitudes towards Scientific Writing." Dryad. Dataset. https://doi.org/10.5061/dryad.fqz612jwn.

Bodenberg, M. M., and K. Nichols. 2019. "Time for an 'Upgrade:' How Incorporating Social Habits Can Further Boost Your Writing Potential." *Currents in Pharmacy Teaching and Learning* 11(11): 1077–82. https://doi.org/10.1016/j.cptl.2019.07.003.

Cunningham, K. 2019. "Graduate Engineering Peer Review Groups: Developing Communicators and Community." In *2019 ASEE Annual Conference & Exposition Proceedings*, 32878. Tampa, FL: ASEE Conferences. https://doi.org/10.18260/1-2–32878.

Dwyer, A., B. Lewis, F. McDonald, and M. Burns. 2012. "It's Always a Pleasure: Exploring Productivity and Pleasure in a

Writing Group for Early Career Academics." *Studies in Continuing Education* 34(2): 129–144. https://doi.org/10.1080/0158037X.2011.580734.

Eckstein, G., K. Evans, D. Moglen, and W. Whitener. 2017. "Graduate Writing Groups: An Interdisciplinary Approach to Writing Productivity." *Journal of Teaching English for Specific and Academic Purposes* 5(1): 1–11. https://doi.org/10.22190/JTESAP1701001E.

Ellwanger, J. H., and J. A. Bogo Chies. 2020. "We Need to Talk about Peer-Review-Experienced Reviewers Are Not Endangered Species, but They Need Motivation." *Journal of Clinical Epidemiology* 125: 201–5. https://doi.org/10.1016/j.jclinepi.2020.02.001.

Fox, J. 2020. "A Data-Based Guide to the North American Ecology Faculty Job Market." *The Bulletin of the Ecological Society of America* 101(2): e01624. https://doi.org/10.1002/bes2.1624.

Gardner, S. A., L. M. Salto, M. L. Riggs, C. A. Casiano, and M. De Leon. 2018. "Supporting the Writing Productivity of Biomedical Graduate Students: An Integrated, Structured Writing Intervention." *CBE—Life Sciences Education* 17(3): ar45. https://doi.org/10.1187/cbe.16-12-0350.

Goodrich, B., J. Gabry, and S. Brilleman. 2020. "Rstanarm: Bayesian Applied Regression Modeling via Stan." R Package. https://mc-stan.org/rstanarm.

Gray, T. 2005. *Publish & Flourish: Become a Prolific Scholar*. Las Cruces, NM: Teaching Academy, New Mexico State University.

Heard, S. B. 2016. *The Scientist's Guide to Writing*. Princeton, NJ: Princeton University Press.

Hu, M., and B. Liu. 2004. "Mining and Summarizing Customer Reviews." In *Proceedings of the Tenth ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, 168–177. Seattle, WA: ACM.

Lamott, A. 1995. "Shitty First Drafts." In *Bird by Bird: Some Instructions on Writing and Life*, 20–27. New York: Anchor.

Maher, M., A. Fallucca, and H. M. Halasz. 2013. "Write On! Through to the Ph.D.: Using Writing Groups to Facilitate Doctoral Degree Progress." *Studies in Continuing Education* 35(2): 193–208. https://doi.org/10.1080/0158037X.2012.736381.

Martin, B. 2012. "Want to Publish More? Then Train Like an Athlete." Stanford: Tomorrow's Professor Postings, September 2012. https://www.bmartin.cc/pubs/12tp.html.

Mendoza-Denton, R., C. Patt, A. Fisher, A. Eppig, I. Young, A. Smith, and M. A. Richards. 2017. "Differences in STEM Doctoral Publication by Ethnicity, Gender and Academic Field at a Large Public Research University." *PLoS One* 12(4): e0174296. https://doi.org/10.1371/journal.pone.0174296.

Mohammad, S. M., and P. D. Turney. 2013. "Crowdsourcing a Word-Emotion Association Lexicon." *arXiv preprint*. https://doi.org/10.48550/arXiv.1308.6297.

Montgomery, B. L. 2021. "Make Equity Essential to Expedite Change in Academia." *Nature Microbiology* 6(1): 7–8. https://doi.org/10.1038/s41564-020-00845-0.

Montgomery, B. L., J. E. Dodson, and S. M. Johnson. 2014. "Guiding the Way: Mentoring Graduate Students and Junior Faculty for Sustainable Academic Careers." *SAGE Open* 4(4): 215824401455804. https://doi.org/10.1177/2158244014558043.

Nielsen, F. Å. 2011. "A New ANEW: Evaluation of a Word List for Sentiment Analysis in Microblogs." *arXiv preprint*. https://doi.org/10.48550/arXiv.1103.2903.

Peterson, T. C., S. R. Kleppner, and C. M. Botham. 2018. "Ten Simple Rules for Scientists: Improving Your Writing Productivity." *PLoS Computational Biology* 14(10): e1006379. https://doi.org/10.1371/journal.pcbi.1006379.

Pinheiro, D., J. Melkers, and J. Youtie. 2014. "Learning to Play the Game: Student Publishing as an Indicator of Future Scholarly Success." *Technological Forecasting and Social Change* 81: 56–66. https://doi.org/10.1016/j.techfore.2012.09.008.

Quartuccio, J. S. 2017. "Forming New Habits: Is It Me or the Habit That Stands in the Way?" Doctoral diss., George Mason University.

R Core Team. 2021. *R: A Language and Environment for Statistical Computing*. Vienna: R Foundation for Statistical Computing. http://www.R-project.org/.

Rickard, C. M., M. R. McGrail, R. Jones, P. O'Meara, A. Robinson, M. Burley, and G. Ray-Barruel. 2009. "Supporting Academic Publication: Evaluation of a Writing Course Combined with Writers' Support Group." *Nurse Education Today* 29(5): 516–521. https://doi.org/10.1016/j.nedt.2008.11.005.

Rouder, J. N., and R. D. Morey. 2021. "BayesFactor: Computation of Bayes Factors for Common Designs." R. R Package. https://CRAN.R-project.org/package=BayesFactor.

Rowland, F., K. Prats, Y. Alshwairikh, M. Burak, A. C. Fanton, and M. Duguid. 2022. "Towards a New Stable State: Equitably Assessing Trainee Writing Productivity Post-COVID-19." *EcoEvoRxiv Preprint*. https://doi.org/10.32942/osf.io/cx4gf.

Schell, C. J., C. Guy, D. S. Shelton, S. C. Campbell-Staton, B. A. Sealey, D. N. Lee, and N. C. Harris. 2020. "Recreating Wakanda by Promoting Black Excellence in Ecology and Evolution." *Nature Ecology & Evolution* 4(10): 1285–87. https://doi.org/10.1038/s41559-020-1266-7.

Scott, S. J. 2014. *Habit Stacking: 97 Small Life Changes That Take Five Minutes or Less*. Lexington, KY: Archangel Ink.

Silvia, P. J. 2007. *How to Write a Lot: A Practical Guide to Productive Academic Writing*, 1st ed. Washington, DC: American Psychological Association.

Stan Development Team. 2020. "RStan: The R Interface to Stan." http://mc-stan.org/.

Strunk, W., and E. B. White. 1999. *The Elements of Style*, 4th ed. Boston, MA: Allyn and Bacon.

Sullivan, P. A. 1991. "Writing in the Graduate Curriculum: Literary Criticism as Composition." *Journal of Advanced Composition* 11(2): 283–299.

Sword, H. 2018. *Air & Light & Time & Space: How Successful Academics Write*. Cambridge, MA: Harvard University Press.

Thorpe, R. J., B. M. Beech, K. C. Norris, E. Heitman, and M. A. Bruce. 2020. "Writing Accountability Groups Are a Tool for Academic Success: The Obesity Health Disparities PRIDE Program." *Ethnicity & Disease* 30(2): 295–304. https://doi.org/10.18865/ed.30.2.295.

Turbek, S. P., T. M. Chock, K. Donahue, C. A. Havrilla, A. M. Oliverio, S. K. Polutchko, L. G. Shoemaker, and L. Vimercati. 2016. "Scientific Writing Made Easy: A Step-by-Step Guide to Undergraduate Writing in the Biological Sciences." *The Bulletin of the Ecological Society of America* 97(4): 417–426. https://doi.org/10.1002/bes2.1258.

Tyndall, D. E., T. H. Forbes, III, J. J. Avery, and S. B. Powell. 2019. "Fostering Scholarship in Doctoral Education: Using a Social Capital Framework to Support PhD Student Writing Groups." *Journal of Professional Nursing* 35(4): 300–304. https://doi.org/10.1016/j.profnurs.2019.02.002.

Wells, J. M., and L. Söderlund. 2018. "Preparing Graduate Students for Academic Publishing." *Pedagogy* 18(1): 131–156.
Williams, J. M. 2005. *Style: Ten Lessons in Clarity and Grace*, 8th ed. New York: Pearson Longman.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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