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Nondisclosure of queer identities is associated with reduced scholarly publication rates

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Abstract

Nondisclosure of lesbian, gay, bisexual, transgender, asexual, or otherwise queer (LGBTQA) identities in the workplace is both common and stressful to those who do not disclose. However, we lack direct evidence that nondisclosure of LGBTQA identity affects worker productivity. In two surveys of LGBTQA-identified scientists, we found that those who did not disclose LGBTQA identities in professional settings authored fewer peer-reviewed publications — a concrete productivity cost. In the second survey, which included straight and cisgender participants as a comparison group, we found that LGBTQA participants who disclosed their sexual orientation had publication counts more like non-LGBTQA participants than those who did not disclose, and that all three groups had similar time since first publication given their academic career stage. These results are most consistent with a productivity cost to nondisclosure of LGBTQA identity in professional settings, and suggest a concrete need to improve scientific workplace climates for sexual and gender minorities.

Introduction

Lesbian, gay, bisexual, transgender, asexual, or otherwise queer (LGBTQA) identities are not necessarily evident without deliberate disclosure. This disclosure is popularly represented as a discrete "coming out," though revelation and expression of queer identity is more often a continuous process [1–4]. Free expression of queer identities is generally understood to be affirming and liberating, but choosing to come out also remains a decision with potentially grave consequences, particularly in professional settings [5–9]. In the United States, Federal law has only recently been interpreted to prohibit employment discrimination based on sexual orientation, gender identity, and transgender status [10,11], and this progress remains fragile and incomplete [12,13]. LGBTQ-identified individuals continue to face barriers across society, including in healthcare [14,15], housing [16], and economic and social services [17–19]. Even when their identities are legally protected, LGBTQA-identifying individuals may fear that coming out will have negative consequences for their relationships with colleagues [20–22]. Disclosure of queer identities in professional settings thus risks career disadvantages, discriminatory treatment, or worse [6,9,23,24].

At the same time, nondisclosure of queer identities in any context has been shown to be a source of stress and distraction for nondisclosing individuals [4,20,21,25,26], and nondisclosure in the workplace reduces job satisfaction, social integration with colleagues, and identification with employers [8,23,27–29]. Proponents of anti-discrimination protections for minority sexual orientation and gender identities have therefore argued that ensuring the freedom to express queer identities openly can promote employee productivity [28,30]. Studies using surveys or interviews have differed over whether disclosure of queer identities leads to greater comfort in

64 professional settings [1,8,22,27,28], however, and no study to date has directly tested whether
65 nondisclosure is associated with reduction in any concrete measure of productivity.

66 Scientific research careers offer a unique opportunity to examine this relationship.
67 Particularly in academic science and technical fields, research productivity is widely judged by a
68 fairly straightforward metric: the number of peer-reviewed articles a researcher publishes. Peer-
69 reviewed publication counts are at best a crude metric of impactful or meaningful scholarly
70 work, as scholars in most disciplines and workplace contexts also contribute in the form of
71 teaching, mentoring, outreach, administrative service, and even activism — to name just a few
72 possibilities. Nevertheless, successful completion of publishable research papers is prioritized in
73 graduate training for most scientific fields, and publication activity informs hiring, promotion,
74 and tenure decisions for academic research faculty [31–33]. Publication counts have been used in
75 prior studies to directly quantify systematic disadvantages to women [31,34,35] and people of
76 color [36] in academic careers. These previous studies suggest that academic publishing rates
77 reflect broader issues regarding the impact of systematic racism and sexism on productivity,
78 career advancement, and longevity in the field. Gender discrimination has close links to
79 discrimination against queer identities: greater representation of women among workers in
80 STEM fields is positively associated with LGBTQA-identifying workers' disclosure of their
81 identities in professional settings [1], and with greater representation of men in same-sex
82 relationships [37].

83 Gender discrimination, including bias in peer review, can result in higher publication
84 rates for men relative to women and create pressure for women to publish more than men to
85 achieve similar status [38]. Some studies have found that although publication rates are more
86 similar at early career stages, women tend to have shorter careers in science than men and higher

rates of dropout or career transition, resulting in lower overall productivity [35,39,40]. Other research has found that scholars from minoritized groups have fewer opportunities to publish at the Ph.D. and postdoctoral levels [41], and that women achieve tenure at lower rates than men even with similar publication records [42]. Moreover, gender gaps persist in authorship of publications, especially in prestigious journals, across science, technology, engineering, mathematics, and medicine [43], and sociocultural expectations of gender roles impact scientific publishing rates and career advancement [44,45]. Although important conclusions have been drawn from the aggregate of work examining gender gaps and discrimination in academic publishing, many of these studies have relied on author name as a proxy for gender, and assume a man/woman gender binary. The literature on gender gaps in scholarly publication has not, to our knowledge, explicitly examined gender identities beyond the man/woman binary, and has not accounted for transgender or questioning individuals. To avoid the limitations of mapping names onto a gender binary, we argue for an understanding of gender as more expansive than a binary, and for methodological approaches in which study participants self-identify aspects of their identity, including gender, whenever possible.

The possibility that disclosure or nondisclosure of queer identities might have a detectable impact on scholarly publication rates is a logical extension of the broader research linking publication rates to the experiences of women and other minoritized identities in STEM careers. We hypothesize that the increased stress and decreased sense of workplace belonging associated with nondisclosure of queer identities creates its own kind of systematic disadvantage that should manifest in academic publication rates, and that disclosure of queer identities in professional settings may offset or eliminate this disadvantage. It is possible that differences in publication rates could be associated with disclosure of LGBTQA identities if individuals who

publish more frequently feel more secure in their jobs, and thereby better able to disclose minoritized identities. However, if this is the case, we would expect that disclosing LGBTQA individuals would publish at rates higher than their straight cisgender colleagues, and achieve key promotions (completion of a PhD, hiring as a postdoc, hiring as faculty, and advancement to tenure) earlier. In the broader context of institutional sexism in academia, we further expect that the effect of disclosure may interact with gender identity, gender expression, and cisgender or transgender status.

Specifically, we hypothesize that

(1) LGBTQA-identified scientists will have reduced publication rates relative to straight-identified, cisgender scientists; but disclosing LGBTQA-identified scientists will have publication rates more like those of their straight cisgender peers.

(2) Disclosing LGBTQA-identified scientists will not have achieved key career stages earlier than nondisclosing LGBTQA-identified scientists, or than straight cisgender scientists.

(3) Disclosure or nondisclosure of gender identity and/or transgender status, which directly confronts an individual's status with respect to institutional sexism, will not have the same effect on productivity as disclosure of sexual orientation. Rather, scientists who identify as women, nonbinary, agender, or otherwise non-male will show reduced publication rates relative to men regardless of disclosure status; and individuals whose gender expression is other than masculine will show reduced publication rates relative to those with masculine gender expression.

Here, we test these hypotheses with responses to two surveys of queer academics in science, technology, engineering, and mathematics (STEM), which relate disclosure of queer identities in

professional settings to publication counts. In both surveys, we find that nondisclosure is associated with reduced publication counts. In the second survey, which included both LGBTQA-identified participants and straight cisgender participants, we find that LGBTQA-identified participants who disclosed their identities in professional settings had publication counts more like those of straight cisgender participants. We further find that disclosing LGBTQA, nondisclosing LGBTQA, and straight cisgender participants at do not differ in their time since first publication within discrete career stages, consistent with differences in publication rate arising from a cost of nondisclosure, rather than security afforded by productivity. Finally, we compare the effect of nondisclosure to the effects of LGBTQA identity apart from disclosure, participants' self-described gender expression, and participants' ratings of the "climate" for LGBTQA-identified individuals in their workplaces, as well as to the possible confounding effects of increasing publication count with career progress. We find that a negative effect of nondisclosure is robust to these other explanatory factors.

Results

Language to describe sexual orientation, gender identities, and transgender experiences is complex and changeable in usage across communities, among individuals, and over time. Here, we use "queer" to refer inclusively to individuals identifying as other than exclusively cisgender and straight, and variants of the initialism "LGBTQA" to refer to sets of specific identities (e.g., LBQ for lesbian, bisexual, and otherwise queer) when applicable, particularly in discussing prior works focused on specific queer identities. We use the word "straight" as opposed to "heterosexual" largely to parallel our inclusive and colloquial usage of "queer". We further follow a recent proposal to clearly differentiate gender identity (whether an individual is a man, a

156 woman, nonbinary, agender, or other gender) from transgender or cisgender status, or "gender
157 modality" (whether an individual's gender identity aligns with the gender they were assigned at
158 birth; [46]), though this differentiation was not formally proposed or commonly used at the time
159 of our survey design and data collection. We use "nonbinary" inclusively of gender identities
160 beyond the binary of men/women, while acknowledging that this simplifies gender diversity,
161 including agender and genderqueer identities. Finally, we describe expression of queer identities
162 in terms of "disclosure" or "nondisclosure" to emphasize that revealing a queer identity is often
163 an intentional act, and that a person's choice not to disclose their queer identity in a particular
164 context does not mean they are deceiving anyone. LGBTQA-identified individuals who do not
165 disclose queer identity may be assumed to be straight or cisgender or to have binary gender
166 identity as a majoritarian default, as has been reported in STEM workplaces [47]. At all points
167 we do our best to follow the self-descriptions of participants in our surveys. We discuss our
168 approach to translating survey participants' open-ended descriptions of their identities into
169 simplified categories for analysis in more depth in Methods, below.
170

171 ## The 2013 Queer in STEM survey

172 In 2013 we recruited LGBTQA-identified professionals in STEM careers to complete an
173 online survey about their career progress and workplace experiences (ref [1]; survey design and
174 participant recruitment briefly described in the Methods, specific survey items in SI,
175 Supplementary Methods). We asked participants to report the number of peer-reviewed papers
176 they had published, to describe their gender identity and cisgender or transgender status, and to
177 describe their current job or career position. We also asked participants to rate their disclosure of
178 their queer identities in professional contexts using a scale from 0 ("I am not out to anyone in

this group") to 5 ("As far as I'm aware, everyone in this group could know"). We classified participants reporting disclosure scores below the midpoint ("Less than half of the people in this group know") as "nondisclosing" in professional settings, and those reporting greater degrees of openness as "disclosing".

Among 633 participants who were working at any stage of an academic career and who had authored at least one peer-reviewed publication, those who did not disclose their queer identities in professional settings also reported having authored significantly fewer peer-reviewed publications (Fig. 1A; mean ± SE publications for nondisclosing participants = 8.5 ± 1.7, for disclosing = 15.1 ± 2.1; $p < 0.001$, two-tailed t-test on log-transformed data). Publication counts also differed by gender identities — whether participants identified as men, women, or nonbinary or agender. This interacted with disclosure such that the difference in publication counts between disclosing and nondisclosing participants was significant for queer men, but not for queer women or nonbinary participants (Fig. 1B; mean ± SE publications for nondisclosing men = 4.9 ± 0.8, for disclosing men = 12.2 ± 1.8, for nondisclosing nonbinary participants = 3.4 ± 0.6, for disclosing nonbinary participants = 10 ± 3.7, for nondisclosing women = 15.8 ± 4.6, for disclosing women = 17.9 ± 3.7; two-way ANOVA $p < 10^{-4}$ for identity, $p < 0.01$ for disclosure, $p = 0.02$ for the interaction). Publication counts were not significantly explained by participants' ratings of their current workplaces as welcoming or unwelcoming to queer individuals (S1 Fig; one-way ANOVA $p = 0.11$); or by their STEM fields (SI S2 Fig; one-way ANOVA $p = 0.13$). However, there was also an expected, and strong, effect of participants' job positions, with those in more senior positions reporting more publications (Fig. 1C; one-way ANOVA $p < 10^{-6}$). Disclosure differed among positions ($X^2_{df=8}$ test, $p < 10^{-5}$) such that participants in more senior positions were also more likely to disclose queer identities (SI S3 Fig;

roughly 51% of Ph.D. students nondisclosing, versus 12% of full professors); and a two-way ANOVA with position and openness found a significant effect for position ($p < 10^{-6}$) but not disclosure ($p = 0.87$). Thus, in the 2013 survey data the effect of nondisclosure is fully confounded with seniority — they are both consistent with the possibility that nondisclosure has a negative effect on productivity, and the possibility that more senior scientists, who have published more, are more likely to disclose LGBTQA identities.

Fig. 1. Factors associated with differences in publication counts reported in the 2013 survey. (**A**) Publication count differs significantly by whether or not participants disclosed their LGBTQA identities in professional settings (two-sided t-test, $p < 0.001$). (**B**) Publication count by gender identity (women; nonbinary, agender, or otherwise beyond the binary; men) and disclosure of LGBTQA identities, colored as in (A). (**C**) Publication count by academic position. In all panels, boxes give 25th, 50th, and 75th quantiles; whiskers reach to 1.5x interquartile range; in (B) and (C) letters indicate groups that differ significantly with $p < 0.05$ in a Tukey HSD test.

The 2016 Queer in STEM survey

To better address the question of how nondisclosure of queer identity may impact productivity, we developed and conducted a second survey in 2016. In the 2016 survey we again asked participants to describe the climates of their workplaces, and to report their STEM fields, job titles, and number of peer-reviewed publications authored (item text in SI, Supplementary Methods). Rather than ask about disclosure of queer identities as a whole, we asked participants to separately rate their openness in professional settings in relation to their sexual orientation and in relation to their "gender identity" — following terminology in use at the time and familiar to

expected survey participants, we defined this to include both gender identity and gender modality (see item text, Supplementary Methods). In addition, to better control for the confounding effect of seniority, we asked participants how many years had elapsed since the publication of their first peer-reviewed paper. Finally, to provide an additional control for the effect of nondisclosure of queer identities, we recruited cisgender straight scientists as well as queer-identified scientists.

A total of 1,116 LGBTQA-identified and 629 cisgender straight survey participants worked in academic settings and had authored at least one peer-reviewed paper. Across all LGBQA participants, those who said they did not disclose their sexual orientation in professional settings reported fewer peer-reviewed papers compared to those who disclosed, or to straight participants (Fig. 2A; mean ± SE publications for nondisclosing LGBQA participants = 7.1 ± 0.5, for disclosing LGBQA participants = 13.9 ± 1.2, and for straight participants = 15.6 ± 1.1; Tukey HSD test $p < 10^{-6}$ for nondisclosing LGBQA versus disclosing LGBQA and for nondisclosing LGBQA versus straight; $p = 0.33$ for disclosing queer versus straight). We found broadly similar patterns when considering disclosure of sexual orientation based on gender identities separately: among GBQA men, LGBQA nonbinary participants, and LGBQA women, those who did not disclose their sexual orientation had significantly fewer publications (Fig. 2B; mean ± SE for disclosing GBQA men = 14.7 ± 1.8, for nondisclosing GBQA men = 7.7 ± 0.9, for disclosing LGBQA nonbinary participants = 15.2 ± 3.0, for nondisclosing LGBQA nonbinary participants = 7.3 ± 1.5, for disclosing LGBQA women = 11.7 ± 1.8, for nondisclosing LGBQA women = 6.6 ± 0.7; Tukey HSD $p < 0.05$ in all cases). We also found that straight women, disclosing and nondisclosing queer women, nondisclosing men, and nondisclosing nonbinary participants all reported fewer publications than straight men (Fig. 2B; mean ± SE publications for straight women = 12.1 ± 1.1, for straight men = 21.0 ± 2.3; Tukey HSD $p < 0.05$ in all cases);

248 while straight women reported publication counts not significantly different from straight
249 nonbinary participants or any queer participants who disclosed their sexual orientation (Fig. 2B;
250 Tukey HSD $p > 0.99$ in all cases).
251
252 **Fig. 2. Factors associated with differences in publication counts reported in the 2016**
253 **survey.** (**A**) Publication counts by whether or not participants disclosed their sexual orientation
254 in professional settings. (**B**) Publication counts by gender identity (as in Fig. 1B) as well as
255 openness about sexual orientation, with color-coding as in (A). (**C**) Publication counts by
256 participants' gender identity and cisgender or transgender status, and disclosure of gender
257 identity or trans status. (**D**) Publication counts by participants' gender expression. (**E**)
258 Publication counts by gender identity and gender expression, with color-coding as in (D).
259 Boxplot interpretation as in Fig. 1. (**F**) Scatterplot of publication count versus time since first
260 publication; line and shaded band indicate linear regression ± standard error.
261
262 In addition to factors paralleling those addressed in the 2013 survey, we asked
263 participants in the 2016 survey to rate their openness about their gender identity in professional
264 settings (following colloquial terminology, the item text defined "gender identity" to encompass
265 both gender identity as men, women, nonbinary, agender, or genderqueer; and gender modality,
266 or cisgender or transgender status [46]; see Supplementary Methods). We also asked participants
267 to describe their gender expression as masculine, feminine, androgynous, or terms of their
268 choosing. This allowed us to address whether gender identity and expression mediated effects
269 associated with queer identity and disclosure. Disclosure of gender identity and cisgender or
270 transgender status did have a significant effect on publication count (one-way ANOVA, $p =$

0.002); but the difference between disclosing and nondisclosing individuals, considered within either nonbinary cisgender participants, transgender men, transgender women, or transgender nonbinary participants, was not greater than expected by chance (Fig. 2C; mean ± SE for disclosing cis nonbinary = 15.1 ± 5.2, for nondisclosing cis nonbinary = 5.6 ± 1.8, for disclosing trans men = 1.5 ± 0.5, for nondisclosing trans men = 4.1 ± 1.5, for disclosing trans women = 22.1 ± 11.1, for nondisclosing trans women = 8.4 ± 6.4, for disclosing trans nonbinary = 11.1 ± 3.2, for nondisclosing trans nonbinary = 10.4 ± 1.8, for cis men = 15.2 ± 1.1, for cis women = 9.7 ± 0.6; Tukey HSD $p < 0.01$ for cis men versus cis women and for cis men versus trans nonbinary nondisclosing, and $p > 0.05$ for all other comparisons). Gender expression did have a significant effect: participants whose self-described gender expression was feminine or nonconforming to the gender binary reported significantly fewer publications than participants whose gender expression was masculine (Fig. 2D; mean ± SE publications for masculine participants = 15.2 ± 1.1, for nonconforming participants = 10.3 ± 1.1, for feminine participants = 9.7 ± 0.7; Tukey HSD test $p < 0.0001$ for masculine versus each other group). These differences associated with gender expression did not translate to significant differences within gender identities, however (Fig. 2E; two-way ANOVA $p < 10^{-5}$ for gender expression, $p = 0.38$ for gender identity, $p = 0.34$ for the interaction; Tukey HSD test $p > 0.05$ in all cases). As in the 2013 survey, we found variation in publication count was not significantly associated with participants' ratings of their workplace climates (SI S4 Fig; one-way ANOVA $p = 0.8$) or by STEM field (SI S5 Fig; one-way ANOVA $p = 0.21$), but there was a strong, positive association between time since the publication of participants' first peer-reviewed paper and the total number of papers they had published (Fig. 2F; product-moment correlation on log-transformed data = 0.76, $p < 10^{-6}$).

293 An association between publication count and disclosure could arise because disclosure
294 facilitates productivity — if disclosure reduces job-related stress and increases workplace
295 satisfaction. The same association could also arise because productivity facilitates disclosure —
296 if more productive individuals feel more secure in taking the risks associated with disclosure. In
297 the latter case, we might expect disclosing queer participants to have *higher* publication rates
298 than straight participants, rather than matching them (Fig. 2A,B). Nevertheless, to more fully
299 understand the causal direction of the association between publication count and disclosure, we
300 also examined time since first publication for different identity groupings within academic career
301 stages (i.e., job position within the academic career progression from graduate student to full
302 professor). If queer participants are more likely to disclose their queer identity when they feel
303 secure as a result of career accomplishment, we might expect them to show evidence of faster
304 academic career advancement. That is, within a given academic career stage, the time elapsed
305 since first publication by queer disclosing participants would be shorter than for both cisgender-
306 straight and queer nondisclosing participants. However, we found no significant difference in
307 time since first publication among identity groups (straight, LGBQA disclosing sexual
308 orientation, and LGBQA nondisclosing) within academic ranks (SI Figure S6; Tukey HSD $p >$
309 0.05 for all comparisons within career stage). This lack of differences in the timing of career
310 advancement suggests that the underlying cause of the association between disclosure and
311 publication rates is more likely the cost of nondisclosure to LGBTQA-identified individuals, as
312 discussed above, rather than disclosure becoming available to more productive LGBTQA-
313 identified individuals.
314 Sexual orientation, gender identity, gender modality, and gender expression are distinct
315 components of identity, and they interact in complex ways (see Methods discussion of our

316 classifications based on participants' self-descriptions). To ascertain which of these factors
317 showing significant association with variation in publication count in the 2016 survey
318 contributed most strongly, we therefore used a model comparison approach. We fitted linear
319 models using additive and interacting combinations of time since first publication (log-
320 transformed), disclosure of sexual orientation, disclosure of gender identity or transgender status,
321 gender expression, sexual orientation, gender identity, and gender modality to log-transformed
322 publication counts, and compared model fit in terms of corrected Akaike Information Criterion
323 (AICc; [48]) scores (Table 1). The best-fit model explained variation in publication count with
324 additive effects of disclosure of sexual orientation and time since first publication, and an
325 interaction between the two (adjusted $R^2 = 0.59$, AICc = 1379.9); a model predicting publication
326 count with the interacting effects of disclosure of sexual orientation and time had ΔAICc = 3.9,
327 indicating worse fit; all other models had ΔAICc $\geq$ 6.8, indicating substantially worse fit
328 (Table 1).

329

330 **Table 1.** Variation explained and model fit for linear models predicting log-transformed
331 publication counts with elements of queer identity and disclosure.
332

Model[a]	df	Adj. R^2	AICc	ΔAICc
D : time	7	0.58	1383.8	3.9
D + time	5	0.58	1394.4	14.4
DOri : time	**19**	**0.59**	**1379.9**	**0.0**
DOri + time	11	0.58	1386.7	6.8
G : time	7	0.57	1424.5	44.6
G + time	5	0.57	1420.7	40.8
DGen : time	21	0.58	1417.6	37.7
DGen + time	12	0.58	1411.4	31.4
GE : time	7	0.58	1402.2	22.3
GE + time	5	0.58	1405.5	25.6
GIO : time	13	0.58	1394.8	14.9
GIO + time	8	0.58	1394.1	14.2
GIM : time	13	0.58	1409.0	29.1
GIM + time	8	0.58	1406.1	26.1

D	10	0.05	2799.2	1419.3
DOri	4	0.06	2807.6	1427.7
G	11	0.06	2871.6	1491.7
DGen	4	0.02	2889.1	1509.2
GE	4	0.04	2871.2	1491.3
GIO	7	0.02	2833.0	1453.1
GIM	7	0.02	2869.2	1489.3
time	3	0.57	1420.0	40.1

Predictor variables are: disclosure of sexual orientation (D, grouping as in Fig. 2A), queer identity and disclosure of sexual orientation (DOri, grouping as in Fig. 2B), disclosure of gender identity (G), gender identity and cisgender or transgender status and disclosure of gender identity or cisgender or transgender status (DGen, groupings as in Fig. 2C), gender expression (GE, groupings as in Fig. 2D), gender identity and orientation (GIO), gender identity and gender modality (GIM), and time since first publication (time)

The best-fit model predicts publication counts that increase with time since first publication, with the greatest rate of publication accumulation predicted for straight men, followed by straight nonbinary individuals, GBQA men who disclosed their sexual orientations, LGBQA women who disclosed their sexual orientations, straight women; and then by LGBQA participants who did not disclose their sexual orientation (Fig. 3; Table 2). The model predicts that, 20 years after first beginning to publish peer-reviewed papers, straight men will have authored an average of 27 papers, disclosing queer men will have authored an average of 24 papers, and nondisclosing queer men will have authored 15. Among nonbinary scientists, straight individuals and disclosing LGBQA individuals are predicted to have authored about 24 papers in their first 20 years of publishing, while nondisclosing LGBQA individuals are predicted to have authored 13. Straight women are predicted to have authored about 17 papers in their first 20 years of publishing, while LGBQA disclosing women are predicted to have authored about 20 papers, and LGBQA nondisclosing women are predicted to have authored about 13.

Table 2. Parameter estimates for the best-fit model (Table 1).

Coefficient for	Estimate	Std. error	t-value	P(|T| > |t|)
(intercept)	-0.033	0.04972	-0.664	0.50699
Straight nonbinary	-0.18836	0.15437	-1.22	0.22255
Straight women	0.02958	0.0631	0.469	0.63923
Queer men, nondisclosing	0.026	0.07075	0.367	0.71332
Queer men, disclosing	-0.06596	0.07077	-0.932	0.35147
Queer nonbinary, nondisclosing	-0.04296	0.07604	-0.565	0.57217
Queer nonbinary, disclosing	-0.0846	0.1	-0.846	0.3977
Queer women, nondisclosing	-0.03311	0.06322	-0.524	0.60051
Queer women, disclosing	-0.07352	0.08025	-0.916	0.35974
Time since first publication	1.10436	0.05301	20.832	$< 10^{-6}$
Straight nonbinary × time	0.10394	0.17001	0.611	0.54104
Straight women × time	-0.172	0.069	-2.493	0.01276
Queer men, nondisclosing × time	-0.21694	0.0859	-2.526	0.01164
Queer men, disclosing × time	0.02016	0.07896	0.255	0.79855
Queer nonbinary, nondisclosing × time	-0.19714	0.09775	-2.017	0.04387
Queer nonbinary, disclosing × time	0.02615	0.1124	0.233	0.81609
Queer women, nondisclosing × time	-0.21438	0.07564	-2.834	0.00464
Queer women, disclosing × time	-0.04379	0.0907	-0.483	0.62927

Fig. 3. Predicted relationship between publication count and time since first publication for different LGBTQA identity/disclosure categories. From the best-fit model explaining publication count in the 2016 survey data (Tables 1,2). Color-coding of prediction lines follows Fig. 1B.

Discussion

Longitudinal, observational, and survey-based studies have begun to delineate a pattern of systematic disparities in STEM careers between minoritized sexual and gender identities and straight, binary, cisgender identities [37,49], similar to disparities seen between women and men,

366 or between people of color and white individuals [34,36,50–52]. LGB-identified individuals are
367 less likely than their straight peers to persist in STEM undergraduate majors [49,53], and they
368 are significantly underrepresented in STEM careers [37]; moreover, LGBT individuals working
369 in STEM are more likely to report negative workplace experiences than non-LGBT colleagues
370 [52]. Open expression or nondisclosure of LGBTQA identities in professional contexts provides
371 a window into the underlying causes of these disparities since, on the one hand, nondisclosure is
372 generally recognized as a source of stress and job dissatisfaction [20,21], and on the other hand,
373 LGBTQA individuals who describe their workplaces as having welcoming climates are more
374 likely to disclose their identities at work [1,47]. The data we present here identify a concrete
375 productivity effect associated with disclosure or nondisclosure, and suggest how gender identity
376 and expression may intersect with this effect.

377 In examining responses to the 2013 and 2016 Queer in STEM surveys, we find support
378 for our hypotheses that (1) nondisclosure of queer identity is associated with reduced
379 productivity in LGBTQA-identified scientists, that (2) productivity differences are better
380 explained by nondisclosure reducing productivity than by productivity facilitating disclosure,
381 and that (3) disclosure of gender identity and transgender status are not associated with
382 productivity differences in the same way as disclosure of sexual orientation. Overall, these
383 results are consistent with the belief that open expression of queer identities in the workplace
384 promotes greater productivity [8,26,27,29], and align with prior work showing the stressful
385 impacts of nondisclosure [20,23,25,26] and its effects on feelings about colleagues and
386 employers [8,27]. Our 2016 survey also finds lower publication rates for cisgender straight
387 women, consistent with prior work documenting a productivity cost attributable to the systematic
388 disadvantages women face in academic and scientific careers [31,34,36,50] — and the

productivity costs we find for nondisclosing LGBQA survey participants are comparable to the reductions found for cisgender straight women (Fig. 3).

Our 2016 survey finds reductions in productivity reported by participants whose self-described gender expression is feminine or nonconforming to the gender binary (Fig. 2D), which expands on our understanding of previously documented gender bias in STEM careers [34,36,50]. It also aligns with a possibility suggested by longitudinal and observational evidence that gay and bisexual men are less likely to persist in STEM undergraduate majors and less likely to be employed in STEM fields than straight men, while lesbian and bisexual women do not show reduced persistence or STEM employment rates relative to straight women [37,49]. Although superficially suggesting contradictory outcomes for men and women who are sexual minorities, both of these observations are consistent with a broader pattern of privileging masculinity in STEM [47]. Our findings of reduced publication rates for women with masculine gender expression would also align with this pattern (Fig. 2E), though this effect is not significant after correction for multiple testing.

Our data enriches understandings of gender-normative "heteroprofessionalism", and its impact on workplace productivity and career advancement [29,31,47]. Because our 2016 survey treats openness about gender identity and cisgender or transgender status separately from openness about sexual orientation, we can see that the effect of disclosing a minority gender identity or transgender status may not neatly parallel the effect of disclosing a minority sexual orientation — though our survey design prevents us from clearly differentiating effects of gender modality and gender identity. This finding reflects the complexity of intersections among gender identity, gender modality, gender expression, and sexual orientation. One key way in which transgender identity can differ from minority sexual orientations is that transgender individuals

412 who present as their true gender without disclosing transgender modality ("passing" or "going
413 stealth", in the terminology used by some members of the community) would not be expected to
414 experience the dissonance or stress associated with nondisclosure of sexual orientation for
415 cisgender gay men or cisgender lesbians — rather, this form of nondisclosure can represent
416 social acceptance of a trans individual's true gender identity [54]. In contrast, disclosing
417 transgender identity directly confronts cisgender-heterosexist norms, and may create greater
418 stress or tension with colleagues and coworkers. We posit that this may explain why disclosure
419 of gender identity or transgender status is not associated with a significant increase in publication
420 count for nonbinary or transgender participants (Fig. 2C), even as feminine or nonconforming
421 gender expression was associated with significant differences in publication counts for cisgender
422 participants (Fig. 2D, E). This highlights the importance of considering gender expression,
423 gender identity, and gender modality relative to cultural expectations in a particular context,
424 especially for interrogating the experiences of transgender, nonbinary, and gender
425 nonconforming individuals.

426 While a positive relationship between productivity and disclosure of queer identity is
427 consistent with the longstanding hypothesis that nondisclosure reduces productivity, in principle
428 it could also be consistent with the alternative hypothesis that more accomplished individuals are
429 more likely to feel secure enough to disclose minority identity and accept the attendant risks.
430 However, the patterns in responses to our 2016 survey are, on balance, more consistent with the
431 former hypothesis than the latter. First, if productivity enabled disclosure, we would expect that
432 LGBQA participants who disclose their sexual orientation would have higher publication rates
433 than straight participants as well as exceeding the publication rate of nondisclosing LGBQA
434 participants; instead, we see that disclosing LGBQA participants have publication rates similar to

straight participants (Fig 2A, B), suggesting that disclosing LGBQA participants are not unusually productive in comparison to their broader peer group. Second, if productivity enabled disclosure, we would expect to see that disclosing LGBQA participants achieve particular academic career stages more rapidly than their peers; but there is no difference in the time since first publication among disclosing LGBQA participants, nondisclosing LGBTA participants, and straight participants of the same career rank (SI Fig S6). Taken together, these patterns are consistent with nondisclosure decreasing publication productivity, rather than LGBQA individuals waiting to disclose until they have achieved exceptional levels of productivity or job security relative to their peers. Methods such as cohort studies that track the productivity of LGBTQA-identified individuals and compare it to their choices of disclosure or nondisclosure over time would more directly address the causal relationship be, though recruiting long-term study participants who do not disclose queer identity in the workplace would likely be a substantial challenge.

We note that differences in publication rates seen in our survey results may not be exclusively attributable to disadvantages imposed by biases against queer identities or women in STEM, but may also reflect differing commitments to forms of scholarship beyond publication of peer-reviewed research articles. Members of minoritized groups in faculty positions may be called upon for more service and mentoring work as a result of their minoritized identities, but they may also put greater priority on that work as a result of their own experiences [35,36,55,56]. Reducing disparities in retention and representation of LGBTQA-identified people in STEM careers may therefore require a broader understanding of how scholarly contributions and impact are evaluated [34].

457 We also note that our survey data capture conditions at two relatively narrow points in
458 time (mid-2013, the second half of 2016) in a decade when the broader legal and social
459 environment for LGBTQA-identifying individuals shifted dramatically in the United States, the
460 region in which the overwhelming majority of survey participants lived — and that changes to
461 these conditions are ongoing [10–12]. The publication records reported by survey participants,
462 however, represent longer individual histories of experience, shaped by conditions pre-dating
463 major legal victories for employment nondiscrimination protections, and we believe there is
464 value in documenting those experiences. Moreover, formal legal protections are far from
465 synonymous with acceptance and security in the interpersonal interactions of an individual's
466 workplace experience. A recognized legal right to sue for wrongful termination does not
467 necessarily reduce tension with coworkers, or other subtle forms of discrimination [6], and, as
468 has been well documented in the cases of other legally protected minoritized identities, it does
469 not eliminate disparities in career outcomes [36,50,57]. These considerations mean that we have
470 every reason to think the phenomena we see in surveys taken in 2013 and 2016 continue to
471 operate in 2022; and indeed studies conducted more since the first publication of results from our
472 2013 survey [1] have generally replicated or elaborated on evidence of disadvantages for
473 LGBTQA-identified individuals in STEM career paths [49,51,58].
474 Future research on queer identities in STEM and other workplaces would benefit from
475 designs such as cohort studies and qualitative approaches that can directly address the diversity
476 of personal experiences and reasons for disclosure or nondisclosure at the individual level. Our
477 anonymous survey data necessarily provide only a view of broad patterns resulting from data
478 collection and aggregation into simplified categories of identity and experience. Nevertheless,
479 the patterns observable with this data align in striking ways with personal experiences recounted

in smaller settings, and with predictions arising from psychological studies of nondisclosure. The observation that open expression of queer identity in the workplace is associated with accomplishment has implications for the quality and value of scientific careers beyond the experiences of sexual and gender-identity minorities — the same pattern may extend to other "invisible" minoritized or stigmatized statuses and identities, such as chronic disease, disabilities, or mental health conditions. We further predict that the effects of sexual and gender minority identities, and their disclosure, will interact with other minoritized identities such as race, ethnicity, and disability status, and we would suggest that focused examination of these interactions is an important direction for future work. We argue that the relationship that we find between productivity and expression of LGBTQA identities reinforces the need for greater support, at all levels of training and advancement, to make STEM careers accessible and sustainable for participants across the full range of human diversity.

Materials and Methods

Data collection

2013 survey

The 2013 Queer in STEM survey is described in detail in ref [1]. In brief, from 7 May to 31 July 2013, we asked LGBTQA-identified professionals in STEM fields to answer a 58-item online survey. The University of Minnesota Institutional Review Board approved the study in February 2013, and approved a change in protocol to allow for a larger-than-expected number of participants in June 2013 (project ID 1302E28561). We recruited participants via online social networks, e-mail listservs, and online forums for relevant STEM and LGBTQA organizations.

Because of the potentially sensitive nature of the survey's topics — particularly asking about identities that individuals may not disclose in professional settings — the survey was conducted anonymously. Informed consent was ensured with a disclosure statement presented to participants prior to beginning the survey, which clearly stated that completing the survey in full would be understood to mean participants consented to the use of their response in our analysis, and that participants could exit the survey at any time prior to final submission to have their responses up to that point excluded from analysis. As our focal population was individuals working in STEM careers, we did not recruit minor participants, and deleted survey responses from any participant indicating they were younger than 18 years old.

We asked participants to provide the number of peer-reviewed papers they had published; in a handful of cases in which a participant gave a range (e.g., "more than 20") we used the lowest value in that range. We asked participants to rate their disclosure of LGBTQ identity to colleagues in the same department or division of their institution, and to colleagues in other departments or divisions, on a numeric scale from 0 ("I am not out to anyone in this group") to 5 ("As far as I'm aware, everyone in this group could know"). These ratings were strongly and positively correlated (correlation = 0.88, $P < 0.001$), with participants most likely to describe themselves as either entirely out to colleagues (averaged openness ratings of 5) or not out at all (averaged ratings of 0; ref [1]). For the present analysis, we classified participants as "nondisclosing" if their averaged rating was 2.5 or lower, and "disclosing" otherwise.

We asked participants to describe their gender identity and cisgender or transgender status, and classified the gender identity of cisgender and transgender participants as "men" or "women" if they used only these terms to describe themselves, or "nonbinary" if they used terms indicating identities beyond the man/woman binary, including "non-binary", "gender-queer",

525 "gender fluid", "gender non-conforming", or "agender". Finally, we asked participants to
526 describe their current job position or career stage. A total of 633 participants from the 2013
527 survey who indicated current employment in academic STEM fields and who reported having
528 published at least one peer-reviewed paper are included in the present analysis (S1 Table).

529 **2016 survey**

530 The 2016 Queer in STEM survey mirrored that of the 2013 Queer in STEM survey was
531 developed as a follow-up to the 2013 study, and its planning and execution followed that prior
532 work in many respects. Notable changes included separate treatment of participants' disclosure
533 of their sexual orientation and their gender identities or modalities, and the addition of responses
534 from non-LGBTQA participants. The California State University Los Angeles Institutional
535 Review Board approved the proposed survey items and study design in 2016, (project ID
536 844053-1). We recruited participants to take the new online survey via online social networks
537 (Twitter and Facebook), e-mail listservs for STEM professional organizations, and online forums
538 for relevant STEM and LGBTQA organizations. Following a "snowball sampling" approach, we
539 also asked participants in the survey to pass the survey link along to colleagues or other
540 acquaintances who could also participate. The online survey was open from 20 June to 25
541 December 2016. As in the 2013 survey, participation in the 2016 survey was anonymous.
542 Informed consent was ensured with a disclosure statement presented to participants prior to
543 beginning the survey, which clearly stated that completing the survey in full would be
544 understood to mean participants consented to the use of their response in our analysis, and that
545 participants could exit the survey at any time prior to final submission to have their responses up
546 to that point excluded from analysis. As our focal population was individuals working in STEM

careers, we did not recruit minor participants, and deleted survey responses from any participant indicating they were younger than 18 years old.

To address productivity, we included an item asking for the time elapsed since participants' first publication as a control for seniority ("How many years have passed since publication of your first peer-reviewed publication?"; full item text is provided in the Supplementary Methods) in addition to an item asking for their publication count ("To date, how many manuscripts have you published in peer-reviewed journals?").

We asked participants to describe their sexual orientation, their gender identity and cisgender or transgender status, and their gender expression, providing common terms as well as an open-ended text entry for each (see Supplementary Methods). For analysis, we classified participants as "LGBQA" (for women or nonbinary participants) or "GBQA" (for men) if they described their sexual orientation using any terms besides "straight". We classified cisgender and transgender participants' gender identities as "men" or "women" if they used those terms to describe themselves, and as "nonbinary" if they selected or wrote in identities beyond the man/woman binary, including "non-binary", "gender-queer", "gender fluid", "gender non-conforming", or "agender". Finally, we classified cisgender and transgender participants' gender expressions as "masculine" or "feminine" if they used only those terms to describe their gender expression, and as "nonconforming" if they selected "androgynous" or wrote in other terms to describe their gender expression.

We then asked participants to rate their disclosure of their sexual orientation and their gender identity and cisgender or transgender status to different groups in professional academic contexts: "Professors at your institution", "Lab assistants and institutional staff", "Advisees and/or graduate students", and "Undergraduate students" on a six-point scale from "As far as I

570 am aware, no one in this group knows" to "As far as I am aware, everyone in this group knows",
571 with an option to select "N/A" if participants did not interact with any particular group in a
572 professional context. Following the approach used in the 2013 study [1] we converted disclosure
573 scores for sexual orientation and for gender identity and cisgender or transgender status to
574 numeric values from 1 to 6, and averaged them across groups, then classified queer participants
575 as "nondisclosing" if their averaged rating was at or below the midpoint value of 3, and
576 "disclosing" otherwise.

577 We filtered 3,884 full survey responses to remove 201 participants from the dataset who
578 were undergraduate students (97 respondents), non-STEM workers (85 respondents), or under 20
579 years of age (19 respondents). Of the remaining 3,683 participants, 2,455 (67%) indicated a
580 current position within academia and 1,228 (33%) within industry. Of the same 3,683 total
581 participants, 2,465 (67%) identified in some way under the LGBTQA umbrella and 1,218
582 respondents (33%) identified as cisgender straight (i.e. non-LGBTQA). We also removed from
583 analysis four participants in the 2016 survey reporting exceptionally high publication counts (>
584 300 papers).

585 We further filtered to include only participants who described themselves as working in
586 an academic setting and having published at least one peer-reviewed paper, resulting in a total of
587 1,745 participant responses in the present analysis (SI Table S1); of these, 1,116 identified as
588 LGBTQA and 629 as straight and cisgender (SI S2 Table). LGBTQA participants did not
589 significantly differ from straight cisgender participants in their distribution among major STEM
590 fields (SI S2 Table; $X^2_{df=8}$ test, $p = 0.17$). However, the two groups did differ significantly in
591 their distribution among academic position types (SI S2 Table; $X^2_{df=9}$ test, $p < 10^{-6}$), and in their
592 time since first publication, with LGBTQA participants having spent less time publishing (SI S2

593 Table; mean ± SE = 6.2 ± 0.2 years since first publication for LGBTQA participants, 8.6 ± 0.4
594 years for straight cisgender participants; Wilcoxon sign-rank test $p < 10^{-6}$).
595

596 ## Statistical analyses

597 We conducted all analysis in R, version 4.0 [59]. We restricted analysis to survey
598 participants who identified themselves as currently working in academic settings and who
599 reported at least one peer-reviewed publication. We tested for differences in log-transformed
600 publication count among groupings based on queer identities, disclosure statuses, gender
601 expression, STEM fields, and academic positions using two-sided t-tests (via the `t.test()`
602 function) when testing for differences between two groups, or one- or two-way ANOVA (the
603 `aov()` function) when testing among more than two groups. When ANOVA testing found
604 significant among-grouping differences in publication count, we identified significant differences
605 in pairwise comparisons among groupings using Tukey honest significant difference testing for
606 nonzero between-group differences, using the `TukeyHSD()` function. In the 2016 data, we
607 tested for a relationship between publication count and time since first publication using the
608 `cor.test()` function to estimate the product-moment correlation between the base-10
609 logarithm of publication count and the base-10 logarithm of years since first publication plus 1.
610 We compared explanatory power for all variables showing significant associations to publication
611 count by fitting linear models to log-transformed publication counts with the `lm()` function,
612 then comparing the fit of alternative models in terms of corrected Akaike information criterion
613 (AICc) scores [48], calculated using the `AICc()` function provided in the `MuMIn` package [60].
614

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Supporting information

Supplementary Methods

S1 Fig. Publication counts and workplace climate in the 2013 survey. Publication counts stratified by participants’ ratings of their workplace’s climate for LGBTQA individuals, in the

2013 survey. Differences among workplace ratings are nonsignificant (one-way ANOVA on log-transformed data, $p = 0.11$).

S2 Fig. Publication counts and STEM fields in the 2013 survey. Publication counts stratified by participants' STEM fields, in the 2013 survey. Differences among fields are nonsignificant (one-way ANOVA on log-transformed data, $p = 0.13$).

S3 Fig. Job position and disclosure of queer identity in the 2013 survey. Participants in the 2013 survey, binned by academic position description (in rough order of seniority, bottom to top) and whether they disclosed LGBTQA identity in professional settings (purple) or did not disclose queer identity (yellow). Disclosure is unevenly distributed among position types (chi-squared test, $p < 10^{-5}$), with larger proportions of participants who did not disclose queer identities in less-senior positions.

S4 Fig. Publication counts and workplace climate in the 2016 survey. Differences among workplace ratings are nonsignificant (one-way ANOVA on log-transformed data, $p = 0.21$).

S5 Fig. Publication counts and STEM fields in the 2016 survey. Differences among workplace ratings are nonsignificant (one-way ANOVA on log-transformed data, $p = 0.80$).

S6 Fig. Time since first publication by academic career stage in the 2016 survey. Time since first publication stratified by identity, disclosure status, and academic career stage, for 1,424 participants at these career stages in the 2016 survey. Differences among identity and disclosure groupings within each career stage are nonsignificant (Tukey HSD, $p > 0.05$ in all cases).

Table S1. Summary of the 2013 and 2016 survey data.

S2 Table. Comparison of LGBTQA and cisgender straight participants in the 2016 survey

S1 File. Supplementary Methods.