

SOCIAL SCIENCES

Gender and retention patterns among U.S. faculty

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Women remain underrepresented among faculty in nearly all academic fields. Using a census of 245,270 tenure-track and tenured professors at United States–based PhD-granting departments, we show that women leave academia overall at higher rates than men at every career age, in large part because of strongly gendered attrition at lower-prestige institutions, in non-STEM fields, and among tenured faculty. A large-scale survey of the same faculty indicates that the reasons faculty leave are gendered, even for institutions, fields, and career ages in which retention rates are not. Women are more likely than men to feel pushed from their jobs and less likely to feel pulled toward better opportunities, and women leave or consider leaving because of workplace climate more often than work-life balance. These results quantify the systemic nature of gendered faculty retention; contextualize its relationship with career age, institutional prestige, and field; and highlight the importance of understanding the gendered reasons for attrition rather than focusing on rates alone.

INTRODUCTION

In most academic fields, women remain underrepresented among tenure-track and tenured faculty compared to the U.S. population (1) despite their steadily rising share of doctoral degrees (2). This pattern is often explained by a so-called "leaky pipeline" effect (3), in which women leave faculty jobs at higher rates than men at each career stage, leading to a progressive increase of men's faculty representation. Because faculty careers often span decades, increases in women's representation among new faculty can take many years to change the gender composition of a field via population turnover (1, 4), and even then, progress may be attenuated to varying degrees by gender disparities in faculty retention. A deeper quantitative understanding of gendered retention patterns among faculty would shed light on the social processes that drive systemic underrepresentation, inform policies to improve retention and mitigate the asymmetric loss of talent and concomitant scientific discoveries (5), and illuminate the more complex gendered dynamics of women's participation in general labor markets (6–10).

Despite broad interest in measuring, explaining, and mitigating gendered attrition in faculty careers, the practical complexity of studying the phenomenon across fields, institutions, and career age has impeded a full accounting of its magnitude and variation because identifying faculty who have left academia is a difficult task. Past studies have often focused on assistant professors, using employment data collected before 2010 that tends to be cross-institution but field-specific, almost entirely in science, technology, engineering, mathematics, and medicine (STEM) fields, and focused on higher-prestige institutions (11–19). Several studies compare STEM fields and non-STEM fields across institutions but focus on gendered promotion, not gendered retention (20–22), or rely on turnover intentions instead of actual attrition events (23, 24). The emphasis on early-career women, especially in higher-prestige

and STEM departments, has provided a deep, but narrow understanding of gendered retention: Women assistant professors in STEM make up just 15% of all tenure-track and tenured women at PhD-granting institutions in the U.S. (1), and those at higher-prestige institutions comprise an even smaller share. Even so, the weight of evidence over many years has spurred policies aimed at closing gender gaps in faculty retention and promotion. However, the effect of these policies in changing gendered retention rates across career stages, fields, and institutions remains unclear.

Similar limitations apply to the large body of survey studies and ethnographies that provide detailed explanations for gendered retention patterns (25–36), many of which are cross-field but institution-specific and mostly focus on higher-prestige institutions. Studies report different specific conclusions, depending on the field, institution, and cross section in time. Most commonly, studies identify gendered difficulties maintaining work-life balance (13, 26–28, 31–33, 35) and the unequal and gendered impact of parenthood (9, 37, 38) as the primary reasons women faculty leave academia. Other common explanations include work-related reasons, e.g., difficulties obtaining research funding (28) and lower salaries (12, 13, 27, 29, 30), as well as workplace climates that are "chilly" toward women (32), including gender-based harassment (27, 36) and overly competitive environments (28, 32, 34). Such studies yield valuable insight into the reasons for gendered faculty attrition, but both they and studies using employment data provide limited insight into how attrition rates and reasons vary across fields, institutions, or career age.

Here, we conduct a systematic investigation of faculty retention across the entire U.S. university system by combining two comprehensive datasets: an employment census of 245,270 tenure-track or tenured faculty who were active in their roles over the 10-year period of 2011–2020 (section S1), across 111 academic fields (table S1) at 391 PhD-granting institutions (1), spanning all domains of academia, including STEM, the social sciences, the humanities, health, business, and education, along with 10,071 responses to a broad survey about faculty attrition (section S2) of former and current tenure-track and tenured professors from within the larger census dataset. Respondents also reported their self-identified gender, race, and parenthood status.

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Our faculty employment census is the result of substantial data cleaning and processing on a larger U.S. faculty census obtained under a data use agreement with the Academic Analytics Research Center (AARC). We included only tenure-track and tenured faculty in our study, specifically those with titles of “assistant professor,” “associate professor,” or “full professor.” We categorically excluded faculty at medical schools because attrition from medical schools can depend on additional factors; faculty in related fields with positions outside medical schools are still included, e.g., faculty in departments such as applied physiology, cell and cancer biology, or environmental health, housed in nonmedical colleges within universities. We annotated these employment records with academic fields and domains of study, gender labels, and a measure of institutional prestige introduced in previous work (1). We organized departmental affiliations into 111 academic fields (e.g., chemistry and sociology) and nine high-level groupings of related fields that we call domains (e.g., natural sciences and social sciences), which we further group into STEM and non-STEM domains (section S1C and table S1). We note that a distinction between STEM and non-STEM fields is socially constructed and somewhat fluid. Nevertheless, STEM versus non-STEM remains a salient division of academic fields and facilitates comparisons with other studies. We annotated each department within an academic domain with a unique institutional prestige score derived from a field-specific faculty hiring network (1). For each faculty record, we assigned a gender label algorithmically using cultural associations between names and the binary categories of man and woman (39), resulting in binary gender annotations for 98.1% of faculty in our dataset (section S1C). We note that the assumption of a gender binary is a critical limitation of algorithmic gender labeling. Details of additional data preparation and quality checks, including an extensive manual audit, along with details of our algorithmic approach for identifying attrition events, can be found in section S1. These measures provide confidence in the integrity of the employment records (section S1D and fig. S1) and validate the absence of gendered errors that would distort or bias our estimates of gendered attrition (section S1E and tables S2 and S3).

Using this employment census, we show that, across U.S. tenure-track academia as a whole, women are more likely to leave their faculty jobs and less likely to be promoted than men at every career age and stage. At the same time, we find that gendered attrition rates vary in magnitude across faculty ranks, academic fields, and institutions, and that the gendered attrition observed for academia as a whole is driven substantially by attrition of tenured faculty, faculty in non-STEM domains, and faculty at lower-prestige institutions. Notably, we find that the gender gap in retention closes for assistant professors after adjusting for academic field. However, even for ranks, domains, and institutions where retention rates are similar for women and men, our survey results show that the reasons that faculty leave remain gendered, implying that faculty attrition can be gendered even if the overall rate of attrition is not. In particular, women are more likely to feel pushed out of their jobs and less likely to feel pulled toward better jobs than men. Although faculty associate these pushes with work-life balance issues early in their career, mid- and late-career faculty highlight issues related to workplace climate, particularly aspects of climate that are not easily measurable, such as a lack of belonging (versus overt gender discrimination).

RESULTS

Retention rates

Analyzing the employment records of 245,270 U.S. tenure-track and tenured professors over 10 years, we identify all instances where any of these faculty left our dataset (attrition) or changed faculty rank (promotion; section S1D). In this way, we are measuring “all-cause” attrition, which is inclusive of all types of and reasons for an attrition event, regardless of whether it was related to not receiving tenure, moving to a nonfaculty job, retirement, or moving to an academic position outside our dataset of U.S. PhD-granting institutions. Hereafter, our use of the term attrition refers to all-cause attrition, unless otherwise noted. Instances where faculty changed their affiliation within our set of 391 institutions were not considered attrition events in this analysis.

As a function of career age, defined as years since receiving their doctorate, we find that the average annual attrition risk for women faculty, across fields, exceeds men’s risk in every year of an academic career (Fig. 1A). This gap persists even as both curves exhibit a similar general pattern of rising through the early-career, pretenure years, falling in the mid-career, posttenure years, and then rising again beyond roughly 20 years post-PhD as faculty begin to retire. Individual domains do exhibit some variability around these central tendencies (Fig. 1A, inset) but most closely follow the general trend. Similarly, we find that men’s rates for promotions to associate and full professor peak 1 and 2 years earlier than women’s, respectively (Fig. 1B), even as the distributions substantially overlap. We note that gendered use of tenure-clock stops, e.g., due to unequal use of parental leave benefits (38), may explain some of the difference in timing for promotion to associate professor.

Such large gendered differences in attrition over the course of a career imply that even faculty cohorts hired at gender parity will become progressively less diverse, on average, as they age. For instance, holding these empirical rates steady over time (Fig. 1A), a hypothetical cohort of new faculty hired at parity would fall to 48.2% women after 15 years, 45.4% after 25 years, and 40.6% after 35 years. In this cohort, it would take 21 years for half of men to leave their academic positions compared to only 17.5 years for women. By implicating attrition, these projections undermine claims that a lack of gender diversity among senior faculty is entirely due to slow demographic turnover and long career lengths among faculty (4).

Differences in overall rates of attrition and promotion may be explained by variation in other factors, such as faculty age, country of training or productivity, and only incidentally correlate with gender. Using logistic regression with adjustments for faculty career age, doctoral degree year, employer prestige, and whether a professor was trained in the U.S. or abroad, we find that across academia and at every level of seniority, covariate-adjusted attrition rates were significantly higher and promotion rates were lower for women. Specifically, women were 6, 10, and 19% more likely to leave than men each year as assistant, associate, and full professors, respectively (Fig. 2A, top row) and 7 and 12% less likely to be promoted than men each year to associate and full professor, respectively (Fig. 2A, top row; attrition from assistant: odds ratio (OR) = 1.07, $z = 4.4$, $N = 376,366$, $P < 0.001$; attrition from associate: OR = 1.22, $z = 11.8$, $N = 459,541$, $P < 0.001$; attrition from full: OR = 1.36, $z = 21.6$, $N = 602,777$, $P < 0.001$; promotion to associate: OR = 0.92, $z = -7.7$, $N = 356,642$, $P < 0.001$; promotion to full: OR =

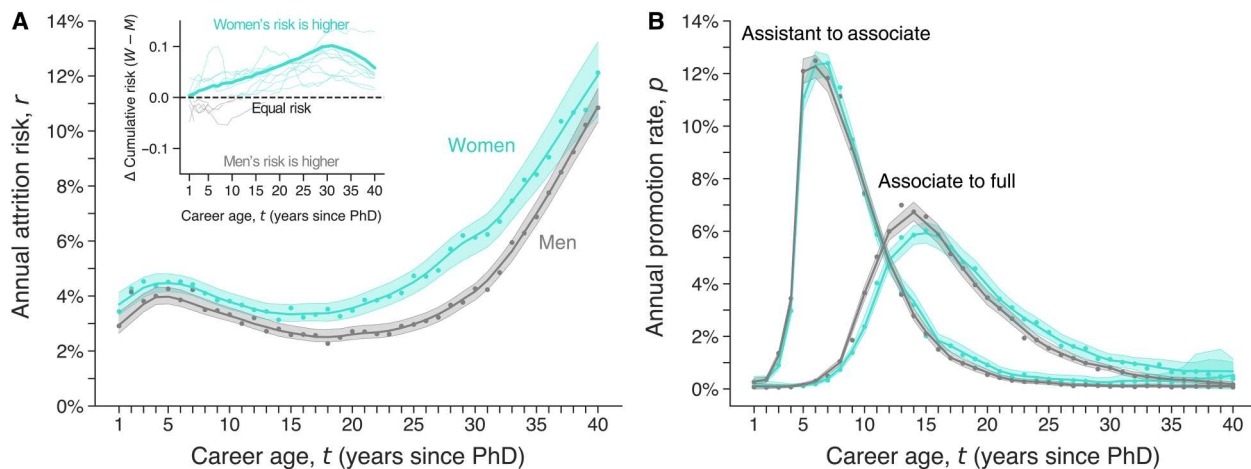


Fig. 1. Gendered retention rates. (A) Annual all-cause attrition risk (see text) and (B) annual promotion rate to associate and to full professor, both as a function of career age (years since PhD); envelopes indicate a 95% confidence interval under a bootstrap on faculty careers (1000 bootstrap iterations). Inset: Differential cumulative attrition risk across academia (heavy line) and by academic domain (lighter lines).

0.88, $z = -11.2$, $N = 444,354$, $P < 0.001$; section S3A and tables S10 and S11). We note that because our dataset is a census, error bars can be interpreted as reflecting variability primarily from the underlying mechanisms rather than uncertainty in the odds that we observe. These analyses do not identify causal relationships between covariates (e.g., gender, institutional prestige, etc.) and faculty outcomes, which would likely require additional data to untangle.

By adjusting for employer prestige, our estimates account for a general proxy of mean productivity (annual publication rates) at the field-institutional level (40). Explicitly adjusting for individual-level productivity measures, however, would make it difficult to interpret the results in the context of all-cause attrition because individual publication rates are known to (i) causally vary with research group size, which tends to be larger at more prestigious institutions (41), (ii) vary nonlinearly over time, depending on an academic's career stage, and are highly diverse, sometimes, but not always, following the canonical "rapid rise, gradual decline" trajectory of productivity (42), and (iii) are influenced by a number of individual factors that are correlated with gender, such as parenthood (38), gendered differences in work-time expectations (43), and the size and composition of research collaboration networks (44). Additional details on the implications of these complexities for accounting for the role of productivity in gendered attrition can be found in section S3D.

Covariate-adjusted gendered attrition rates are not distributed evenly across career stages, domains, and fields. In all nine domains, with the exception of engineering, we find some significant pattern of retention or promotion advantage for men, but the magnitude and career stage at which those patterns appear varies, with 63% of faculty being in a domain and at a career stage in which women are statistically significantly more likely to leave than men. Moreover, we find that overall gendered attrition rates are primarily driven by attrition among tenured women and especially by full professors (Fig. 2A, top row). In addition, we find that these disparities are larger in non-STEM domains than in STEM domains at every rank (Fig. 2A and tables S12 to S14).

There are no STEM domains in which women assistant professors are more likely to leave than men over this time period, after adjusting for covariates. In engineering, in particular, men are more likely to leave than women, even though engineering has the greatest overrepresentation of men of any domain (77% men assistant professors). In contrast, the largest gendered attrition gap is for full professors in non-STEM domains: Women full professors in every non-STEM domain are more likely to leave than men. These findings indicate that gendered attrition among faculty must be driven by more than career-family incongruences for women, which are expected to be greater early in a faculty career (22), and yet we observe large effects for late-career women faculty and only modest, if any, effects among early-career women.

Individual fields can have different gender ratios and turnover patterns. Accounting for these differences provides useful information about how overall retention patterns disaggregate across academic fields by comparing overall rates with field-adjusted ones. By adding fixed effects to the model for each of the 111 academic fields, we find that a portion of the overall gender gap in academia can be attributed to such cross-field differences, e.g., because women are more likely than men to be faculty in high-turnover fields (section S3C1, fig. S3, and table S20). Adjusting for these cross-field differences eliminates the gender gap in retention for assistant professors, implying that a man and a woman in the same department, both assistant professors, and with similar PhD training, are equally likely to leave their faculty jobs. However, gendered differences in retention remain (at reduced effect sizes) for associate and full professors, suggesting that both field-level norms and individual departmental environments influence gendered retention patterns among tenured professors.

We also find that gendered attrition varies substantially between higher- and lower-prestige institutions (Fig. 2, B to D). In general, faculty from lower-prestige institutions are significantly more likely to leave academia than faculty from higher-prestige institutions, a pattern that increases with career age: A professor at the least prestigious institution is 2.5, 3.0, and 3.3 times more likely to leave at the assistant, associate, and full professor rank, respectively, than a faculty member at the most prestigious institution (assistant: OR

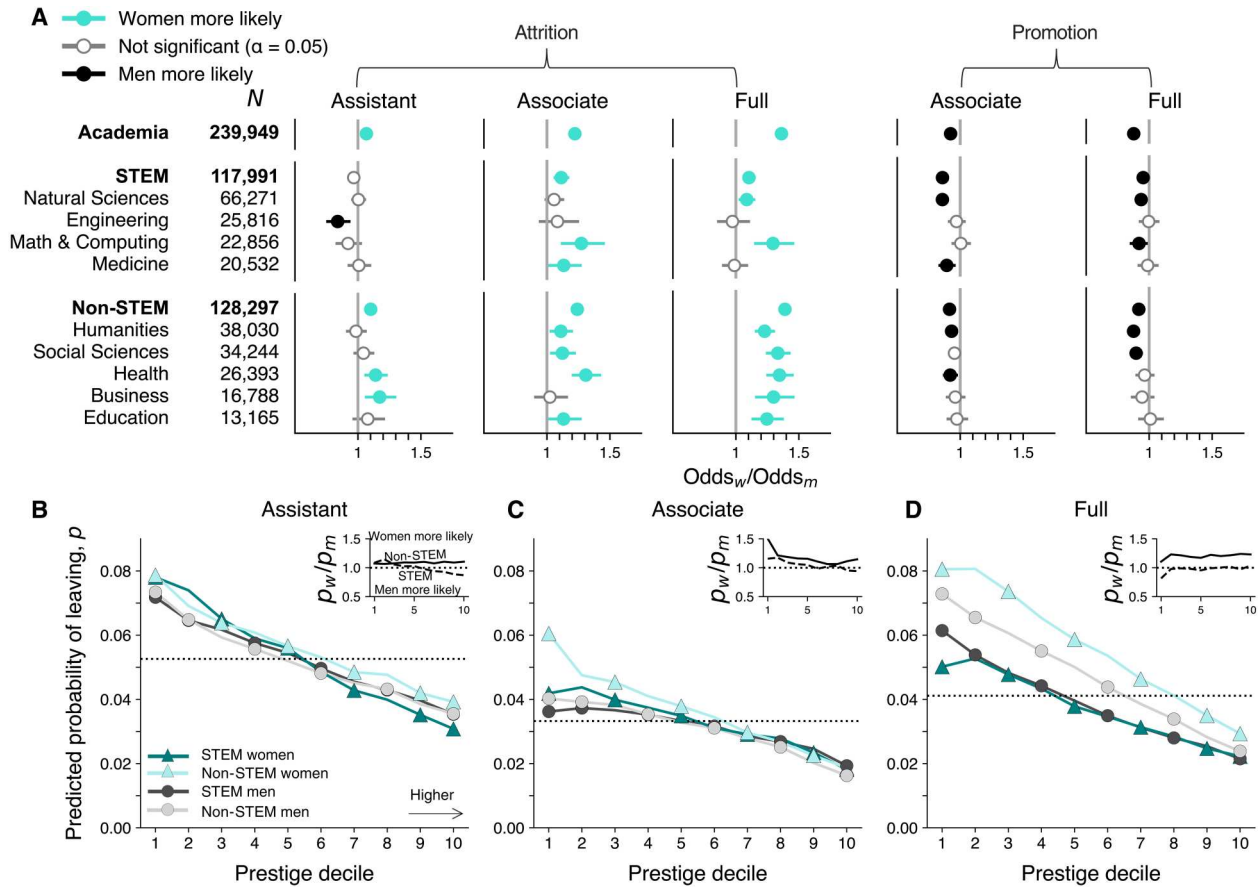


Fig. 2. Retention rates by domain and prestige. (A) Time-averaged attrition and promotion ORs, split by academic rank, controlling for career length, employer prestige, and doctoral degree (domestic versus international), with 95% confidence intervals and statistical significance assessed via a z test. Because our dataset is a census, error bars can be interpreted as reflecting variability primarily from the underlying mechanisms rather than uncertainty in the odds that we observe. Individuals with appointments in multiple domains (12.8% of faculty) are counted in each domain. Contrasting Fig. 1, here, faculty without PhD country or employer prestige information were excluded. (B to D) Average predicted probability of leaving, split by academic rank and across prestige decile, with 10 representing the most prestigious employer, and 1 the least prestigious employer, for women and men in STEM versus non-STEM domains. Dotted horizontal lines represent the average probability of leaving for all professors at that rank. Inset: $p_{\text{women}}/p_{\text{men}}$ across prestige decile, for STEM (dashed) versus non-STEM (solid) domains.

= 2.01, $z = -19.3$, $N = 376,366$, $P < 0.001$; Fig. 2B; associate: OR = 2.22, $z = -17.4$, $N = 459,541$, $P < 0.001$; Fig. 2C; full: OR = 4.05, $z = -41.9$, $N = 602,777$, $P < 0.001$; Fig. 2D; section S3A and table S10). This effect is stronger for women, who are even more likely to leave lower-prestige institutions than men ($P = 0.03$, $P < 0.001$, and $P = 0.01$ for assistant, associate, and full professors, respectively; section S3B and table S17). We note that we find smooth interpolations between higher- and lower-prestige institutions, such that even faculty at midranked institutions exhibit substantially higher attrition rates than faculty at the most elite institutions.

These results demonstrate that, after adjusting for a number of covariates, gendered attrition is driven more strongly by tenured women, women in non-STEM fields, and women at lower-prestige institutions, with women at the intersection of these groups experiencing the highest rates of attrition. Fully 89% of women full professors in non-STEM domains are at institutions with higher-than-average risk of leaving compared to only 23% of women full professors in STEM domains (Fig. 2D).

Reasons for leaving

Independent of whether attrition rates are gendered, the rates themselves say little about whether the underlying reasons for why women and men leave a faculty position are gendered. Women and men may leave their jobs at different rates for similar reasons or at similar rates for different reasons. To elucidate the individual-level reasons underlying faculty attrition, we surveyed former faculty (those identified as having left academia not to retire, $N = 433$ or to retire, $N = 954$) and current faculty (those who held positions at the end of our observation window, $N = 7195$). Because changing faculty positions is an important, but separate, aspect of retention, we also surveyed faculty who switched institutions but excluded these faculty from the main analyses ($N = 1489$; see section S4C for separate analyses; figs. S6 to S8 and table S28). We then assessed (i) the positive and negative factors that led faculty to leave or consider leaving their positions and (ii) which specific reasons did or would contribute to their decision to leave a faculty job, grouped into three broad categories based on prior work: professional reasons, work-life balance, and workplace climate.

The decision to leave a faculty position can be complex, and faculty may seek to balance negatives associated with the current position with potential positives associated with a future position. Theories of stress suggest that faculty will use one of two main coping mechanisms in response to workplace stressors: approach or avoidance, orienting toward or away from threat, respectively (45, 46). From this perspective, gendered attrition is driven by gendered differences in the degree to which faculty feel “pushed” to leave their current position or “pulled” to a more attractive opportunity (47). Respondents were asked if they left or would leave academia because they were unhappy, stressed, or otherwise unsatisfied with their position (a push); because they were drawn to, excited by, or otherwise attracted to a new position (a pull); or both.

At all career ages, current and former faculty report feeling pushed out of their jobs (Fig. 3A) at higher rates than they report feeling pulled toward better jobs (Fig. 3B), but those reports vary substantially across different groups of faculty (section S4A and table S23). These rates tend to increase with career age, such that the oldest cohort of faculty (with a career age between 30 and 40 years since PhD) has 2.9× higher odds of feeling pushed out of their position than the youngest cohort (with a career age between 1 and 10 years since PhD; $z = 8.5$, $N = 4919$, $P < 0.001$; table S24). However, we also find that greater fractions of women in both STEM and non-STEM domains report feeling pushed out (Fig. 3A), and lower fractions felt pulled toward better jobs than do men (Fig. 3B). Women’s odds of feeling pushed were 44% higher than men’s ($z = 6.0$, $N = 4919$, $P < 0.001$; Fig. 3C and table S24), and women’s odds of feeling pulled were 39% lower than men’s ($z = -7.0$, $N = 4919$, $P < 0.001$; Fig. 3D and table S24), making gender the strongest predictor of feeling pushed or pulled among

the factors of gender, domain (STEM versus non-STEM), or institutional prestige, adjusting for career age (scaled as decades since PhD), in a multiple regression analysis of all covariates. Faculty who said they would not consider leaving ($N = 1623$) or that they only wanted to retire ($N = 401$) were excluded from this analysis.

While faculty in non-STEM domains are at a higher risk of attrition than faculty in STEM domains (Fig. 2), faculty in STEM and non-STEM domains were equally likely to report feeling pushed out ($P = 0.6$; Fig. 3C), but faculty in STEM domains had 16% lower odds of feeling pulled toward better positions ($z = -2.5$, $N = 4919$, $P = 0.01$; Fig. 3D and table S24). We also note some variability among the domains in feeling pushed or pulled (table S27).

Similarly, we find that prestige both mitigates attrition rates in general and appears to influence the underlying reasons that faculty leave academia. Faculty at the least prestigious institution had 27% higher odds of reporting feeling pushed and 48% lower odds of reporting feeling pulled than faculty at the most prestigious institution (push: $z = -2.7$, $N = 4919$, $P = 0.007$; Fig. 3C; pull: $z = 2.9$, $N = 4919$, $P = 0.01$; Fig. 3D and table S24). Just as women full professors in non-STEM domains at lower-prestige institutions were the group of women at highest risk for attrition, they are also the group of women most likely to report feeling pushed out of their faculty positions (60% higher odds than faculty in all other groups; $z = 2.5$, $N = 4919$, $P = 0.01$).

While faculty of color face unique pressures in academia (48), we do not find that women or men of color were more or less likely to report feeling pushed or pulled than white women or men, respectively (table S26). This remains the case whether we limit our analysis to faculty who identified as Black, Indigenous, or Hispanic ($N = 186$ women and 255 men) or when we also include Asian faculty (N

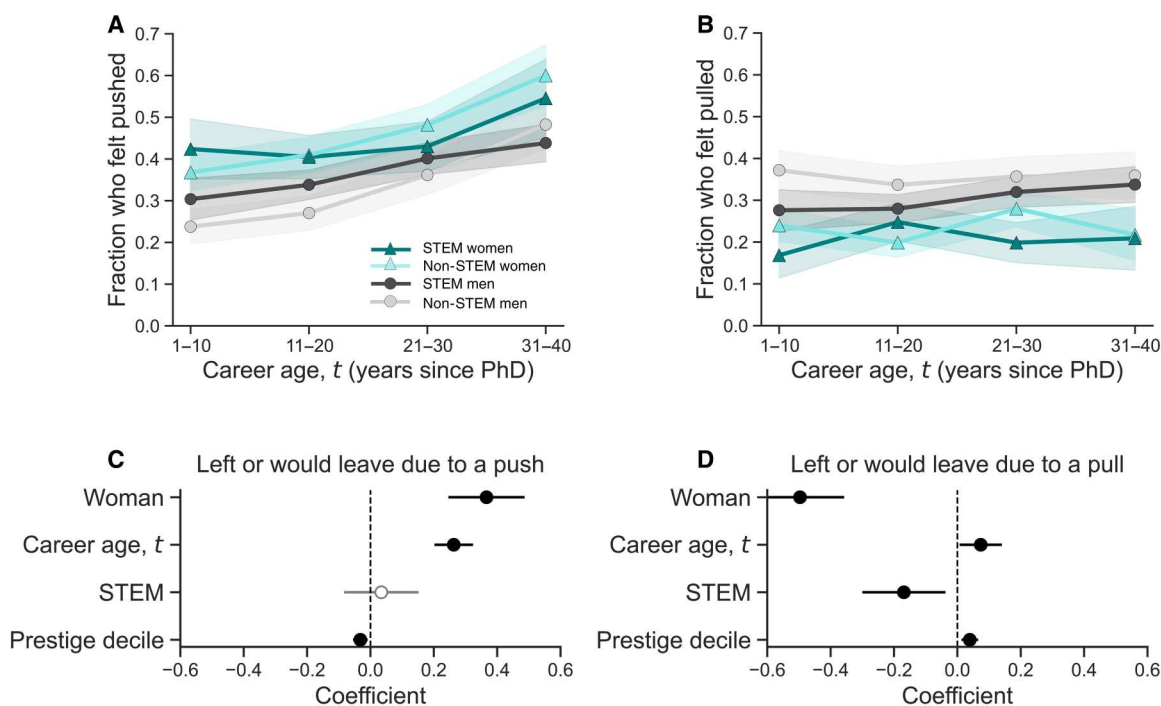


Fig. 3. Pushes and pulls. Fraction of women and men in STEM versus non-STEM domains across career age who left or would leave their position because (A) they felt pushed out of their position or (B) they felt pulled toward a better position. Envelopes indicate a 95% confidence interval using a normal approximation to a binomial proportion. Coefficients from logistic regression models predicting whether someone felt (C) pushed or (D) pulled.

= 155 women and 234 men). The relatively small sample sizes of faculty self-identifying as part of these groups precludes a sufficiently well-powered statistical comparison.

Past work has shown that parents of young children often seek to balance a larger set of constraints than nonparents (22). Our data show that faculty parents of children under 18 ($N = 2132$) had 45% higher odds of feeling pulled ($z = 4.3$, $N = 4919$, $P < 0.001$) than nonparents (table S25).

Because reports of feeling pushed differ significantly between women and men, the reasons underpinning those experiences may also differ. To elucidate these reasons, our survey asked former faculty about a variety of faculty-specific stressors, under a "person-environment fit" theoretical framework, which characterizes the perceived alignment of a person's social characteristics (e.g., their gender) with those of their professional environment and which encompasses a number of individual theories as special cases (49–52). Under this framework, feeling pushed out is caused by the (perceived) lack of fit or congruence of an individual and their professional environment (53–59), and a stressor is a stimulus or event (60) that a person considers challenging or threatening to their well-being (61). Norms and procedures in academic environments can implicitly reflect the historical overrepresentation of men, and gender schemas in workplaces more broadly can lead men to be overrated and women to be underrated (10), making these environments incongruent for women, which may then contribute to their decisions to leave academia.

We asked faculty who left academia ($N = 433$) or retired ($N = 954$) which specific factors contributed to that decision, grouped into three broad categories: professional reasons, work-life balance, and workplace climate. These categories of stressors (25–38, 40, 62–76) align with existing theoretical constructs (section S2B and table S8). Professional reasons are stressors related to the job itself (e.g., obtaining research funding, salary, and poor administrative support). Work-life balance includes stressors such as caring responsibilities or the number of hours worked per week. Workplace climate includes stressors related to the way an academic feels around their colleagues, including dysfunctional departmental culture or leadership, harassment, or feeling like they do not belong or fit in their department.

Women who left academia most often reported doing so because of factors related to workplace climate (43% of all reasons women gave), while men most often reported leaving because of professional reasons (40% of all reasons men gave; Fig. 4A and section S4B). Workplace climate was also an influential factor for men, encompassing 34% of all reasons men gave (Fig. 4A). Faculty retirees follow a similar pattern (Fig. 4A).

Both men and women who left academia report work-life balance reasons at statistically indistinguishable rates ($26 \pm 5.1\%$ and $29 \pm 5.6\%$ of all reasons men and women gave, respectively; Fig. 4A). This lack of difference contrasts much of the existing literature on gendered retention in academia and the workforce in general, which concludes that work-life balance is the primary reason that women leave their jobs, but not men (13, 26–28, 31–33, 35, 37, 38), but with exceptions (77). However, no category made up more than half of the reasons women report, and all three categories represent factors women report as contributing to a decision to leave. In addition, while some reasons within these broad categories were commonly cited by both women and men, others had substantial gender differences; for instance, while 29%

of women who left academia reported doing so in part due to discrimination, only 10% of men did (fig. S8).

The reasons current faculty would leave their jobs follow roughly similar patterns as the reasons reported by former faculty who did leave their jobs. Instead of seeking to identify exact reasons why current faculty would choose to leave their position, we asked current faculty how much of an impact each broad category of reasons (professional, work-life balance, or workplace climate) would have in a hypothetical decision to leave their job (section S4B). Across categories and career age, we find the largest gender gap in leaving for reasons related to workplace climate. Moreover, women in both STEM and non-STEM domains cite this category of reasons at similar rates, and workplace climate was the primary category for tenured women in both groups (Fig. 4D). The relatively small sample sizes of former faculty precluded a sufficiently well-powered statistical comparison between STEM and non-STEM domains, but we do observe some variations between current faculty in STEM domains versus non-STEM domains. For example, professional reasons were more commonly cited by STEM faculty than by non-STEM faculty, especially by women in STEM domains in their mid-career or later (Fig. 4B). We note, however, that in the early career, women in both STEM and non-STEM domains cited work-life balance as often as climate, a pattern consistent with past literature on early-career, pretenure faculty (25–36).

Together, these results illustrate the necessity of contextualizing employment-based measurements of gendered attrition (Figs. 1 and 2) by examining the underlying reasons that faculty leave their jobs. In particular, these results highlight the critical and career-spanning role of workplace climate, which has received comparatively less attention in the past than issues associated with work-life balance in the early career, and reveal that although early-career women and men in STEM leave at equal rates, early-career women leave for different reasons than men, reasons that are more often associated with feeling pushed out, rather than pulled to new opportunities.

DISCUSSION

A broad consensus exists that attrition is gendered for tenured and tenure-track faculty. Our census-level data, cross-field comparative analysis, and social survey of U.S. faculty reaffirms this consensus at a high level through broad quantitative evidence, and substantially extends and deepens it by expanding evidence for some past findings, revealing substantial variability by career age, institution, and field, and identifying the importance of understanding the gendered reasons for attrition, not just the rates.

On average, across fields and institutions, women leave their faculty jobs at consistently higher rates than men at every career age (Fig. 1A). This pattern persists for tenured women even comparing women to men at the same career age and stage, from the same PhD cohort, who work at the same institution and in the same field. However, gendered attrition is not a uniform phenomenon, with rates that vary across fields (Fig. 2A), which tend to be higher among more senior faculty, higher for faculty at lower-prestige institutions, and higher in non-STEM fields (Fig. 2, B to D). In roughly 37% of domains and career stages, women are statistically no more likely than men to leave an academic faculty position, and in particular, adjusting for field-level differences, the gender difference disappears for assistant professors in the same field.

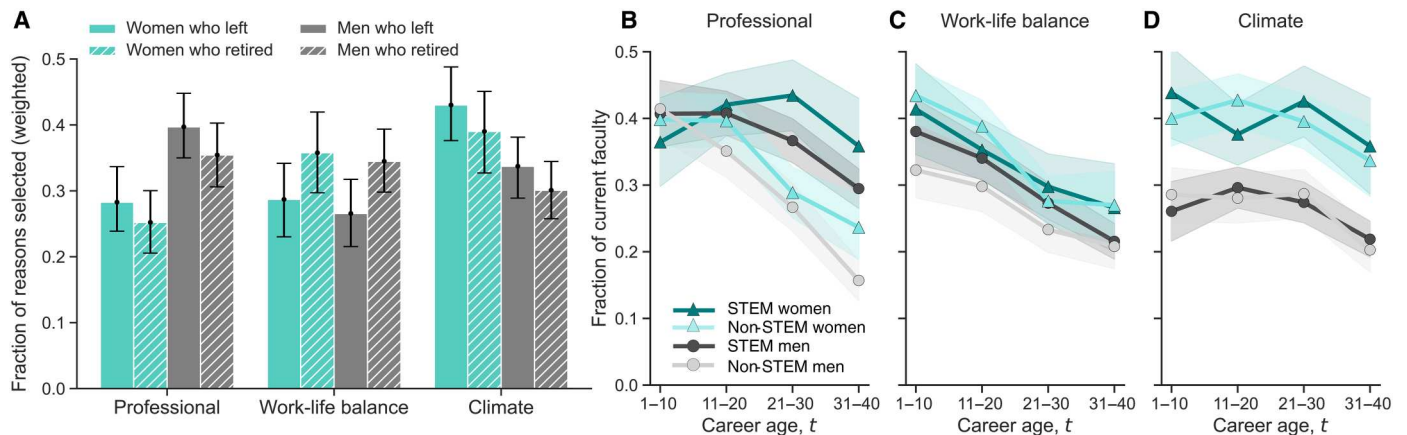


Fig. 4. Reasons for leaving academia. (A) Fraction of reasons from each category selected by faculty who left academia or retired, weighted by both the number of reasons in that category and the number of total reasons the respondent selected (section S4B). We note that these comparisons focus on the relative importance of each category, and fractions for each group sum to 1, meaning that while the fraction of women who left academia because of work-life balance reasons may be greater than the fraction of women who retired because of work-life balance reasons, workplace climate made up a larger fraction of the reasons women left academia than work-life balance. 95% confidence intervals are shown under a bootstrap of faculty (1000 bootstrap iterations). (B to D) Fraction of women and men current faculty members in STEM versus non-STEM domains who reported each category as having a “major impact” in their potential decision to leave. Respondents could list multiple categories as a major impact, so fractions do not sum to 1. Envelopes indicate a 95% confidence interval using a normal approximation to a binomial proportion.

Understanding the causes of this variability, as well as whether it persists over time, is a critical direction of future work. Of particular importance will be understanding the substantial gender disparity between attrition for tenured versus pretenure faculty, in STEM versus non-STEM domains, as well as the mechanisms by which greater institutional prestige appears to mitigate gendered disparities in attrition rates.

The broad scale of our analysis and the variability that we find suggests a simple explanation for why past studies of gendered attrition have sometimes reached conflicting conclusions: They have tended to focus on (i) higher-prestige institutions and STEM fields, which have less gendered attrition rates than lower-prestige institutions and non-STEM fields, and on (ii) assistant professors, which have smaller (or no) gendered attrition rates than do tenured women. Furthermore, although past work has identified work-life balance factors as a dominant reason for gendered faculty attrition (13, 26–28, 31–33, 35, 37, 38), our broad analysis shows that this explanation applies primarily to assistant professors, who we find tend to particularly emphasize work-life balance factors (Fig. 4C and fig. S7), e.g., due to the gendered and unequal impact of parenthood (37, 38). In contrast with past work, we find that tenured women, who make up 61% of all women in permanent faculty positions, more strongly emphasize factors related to workplace climate. This emphasis on climate factors for driving attrition is strongest among senior women faculty, and it appears regardless of whether a field is STEM or non-STEM (Fig. 4D); in contrast, men tend to emphasize professional factors (Fig. 4B), and they cite climate factors at substantially lower rates than women.

These findings illustrate that individual faculty often experience academia differently depending on their gender, career stage, field, and institution. Leaving an academic job, hypothetically or in practice, can encompass a complicated mix of pushes and pulls, and our results show that as their career progresses, all faculty are more likely to report feeling pushed out of their jobs (Fig. 3A). However, independent of career age, women are substantially more likely to report

feeling pushed out, while men are more likely to report feeling pulled toward an attractive opportunity when they leave (Fig. 3, A and B). Furthermore, although women and men faculty report overlapping reasons for leaving a faculty position, gendered experiences of workplace climate represent a distinguishing reason for women’s higher attrition rates, at every career age. Hence, even in fields or at institutions where rates of attrition may not be particularly gendered, our findings show that the reasons faculty leave their positions can remain strongly gendered, and efforts to address gendered attrition should focus on those gendered reasons rather than gendered rates.

Under the person-environment fit theoretical framework (53–59), our findings indicate that gender incongruences are real, substantial, and universal in academia, even in disciplines with larger proportions of women, such as health and education. The dominant incongruences for women arise from workplace climate, including dysfunctional leadership, feelings of not belonging to the department or university, harassment and discrimination. As a result, workplace climate is a major reason that women faculty leave academia, at every career age, but especially for tenured women (Fig. 4 and fig. S7). Such incongruences highlight the way departmental and institutional policies and norms tend to reflect, accommodate, and reinforce the traditional overrepresentation of white men from more privileged backgrounds, thereby driving gendered attrition over a career and inducing a substantial, asymmetric loss of overall talent and scholarship (5).

Both structural and individual workplace climate factors can push women out of their positions. For example, in computer science, women are more likely to be employed in subfields that are relatively less prestigious (78), and such systemic devaluation can influence a faculty member’s sense of belonging, leading them to consider leaving their position. In contrast to past work’s investigation of work-life balance factors, climate factors that influence a professor’s sense of belonging or decision to leave academia can be more difficult to measure, even when they relate to specific

events such as gender discrimination (e.g., in hiring, publishing, grant applications, and tenure decisions). Developing new instruments with external validity for measuring workplace climate and gendered exclusionary effects in academia represents an important direction for future work. Related work on gendered participation in labor markets more broadly reveals many parallels with our findings for gendered retention among faculty (6–10), suggesting that common factors affect women across many occupations. Achieving gender equity will require substantial and sustained efforts across institutions to change workplace climate, and likely more experimentation to evaluate effective and sustainable interventions in this direction.

Our statistical analysis of attrition rates spans specifically the years 2011–2020. Hence, our estimates of career age variations, e.g., in attrition rates or reasons for leaving, represent mixtures over different faculty cohorts, and relatively older or younger cohorts in this period may have had different faculty experiences. Hence, the estimated career-age functions (Fig. 1A) may evolve with time, e.g., as younger cohorts age into more senior positions. Future studies will need to assess the stability of these functions. In particular, our employment data concluded in 2020 and thus does not include the social effects of the coronavirus disease of 2019 (COVID-19) pandemic on faculty, which had disproportionate effects on women (79). However, our survey was conducted during 2021, and responses may include the effects of the pandemic. Similarly, our analyses included only tenured and tenure-track faculty at U.S. PhD-granting institutions, and our results say little about gendered attrition among other faculty groups, including research or teaching-track faculty, adjuncts, or nonfaculty groups like postdoctoral researchers or graduate students. Expanding analyses like those carried out here to include gendered attrition of postdocs in particular is an important direction for future work (section S3C4), as many factors may lead women to differentially leave academia before seeking or starting a tenure-track faculty job. In addition, our analysis focused entirely on retention, and assessing the relative importance of hiring versus retention in the long-term representation of women in different fields is a critical direction of future work.

Because women of color have been historically excluded from academic positions, academia remains disproportionately white, and our analyses statistically reflect the experiences of white women. The accuracy of name-based algorithms for estimating race and/or ethnicity labels is uneven across groups (80), and the unreliability of these tools precludes estimating the attrition of women of color compared to white women, by field and institution. For similar reasons, we were unable to estimate the attrition of gender-diverse faculty, such as nonbinary faculty. Both are critical directions for future work.

Our survey relied on retrospective accounts of reasons for leaving from faculty respondents who left academia or who retired, which may be less accurate than accounts of current faculty members. In addition, reasons for leaving a faculty position are often complex, and our survey categories provide only coarse, theoretically grounded categories that are unlikely to capture all aspects of such events. For example, the line between feeling pushed out and pulled toward a better opportunity may be conceptually blurry. At the same time, our respondents nevertheless could (and often did) select both push and pull reasons, suggesting that they had, and exercised, the option to draw a distinction between

the two concepts based on their own perceptions. The push/pull survey question was a coarse and concise way for respondents to summarize their experiences (81, 82), but a more robust measure of push/pull could be obtained by using separate scales for each of the constructs listed in the summary question.

As a group, our respondent population differed slightly from the census population of faculty that we surveyed. Specifically, full professors were somewhat overrepresented, assistant professors were somewhat underrepresented, and professors from higher-prestige institutions were somewhat overrepresented (table S7). To mitigate these representation differences by rank, we split analyses by career age where possible, with the exception of the analysis of former faculty, where we split by those who left versus retired because of small sample sizes (Fig. 4). Where possible, we added institutional prestige as an adjustment (Fig. 3, C and D); results without these adjustments are weighted slightly more by the experiences of professors at higher-prestige institutions. As with any survey, there remain potentially unobservable differences between our respondents and the set of faculty that we emailed, which may have influenced our survey results. For instance, if faculty who are also parents were less likely to respond because of work-life balance issues, our respondent group may undersample faculty who emphasize work-life balance over climate.

Our results may also underestimate the true extent of reasons for leaving academia because of the retrospective design of the survey. System justification theory (83, 84) suggests that people can be motivated to defend, justify, or merely soften criticism of an existing social system, particularly if they belong to a marginalized social group (85). In this way, faculty of all genders may be more inclined to criticize academia for workplace climate reasons, which are experienced more individually and are less visible as attributes of the academic system as a whole. As a result, women faculty in our sample may underemphasize the true extent of professional or work-life balance reasons in their decisions to leave. On the other hand, system justification theory may also imply that women faculty may underestimate the true extent of gender-based exclusion, harassment, or discrimination that they experienced and hence underemphasize the true extent of workplace climate factors in their decisions to leave. Future surveys should include explicit and implicit measures of support for the overall system and of perceived personal responsibility for one's success to adjust for these individual-level effects.

A key conclusion of our study is that attrition rates of faculty alone do not provide a sufficiently clear view of gendered attrition in academia because they ultimately shed little light on whether women leave for similar or different reasons than men. As we found with assistant professors in STEM, there may be no measurable difference in the rates that women and men leave academia, but the reasons they leave nevertheless remain strongly gendered, and gendered in highly inequitable ways. Hence, it would be a mistake to observe equal rates of attrition in any case and then conclude that gender equity had been achieved. This fact highlights a more general need for studies of gender in academia to go beyond simply measuring gendered disparities of different kinds, e.g., in attrition, hiring, publication rates, citations, awards, etc., and to instead focus both on identifying the underlying social mechanisms or biases and on whether they are gendered (86).

For faculty attrition, policies intended to increase gender equity, i.e., to improve retention rates for women, should focus on the

reasons, not the rates, which we show vary by career age, field, and institution, and in which workplace climate plays a broad role. For instance, efforts over the past several decades around work-life balance, e.g., paid parental leave, flexible hours, on-campus child-care, and dual-career solutions, may have reduced the disparate impact of work-life balance on women faculty, particularly in the early career. These efforts to improve work-life balance for early-career women in STEM, especially at higher-prestige, highly-resourced institutions, may explain, in part, the smaller gender gap that we observe in our data for these subpopulations. Fundamentally, different kinds of interventions will likely be required to mitigate the gendered impact of workplace climate factors, such as dysfunctional departmental leadership, competition, and a lack of belonging. While workplace climate factors include many types of potentially measurable gender discrimination (such as in formal evaluations like tenure decisions), they also include more subtle exclusionary social behaviors that may be difficult to individually identify but nevertheless accumulate to influence a faculty member's willingness to stay in their job (70). Developing new instruments that can reliably measure these climate factors and their effects at scale, including those that are subtly exclusionary, represents an important direction for future work in this area.

Our work does much to resolve the apparent tensions and contradictions of the extensive literature on gender and retention in academia. For instance, several studies report no gendered differences in all-cause attrition for most STEM fields (11, 17, 33), but they also focused on assistant professors at land-grant or highly research-intensive universities, which tend to be more prestigious. We, too, observe attenuated differences for assistant professors in STEM (Fig. 2A) and for professors at higher-prestige institutions (Fig. 2, B to D). Similarly, several studies report significant gendered attrition (12, 14, 16), and they included tenured faculty, which we also observe in our data (Fig. 2A). Our census-level analysis of tenured and tenure-track faculty across the U.S. university system reveals that past studies are mostly consistent with the larger, more varied picture that our study reveals, given the particular study populations each used.

Variation in gendered attrition rates across different academic domains and fields opens a comparative approach by which to untangle the multiple causes of gendered attrition and their evolution over time. Broad cross-field comparisons may enable more accurate estimates of the effects of demographic shifts on gendered attrition, e.g., from increasing representation via hiring versus specific retention policies or norms. Comparisons may also help elucidate attrition dynamics in domains like engineering, where early-career men leave at higher rates than early-career women. In such fields, different interventions may be needed depending on whether, for example, engineering's unusual early-career pattern is caused by gendered outside opportunities, by effective internal retention policies, or by selection bias from upstream effects, e.g., women leaving engineering before starting their faculty positions (87). Finally, research that identifies effective interventions that mitigate workplace climate-induced incongruences would provide tangible benefits to advancing women's equity in academia. We look forward to these and other studies.

MATERIALS AND METHODS

Administrative analysis

Our administrative data was obtained under a data use agreement with Academic Analytics Research Center, which we then cleaned, processed, and annotated to define annual attrition and promotion events for our analysis (section S1). We fit a separate logistic regression model (section S3) for each academic rank to the administrative dataset to model the probability p of faculty attrition (and separately, promotion) using faculty gender (0 = man and 1 = woman), career age (integer number of years since PhD), PhD year, PhD degree location (0 = non-U.S. degree and 1 = U.S. degree), and faculty employer prestige (scaled such that a 1 unit increase corresponds to a 1 decile increase up the prestige hierarchy, but note that each rank in the regression represents a unique institution; section S1A)

$$\text{logit}(p) = \beta_0 + \beta_1[\text{Women}] + \beta_2[\text{Career age}] + \beta_3[\text{PhD year}] \\ + \beta_4[\text{U.S. degree}] + \beta_5[\text{Prestige decile}]$$

Gendered ORs [$\exp(\beta_1)$] for academia as a whole are visualized in Fig. 2A (top row). We then ran additional subgroup analyses for STEM and non-STEM domains, separately, and each of the nine domains (Fig. 2A and section S3A). Finally, we used a second model, with the same covariates as the main model but with an interaction between prestige and gender, to allow attrition to vary across the prestige hierarchy differently for women and men (Fig. 2, B to D, and section S3B).

Survey analysis

Participants were identified from the administrative dataset. We selected 29 fields across all nine domains of study, chosen to obtain (i) a mix of men-dominated fields (e.g., mechanical engineering) and women-dominated fields (e.g., nursing), (ii) a mix of large fields (e.g., biology) and medium-sized fields (e.g., information science), excluding very small fields, and (iii) a mix of commonly studied fields (e.g., computer science) and less commonly studied fields (e.g., education). We attempted to obtain email addresses for all faculty using a combination of web scraping and an Amazon Mechanical Turk crowdsourcing task. This resulted in a frame of 73,049 current and former faculty, who we emailed survey invitations from July to September 2021. Our final response rate was 14.1% (section S2A), similar to that of other large-scale surveys of faculty (88, 89) and on the upper end of the response rate range for surveys of authors of scientific publications.

Survey questions were designed by conducting a literature review of past survey and interview studies of faculty retention and grouping the results of those studies into three themes (section S2, B and C). Participants were asked questions about how frequently they experienced stressors from each of the three categories, a total of 22 items (table S9). Former faculty were also asked, for each stressor, to check a box if that stressor contributed to their decision to leave their job, and current faculty were asked how much impact each broad category (professional, work-life balance, and climate) would have on a potential decision to leave their job ("No impact," "Minor impact," "Moderate impact," and "Major impact").

Human subjects research

Oversight of human subjects research was provided by the University of Colorado Institutional Review Board, protocol 21-0293, and informed consent was obtained from all participants.

Supplementary Materials

This PDF file includes:

Supplementary Materials

Figs. S1 to S8

Tables S1 to S28

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