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Rural exclusion from science and academia

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Abstract

Rural individuals are underrepresented in science at all levels. The disenfranchisement of rural people in science and research foments a cultural divide between rural America and the scientific community. Science can improve inclusion of rural individuals by removing barriers in academia that disfavor those from first-generation and low-socioeconomic backgrounds.

In the USA 60 million people, approximately 20% of the population, live in rural areas (US Census[i]). Seminal advances in microbiology have come from rural individuals. Examples include (i) Nobel Peace laureate Norman Borlaug, the 'Father of the Green Revolution', whose innovations in combating plant pathogens improved food stability for many nations; (ii) Alice Evans, who linked brucellosis to unpasteurized milk; (iii) William Hinton, who developed the first high-accuracy syphilis test; and (iv) Thomas Brock, who reported the Yellowstone hyperthermophile *Thermus aquaticus*. Despite these and other contributions, rural individuals are substantially underrepresented in the sciences (NCES[ii]). As early career microbiologists from rural backgrounds, we have observed how unequal access to science education inhibits rural Americans from becoming scientists and contributing to scientific research. Here, we discuss the need to change educational sorting mechanisms that disfavor rural students and consider how excluding rural individuals from science furthers a disconnect between rural America and the scientific community.

Drivers of rural educational inequity

Few data are available regarding rural individuals in science and research. For instance, only three studies have been conducted in North America examining how class and socioeconomic origin affect obtaining professorship, and none focused on rurality [1., 2., 3.]. The National Science Foundation, which conducts the Survey of Earned Doctorates (SED),

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Declaration of interests

There are no interests to declare.

Resources

[i] www.census.gov/library/publications/2016/acs/acsgeo-1.html

[xv] www.maryvillecollege.edu/academics/learn-by-experience/scots-science-scholars

[ii] https://nces.ed.gov/surveys/ruraled/students.asp?StudentType=6

[iii] https://nces.ed.gov/surveys/sass/tables/TFS1213_2014077_cf1n_002.asp

could provide valuable insights by reporting geographical workforce data. These data would inform the design and assessment of evidence-based approaches to retain rural students in STEM careers. There does exist a sizable body of literature on three factors known to inhibit academic success that are common in rural areas: (i) remoteness that limits access to educational resources, (ii) low parental educational attainment, and (iii) low socioeconomic status. We discuss these drivers of rural educational inequity in the following text.

As research careers most often require the completion of a doctoral degree, the early exit of rural students from the academic arena is an important issue underlying rural underrepresentation in science (Figure 1). Rural students enroll in college at 1.6-fold lower rates than urban peers (NCES[ii]). Other than personal choice, what factors may contribute to this disparity? Nationally aggregated data shows the high school graduation rate to be higher for rural students than urban students, and no major achievement gaps exist in standardized assessments [4,5]. However, concerning disparities emerge when data are disaggregated – for example, remoteness corresponds to decreasing access to Advanced Placement courses that prepare students for college [6]. One of the strongest predictors of attending college is proximity to a college campus, and most students attend college within a 50-mile radius of their home [7]. But many rural areas are 'education deserts' far from higher learning institutions, making access to postsecondary education personally and financially costly for rural individuals [7]. Additional barriers stemming from remoteness include the lack of reliable internet access, mental health resources, and experienced guidance counselors and teachers [8,9] (NCES[iii]).

Parental educational attainment is another established predictor of postsecondary outcomes and is substantially lower in rural communities [5]. Parental education influences whether children are encouraged to attend college and parental ability to assist children with success in academia [1,9]. First-generation students (no bachelor's degree held by either parent) are 15% less likely to complete a bachelor's degree within 6 years [10]. In rural areas, just 20% of people hold a bachelor's degree, 15% lower than in urban areas (USDA ERS[iv]). Evidence suggests that low parental educational attainment inhibits completion of graduate degrees and advancement to tenure-track faculty positions. Currently, first-generation students account for only 17% of newly awarded doctoral degrees (SED[v]), and tenure-track faculty in STEM fields are 50% more likely to have a parent with a graduate degree than the general population [1].

Low socioeconomic status (SES) is a central driver in rural educational inequity. Family income is a predictor of academic success and is lower on average for rural students [5]. Rural counties also bear the largest share of 'concentrated poverty', in which over 20% of a population is poor; 31% of rural counties have concentrated poverty, nearly double that of urban and suburban counties (Pew Research[vi]). Historically, low SES has been underappreciated for its potential to exclude people from academic spaces, but this is changing [11]. Earlier work on postsecondary outcomes among women found social class to

[iv] www.ers.usda.gov/topics/rural-economy-population/employment-education/rural-education
[v] https://ncses.nsf.gov/pubs/nsf21308/report
[vi] www.pewresearch.org/social-trends/2018/05/22/demographic-and-economic-trends-in-urban-suburban-and-rural-communities
[vii] www.prb.org/hispanicgains

be a more significant barrier than gender [2,3]. One longitudinal study found that low SES was largely responsible for lower postsecondary achievement among rural students [5].

Lastly, rural America is increasingly diverse in terms of race and ethnicity and is home to historically marginalized people. The majority of American Indians and Alaskan Natives reside in rural areas [12] (USDA ERS[iv]) and the rural Hispanic population has nearly doubled since 1990 (PRB[vii]). We do not provide adequate discussion on the important intersectionality of race and rurality here, and instead refer readers to more systematic studies of race and ethnicity in academia [13,14].

The impacts of educational inequalities on the science careers of rural individuals

Next, we consider how these disadvantages impinge upon the graduate and professional stages for rural individuals who have chosen to pursue careers in science (Figure 1). For those who attend college, rural students may opt for nearby institutions that are more affordable, smaller, and closer to familiar support structures (Illinois's Partnership for College Completion[viii]). While such institutions can provide an economical solution for low-SES rural students to obtain postsecondary science education, they commonly lack science graduate programs and have limited research opportunities. Additionally, undergraduate research experience is often obtained on an unpaid, volunteer basis, which may not be feasible for low-SES rural students who work to support themselves. Although rural students majoring in STEM disciplines may envision a career in science, many are first-generation and lack a parental model of success in academia [5]. Our personal observation is that these circumstances produce rural STEM-field graduates with a solid understanding of the curriculum but who may lack (i) research experience and (ii) knowledge of how to navigate the graduate program application process (Figure 1).

In the current structure of graduate program admittance, which strongly values prior research experience and institutional prestige, these differences in college experiences may predispose rural students to be viewed as less competitive applicants. Indeed, rural students are about threefold less represented than urban students in graduate and professional programs (Figure 1, NCES[ii]). We must consider the extent to which qualifications for graduate school admittance are based on implicit and explicit biases against low-income and working-class people, that is, classism, as well as other educational sorting mechanisms that favor those from high-SES backgrounds and educated families. The expenses of Graduate Record Examinations (GRE) testing and graduate school application fees unfairly burden rural students from low-SES backgrounds and limit the number of schools to which they can apply. This can be alleviated by providing (and advertising) need-based fee waivers or eliminating fees entirely. Rural students may have other noteworthy qualifications that can translate into success in graduate programs, such as knowledge of mechanics, familiarity with animal care, and nonacademic work experience that demonstrate work ethic

[viii] https://partnershipfcc.org/affordability-ruralstudents#RFootnote6
[ix] www.npr.org/sections/thetwo-way/2014/07/29/336364371/yall-keep-talking-lab-scratches-southern-accent-reduction-course

and professionalism. These experiences and skills should be considered alongside other acceptance criteria.

Classism remains a persistent limitation for rural individuals at the professional level. In 2014, Oak Ridge National Labs in Tennessee offered a course aimed at Southern accent reduction, advertising that the class would help participants 'be remembered for what you say, not how you say it'. (NPR[ix]). A collection of narratives captured in 'Where people like me don't belong', recounts how first-generation, rural, and low-income backgrounds are stigmatized in academia, such as implicit bias that low-SES communities are ignorant [11]. This bias and lack of common lived experiences can make it difficult to find community among academic colleagues. In general, professors from low-SES backgrounds are acutely aware of the challenges of class, whereas high-SES professors tend to discount the importance of class and view academia as an equalizer [11]. Evidence shows fewer than one-sixth of faculty are from low-SES backgrounds [11] (SED[x]), and about 90% of tenure-track faculty originate from urban areas [1].

Educational institutions and funding agencies have increasingly recognized the role of 'disadvantaged backgrounds' in the underrepresentation of individuals in science based on socioeconomic origin (Box 1). An important resource that can be used to support rural individuals in health-related research fields is the National Institutes of Health Diversity Supplement Program. Many NIH awards are eligible for this supplement, such as R00, R01, R21, and P01, which can be used to support any rural individual (defined by zip code) who is either first-generation and/or from a low-SES background [15]. An exceptional tool for visualizing disadvantaged backgrounds is Neighborhood Atlas[xi] which maps socioeconomic disadvantage at the neighborhood level across the US [16].

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Box 1

Mechanisms for improving rural representation in science

Exemplar rural science outreach programs

Early, no cost exposure of STEM opportunities for K-12 rural students:

Virtual interactions through Skype a Scientist[xii], Year-long pen pal through Letters to a Pre-Scientist[xiii]; and hands-on experiences through Roane State's Lab-in-a-Box[xiv].

College bridge programs that support those from disadvantaged backgrounds:

Maryville College Scots Science Scholars (S^3) program[xv]; and Milligan College rural outreach program[xvi].

Recommendations for academics

Professors and faculty:

1. Recognize that rural individuals are underrepresented in science, and many originate from low-SES and/or first-generation circumstances that qualify them as being from a disadvantaged background.
2. Apply for NIH diversity supplement funding to support individuals from disadvantaged backgrounds. These awards have an approximate success rate of 70%.
3. Identify ways to eliminate financial barriers for low-income students. Review financial costs associated with your program (e.g., application fees, moving expenses, average rent, and reimbursement policies).
4. Whenever possible, fund undergraduate research work to eliminate the reliance on volunteers, which biases opportunities toward high-SES individuals.
5. Give seminars on your research at small universities and colleges to erode information barriers.
6. Include considerations of rurality and disadvantaged backgrounds in departmental Diversity, Equity, and Inclusion committee meetings.

Graduate degree programs:

1. Include application questions that permit voluntary disclosure of background disadvantage along definitions already in use by NIH:
    - Ask whether parents/guardians obtained a bachelor's degree, as applicants may be unfamiliar with the term 'first-generation'.

[xiii] www.prescientist.org
[xiv] www.roanestate.edu/?10681-Lab-in-a-Box-and-Rural-Communities-STEM-Initiative
[xvi] https://journals.asm.org/doi/full/10.1128/jmbe.v17i1.996

- Request the zip code of the high school from which students graduated to eliminate the need to self-identify as being from a rural/disadvantaged background.

2. Consider nonacademic work experience alongside research experience for program applicants.
3. Reduce application costs. Provide and advertise fee waivers or eliminate application fees.
4. Evaluate and track the number of rural, first-generation, and low-SES individuals attending your program.
5. Eliminate delays in paychecks for beginning first-year graduate students. A prolonged period without income is exacerbated by the cost of moving.

What is the cost of excluding rural people from science, research, and academia?

Rural individuals are underrepresented by about half at the level of tenure-track faculty in the USA (Figure 1) [1]. The professoriate exerts substantial influence over the directions of science, the disbursement of research funding, and what research questions are addressed. The absence of rural people from these processes skews the priorities and ethical considerations of science in ways not reflective of the nation. In turn, this results in the loss of important perspectives that lead to innovations and stokes a cultural divide between urban and rural populations that propagates large-scale societal problems such as science skepticism, vaccine hesitancy, susceptibility to misinformation, and lack of support for science funding. The COVID-19 pandemic is one salient example of how these problems can manifest into class-based discordance that hinders progress in science and human health.

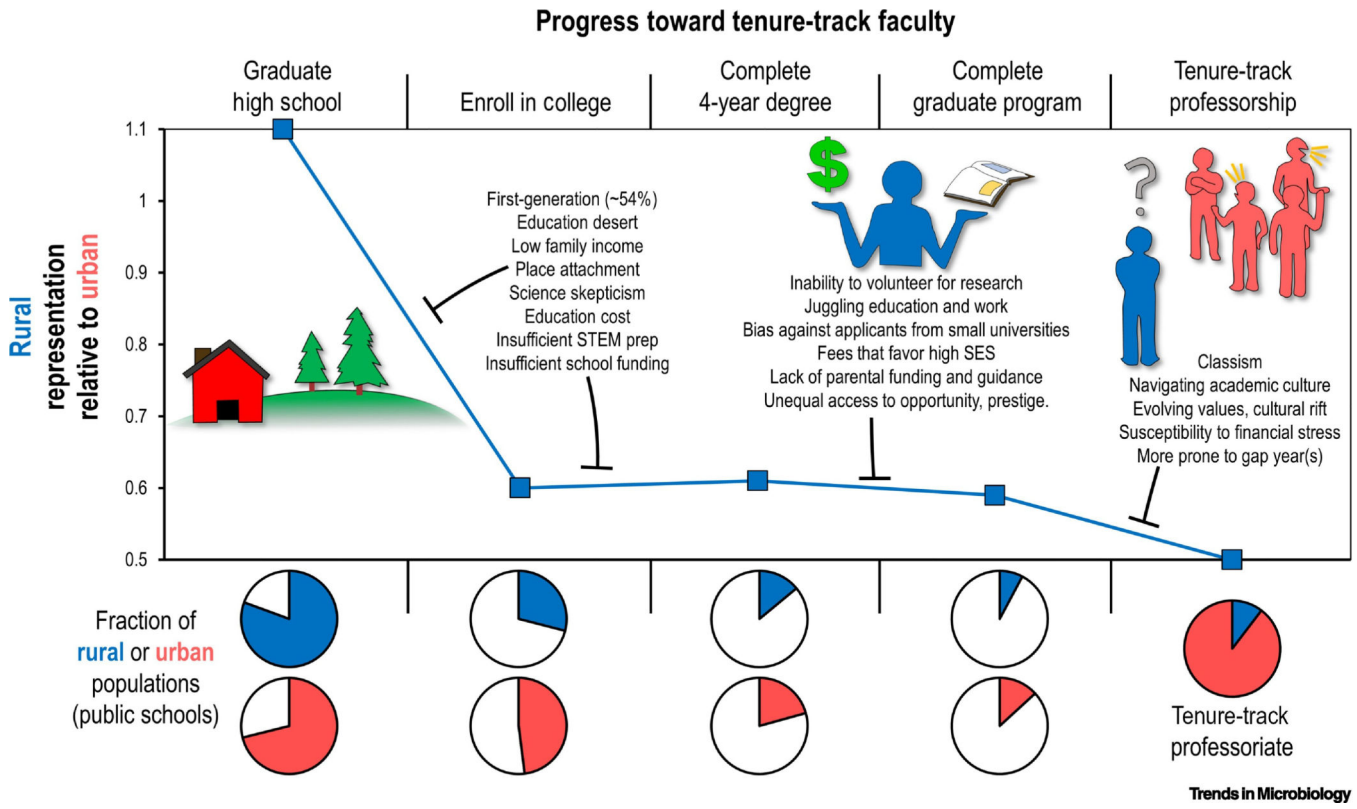

Figure 1.

Underrepresentation of rural individuals along the pathway to obtaining professorship. The representation of rural (blue) vs urban (pink) individuals at different educational and career stages is modeled based on available data. High school graduation through graduate degree completion are based on data from public schools (USDA ERS[iv]) and calculated as a ratio of rural/urban. Note that this is likely an underestimate as it does not account for affluent urban individuals attending private schools. Underrepresentation at the tenure-track professor level is based on a recent survey of 7218 STEM, social sciences, and humanities professors [1], and calculated as the fraction of rural individuals who are tenure-track professors (10%) relative to the fraction of the population who are rural Americans (20%). Equal representation corresponds to a value of 1, and values <1 indicate underrepresentation of rural individuals. Key barriers for rural individuals are highlighted with black inhibitory arrows. Abbreviation: SES, socioeconomic status.