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RESEARCH ARTICLE

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Investigating perceived heritability of mental health disorders and attitudes toward genetic testing in the United States, United Kingdom, and Australia

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Abstract

Our beliefs about the heritability of psychiatric traits may influence how we respond to the use of genetic information in this area. In the present study, we aim to inform future education campaigns as well as genetic counseling interventions by exploring common fears and misunderstandings associated with learning about genetic predispositions for mental health disorders. We surveyed 3,646 genetic research participants from Australia, and 960 members of the public from the United Kingdom, and the United States, and evaluated attitudes toward psychiatric genetic testing. Participants were asked hypothetical questions about their interest in psychiatric genetic testing, perceived usefulness of psychiatric genetic testing, and beliefs about malleability of behavior, among others. We also asked them to estimate the heritability of alcohol dependence, schizophrenia, and major depression. We found a high interest in psychiatric genetic testing. In most cases, more than a third of the participants showed serious concerns related to learning about personal genetic predisposition, such as not wanting to have children if they knew they had a high genetic predisposition, or not wanting to choose a partner with a high genetic predisposition for a mental health problem. Finally, we found a significant association between most participants' attitudes and their lay estimates of heritability, which highlights the complexity of educating the public about genetics.

KEYWORDS
attitudes, genetic literacy, genetic testing, public understanding of genetics

1 | INTRODUCTION

The number of publications about the role of genetic factors in the development of common mental health disorders has notably increased since the development of genome-wide association studies (GWAS) and the availability of large datasets generated by biobanks and international consortia (Morosoli, Colodro-Conde, Barlow, & Medland, 2020). Furthermore, this research has facilitated the calculation of individual polygenic risk scores, which have the potential to allow the development of genetically tailored pharmacological treatments, and the screening of high-risk individuals for early intervention and prevention programs for many complex traits (Lewis & Vassos, 2020). It is now evident that polygenic risk scores for mental health traits are accessible to the public without the support of a genetic counselor or other health professional. Individuals are choosing to obtain these risk scores either by directly obtaining a health report from a direct-to-consumer genetic testing companies (e.g., 23andMe personalized genetic health reports) or via third-party applications such as Promethease or Impute.me (Folkersen et al., 2020). Anyone who has access to their genome-wide data can access their individual polygenic risk scores for many mental health

disorders, including alcohol dependence, depression, and schizophrenia. This information has the potential to influence how people understand their behavior, as well as trigger worrying thoughts about prognosis, discrimination, or reproductive decisions (Haslam & Kvaale, 2015; Lebowitz & Ahn, 2017; Meiser et al., 2020). The application of genetic technologies will require proving its clinical utility as well as acceptance from the community (Austin, 2020). However, public attitudes toward the use of psychiatric genetic testing may be influenced by people's beliefs about the cause underlying mental health disorders. In the present study, we surveyed members of the public from three different countries about their attitudes toward psychiatric genetic testing and evaluated how their perception of heritability for three mental health traits influences their responses to genetic risk information.

Meiser et al. (2020) recently conducted the first systematic review on attitudes toward psychiatric genetic testing. The review covered topics such as the perceived usefulness of genetic information, concerns about having children, coping with the information and discrimination by insurance companies, and interest in genetic testing for children. They concluded that there is strong interest in psychiatric genetic testing and that most participants, including those with lived experience of mental disorders, expected that a genetic explanation of mental disorders would alleviate stigma (Meiser et al., 2020). Their review included both qualitative studies, such as interviews and focus groups, and quantitative studies, which were mostly cross-sectional surveys. While most surveys included in the review used small convenience samples, there are some exceptions. Laegsgaard and Mors (2008) surveyed 397 Danish patients with a psychiatric diagnosis (including recurrent depression, bipolar I disorder, schizophrenia, and anxiety disorders), 164 of their relatives, and 100 medical and psychology students. They found that 30% of respondents with a psychiatric diagnosis would avoid having children if they knew their child would have a 75% risk of having a "moderate mental illness", while 45% would have a psychiatric genetic test only if effective intervention exists. These percentages were higher among the relatives of psychiatric patients. In addition, 21–45% of respondents feared not being able to cope emotionally with the results of a psychiatric genetic test. Wilde, Meiser, Mitchell, Hadzi-Pavlovic, and Schofield (2011) surveyed 1,046 adults from the general population in Australia regarding beliefs about potential benefits and disadvantages of a genetic test for depression and found a strong interest in genetic testing. Around 80% of participants agreed that genetic testing for depression had multiple benefits, although 64% of participants were worried about discrimination by insurance companies and 52.4% were worried about being labeled or stigmatized.

In addition, we found two surveys on attitudes toward psychiatric genetic testing that were not included in the review by Meiser and colleagues. Flatau et al. (2018) surveyed 518 participants (health care professionals, patients, participants of genetic counseling sessions, and members of the general population), and found that over 90% of participants would like to know their genetic predisposition for a depressive episode. Finally, Lent et al. (2017) surveyed 700 community-based U.S. army veterans about their attitudes on genetic testing for post-traumatic stress disorder and alcohol dependency. They found that 58.6% of the participants reported *not* wanting to know about their genetic results before or after deployment. The main reasons reported for not wanting to know were not having a history of the condition, and believing the test to be unnecessary.

Furthermore, in relation to the ability of genetic explanations to alleviate stigma in mental health disorders, the expectation by Meiser and colleagues that this would happen is only partly supported by two meta-analyses that have reviewed experimental and associational studies on biogenetic explanations of mental health disorders and stigma. In their meta-analysis, Kvaale, Gottdiener, and Haslam (2013); Kvaale, Haslam, and Gottdiener (2013) found that bio-genetic explanations of mental disorders reduce blame (e.g., the idea that people with a mental disorder are weak, or somehow choosing not to get better), but they also found that they increased pessimism about the prognosis and perception of dangerousness. Regarding prognostic pessimism, Lebowitz and Ahn (2017) found that participants who were told that they had a genetic predisposition to depression recalled higher levels of depressive symptoms over the previous 2 weeks than those who did not receive this feedback. The conclusions from the two meta-analysis conducted by Kvaale and colleagues and the study by Lebowitz and Ahn, suggest that genetic information might not be as effective alleviating stigma as suggested by Meiser et al. (2020).

That is, even if biogenetic explanations of mental health disorders can reduce blame, they may have unexpected consequences that should be further explored. Tate (2013) found that patients who believe in a biological explanation of depression prefer medical treatments (i.e., pharmacotherapy, hospitalization, and electroconvulsive therapy) rather than psychotherapy and that they seek professional help more often. Conversely, when clinicians believed that depression was caused by biological factors, they were more likely to advocate for medical treatments. The review of the literature by Tate (2013) also suggested that discrepancy in the beliefs about the causes of depression (i.e., biomedical vs psychosocial) between clinicians and clients was associated with worse outcomes and reduced motivation for treatment. In another study, Read, Cartwright, Gibson, Shiels, and Haslam (2014) found an association between holding biogenetic beliefs about depression and more self-reported efficacy of antidepressants among people currently taking antidepressants. In their review of the impact of biogenetic explanation of mental health disorders, Haslam and Kvaale (2015) supported these findings. All this together suggests that people's explanations of mental health disorders have a significant impact in how they respond to and interact with clinicians, other individuals, and themselves.

In order to assess how people explain mental disorders, we can ask individuals to estimate the importance of genetic factors in the development of different mental health disorders (i.e., their intuitive or lay heritability). These estimates might reflect their personal theories about mental health problems and provide us with information about how accurate their estimates are in comparison to published estimates of heritability. A few studies have previously surveyed members of the public about the role of genetic factors in individual differences in mental health traits. Willoughby et al. (2019) asked 1,041 participants in the United States on their lay estimates of genetic influence on 21 human

traits. Participants estimated the heritability of alcoholism, schizophrenia, and depression, to be 43.0, 62.2, and 47.5%, respectively. Carver, Castéra, Gericke, Evangelista, and El-Hani (2017) surveyed 285 Brazilian first-year university students on 18 human traits, including alcoholism, schizophrenia, and severe depression, as part of their genetic literacy survey validation study. They estimated the heritability of these traits to be 51.5, 85.7, and 15.8%, respectively. Chapman et al. (2019) surveyed 5,404 participants from Russia, the United Kingdom, and the United States and asked them to indicate the *strength* of genetic effects on eight common traits from 0 to 100, and found estimates for depression of 45.0%. Lastly, Molster, Charles, Samanek, and O'Leary (2009) surveyed 1,009 participants from Australia on their lay estimates of genetic influence on 11 medical conditions, including depression. Participants had to choose which factors decided each condition out of three options: all genes, mix, or all environment. For depression, 5% chose "all genes," 63% "mix," 27% "all environment, and 5% did not know. Such estimates not only reflect people's theories of mental health problems, but also tell us how accurate their heritability estimates are.

As reviewed above, beliefs about the causes of mental health disorders are associated with how people respond to their diagnosis, as well as clinicians' behavior. However, the link between lay heritability estimates and attitudes toward psychiatric genetics has received relatively little attention. In one study, Austin, Smith, and Honer (2006) surveyed relatives of people with psychosis, asking them to what extent they thought that siblings of people with psychosis were likely to personally develop psychosis. Overestimates on this measure were associated with reproductive decisions favoring fewer children and more positive attitudes toward genetic testing. Moreover, overestimation of heritability can be interpreted as an indicator of genetic deterministic thinking (Carver et al., 2017), which is associated with negative outcomes such as stigma and discrimination (Lynch, Morandini, Dar-Nimrod, & Griffiths, 2019). On the other hand, underestimation of heritability might indicate a motivated rejection of genetics (Barlow, 2019; Morosoli, Colodro-Conde, Barlow, & Medland, 2019). Thus, the accuracy of heritability estimates for mental health traits, and the factors that influence this accuracy represent an important target for genetic education campaigns. Moreover, it helps us appraise the potential of disseminating seemingly innocuous information about genetics (e.g., heritability, new findings from GWAS) to influence public opinion.

The present study aims to provide additional information about lay heritability and attitudes toward psychiatric genetic testing specifically targeting three mental health problems: alcohol dependence, schizophrenia, and depression, in a large sample of members of the public from three different countries. The majority of the sample was recruited in Australia among research participants of genetic studies conducted by the psychiatric genetics group at QIMR Berghofer. The remaining participants were recruited online from other English-speaking countries to increase the sample size and explore potential differences in other contexts. In regards to the survey, instead of broadly asking participants if they believe that each condition is caused by biogenetic or psychosocial factors, we asked them to estimate the heritability of each trait. Then we surveyed their attitudes regarding the use of psychiatric genetic information in clinical and social contexts, such as worries about coping with the knowledge, worries about insurance coverage, usefulness for parenting, or attitudes toward potential partners based on their genetic predisposition. Finally, we evaluated how their beliefs about the genetic influence on mental health traits correlates with their attitudes, as well as with sociodemographic variables and their level of genetic literacy. Our goal is to inform future education campaigns as well as genetic counseling interventions by bringing attention to common fears and misunderstandings associated with learning about genetic predispositions for mental health disorders.

2 | METHODS

2.1 | Participants

Participants were recruited from (a) families that had already participated in genetic research studies at QIMR Berghofer, Australia ($N = 3{,}646$), or from (b) general population from United Kingdom ($N = 501$) and United States ($N = 500$) via Prolific Academic:

1. Participants from QIMR Berghofer have been part of the Brisbane Longitudinal Adolescent Twin Study (BLATS; Wright & Martin, 2004). The BLATS study began in 1992 and until 2016 it continuously recruited 12-year-old twins and their parents into the study. The twins, their parents, and siblings have participated in studies on the genetics of a wide range of health conditions, including psychiatric disorders. For the present study, surveys were sent to 2,236 families, of which 1,686 had at least one family member providing data.
2. Participants residing in either United Kingdom or United States and having fluent in English were selected via Prolific Academic, an online platform for subject recruitment that has been shown to produce high-quality data from a diverse range of population (Palan & Schitter, 2018). Participants were offered £4.35 for their time (estimated duration of the survey 40 minutes). There were no other selection criteria and participants entered the study on a first-come first-served basis.

The number of participants varied across different analyses due to missing data, as not all participants answered all questions. The survey was distributed online, therefore all participants were computer literate and had access to an internet connection. In the Australian sample, only biological sex was assessed, whereas in the U.K. and U.S. samples, both information about biological sex and gender was available. In the latter samples, gender was assessed by asking participants: "What is your gender?" Response options were: woman, man, non-binary/third gender, prefer to self-describe (followed by a text box), and prefer not to say. Throughout the article, we look at differences depending on whether participants were men or women (operationalized as biological sex in the Australian sample, and gender in the U.K. and U.S. samples). A minority of our participants identified as gender diverse (in the U.K. and the U.S. samples combined, 15 participants identified as non-binary/third

gender, 26 as transgender, and four participants preferred not to say). Unfortunately, the small sample sizes meant that we did not have adequate power to conduct analyses across all gender groups. Consequently, data from gender diverse participants were excluded from analysis. All participants provided informed consent at the beginning of the survey. The Human Research Committee of QIMR Berghofer Medical Research Institute and the Human Research Ethics Committee of the University of Queensland provided approval of this study (approval numbers: P2227 and JM03024).

2.2 | Materials

A questionnaire was developed specifically for this study, which included items based on previous studies on attitudes toward genetics (Doukas, Localio, & Li, 2004; Laegsgaard & Mors, 2008) and motivated reasoning in science communication (Morosoli et al., 2019). The questionnaire contained 258 items and had an average time of completion of approximately 35 min. The present study focuses on two of the scales included in the questionnaire, *Lay heritability of mental health traits* and *Personal responses to genetic risk information*. All items were asked separately for alcohol dependence, depression, and schizophrenia. The questionnaire also included a measure of genetic literacy that was used as covariate in the main analysis.

2.2.1 | Lay heritability of mental health traits

Participants were asked to estimate the heritability of each trait either using a 5-point Likert scale (Australian survey), or a continuous slider (U.K. and U.S. surveys). A sample item can be found in Box 1. Responses in the Australian sample could only take the values 0, 25, 50, 75, and 100% and were considered continuous for analytic purposes. The U.K. and U.S. surveys were designed later on and we found a continuous slider to have better statistical properties than the 5-point Likert scale. We argue that the impact of this difference in negligible given that this variable was used as a predictor and showed a linear relationship with the dependent variables. The initial position of the slider was randomized across items and participants.

2.2.2 | Personal responses to genetic risk information

Participants were asked about their attitudes toward psychiatric genetic testing. They were presented the following statements for each one of the three traits. Possible responses were *agree* or *disagree* (see Box 2).

Item 1 was intended to measure interest in psychiatric genetic testing. Items 2, 3, 4, and 7 were intended to measure beliefs about consequences of psychiatric genetic testing, including beliefs about gravity of genetic risk, self-efficacy managing the information, and potential discrimination. Item 5 was intended to measure potential prejudice based on genetic information. Item 6 was intended to measure perceived usefulness of psychiatric genetic testing. Item 8 was intended to measure beliefs about malleability of behavior.

2.2.3 | Genetic literacy

Genetic literacy was measured with 33 statements to which participants were asked to respond true, false or "I don't know" (i.e., "Most human traits and diseases are caused by a single gene."). Items were selected from Jallinoja and Aro (1999), Molster et al. (2009), and Carver et al. (2017). The scale was scored by summing the number of correct responses. The complete genetic literacy questionnaire can be found in Supporting Information.

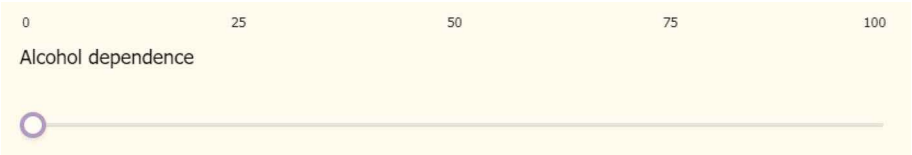
BOX 1 Text used to introduce item about heritability of traits

In the field of genetics, the term 'heritability' (of a given trait) refers to how much of the differences we observe between people in a specific community or population are due to those people having differences in their DNA.

For example, if the heritability of "body weight" is extremely high in a specific community, that means that the main reason why some people weigh more than others is because of them having different DNA.

Having this concept of heritability in mind, please answer how much do you think genetic differences explain why people are different for the following traits.

Remember that 0% means no genetic influence at all, 50% an equal influence of genetic and environmental factors, and 100% means that differences are exclusively due to genetic influence.



BOX 2 Attitudinal items presented to the participants

1. I would like to know my genetic predisposition just *for the sake* of knowing.
2. If I knew I had a strong genetic predisposition, I'm worried I wouldn't be *able to cope* with it.
3. I would like to know my genetic predisposition *only if* there is something I can do about it.
4. I wouldn't want to *have children* if I knew I had a strong genetic predisposition.
5. I wouldn't *choose a partner* who has a strong genetic predisposition.
6. Knowing my children's genetic predisposition would help me be a *better parent* to them.
7. I'm concerned I won't be able to get health/life *insurance* if I get a genetic test.
8. Changes in my *lifestyle* could compensate my genetic predisposition.

Note: In italics, keyword that we will use to abbreviate each item in Table 4.

2.3 | Statistical analysis

Descriptive statistics were generated separately for each sample. One-way ANOVA tests and χ^2 tests of independence were used to examine differences across countries. The rate of missingness was lower than 5% for all variables except for family history (3.4–10.7%), and parenthood in the Australian sample, where there was a missing rate of 15.7%. Missing values in parenthood were imputed by obtaining the probability of having had children based on gender, age, and level of education. After imputation, missing rate was 0.21%, due to missingness in the covariates. All analyses were conducted with and without imputed values as a sensitivity check. For the rest of the variables, participants with any missing data were excluded from that specific analysis. We used logistic regression to estimate the association between lay estimates of heritability, the main predictor, and each of the attitudes toward genetic testing, the outcome. All regression models included age, gender, level of education, and genetic literacy as covariates. For the regression analysis, participants from the three surveys were pooled together. Mixed-effects logistic nested regression was used to control for country and family effects: country and family are random effects, with family being nested within country in the Australian sample. All variables were standardized within country prior to analysis. Linearity and multicollinearity assumptions were tested in all models. Goodness of fit was tested using the Hosmer-Lemeshow test (Hosmer, Lemeshow, & Sturdivant, 2013). All analyses were conducted in R 4.0.2 (R Core Team, 2020). Mixed-effect logistic regression was performed using the lme4 package (Bates, Mächler, Bolker, & Walker, 2015).

2.4 | Additional analysis

2.4.1 | Genetic research participants versus general population

Research participants at QIMR Berghofer receive periodic newsletter with information about the latest outcomes from research conducted at the institute on the genetics of mental health traits. We expect them to have a higher level of specific psychiatric genetic literacy than the general population. Therefore, we repeated all analysis introducing a new binary covariate where Australian participants were assigned the Code 1 and both U.K. and U.S. participants were assigned the Code 0. The same mixed-effects models controlling for family and country was used.

3 | RESULTS

3.1 | Preliminary analysis

Frequency data for the main demographic variables are summarized for the three samples in Table 1. Chi-square test of independence was performed across samples for each demographic variable listed. Samples from the three countries differed significantly in all covariates (see Table 1). There was no multicollinearity and most predictors showed a linear relationship with the outcome. However, goodness of fit of our models was poor and Hosmer-Lemeshow tests indicated that only two out of the 24 regression models performed better than the null model. This was congruent with pseudo-R^2 values ranging between 0.4 and 4.9% of variance explained. Sensitivity analysis showed that results did not differ between removing missing data and imputing missing values in the parenthood covariate.

3.2 | Lay heritability of mental health traits

Table 2 provides perceived (i.e., lay) heritability estimates for alcohol dependence, schizophrenia, and depression by country. For reference, we have included the empirical heritability estimates for the three traits surveyed from a recent meta-analysis (Polderman et al., 2015). Lay estimates of heritability of mental health traits varied across country. When comparing the Australian sample to United Kingdom and United States, Australian participants were slightly more accurate on average. Heritability estimates from U.S. participants were higher than those from Australian and U.K. participants for alcohol dependence and depression but not for schizophrenia, where Australian respondents estimated its heritability to be higher on average. For all traits,

TABLE 1 Description of samples and tests of differences between the cohorts based on a selection of demographic variables

	Australia ($N = 3,646$)	United Kingdom ($N = 489$)	United States ($N = 471$)
Age range (%)			
15–24	18.1	22.1	26.0
25–34	32.1	30.5	35.4
35–44	19.0	17.6	21.0
45–54	9.4	14.1	9.4
55–64	15.2	13.1	5.0
65+	6.0	2.7	3.2
			$F(2, 4,566) = 17.75, p < .001$
Gender (%)			
Women	65.5	63.4	46.5
Men	34.5	36.6	53.5
			$\chi^2(2, N = 4,606) = 64.64, p < .001$
Highest educational degree (%)			
Compulsory education[a]	6.0	2.9	1.5
Senior high school	11.5	21.3	31.8
Certificate or diploma	25.7	23.7	18.0
Undergraduate degree	38.0	35.4	36.3
Postgraduate degree	18.7	16.8	12.3
			$F(2, 4,601) = 12.3, p < .001$
Genetic literacy test (%)			
<25% correct answers	7.2	5.4	3.2
25–50% correct answers	31.8	33.1	22.6
51–75% correct answers	47.2	47.7	59.6
>75% correct answers	13.7	13.8	14.6
			$F(2, 4,559) = 1.19, p = .305$
Have children[b] (%)			
Yes	54.7	56.4	70.3
No	31.5	43.6	29.7
Missing	13.8	0	0
			$\chi^2(2, N = 4,647) = 150.45, p < .001$
Personal experience or blood relative with diagnosis[c] (%)			
Alcohol dependence			
Yes	54.4	15.1	33.5
No	43.9	81.0	61.4
Missing	1.7	3.9	5.1
			$\chi^2(2, N = 4,501) = 149.97, p < .001$
Schizophrenia			
Yes	14.9	4.3	7.9
No	82.9	92.2	86.6
Missing	2.2	3.5	5.5
			$\chi^2(2, N = 4,481) = 52.57, p < .001$
Depression			
Yes	78.3	48.7	52.4
No	20.3	47.8	41.2
Missing	1.4	3.5	6.4
			$\chi^2(2, N = 4,508) = 265.24, p < .001$

Note: Values rounded to the nearest whole number. Percentages may not add up to 100.
[a]Primary and high school up to senior secondary school.
[b]Biological or adopted.
[c]Participants were asked if themselves or a blood relative had received a diagnosis of the condition.

TABLE 2 Distribution of lay heritability estimates divided in quintiles

		(0–12.5)	(12.5–37.5)	(37.5–62.5)	(62.5–87.5)	(87.5–100)	*N*	Mean (*SD*)
Alcohol dependence, $h^2 = 0.41$[a]	Australia	12.6	38.9	39.4	7.9	1.2	3,579	36.5 (21.3)
	United Kingdom	15.8	39.9	31.1	11.6	1.6	424	35.5 (21.9)
	United States	9.7	26.0	40.2	21.4	2.6	453	45.0 (22.3)
	$\chi^2 = 115.8$ ($p < .0001$)							
Schizophrenia, $h^2 = 0.77$[a]	Australia	2.0	11.8	39.2	39.6	7.4	3,347	59.7 (21.5)
	United Kingdom	9.5	22.1	35.7	28.4	4.3	465	48.5 (24.7)
	United States	6.9	14.2	30.8	35.1	12.9	464	58.0 (24.8)
	$\chi^2 = 169.9$ ($p < .0001$)							
Depression, $h^2 = 0.34$[a]	Australia	6.6	27.5	50.6	13.5	1.8	3,554	44.1 (20.8)
	United Kingdom	2.7	25.6	46.7	21.8	3.2	459	46.8 (21.7)
	United States	2.4	21.7	42.9	29.6	3.3	460	50.9 (21.3)
	$\chi^2 = 114.3$ ($p < .0001$)							

[a]Most recent published h^2 point estimate available for "mental and behavioral disorders due to use of alcohol," "schizophrenia," and "depressive episode," respectively, in the meta-analysis by Polderman et al. (2015).

Australian participants were closer to the correct estimate of heritability on average than the other two samples. The mode in every combination of country and trait was 50%, except for alcohol dependence in Australia where there were approximately the same number of participants estimating the heritability to be 25% or 50%.

3.2.1 | Attitudes toward psychiatric genetic testing

Table 3 presents the participants' answers to all statements regarding consequences of psychiatric genetic testing, potential prejudice, and perceived usefulness. The table presents the percentage of participants that agreed to each statement by trait and by country, as well as the results of chi-square tests of independence assessing differences across countries.

3.2.2 | Interest in psychiatric genetic testing

Interest in learning about their own genetic predisposition for alcohol dependence, schizophrenia, and depression, was higher in the U.S. sample than in Australia and the United Kingdom In the United Kingdom, only about a third of the sample wanted to know their genetic predisposition just for the sake of knowing, while in the United States, this proportion went up to two thirds, and the Australian sample fell in between.

3.2.3 | Beliefs about consequences of psychiatric genetic testing

Participants from the Australian sample showed less worry about being able to cope with having a high genetic predisposition for the three traits. This difference was considerably larger in the case of schizophrenia. A minority of respondents reported concerns about coping with the information, having children, and obtaining an insurance for alcohol dependence and depression. It is worth noting that percentages of agreement were larger in the U.S. sample. For all traits in the three samples, around 50% of participants would only like to know about their genetic predisposition only if there was something they could do about it.

3.2.4 | Impact of genetic risk information on partner choice

Impact on partner choice was higher for genetic predisposition for schizophrenia, and in the Australian sample of genetic research participants. Genetic risk for depression had the least impact on partner choice, with approximately one out of five participants responding that they would not choose a partner who had a strong genetic predisposition for the condition.

3.2.5 | Perceived usefulness of psychiatric genetic testing

The majority of respondents agreed that knowing their children's predisposition for the three conditions would make them better parents. Perceived usefulness of genetic information was higher in the U.S. sample.

3.2.6 | Beliefs about malleability of behavior

The majority of respondents agreed that changes in their lifestyle could compensate for their genetic predisposition for alcohol dependence and depression. This was especially true for alcohol

TABLE 3 Percentage of agreement to each statement by trait and by country

I agree that…	Australia	United Kingdom	United States	χ^2, *p* value
Alcohol dependence				
1. I would like to know my genetic predisposition just for the sake of knowing	45.1	35.8	62.8	<.001
2. If I knew I had a strong genetic predisposition, I'm worried I wouldn't be able to cope with it	12.2	22.9	19.1	<.001
3. I would like to know my genetic predisposition only if there is something I can do about it	41.8	38.9	39.4	.325
4. I wouldn't want to have children if I knew I had a strong genetic predisposition	11.7	16.2	25.1	<.001
5. I wouldn't choose a partner who has a strong genetic predisposition	32.7	29.5	31.6	.370
6. Knowing my children's genetic predisposition would help me be a better parent to them	55.5	54.4	69.4	<.001
7. I'm concerned I won't be able to get health/life insurance	20.4	27.2	30.7	<.001
8. Changes in my lifestyle could compensate my genetic predisposition	63.5	64.4	74.3	<.001
Schizophrenia				
1. I would like to know my genetic predisposition just for the sake of knowing	52.0	39.1	65.1	<.001
2. If I knew I had a strong genetic predisposition, I'm worried I wouldn't be able to cope with it	29.4	48.7	47.6	<.001
3. I would like to know my genetic predisposition only if there is something I can do about it	49.8	49.5	48.3	.837
4. I wouldn't want to have children if I knew I had a strong genetic predisposition	35.7	40.9	54.1	<.001
5. I wouldn't choose a partner who has a strong genetic predisposition	42.3	37.2	44.8	.043
6. Knowing my children's genetic predisposition would help me be a better parent to them	60.4	59.5	74.7	<.001
7. I'm concerned I won't be able to get health/life insurance	30.7	37.8	41.6	<.001
8. Changes in my lifestyle could compensate my genetic predisposition	32.4	31.7	30.4	.668
Depression				
1. I would like to know my genetic predisposition just for the sake of knowing	62.1	42.5	67.2	<.001
2. If I knew I had a strong genetic predisposition, I'm worried I wouldn't be able to cope with it	23.2	34.4	29.4	<.001
3. I would like to know my genetic predisposition only if there is something I can do about it	55.5	52.5	51.7	.158
4. I wouldn't want to have children if I knew I had a strong genetic predisposition	17.7	22.1	29.9	<.001
5. I wouldn't choose a partner who has a strong genetic predisposition	25.7	19.8	24.0	.016
6. Knowing my children's genetic predisposition would help me be a better parent to them	67.6	65.2	80.4	<.001
7. I'm concerned I won't be able to get health/life insurance	31.7	35.6	40.2	<.001
8. Changes in my lifestyle could compensate my genetic predisposition	71.4	65.8	66.2	.005

dependence in the United States, whereas for schizophrenia, in all countries only around a third of participants agreed with this statement.

3.3 | Association between lay heritability and attitudes

Lay heritability was significantly associated with most attitudes and traits after controlling for age, gender, educational attainment, and genetic literacy. In particular, across all traits, the higher the heritability estimate, the more likely participants were to declare that: (a) they wanted to know for the sake of knowing; (b) they were worried about having children; (c) they were worried about not being able to get health/life insurance; (d) they did not want to choose a partner with high genetic predisposition; and (e) knowing their children's predisposition would make them better parents. All these associations were significant for schizophrenia and depression, but only in some cases for alcohol dependence. In addition, higher heritability estimates of schizophrenia were associated with a perception that changes in lifestyle have a lower impact in compensating one's genetic predisposition for the condition (see Table 4). See Figure 1 for a visual representation of how participants' agreement with a selection of attitudinal questions are associated with their lay estimates of heritability. For example, 60% of participants who estimate the heritability of alcohol dependence to be 37.5–62.5% (i.e., interval that encompasses the published estimate, noted with a star) in contrast to 50% of participants who estimate the heritability to be 0–12.5%.

Next, we looked at the associations between attitudes and the covariates. We found that participants with higher genetic literacy were less worried about not being able to cope and were less likely to declare that they would reject a partner based on a high-risk status for all traits. They were also less likely to worry about having children if they had a high genetic risk, and more likely to agree that changes in lifestyle could compensate their genetic predisposition for all traits.

TABLE 4 Association between perceived h^2 and personal responses

	Alcohol dependence	Schizophrenia	Depression
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Sake of knowing	1.010*** (1.007–1.013)	1.007*** (1.004–1.000)	1.010*** (1.007–1.013)
Able to cope	1.001 (0.997–1.005)	1.005** (1.002–1.008)	1.004* (1.001–1.008)
Only if	1.004* (1.001–1.007)	0.998 (0.995–1.001)	1.002 (0.999–1.005)
Have children	1.003 (0.998–1.007)	1.007*** (1.004–1.010)	1.006** (1.002–1.010)
Choose a partner	1.004* (1.000–1.007)	1.005*** (1.002–1.008)	1.006** (1.002–1.009)
Better parent	1.008*** (1.004–1.011)	1.007*** (1.004–1.010)	1.004** (1.001–1.008)
Insurance	1.008*** (1.004–1.011)	1.007*** (1.004–1.010)	1.008*** (1.005–1.011)
Lifestyle	1.002 (0.999–1.005)	0.987*** (0.984–0.990)	0.999 (0.996–1.002)

Note: Significance codes: 0 "***" 0.001 "**" 0.01 "*" 0.05 " " 1.

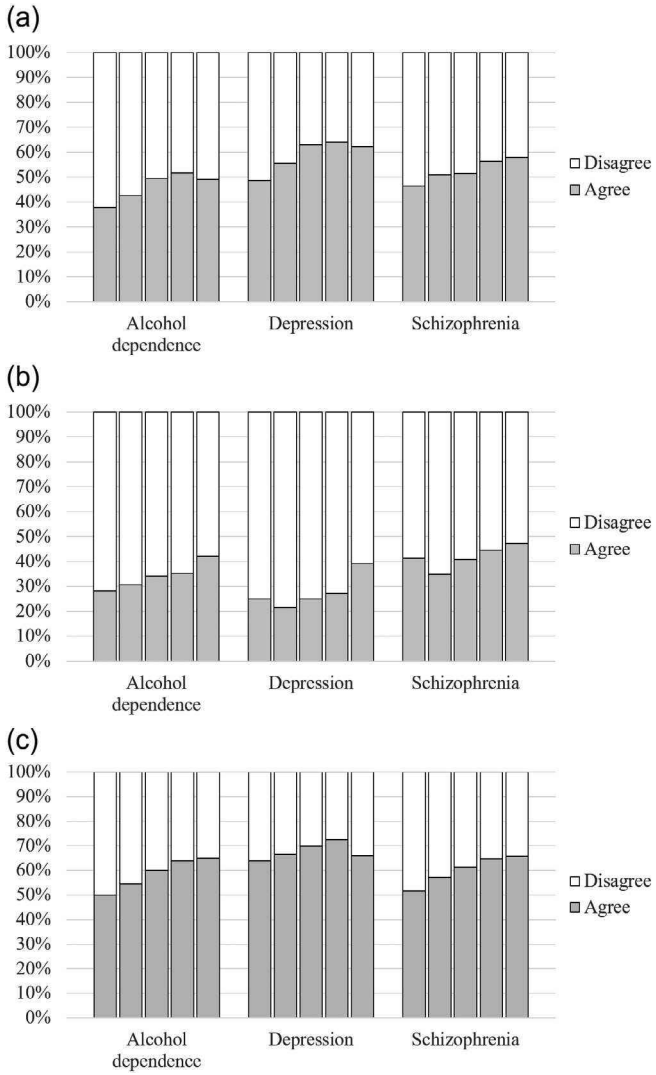


FIGURE 1 From top to bottom, percentages of agreement within trait for: (a) *I would like to know my genetic predisposition just for the sake of knowing*; (b) *I wouldn't choose a partner who has a strong genetic predisposition*; and (c) *Knowing my children's genetic predisposition would help me be a better parent to them*. Lay heritability estimates have been grouped into quintiles (same categories used in Table 2). Star indicates closest category to published heritability estimate

Other significant results were that *women* and *younger people* were more worried about their ability to cope with high genetic risk for all traits. Women also were more likely to declare that they would reject a partner based on a high-risk status for alcohol dependence and schizophrenia, but not depression. Older participants were more likely to declare that they would reject a partner based on a high-risk status, less likely to perceive that genetic information would make them better parents, and less likely to declare wanting to know for the sake of knowing, for all traits. Older participants and participants that were more educated were more worried about not being able to get life/health insurance if they were tested. When it came to *family history*, participants that had experience with any of the conditions (i.e., either themselves or a blood relative had been diagnosed with the condition) agreed more often that they would only want to know their genetic predisposition if there was something they could do about it. However, they were also more likely to declare wanting to know for the sake of knowing. They also agreed more often that knowing their children's genetic predisposition would make them better parents. Both participants with family history of the condition and more educated participants were more likely to agree that changes in lifestyle could compensate a genetic predisposition for all traits. Finally, participants that already had *children* disagreed more with not wanting to have children if they knew they had a strong genetic predisposition. This was the same for the three traits. For detailed results, including odd ratios and significance tests, see Supporting Information.

3.4 | Additional analysis

3.4.1 | Genetic research participants *vs* general population

Genetic research participants were less worried about their ability to cope, having children, and obtaining a health/life insurance for all traits. However, they were more likely to agree that changes in their lifestyle could not compensate their genetic predisposition for alcohol dependence and schizophrenia, and were more likely to declare that they would not choose a partner that had a high genetic

predisposition for depression. Being a genetic research participant was not significantly associated with the other attitudinal questions.

4 | DISCUSSION

In the present study, we intended to provide insight on lay estimates of heritability in three mental health problems as well as attitudes toward psychiatric genetic testing in large samples from three different countries. In addition, we aimed to assess the association between sociodemographic variables, exposure to the disorders, perceived heritability, and genetic literacy, with participants' attitudes. In summary, we found that there is a high variability in attitudes toward psychiatric genetic testing and lay estimates of heritability for alcohol dependence, depression, and schizophrenia. Moreover, lay estimates of heritability are associated with attitudes toward genetic testing.

Our results show that lay heritability estimates of mental health traits are very heterogeneous, even within communities in close contact with psychiatric genetic research. Lay estimates of heritability were similar to those published by Chapman et al. (2019) and Willoughby et al. (2019). People tended to estimate the heritability of all traits closer to 50%, meaning that participants acknowledged the importance of both genetic and environmental factors. However, this means that the heritability of depression is overestimated, the heritability of schizophrenia is underestimated, and heritability estimates for alcohol dependence are more accurate. In regards to attitudinal questions, attitudes toward the application of psychiatric genetic testing varied markedly across questions and traits. Similar to what Meiser et al. (2020) reported in their systematic review, there is a high interest in psychiatric genetic testing. For example, the majority of participants agree that genetic information would but useful as parents and over half the participants would like to know their genetic predisposition for the three traits, especially in the United States. There is, however, a non-trivial percentage of participants with serious concerns related to learning about personal genetic predisposition. In particular, 11.7–53.8% of the participants would not want to have children if they knew they had a high genetic risk for depression, alcohol dependence, or schizophrenia, and 20.2–43.7% would not choose a partner if they had a high genetic risk for these disorders, with the highest percentages reported for schizophrenia. This suggests that the availability of personal genetic information could trigger concerns among the general population regarding potential discrimination and family planning.

In addition, we found that people's attitudes toward psychiatric genetic testing are associated with their lay heritability estimates. Across all traits, participants who estimated heritability to be higher were more likely to have concerns regarding insurance, reproductive and partner choices, but were also more likely to see genetic testing as more useful, and wanted to know their genetic predisposition more. These results provide one more piece of the puzzle that is public understanding of genetics. When looking at other relevant predictors of attitudes toward psychiatric genetics, higher genetic literacy, both general and specific to psychiatric genetics, was associated with a more positive attitude toward psychiatric genetic testing. The fact that individuals who participate in psychiatric genetic research were more likely to express that changes in their lifestyle could not compensate their genetic predisposition for mental health disorders might indicate that the way we currently communicate about genetics may be overlooking the role of environmental and lifestyle factors. Relating to this, the majority of participants agreed that changes in their lifestyle can compensate their genetic predisposition for alcohol dependence and depression, but only about a third of them thought this was the case for schizophrenia, which give us information about public perceptions of malleability of behavior. Overall, these results help us identifying sources of anxiety and resistance to change that could hinder educational and counseling interventions (Morosoli et al., 2019). Previous work on biases in affective forecasting (i.e., predicting how one will feel in the future) shows that people overestimate the duration and intensity of their emotional reactions to health information, such as receiving a diagnosis, and underestimate their resilience (Peters, Laham, Pachter, & Winship, 2014). Rather than arguing that genetic information is dangerous or should not be distributed, our results can be used to highlight sensitive areas that should be explicitly addressed in educational campaigns or when disclosing personal genetic information. In fact, the few studies that have been conducted on the impact of psychiatric genetic counseling suggest that genetic counseling can increase empowerment and self-efficacy in individuals with mental illness (Inglis, Koehn, McGillivray, Stewart, & Austin, 2015) and reduce some of their symptoms, above and beyond medication adherence (Morris et al., 2021). Altogether, these results support the idea that psychiatric genetic counseling and the use of genetic information in mental health can improve the quality of life of clients and their families, as long as educational and counseling interventions pay attention to their needs and worries.

There are certain limitations to this study. While we provide insight into current perceptions of psychiatric genetic testing and potential relationships between specific components of genetic literacy and public attitudes, we do not explain how the public form their attitudes, nor how can we intervene on them. A combination of experimental quantitative and qualitative research remains the only way to address these questions. Our study does not look specifically into what predicts accurate estimates of heritability. Willoughby et al. (2019) who did look into this question, found that belief in genetic determinism, gender, and parenthood, were significantly associated with accuracy in lay estimates of heritability. In addition, our study focused on hypothetical reactions to genetic information rather than actual information. There is an urgent need for studies that assess responses to actual genetic results. However, given the ethical challenges associated with disclosing genetic information, we believe studies focusing on hypothetical situations are still useful for improving our understanding of the conceptions and attitudes that the public has regarding to psychiatric genetic testing. More limitations to our study include that participants in the Australian survey had to select one out of five values when estimating the heritability of the three traits whereas in the United Kingdom and United States this variable was continuous. However, as stated before, we consider its impact to

be negligible given that this variable was used as a predictor and showed a linear relationship with the dependent variables. Sample sizes varied considerably between Australia and the other countries and homogeneity tests showed statistically significant difference across countries for all control variables. Despite using statistical methods to control for country, we may not have been able to remove its effect. Nonetheless, we opted for pooling all samples together in order to increase our power to identify general trends in public attitudes, as we were more interested in what these countries had in common rather than country-specific effects. In addition, our samples are likely not representative from their countries due to the nature of the sampling.

In conclusion, our study provides an updated estimate of public interest in genetic testing for alcohol dependence, depression, and schizophrenia, as well as the prevalence of concerns associated with the availability of this technology. The association between attitudes and lay heritability highlight the complexity of learning about genetics. Science communication in the field cannot ignore how embedded this research is in personal values and experiences and its impact in individuals' health and social behavior. We believe is our duty as researchers to clarify and address such concerns to the best of our ability in every occasion we have.

CONFLICT OF INTEREST

None.

AUTHOR CONTRIBUTION

José J. Morosoli carried out the research and completed this manuscript under the guidance of Sarah E. Medland, Fiona K. Barlow, and Lucía Colodro-Conde. Specifically, José J. Morosoli analyzed the data and wrote the manuscript. Sarah E. Medland assisted in conceiving and planning the research. Sarah E. Medland, Fiona K. Barlow, and Lucía Colodro-Conde, revised the manuscript.

ETHICS STATEMENT

Approval was obtained from the ethics committees of the QIMR Berghofer Medical Research Institute and the University of Queensland.

DATA AVAILABILITY STATEMENT

Data available upon request.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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