Towards unified best practices in behavioural and social science genetics

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1 Fig; 3 Boxes; 2 Tables

References: 30 [max=10]

We reflect on current challenges in behavioural and social science genetics, especially around the interpretation and application of polygenic indices. As early-career researchers, we call to unify best practices, update training, and embed participatory approaches to ethics to ensure the field advances

responsibly and accounts for both its historical legacy and contemporary societal impact.

As the field of behavioural and social science genetics (SSG) grows in prominence (**Fig. 1**), it is revealing a dynamic interplay between genetic variation and social constructs. Genetic differences are associated with differences in social outcomes, such as socioeconomic status, and social structures can influence patterns of genetic transmission across generations (Abdellaoui et al., 2025). This bidirectional relationship underscores that SSG findings are themselves shaped by—and must be interpreted within—the broader societal context (**Fig. 1b**). For instance, it is well-documented that genome-wide association study (GWAS; see **Box 1** for definitions) samples often reflect a Eurocentric bias (Mills and Rahal, 2020).

Today, this issue warrants renewed attention. Concerns are growing over a rise in 'race science', race-based genetic analyses in leading journals, and cuts to national funding for genomic initiatives aiming to enhance diversity, equity, and inclusion (DEI). The parallel rise of commercial polygenic embryo screening (or preimplantation genetic testing for polygenic outcomes, PGT-P) means genetic tests for behavioural traits (and perhaps soon socioeconomic outcomes) are now offered by direct-to-consumer companies, despite known ethical and validity issues (Turley et al., 2021). Together, these concerns amplify future societal risks and potential real-world harms related to SSG research (**Box 2**).

Whilst calls for communicating results responsibly have been a part of SSG since the field emerged (Harden, 2020), we propose that current risks demand more concrete, anticipatory action. As early-career researchers, we call for a more proactive, united response from the scientific community (including both academic and institutional actors), that unifies best practices across research, education, and outreach, to ensure that scholarship proceeds in a robust and ethically grounded manner. As a starting point, we outline current challenges in SSG, before suggesting strategies for fostering a more robust and responsible polygenic science, spanning improved measurement practices, study design, and deeper engagement with public communities. Finally, we

suggest that these strategies can be supported by an evidence-based approach to education, DEI, and regulation (see **Table 1** for summary). Our piece complements recent reviews of the ethics of behavioural genomic research, and relevant guidance on polygenic score

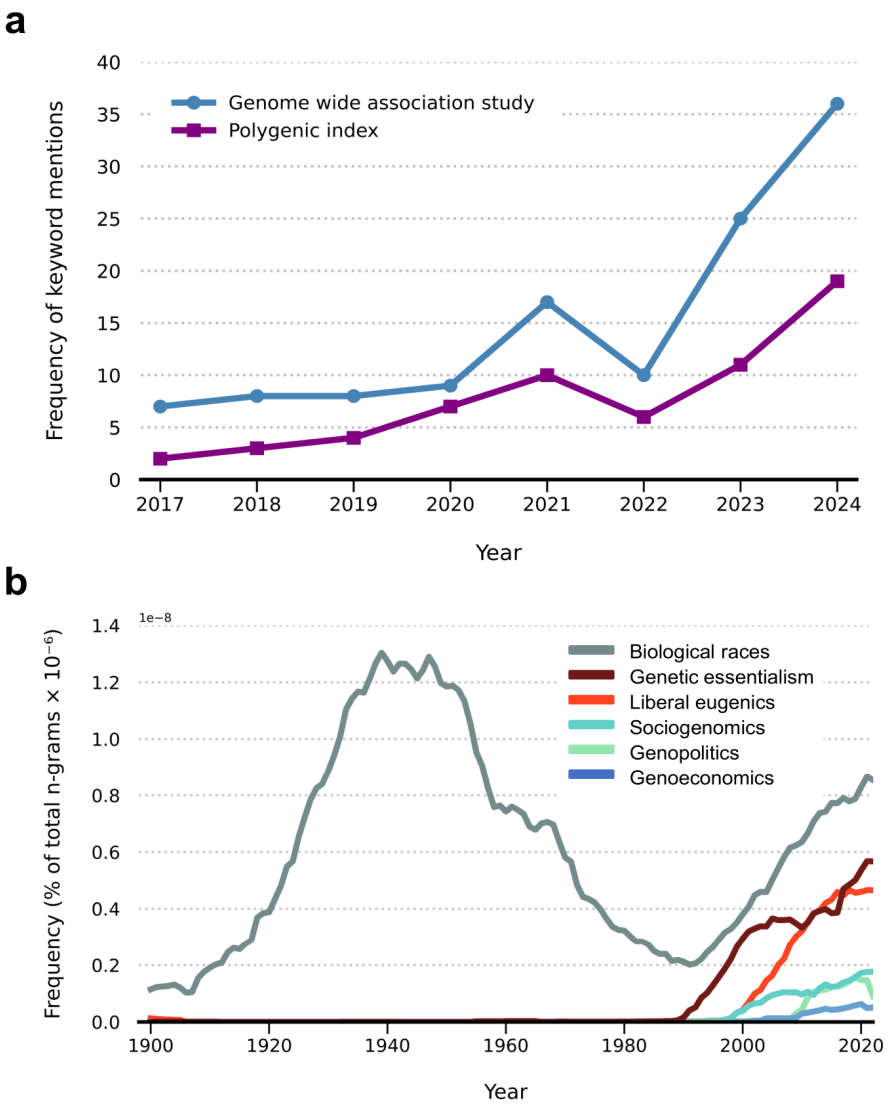

Fig. 1: Trends in the use of genetic terminology in scientific and public discourse. **(a)** Annual count of scholarly articles in *Nature Human Behaviour* articles mentioning GWAS and PGI from 2017 to 2024, showing continued growth in usage with a temporary decline during the COVID-19 pandemic. **(b)** Relative frequency of selected terms related to social science genetics and historical eugenics in the Google Books English corpus (1900–2022). Recent

increases in terms such as *sociogenomics*, *genopolitics*, and *genoeconomics* occur alongside a broader resurgence of discourse involving genetic and eugenics-related language.

research published by the ASHG and others, which we also refer readers to (Martaschenko et al., 2025; Meyer et al., 2023; Novembre et al., 2022).

Polygenic prediction in context

The central tool in the SSG toolbox are polygenic indices (PGIs), DNA-based predictors for estimating the contribution of genetics to variation in trait expression. They are constructed from estimated associations between common genetic variants and a behavioural or socioeconomic trait of interest through GWAS. As the use of PGIs grows (**Fig. 1a**), it is critical to clarify what kind of knowledge they offer and examine the implications of their growing application in non-research settings.

Firstly, while the computation of PGIs is well established (Becker et al., 2021), the confidence and type of interpretation they warrant—their epistemic validity (**Box 1**)—is not always made explicit in research outputs. Crucially, PGIs are statistical constructs and capture only a fraction of heritable variation in a given trait, also reflecting environmental factors (Abdellaoui et al., 2025). Because most are computed using between-family GWAS, they embed specific sources of confounding like population stratification (**Box 1**). Many PGIs—particularly those for latent constructs like cognitive ability—serve as proxies for genetic correlates of phenotypes that are themselves indirectly measured, making them, in effect, proxies of proxies.

Secondly, PGIs are often highly context-specific (Tropf et al., 2017) and poorly generalisable across populations. Even PGIs for common diseases derived from European-ancestry samples retain less than half of their predictive power in African-ancestry populations (Duncan et al., 2019). This ‘portability issue’ is due not only to the lack of the diversity of participants included in genetic studies but to long-term coevolution between genes and cultural environments, which influences how traits manifest across populations (Uchiyama et al., 2021). Alone short-term changes, such

as shifting cultural norms, can reshape how PGIs for traits like educational attainment relate to realised outcomes across gender and cohorts (Herd et al., 2019).

Box 1: Glossary of key terms

Below we define terms used in social science genetics. We note that some terms (such as 'direct genetic effect') are still contested and require additional consensus work, as they may be misinterpreted by researchers from other disciplines.

Direct genetic effect: The influence of an individual's own genotype on their phenotype, independent of the genotypes of others (e.g., parents or siblings). In social science genetics, "direct" is sometimes interpreted as "causal," given that genetic transmission from parents is randomised under standard reproduction. However, a direct genetic effect does not strictly imply a biological pathway or immutability, as such effects may operate through modifiable environmental mechanisms.

Epistemic validity: Epistemic validity refers to the extent to which a measurement or construct—such as a polygenic index—yields meaningful, interpretable, and reliable knowledge about the phenomenon it purports to represent. In the context of social science genetics, this includes not only statistical validity but also whether the underlying assumptions, methods, and uses of PGIs are conceptually justified. As Prilleltensky (2003) notes, epistemic validity also involves examining the power dynamics—personal, relational, and structural—that shape how knowledge is produced, interpreted, and applied.

Exposome: The full spectrum of environmental exposures—social, chemical, biological, and psychological—that an individual experiences across the life course.

Family-based analyses: Methodological approaches that use genetic data from siblings, twins, or parent–offspring pairs to account for shared environmental and demographic factors. These designs help reduce confounding and more robustly estimate direct genetic effects.

Genome-wide association study (GWAS): A statistical method used to identify associations between common genetic variants and phenotypes. GWAS tests for correlations between millions of single nucleotide polymorphisms (SNPs) across the genome and a given phenotype, typically in large, unrelated samples.

Omics: Comprehensive approaches to measuring biological systems at multiple molecular levels, such as the genome, epigenome, transcriptome, proteome, or metabolome.

Population stratification: Systematic ancestry differences within a population that can

confound genetic associations when correlated with environmental or social factors. These differences may reflect broad continental groupings or finer-scale population structure. Related sources of bias include **non-random mating**, where individuals with similar traits are more likely to partner, and **dynastic effects**, where parental genotypes influence offspring outcomes through environmental pathways.

Preimplantation Genetic Testing for Polygenic Traits (PGT-P): A commercial practice that uses PGIs to estimate the likelihood of various traits in embryos during in-vitro fertilisation. .

Finally, despite their issues, PGIs for traits including IQ are increasingly bundled together by private companies offering PGT (e.g., Nucleus, Heliospect Genomics) with disease-related PGIs (**Box 1**). Whilst many commentaries have now noted that the expected *individual benefits* from PGT-P would be modest (Turley et al., 2021), we wish to stress that the potential *societal harms* of PGT-P for non-disease traits may be substantial (**Box 2**). These are further compounded by unresolved methodological issues, including model variability (Namba et al., 2024), and a limited understanding of how missing heritability represents an evolutionary problem underlying complex traits (Uchiyama et al., 2021). In the absence of unified PGT-P regulation across regions like the European Union (Sierman et al., 2024), the SSG community arguably has the responsibility—and opportunity—to help establish clear norms for the interpretation and use of PGIs, especially for socioeconomic traits, before these are adopted in ways that cause harm.

Building better sociogenomic science

Thankfully, there is a growing consensus within SSG that PGIs should not be treated as static outcome predictors, but as indices reflecting gene–environment interplay (Benjamin et al., 2024; Biroli et al., 2025). Methodological advances, such as the shift toward within-family GWAS designs (**Box 1**) further promise more robust estimates of 'direct genetic effects'. Building on this momentum, we recommend additional shifts in research practice.

Clarify aims, interpret findings, and update language: PGIs are typically used for both prediction and explanation—two aims that require different tools, assumptions, and interpretive frameworks. Yet, these aims may be blended or left unstated, leaving PGI-based findings vulnerable to misinterpretation. We encourage researchers to clearly state the purpose of their analyses: whether to model variance, predict outcomes, or probe mechanisms.

Language, too, may need refinement (see **Box 3**). Terms implying causality such as "causes," "explains," or "determines" are best used when clearly justified. To avoid conflation of correlation with causation, we encourage researchers to follow epidemiological convention and describe observational findings using terms like "association estimates," "polygenic associations," or "genetic correlates," and to

Box 2: Examples of potential risks and real-world harm related to social science genetics

Social science genetics (SSG) is embedded in layers of complexity that scholars, especially early career researchers, need to be aware of and equipped to deal with. Concerns can arise at multiple stages—from topic selection to downstream applications and public perception.

1. Reputational damage risks across the research pipeline

- *Research scope*: Broad participant consent may not anticipate studies on traits that stretch the bounds of traditional health-related research—e.g. educational attainment, personality, or income.
- *Public association with eugenics*: The field is sometimes unfairly linked with histories of eugenics, population control, and gene editing (Cadigan et al., 2025)
- *Misinterpretation of findings:* SSG findings may be misinterpreted or co-opted and equated with genetic determinism and essentialism.

2. Documented instances of harm violent misuse of research:

- While rare, there have been high-profile instances where genetic research related to human traits has been misappropriated to justify deadly harm. For instance, the perpetrator of the 2022 Buffalo shooting "foregrounded genetic studies and figures to purportedly demonstrate the genetic distinctiveness of Black people and the genetic causation of racial differences in intelligence and crime" (Panofsky et al., 2024).

3. Emerging concerns around polygenic indices (PGIs)

Although no well-documented cases of discrimination using PGIs currently exist, Kaiser

and colleagues (2024) remind us that multiple risks are increasingly plausible:

- *Corporate misuse:*
  - Insurance firms could seek data on traits like risk tolerance to set premiums.
  - Employers, academic institutions, or sports authorities might use PGIs in selection or exclusion practices.
  - Companies could tailor or restrict services based on inferred traits
- *Precedents of genetic surveillance:*
  - DNA testing is already used in immigration and family reunification contexts—demonstrating a willingness to repurpose genetic data in ways that disproportionately affect vulnerable populations (Granadas and Moreno et al., 2017)

4. Use of PGIs in commercial reproductive technologies

Polygenic embryo screening (PGT-P) is already in use, though long-term consequences remain untested. Analogies from plant and animal breeding raise concerns:

- *Genetic erosion in agriculture:*
  - Selection for high-yield traits in crops has reduced genetic diversity, increasing vulnerability to pests and climate stress (Khoury et al., 2021).
- *Unintended consequences in animal breeding:*
  - Intense selection (e.g. for milk production) has compromised animal health and welfare (Oltenacu and Broom, 2023).
- *Distraction from structural factors affecting health*
  - Offering PGT-P for socioeconomic traits reinforces a misleading equivalence between clinically validated conditions and socially contingent traits.

While selection in human reproduction is unlikely to be as coordinated or intense, even small-scale use of PGIs could gradually reshape the genetic landscape—potentially reducing diversity and resilience in unpredictable ways.

consistently emphasise that PGI estimates reflect *on-average, population-level predictions*. Equally important is the contextualization of effect sizes. Reporting R^2 values without clarifying their practical significance risks overstating claims—particularly for behavioural traits, where PGIs explain minimal variance. The largest family-based GWAS to date (Tan et al. 2024) found that PGIs accounted for a median of just 0.1% of variance across a range of behavioural traits. Such findings underscore the importance of interpreting estimates in terms of their real-world meaning, especially as calls for their potential utility for individual-level prediction persist (Plomin and van Stumm, 2021).

Design with complexity and intersectionality in mind: Predictive power may benefit from integrating additional data—such as transcriptomic or epigenomic markers.

Medical research increasingly employs multimodal models that combine genomic, exposome, and other omic data into an integrated risk score or 'poly-omic' model (Argentieri et al., 2025). SSG could follow suit; similarly, explanatory research may gain from incorporating more insights from epigenetics, developmental biology, and theories of cultural evolution to better understand how genetic variation interacts with social transmission, norms, and institutional change (Abdellaoui et al., 2025). These approaches can help ensure that SSG keeps up with developments in other fields and truly advances "second-generation" mechanistic causal knowledge (Bondarenko, 2023).

In parallel, research on inequalities—a central concern in SSG—may benefit from adopting intersectional approaches, which account for the fact that human behaviour is

Box 3: How language shapes understanding in social science genetics

The words used to describe SSG research shape academic interpretation, public understanding, policy uptake, and the ethical framing of findings. Researchers have a responsibility to communicate complexity without reinforcing genetic determinism, essentialism, or reductionism (Harden 2023).

We provide OED definitions for terms commonly used in SSG to discuss PGIs for behavioural traits and socioeconomic outcomes. We highlight concerns with each and offer our own recommendation:

- **Endowment:** A 'gift', power, capacity, or other advantage with which a person is endowed by nature or fortune. *Concern*: 'Genetic endowment' can imply a static allotment of worth or ability, reinforcing essentialist interpretations of achievement.
- **Liability:** An attribute or trait which sets one at a disadvantage; hence, a burdensome or disadvantageous person or thing, a handicap. *Concern*: The term 'genetic liability' may suggest an innate burden or flaw, reinforcing deterministic assumptions.
- **Potential:** Possible as opposed to actual; having or showing the capacity to develop into something in the future; latent; prospective. *Concern:* In social science contexts, invoking "potential" can be problematic: it suggests a fixed innate ceiling for achievement or ability, echoing genetic essentialism.
- **Predisposition:** The condition of being predisposed or inclined beforehand (to do something, or to a particular opinion, course of action, etc.); a prior inclination or pre-existing tendency. *Concern:* For behavioural or socioeconomic outcomes, invoking a "predisposition" risks oversimplification, as it can suggest a built-in

destiny, downplaying environmental influence and reinforcing essentialism.

- **Propensity:** Essentially synonymous with predisposition—it denotes an inclination to, towards, or for a particular action, habit, quality, etc.; a tendency to do something. *Concern*: Although somewhat probabilistic, it may be misread as an innate push toward a trait, inviting reductionist readings.
- **Susceptibility:** Essentially synonymous with predisposition – it denotes an inherited sensitivity to developing a trait given certain genetic variants. *Concern:* Implies passive 'vulnerability' and risks deterministic interpretations, especially if environmental context is ignored.
- **Tendency:** The fact or quality of tending to something; a constant disposition to move or act in some direction or toward some point, end, or purpose. *Concern*: May imply traits (e.g., low income) are constant and naturally programmed, encouraging reductionist views unless explicitly framed as probabilistic.
- **Risk:** (Exposure to) the possibility of loss, injury, or other adverse or unwelcome circumstance. *Concern*: While a standard term in medical settings, it brings clinical overtones and can foster stigma or fatalism if misinterpreted as fate in social science studies.

Recommendation: We encourage researchers to use the term "genetic likelihood" to describe how PGIs relate to the probability of *expressing* behavioural traits or *experiencing* socioeconomic outcomes. This emphasizes their probabilistic, non-deterministic nature and minimises the risk of genetic determinism, essentialism or reductionism.

shaped by overlapping systems of identity and institutional structures. As Matthews and colleagues (2023) suggest, addressing this gap requires richer phenotyping of structural forces—such as exposure to racism or gender discrimination—to better capture the heterogeneity of trait development across social contexts. Take the educational attainment PGI: it is also shaped by cultural capital, institutional barriers, and unequal access to opportunity (Herd et al., 2019).

Build participatory infrastructure: Finally, fostering public understanding and trust should become more embedded into SSG research practice. Most studies proceed under broad or blanket consent agreements from biobank participants, a model that arguably falls short of truly informed consent (Thompson et al., 2025). This gap can leave ethical quandaries in the hands of biobanks, academic institutions, and researchers. In the absence of formal oversight, there is a need to develop ethical guidelines grounded in genuine engagement with participants and communities. More participatory approaches, such as those pioneered in socially sensitive GWAS studies and taken up in related disciplines like computational social science (Straub et al.,

2025), which engage affected groups in study design, offer a useful starting point (see Meyer et al., 2023). One promising future direction is benefit-sharing and capacity-building initiatives with the communities that contribute to genomic research (see LeBaron von Baeyer et al., 2024).

When it comes to communicating findings, steps like the inclusion of FAQs pioneered by the Social Science Genetics Association Consortium (https://www.thessgac.org/faqs) (and adopted in this journal) are a welcome step. Though building lasting trust requires more comprehensive efforts. Building on existing suggestions (Meyer et al. 2023), we recommend a number of practices (**Table 1**), including for researchers to consistently include ethics and broader impacts sections into their manuscripts. Effective dissemination may also need to go beyond traditional publications, incorporating interactive tools and games and creative formats to make research more accessible and meaningful to the public.

Table 1. Key recommendations for researchers and academic associations building on past work (Meyer et al., 2024).

Theme	Recommendation
Research practices	**Clarify study aims and interpretability** *For researchers and journals*: Always specify whether PGI-based analyses aim to predict, explain, or explore mechanisms. *Why it matters*: Prevents misinterpretation and clarifies the scope of findings. *Cost*: Minor increase in documentation and peer review time. *Counterpoint*: Some may consider this redundant—but in practice, clarity enhances replicability and public understanding
	Contextualise effect sizes and epistemic limitations *For researchers*: Situate PGI effect sizes relative to established benchmarks (e.g., median R^2 values), and clarify their population-level, probabilistic nature. *Why it matters*: Avoids exaggerating utility and informs responsible interpretation. *Cost*: Requires more careful statistical communication. *Counterpoint*: Small effects can still matter (e.g., PGIs may be useful

	as control variables), but only when properly contextualised.
	Use within-family designs to improve causal inference *For study designers and analysts*: Prioritise family-based methods when available to reduce confounding. *Goal*: Better isolate direct genetic effects. *Cost*: Demands family data and specialised statistical methods. *Counterpoint*: Not always feasible, but researchers should acknowledge limitations when such designs are absent.
	Adopt richer and intersectional phenotyping *For funders and data providers*: Collect and make available variables reflecting structural inequality (e.g., racism, class, gender identity). *Goal*: Enable research that meaningfully reflects lived experience and context. *Cost*: May increase data collection demands and raise ethical questions. *Counterpoint*: With appropriate safeguards, the benefits to rigor and inclusion outweigh risks.
	Promote research codes of conduct to guide practice and acknowledge harms *For academic associations and consortia*: Develop and adopt codes of conduct that commit researchers to ethical responsibility, transparency, and reflection. *Goal*: Establish shared standards and acknowledge historical misuse (e.g., eugenic misappropriations). *Cost*: Requires institutional commitment and time for consultation. *Counterpoint*: May be viewed as performative—can be avoided if tied to real accountability measures (e.g. journal policies, training)
Public Engagement	**Engage communities in participatory study design** *For consortia and ethics boards*: Involve participants and affected groups early in the research process through advisory groups or design consultations. *Goal*: Increase relevance, trust, and ethical legitimacy of research. *Cost*: Resource- and time-intensive. *Counterpoint*: Not all projects can support this—but it's essential for sensitive or high-impact work.
	Use lay-accessible outputs and broaden dissemination formats *For researchers and institutions*: Publish lay summaries, develop significance statements, and explore non-traditional formats (e.g., games, infographics). *Goal*: Improve public understanding and reduce misinterpretation. *Cost*: Modest time investment or journal-level support needed. *Counterpoint*: Not all researchers are trained in this—institutions should provide guidance.
Diversity, equity and inclusion	**Diversify research teams and leadership** *For funders and universities*: Invest in fellowships and support for early-career researchers from historically excluded groups. *Goal*: Ensure research questions and outcomes reflect broader

	societal concerns. *Cost*: Requires structural change and sustained funding. *Counterpoint*: Impact depends on follow-through—so must be linked to leadership pathways and research autonomy.
	Expand inclusion of global and underrepresented populations *For funders and biobanks*: Ensure diverse population recruitment and equitable access to data and training. *Goal*: Improve the generalisability and fairness of PGI research. *Cost*: May require translation, community partnerships, and local infrastructure. *Counterpoint*: Slows initial data collection, but expands long-term impact and relevance.

An evidence-based approach to engagement, teaching, and diversity

Implementing the proposals above requires coordinated effort and a collective commitment from the broader SSG community to reform behavioural genetics education, revise training pathways, and embrace more diverse genetic datasets.

When it comes to educational curricula, programs should move beyond historical overviews to engage with the enduring legacy of eugenics in genetics, considering how open genetic data may become vulnerable to appropriation by those seeking to justify racist ideologies, for instance. Resources from institutions like the NIH provide strong foundations for cultivating critical thinking and training in ethics, including in the relevant subfields of research ethics, bioethics, and reproductive ethics (**Table 2**).

Second, SSG training should complement statistics with courses on measurement theory. Students need not become philosophers of science, but they must learn to grapple with internal, external, and epistemic validity (**Box 1**). As Penders and Janssens (2022) ask, “do we measure or compute polygenic indices (PGIs)?” Students also need to understand the epistemological difference between biomarkers, such as blood pressure, and statistical constructs like PGIs, and learn to approach the latter with appropriate epistemic caution.

Third, programs would do well to more deeply reflect the complexity and intersectional nature of behavioural traits and socioeconomic outcomes. Beginning with Mendelian inheritance is common, but evidence is increasingly showing that it can reinforce

deterministic assumptions (Ball, 2025). Teaching complex traits first instead can foster more accurate scientific reasoning and counter genetic essentialism. Similarly, introducing new frameworks such as multilevel analysis of individual heterogeneity and discriminatory accuracy (MAIHDA) (**Table 2**), hailed as a new gold standard in social epidemiology (Evans 2024), can help students analyse how genetic associations are shaped by intersecting constructs.

Achieving unbiased research in SSG, as in other scientific domains, demands moving beyond rhetoric toward the active integration of representative data. More diverse, large-scale initiatives such as the NIH's *All of Us* and the UK's *Our Future Health* provide now provide this opportunity and should be leveraged where appropriate. Also essential is the inclusion (not restriction) of variables that are often ignored, such as gender. Equity and diversity also needs to extend to the research environment itself, as scientists from historically excluded groups continue to face disparities in advancement and funding across disciplines; without focused investment in diverse teams—which has been shown to drive scientific innovation—current funding cuts risk entrenching these inequities.

Table 2. List of reference materials for educators, researchers, and students

Resource	Summary	Available materials
Stanford University's Genetics, Ethics, and Society course	A graduate-level curriculum examining the past, present, and future relationship between human genetics and society to evaluate the ethical implications of social science genetics research.	Reading lists and homework assignments are available at www.stanford-genethics.github.io.index/html
University of Bristol's tutorial on Intersectional MAIHDA	A short tutorial on multilevel analysis of individual heterogeneity and discriminatory accuracy (MAIHDA), which models variation within and between intersectional groups (e.g. by gender) and assesses how accurately these strata predict individual outcomes, revealing both structural	Stata and R scripts and datasets are available at https://www.bristol.ac.uk/cmm/research/imaihda/

	patterns and individual heterogeneity.	
University of St Andrews' Biology Anti-Racism Committee	A network of students and early career researchers who have organised educational and social activities designed to promote antiracism and an inclusive culture.	Publications, conference guidelines, recruitment advice, teaching guides are available at www.biology.st-andrews.ac.uk/edi/anti-racism/
Personal Genetics Education & Dialogue (PGED)	An initiative that offers resources and programs that explore the relevance and impact of genetics in people's lives.	Lesson plans, videos, conversation guides, games are available at www.pged.org/resource-hub/
Center for ELSI Resources and Analysis (CERA)	A dissemination hub for the field of study focused on the ethical, legal, and social implications (ELSI) of genetics and genomics.	Publications, reading lists, research tools, policy resources, videos are available at www.elsihub.org/resources
The Anti-Eugenics Project	A network of scholars, organizers, cultural workers and artists working to understand and bring awareness to the continuing legacies and harm of eugenicist ideologies.	Readings lists, podcasts, articles are available at www.antieugenicsproject.org
Confront Eugenics project	A platform to facilitate collaboration among scholars of eugenics, activists, practitioners, journalists, curators and artists alongside public engagement on the history and legacies of eugenics.	Podcasts, videos, interviews and publications are available at www.confront-eugenics.org/resources/

Concluding thoughts

While improving research is essential, responsible governance also demands coordinated regulation—especially for PGT-P, where researchers should help establish clear guidelines for PGI use in socioeconomic traits. In the absence of regulation, the SSG community should not be afraid to lead, and as publicly funded scientists, we see this as both a responsibility and a privilege.

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Acknowledgements

V.J.S. is funded by UK Research and Innovation (UKRI) under the UK government's Horizon Europe funding guarantee [EP/X027694/1] and the Leverhulme Trust Large Centre Grant LCDS (RC-2018-003). N.V.H, L.I.A.A., S.O.B., A.B., T.L.N.V., Q.P., R.D.S., and M. T. are funded by the European Union under HORIZON-MSCA-2021-DN-01 programme [Grant No. 101073237]. V.J.S. is a Research Scholar for Our Future Health. We would like to thank Neil Wary, Muna Aikins, and the European Social Science Genetics Network for feedback.