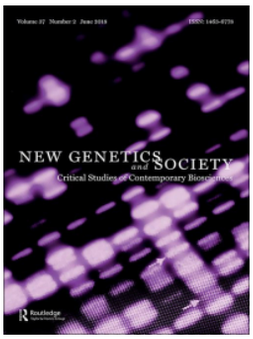

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Are we ready for the genomic era? Insights from judges and lawyers

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Genetic advances have brought new opportunities to society, with new powers of polygenic prediction, genetic engineering and gene-based environmental interventions. Judges and lawyers influence interpretations and attitudes towards complex societal issues and develop regulation. Therefore, their genetic literacy and views are an important part of society's readiness for the genomic era. The study explored judges' and lawyers' ($N = 117$) genetic literacy, as well as views on the use of genetic advances. Quantitative and qualitative analyses showed insufficient knowledge of essential genetic concepts, including striking cases of over- and under-estimation of genetic and environmental influences on behavior. Participants' views on every issue were widely varied, from strong agreement to strong disagreement. The majority of the participants thought that current laws are not sufficient to protect individuals from misuses of genetic data. The results suggest that society is not ready for the genomic era and call for multidisciplinary efforts to increase the readiness.

Keywords: Genetic advances; genomic era; judges' genetic knowledge; judges' views; regulation of genetics; genetic data use and misuse; lawyers' genetic knowledge and views

1. Introduction

Genomic advances have brought enormous potential benefits but also risks for individuals and societies. This is because applications of genomic advances stretch across many aspects of life, including health, sports, insurance, education, and criminal justice; as well as from pre-birth to future generations. Progressing towards societal readiness for successful applications of genomic advances relies on knowledge and views of key stakeholders, including judges and lawyers.

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Judges and lawyers are guardians in the process of implementation and regulation of scientific advances. As key justice stakeholders, they have the power and duty to protect people from potential injustices associated with the use of new technologies. Genetics is an area where sophisticated regulation of current and future advances is paramount – as genetic applications have many unaddressed practical, ethical, philosophical and other societal implications.

For example, existing laws are not designed to protect from missuses of information extracted from sequenced DNA data (Andrews, Mehlman, and Rothstein 2015; Furrow *et al*. 2013; Selita 2019b). Information extracted from sequenced DNA can be used for polygenic prediction, such as estimating one's health risk or educational potential. This prediction can be used for disease prevention and personalized education, but also brings risks of discriminatory use (Andrews, Mehlman, and Rothstein 2015; Selita 2019b). Another area of concern is gene editing, including the germline. It brings great promise for new treatments, but it also presents risks for irreversible damage to an organism, population genetic pool, and societal organization (Bosley *et al*. 2015; Kovas and Selita 2021; Raposo, 2019). Addressing such issues, including via sophisticated legal regulation, require *informed* deliberations of the relevant stakeholders.

A growing body of research has identified genetic literacy – sufficient understanding of the key genetic concepts – as a prerequisite to the ability to assess and appreciate risks associated with the use of genetic advances. Genetic literacy is also foundational for the drafting of legislation and legal procedures that can prevent harm. Several studies to date explored genetic literacy of judges and lawyers, as well as their views on applications of genetic advances. The current paper provides an overview of this literature from the limited number of explored jurisdictions (US, Germany, Romania); and extends this research in another jurisdiction – Russia.

In 2012 and 2015, Aspinwall *et al.* (181 judges in the US) and Fuss *et al.* (372 judges in Germany), using the same vignette assessed the extent to which biological evidence concerning psychopathy mitigated, aggravated, or had no effect on the punishment judges would issue (Aspinwall, Brown, and Tabery 2012; Fuss, Dressing, and Briken 2015). The results showed that within the same jurisdiction judges viewed the biological evidence as mitigating and aggravating. Cross-national differences also emerged: the presentation of genetic information led to a shorter sentence in the US sample, but to an increased likelihood of involuntary commitment in a forensic psychiatric hospital in Germany. The results indirectly indicate that judges do not have sufficient genetic knowledge, and also that genetic literacy interacts with societal setups and general attitudes (e.g. misconceptions about immutability of traits; and assumed purpose of the prison sentence – punishment, keeping offender off the streets, deterrence). In 2016, Berryessa CM, using a sample of 21 US judges, examined how judges would react if they were told or were presented evidence that an offender has a mental disorder with genetic influences (Berryessa 2016). Different judges viewed the same evidence as mitigating

or aggravating, some were sceptical about such evidence and some judges expressed reliance on experts interpreting such evidence. These results also indirectly indicate lack of relevant genetic knowledge.

In 2019, Berryessa CM reported results of a study where 59 US judges were asked to describe their thoughts about sentencing if an offender's mental disorder was known to be genetically influenced (Berryessa 2019). The study reported that a knowledge of genetic aetiology of a mental disorder was associated with more restrictive sentence, likely driven by essentialist beliefs and stigmatization biases. These results, again, indirectly suggested a lack of nuanced understanding of genetics, such as importance of gene-environment interplay. A further paper in 2019 provided indirect evidence for lack of understanding of contemporary genetics among judges. The paper examined paternity cases in UK and Australian courts in relation to judges' "biotruth" rhetoric, whereby genetic parentage is viewed as a simple scientific reality (Robert 2019). The author discusses how such rhetoric conflates precision of genetic identification with establishing legal parentage, child's identity and reflecting child's interests. Such simplistic and reductionist approach contrasts with findings from contemporary genetics of complex gene-gene and gene-environment interplay affecting phenotypic expression.

Another study highlighted concerns about lack of legal stakeholders' understanding of genetics and related perceptions of genetic science as a "truth machine" (Amelung, Granja, and Machado 2020). The paper presented analyses of 9 forensic geneticists' evaluation of the views on genetics by publics-in-particular – active members of the criminal justice system, including judges, lawyers and police force. These views were described as often overly enthusiastic and unrealistic in regards to applications of DNA technologies in criminal cases. Another study in 2019 explored views on the use of genetic advances of an opportunistic sample of lawyers and law students from different countries (Selita, Chapman, and Kovas 2019). The results showed strong endorsement for the State using genetic information on propensity for violence for prevention of crime; and for considering genetic information in sentencing. Such strong endorsement of controversial uses is again an indication of lack of genetic literacy. Higher genetic literacy would include understanding of limitations of DNA analyses, potential risks and unintended consequences of overstating DNA evidence, and misuses that may stem from predictive use of probabilistic information.

In 2019, a study directly assessed genetic literacy of an opportunistic sample of 5405 participants from different countries (Chapman *et al*. 2019). The analyses by profession indicated that genetic knowledge of lawyers ($N = 80$) was similarly low to that of representatives of other professions. In 2020, Selita *et al*. examined genetic literacy of 73 Supreme Court judges and 94 lawyers in Romania, using a 17-item survey (Selita *et al*. 2020). The results showed that judges' and lawyers' knowledge of genetics was inconsistent: some items, that could be answered using general reasoning, were answered correctly by ∼90% of the

judges (e.g. the approximate number of genes in the genome). Other items, requiring knowledge of basic genetic concepts, were answered correctly by only ∼24% of the judges. The Romanian judges and lawyers also shared their views on the use of genetic information in different life contexts, and on application of genetic advances (Selita *et al*. 2023). The results showed a high agreement among judges and other lawyers endorsing the use of gene editing for prevention and treatment of disease; as well as for other purposes ("improving self or children"). The judges and lawyers also reported strong endorsement for use of genetic information by the State for crime prevention, but much weaker endorsement for the use of genetic information by insurers, schools or employers.

Overall, the research to date uncovered important limitations in legal stakeholders' genetic knowledge. Possessing *some* knowledge may provide a false sense of security and form a basis for misinformed decisions. Legal practitioners themselves acknowledge the need for improved genetic literacy. For example, judges in the Romanian study almost unanimously welcomed training in gene-environment processes for judges (Selita *et al*. 2020). The research to date also suggested specific patterns in legal stakeholders' endorsement of different applications of genetic advances. Further research is needed to understand what these results mean for our genomic readiness.

As genetics has no borders, further research is also needed to examine whether these patterns of results can be replicated in other jurisdictions. Establishing universality vs. specificity of the results is important, as developing appropriate genetic regulation is a global concern. For example, gene editing has cross-generational implications and has the power to affect the future of humankind. Effective regulation of germline editing in just a few countries would not protect from potential harm, if other jurisdictions were to allow such a practice. Moreover, different jurisdictions have different legal reasoning, application of laws and method of developing laws. Therefore, it is important to see whether views match or differ across jurisdictions. Cross-national research may also help uncover factors that influence knowledge and views on these matters.

1.1. *The present study*

This study explores genetic literacy and opinions of a representative group of judges and lawyers from Russia. The study uses largely the same measures as those used in the two previous studies with Romanian participants (Selita *et al*. 2020, 2023). This allows for a systematic exploration of whether the same pattern of results can be observed in a different jurisdiction. Based on the pattern of results found with Romanian legal professionals, we explored whether the Russian legal professionals would show:

(1) Uneven knowledge across different genetic concepts.

(2) High endorsement of gene editing for medical purposes, for use of genetic information by the State for prevention of crime and for using genetic information to adapt environments to people's needs; and low endorsement for allowing insurance companies to access clients' genetic information.
(3) High agreement that laws in place are insufficient to protect individuals from misuses of genetic information; and in recognizing the urgent need for updating relevant laws and procedure; as well as for training of judges in gene-environment processes.

2. Materials and methods

The study was approved by the Goldsmiths Department of Psychology Ethics Committee (PSY10.10.2016). Informed consent was obtained before the beginning of data collection.

2.1. *Participants*

The 102 participants were 56 judges (commercial court, $N = 36$; and common court, $N = 20$); and 46 lawyers (27 advocates and 19 prosecutors). Participants were recruited by personal invitation by academics and advocates – Russian members of the international Working Group on Legal, Ethical and Societal Implications of Genetics (LESIG, 2016-2020). Participation rate of judges was 90.3% (62 judges were approached, 56 provided full data). Participation rate of lawyers was 92% (50 lawyers were approached, 46 provided full data). Participants returned completed questionnaires in-person. Therefore, no demographic information (age, sex or gender) was collected to preserve anonymity. The number of responses varied for different analyses, as participants could skip any items they did not wish to answer.

2.2. *Measures and procedure*

This study used 30 items in total. Twenty nine items were drawn from the International Genetic Literacy and Attitudes Survey (iGLAS) (Chapman *et al*. 2017). The iGLAS was first created and validated in English (Chapman *et al*. 2017), and has been adapted to 9 other languages. The adaptations were created following established procedures (Fenn, Tan, and George 2020). This included forward translation by 2 translators working separately; backwards translations by 2 translators working separately; followed by checks by a committee of experts – members of the iGLAS team. More than 14,000 participants from different countries completed the survey. Detailed information on validation, construction, translation and use of iGLAS can be found in a previous publication (Chapman *et al*. 2017). In the current study, we used the Russian adaptation of iGLAS –

the first language of the participants. Additionally, one item (item 5, Table 1) was developed specifically for this study by the iGLAS research team.

2.2.1. *Judges' and lawyers' genetic literacy*

Judges' and lawyers' genetic knowledge was explored with 18 iGLAS items and 1 additional item (item 5 in Table 1). Five knowledge items required participants to select a response from the provided list: 3 items had yes/no or true/false responses; 2 items had 1 correct and 3 incorrect response options (see Table 1). These responses were combined into an overall knowledge score. The remaining 14 knowledge items examined participants' knowledge of heritability for 14 complex traits (see Table 2). Heritability expresses the extent to which individual differences in a particular trait in a particular population are due to people's genetic differences (e.g. Polderman *et al*. 2015; Selita and Kovas 2018). Participants were asked to provide responses to: "On a scale of 0–100 how important are genetic differences between people in explaining individual differences in the following traits".

2.2.2. *Judges' and lawyers' views on genetics*

Judges' and lawyers' views were explored with 11 iGLAS items, of which 10 were presented on 7-point Likert scales from 1 (strongly disagree), through 4 (neither

Table 1. Frequencies (N participants and proportions) of correct responses for each of the multiple-choice options for the 5 genetic knowledge items.

Q1. What is a genome?			
A sex chromosome 4 (4.0%)	**The entire sequence of an individual's DNA 25 (24.8%)**	All the genes in DNA 68 (67.3%)	Gene expression 4 (4.0%)
Q2. The DNA sequence in two different cells, for example a neuron and a heart cell, of one person, is …			
Entirely different 12 (12.2%)	About 50% the same 42 (42.9%)	More than 90% the same 25 (25.5%)	**100% identical 19 (19.4%)**
Q3. Can we fully predict a person's behavior from examining their DNA sequence?			
Yes 32 (31.4%)		**No 70 (68.6%)**	
Q4. At present in Russia / your country, new born infants are tested for genetic mutations			
True 66 (64.7%)		False 36 (35.3%)	
Q5. Most traits are influenced by genes			
True 81 (79.4%)		False 21 (20.6%)	

Note: Darker shade indicates greater proportion of participants selecting this option. Correct responses are shown in **bold**.

Table 2. Participants' estimates of heritability (genetic influence) for 14 complex traits.

Trait	*N*	Mean	SD	Min	Max
H1. Eye Color	96	64.48	32.08	0	100
H2. Height	94	66.49	27.5	0	100
H3. Weight	96	50.21	25.63	0	100
H4. IQ	96	65.89	24.3	0	100
H5. Motivation	96	53.85	26.29	0	100
H6. School Achievement	96	53.54	22.64	0	100
H7. Sexual Orientation*	Judges: 54	29.63	28.81	0	100
	Lawyers: 42	46.79	37.02	0	100
H8. Clinical Depression	96	48.23	27.72	0	100
H9. ADHD†	96	46.41	25.48	0	90
H10. Dyslexia	96	47.14	27.69	0	100
H11. Schizophrenia	96	65.83	28.46	0	100
H12. Insomnia	96	35.68	23.67	0	90
H13. Sleep Quality	96	42.81	25.86	0	100
H14. Sleep Length	96	45.42	27.64	0	100

Note: Participants were asked to estimate: How important are genetic differences between people in explaining individual differences in the following 14 traits (on a scale of 0–100). Darker shading indicates higher heritability estimates;
*Significant group differences at the 0.05 level.
†ADHD = Attention Deficit Hyperactivity Disorder.

agree nor disagree), to 7 (strongly agree); and 1 item required participants to choose 1 of 4 responses. For the present paper, views are grouped into the following two themes (Table 3 and Figure 2): views on gene editing and use of genetic information (4 items); and views on updating key genomics-related laws and on the need for training of judges (7 items).

2.2.3. *Supplementary report from another sample of Russian lawyers*

The report contains results from a seminar with 15 lawyers and judges, including practitioners from a number of areas and Law School academics – organized as part of the LESIG Working Group's activities. The session lasted 2.5 h. During the session, participants completed questionnaires, received information (2 presentations on genetics and law), and engaged in discussions. The discussions were recorded with permission from participants and then transcribed, preserving full anonymity of the participants.

Fourteen of the 15 participants also completed questionnaire booklets at the beginning of the session. The questions were taken from the earlier versions of iGLAS, including 16 genetic knowledge items, of which 4 overlapped with the ones used in the main analyses of this paper. The participants also provided

Table 3. Means, Standard Deviations and Frequency responses for the 10 opinion items presented on Likert scales.

Item		Mean (SD)	Frequencies (Likert scales 1 = strongly disagree , 4 = neither agree nor disagree, 7 = strongly agree)							
			1	2	3	4	5	6	7	N
1. I believe that genetic manipulation, such as gene editing, should be allowed for the prevention and treatment of disease		4.44 (1.51)	3	8	20	12	36	13	9	101
2. Genetic information should be used to adapt environments to people's needs, for example through individualised health advise		4.55 (1.40)	5	5	9	22	35	23	3	102
3. Insurance companies should be allowed to request genetic data prior to issuing health and/or life insurance		3.27 (1.53)	10	32	15	18	18	7	1	101
4. Over 40 markers in the human genome have been linked to aggressiveness. The state should use this information for prevention of crime		4.35 (1.37)	3	12	10	15	46	13	2	101
5 – 7. Current laws in your country are sufficient to protect individuals from misuses of genetic data by:	Insurance companies	3.20 (1.66)	16	27	14	25	6	10	3	101
	Employers (e.g., for hiring or firing purposes)	3.22 (1.63)	15	26	15	21	12	7	3	99
	Schools' admission	3.18 (1.65)	15	29	11	23	8	10	2	98
8. Breaches of genetic data should be made a criminal offence		5.41 (1.55)	2	3	10	11	15	31	29	101
9. Findings show that within any population there is a very large variability among people, including in terms of ability, personality and level of education. To provide justice for all, the legal system should accommodate this variability, including in terms of procedure and resources. For example, providing accessible jargon free information and making court proceedings people friendly:		4.20 (1.33)	2	12	10	30	30	10	3	97
10. Training in the fundamentals of gene-environment processes involved in individual differences in behaviour should be included in the curricular of: Judges		4.06 (1.51)	4	16	15	15	34	11	3	98

Note: Darker shading indicates greater number of participants selecting this option.

heritability estimates of 8 traits; as well as responses to 4 vignettes. Following this, participants discussed the answers to the knowledge questions and related issues; these data were qualitatively analysed (see SOM).

3. Results

First, we compared responses of judges and lawyers on each of the 30 items. Inferential analyses revealed no significant differences between judges and lawyers in variability or average values for 29 out of the 30 items. The exception was a small but significant (t (75.73) = 2.48, p = .016) difference in heritability estimate of sexual orientation: judges' estimate was lower (M = 29.63, SD = 28.81) than that of lawyers (M = 37.38, SD = 24.20). As the groups did not otherwise differ significantly, we re-ran analyses on a combined sample of judges and lawyers. The following sections describe the results from this combined sample.

3.1. *Genetic knowledge*

First, we calculated total genetic knowledge for each participant by summing their correct responses for the 5 questions (possible score range 0–5). These scores were then converted into an average correct score (raw genetic knowledge score, divided by 5, multiplied by 100). The average knowledge score was relatively low at 2.56 (or 51.18% correct). As can be seen from the frequencies in Table 1, only 24.8% of the participants knew the correct definition of a genome; and only 19.4% of the participants knew that the DNA sequence in two different cells is identical. Most of the participants (64–79%), however, answered correctly that we cannot fully predict a person's behavior from examining their DNA, that most traits are influenced by genes, and that in Russia new born infants are tested for genetic mutations.

Next, we examined participants' knowledge of heritability for 14 complex traits. The results, presented in Table 2, show a wide variability in participants' responses for each trait, with substantial proportions of participants estimating 0 or 100% heritability (see Figure 1).

3.2. *Opinions on the use of genetic information and regulation of genomic advances*

We assessed views on several key matters, grouped into: (1) views on use of gene editing and use of genetic information; and (2) updating of relevant laws, procedure and training of judges. The results for the 10 Likert scale opinion items are presented in Table 3. For all items, a large variability was observed, with the whole range of response options (1–7) used. To simplify the discussion in this section, we created two groups of responses: "Disagree" – combining scores 1–3 (strongly disagree, disagree, and somewhat disagree); and "Agree" – combining scores 5–7 (somewhat agree, agree, and strongly agree).

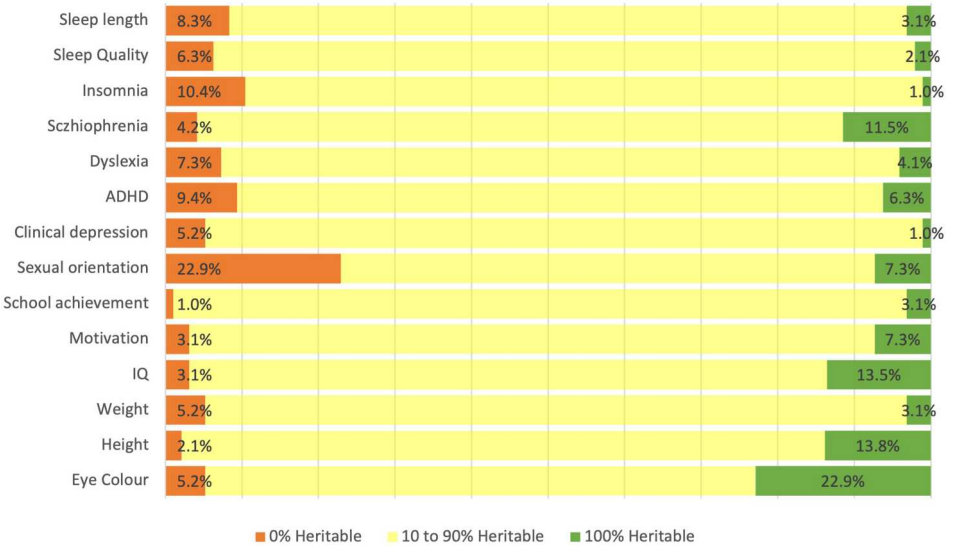

Figure 1. Proportion of participants responding that traits are either 0% or 100% heritable.

3.2.1. *Views on gene editing and use of genetic information*

Around 60% of participants agreed with each of the following uses of genetic advances: that gene editing should be used for prevention and treatment of disease (Item 1, Table 3); that genetic information should be used to adapt environments to people's needs, e.g. individualized health advice (Item 2, Table 3); and that the State should use genetic information about aggressiveness for prevention of crime (Item 4, Table 3). In contrast, only 25.7% of participants agreed that insurance companies should be allowed access to genetic data prior to issuing health and/or life insurance (Item 3, Table 3).

3.2.2. *Views on updating the relevant laws and training*

Only around 20% of the participants felt that current laws are sufficient to protect individuals from misuses of genetic data by insurance companies, employers, and schools (Items 5–7 in Table 3). As to when the relevant laws should be amended, the two most common answers were "now (ASAP)" (35.8%); and "after we are certain of the scale of the risk" (39.6%) (Figure 2).

Participants were divided in their views, with substantial proportions agreeing, disagreeing and neither agreeing nor disagreeing, on whether the legal system should accommodate the large variability among the people, including in terms of ability, personality and level of education (Item 9, Table 3); and on whether information about gene-environment processes should be included in judges' training (Item 10, Table 3).

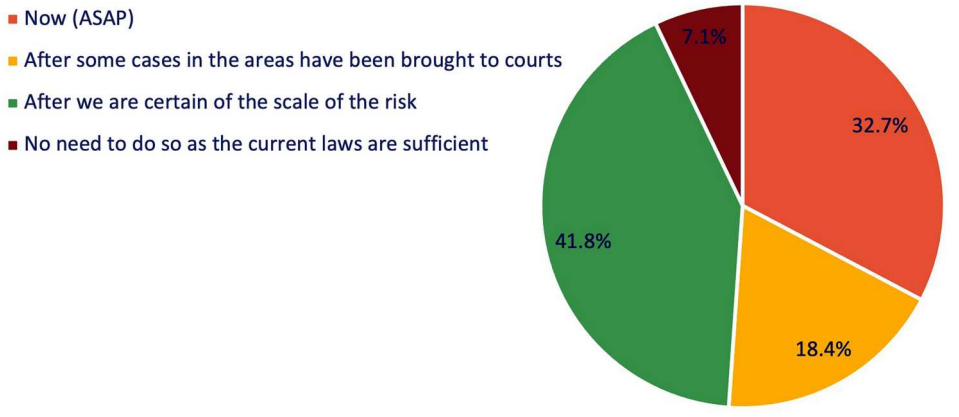

Figure 2. Frequency and proportion responses to "when the relevant laws should be amended".Note: The question asked: From a DNA sample taken at birth we already can predict, with a degree of probability, future behavior (such as school performance). The precision of prediction is continuously increasing. Moreover, sequencing is already routinely conducted for medical research and other purposes. When should relevant laws (e.g. data protection, privacy, non-discrimination, insurance, employment) be updated/introduced accordingly?

3.3. *Results from the seminar (Supplementary report)*

The quantitative analyses of the data on genetic knowledge and views of 14 lawyers indicated overall low genetic knowledge in this group, with similarly uneven knowledge across items as shown in the main study. For example, similar to the main analyses in this study, only about 20% of the seminar participants selected a correct response for "DNA in different cells is identical". The detailed results are reported in SOM.

Qualitative analyses of participants' comments and discussions, reported in SOM, produced the following two broad conclusions: (1) The lawyers and judges thought that genetic information is difficult and they did not possess the necessary genetic knowledge; and that they would like to know more in this field; and (2) The lawyers and judges are aware of multiple legal issues associated with genetic advances, including: data misuse and eugenics; ownership of genetic data; gene editing; national security; lack of legal protection and of uniform enforcement of laws.

4. Discussion

In this study we collected data from a representative sample of judges and lawyers in the Russian Federation – extending previous research into genomic era readiness with judges and lawyers in other jurisdictions.

Comparing the results with those reported in two recent papers exploring knowledge and views of Romanian judges and lawyers (Selita *et al*. 2020; 2023), suggested some potentially universal as well as country-specific trends.

For example, in both Russia and Romania, the genetic literacy of judges and lawyers was relatively low; the majority of participants endorsed gene editing for medical purposes, as well as the use of genetic information for adapting environments to people' needs and for crime prevention. At the same time most participants disagreed with use of genetic information by insurers. In addition, in both countries, the majority of the judges and lawyers thought that current laws are not sufficient to protect individuals from misuses of genetic data in insurance, education and employment contexts; and that relevant laws need to be amended. However, the views of the Russian judges and lawyers were overall more varied than those of Romanian judges and lawyers. In the following sections we provide a detailed discussion of the results.

4.1. *Genetic knowledge*

The knowledge of genetic concepts and heritability tested is essential to understanding risks and benefits associated with use of genetic data. The results showed that the average knowledge of judges and lawyers was relatively low and not evenly distributed across the items. The 5 multiple-choice knowledge items had either 2 or 4 response options, with 35% being chance level. This means that the average number of correct answers (53.94% for judges and 47.83% for lawyers) was close to chance level. Similarly low genetic knowledge was observed in the second group of Russian judges and lawyers (reported in SOM). Most participants chose incorrect answers to the questions about DNA: what is a genome; and DNA sequence in two different cells. In contrast, most participants gave correct answers to the other questions: that new borns undergo genetic testing; that most traits are influenced by genes; and that behavior cannot be fully predicted from examining DNA.

For the 14 heritability items, mean estimates for the traits ranged from about 30% to 70%, suggesting that most participants thought that these traits are moderately to substantially influenced by genetic factors. These means are consistent with the pattern of heritability estimates obtained in scientific studies (e.g. Polderman *et al*. 2015), although some means were somewhat lower than established heritability estimates (eye color, height, and especially weight). The underestimation of weight heritability is consistent with results from Romanian judges and lawyers (Selita *et al*. 2020), and with an unselected international sample (Chapman *et al*. 2019). This underestimation of weight heritability may stem from the fact that weight is more malleable than some other traits (e.g. height), and is viewed as being under greater individual control, which is erroneously equated with absence of genetic effects.

Further examination of the results showed that the relatively accurate means for most traits masked the great variability in responses across individuals, ranging from 0% to 100% for most traits. For example, approximately 9% of the participants erroneously believed that ADHD is 100% environmental; and approximately

6% of the participants believed it was 100% genetic. Similarly, 13.5% of participants felt that IQ was fully determined by genes, with no environmental influences. These results are consistent with those from previous studies with judges and lawyers, as well as general population, which also showed wide variability in responses (Chapman *et al*. 2019; Selita *et al*. 2020).

The gaps in genetic knowledge shown by many of the judges and lawyers in this study may have practical consequences. For example, if lawyers do not know that genetic testing on new borns is carried out in the country, they will not see a need for developing measures to protect children's genetic data. Such protection, however, is necessary, considering that breaches of children's genetic data have already been reported (Bailey *et al*. 2019; Supreme Court of Minnesota 2011a). Similarly, the lack of understanding of what a genome is, and that DNA is identical in different cells, may lead to underestimation of the risks posed by sequencing of the genome. Once a person's DNA from any cell is sequenced, it presents a lifelong wealth of information about the person, with risks for discrimination across life aspects (Selita 2019b).

Incorrect knowledge of heritability of traits may also interfere with justice as it is erroneously associated by many people with malleability of traits ("more heritable – less malleable" fallacy). Previous research found that people's estimates of heritability of traits were linked to people's views and attitudes more broadly. For example, people tend to think (erroneously) that, when treating more heritable traits, medication is more effective than psychological interventions (Madrid-Valero *et al*. 2021; Pope *et al*., in press). In the justice context, under- and overestimation of genetic and environmental effects on behavior – may serve as foundation for a coherent but erroneous pattern of views regarding blame, determinism, immutability, high risk of recidivism, etc.

4.2. *Opinions of judges and lawyers on use of genetic information and regulation of genomic advances*

4.2.1. *Views on gene editing and use of genetic information*

Participants' views were varied, with substantial proportions of participants agreeing, disagreeing and undecided on gene editing for prevention and treatment of disease; using genetic information to adapt environments to people's needs; and the State using genetic information for crime prevention. Around 60% of participants endorsed such use.

This lack of agreement among legal professionals from the same jurisdiction reflects the complexity of decisions in this area, particularly given the many issues that are yet to be resolved including: technical (e.g. specificity of effects in gene editing); practical (e.g. accessibility); and ethical (e.g. effects on future generations, human rights violations) (Godard *et al*. 2003; Government Office for Science 2022a; Sperber *et al*. 2017). For example, although the use of gene editing in medicine is viewed by many positively, gene engineering to enhance

human capacity more broadly is much more controversial (Government Office for Science 2022b). Similarly, although some benefits (e.g. personalized medication or screening regimes) are obvious, gene-based treatments may be prohibitively expensive, which may further exacerbate existing inequalities in access to medical care (Naddaf 2022). Moreover, advice and treatments based on probabilistic polygenic information may be inaccurate and even harmful; and some uses of genetic information may be linked to discrimination, such as gene-based streaming in education or job selection.

Similarly, the use of genetic information for crime prevention can lead to violations of individuals' rights. For example, the State could take actions such as surveillance, compulsory education or therapy programmes – based on people's polygenic information. However, such use is not warranted by the current state of knowledge: it is not known how many genetic markers for aggression exist; whether the same markers operate in different populations; and how many "risk" variants one should have before one is classified "high risk". Moreover, genetic markers interact with each other and with environments – making predictions probabilistic and requiring many pieces of information to be put into the equation. It is therefore clear that gene-based crime prevention is an ethical minefield, requiring extensive evaluation and wider discussion.

Participants' views on whether insurance companies should be allowed access to genetic data prior to issuing health and/or life insurance were less varied – with almost 75% disagreeing with such use. This result suggests that judges and lawyers recognize injustices associated with insurance premiums being determined on genetic information – potentially making insurance inaccessible for people with high polygenic risks. However, simply denying insurance companies access to genetic information may not be a viable option for societies in the genomic era, primarily because the insurance industry relies on monies collected from the healthy to cover the costs of those less healthy (Pugh 2021; Rodriguez-Rincon *et al*. 2022; Selita *et al*. 2023; UK Department of Health 2022). Therefore, society needs to evaluate and implement alternative solutions, such as different models of State insurance provision (Chapman *et al*. 2020; Selita 2020).

4.2.2. *Views on updating the relevant laws and need for training*

We assessed judges' and lawyers' views on whether, when and which genetics related laws should be updated; and if they believe that judges should receive some training in genetics.

Around 56% of the judges and lawyers thought that **current laws in Russia are insufficient** to protect individuals from misuses of genetic advances in insurance, education and employment. The results of content analysis from the Seminar (reported in SOM) identified specific genetics related concerns, including misuse of genetic data/eugenics, ownership of genetic data, gene editing, national security, lack of legal protection and uniform enforcement of laws. Indeed, pre-

genomic era laws are not sufficient in the genomic era, where DNA sequencing is becoming routine. Similarly, the use of data resulting from whole genome sequencing is not effectively covered by new specific laws passed in some jurisdictions, such as the U.S. (Andrews, Mehlman, and Rothstein 2015; Furrow *et al*. 2013; Selita 2019b).

As to **when the relevant laws should be amended**, ∼30% of the participants responded that the relevant laws (e.g. data protection, privacy, non-discrimination, insurance, employment) should be updated "now (ASAP)" and ∼20% – that the laws should be updated "after some cases in these areas have been brought to courts". Interestingly, ∼40% thought that the laws should be amended "after we are certain of the scale of the risk". However, calculating with certainty the scale of harm from misuses of predictive information of genetic data is not possible. This is because continuous genetic advances mean that an individual's DNA sequence, once extracted, can become a source of increasing amount of information in the course of the person's life across different life aspects – from education, to insurance, to health, to employment, to influences on decisions (Selita 2019b).

In relation to **how laws should be amended**, 74% of the participants agreed that breaches of genetic data should be made a criminal offence, although it was not clear whether participants endorsed a fine only or also imprisonment. The fact that the majority of the participants endorsed criminalization of genetic data breaches may reflect their awareness that breaches of genetic data have life-long and intergenerational consequences for individuals and their families. At present, in many jurisdictions (e.g. Russia, UK), genetic data receives the same protection as other sensitive personal data, such as medical data – with no custodial sentence or power of arrest e.g. (Data Protection Act 2018, n.d.; General Data Protection Regulation (GDPR) 2016; The Crown Prosecution Service 2018). Offences are punishable only by a fine, often small (ICO 2006; 2018; Supreme Court of Minnesota 2011a; WiredGov 2018). This may not be sufficient to deter data breaches, which are common (e.g. Cyentia Institute 2016; Lintern 2021; Merrick 2017; Selita 2019b; Supreme Court of Minnesota 2011b).

The views of participants on **whether the legal system should accommodate the population variability** were split, with approximately one third – agreeing; one third – disagreeing and one third – neither agreeing nor disagreeing. This split in opinions may reflect the uncertainty about how exactly the individual differences can be accommodated in the legal system (Selita 2018). Some accommodations have already been implemented in some jurisdictions, for example providing lawyers with detailed guidelines on accommodating people's learning disabilities and other personal difficulties (Bowden, Douds, and Simpson 2011; UK Government, n.d.). Similar provisions will have to take place in regard to accommodating individual differences more broadly, for example by reducing legal jargon; and making the legal system more accessible in terms of cost and

more representative of the population it represents (Civil Justice Council 2011; Moorhead and Sefton 2005; Selita 2019a).

Finally, we explored judges' and lawyers' views on **whether training of judges should include fundamentals of gene-environment processes** involved in individual differences in behavior. Around 50% agreed and around 35% disagreed. We performed additional analyses to test whether those participants who think that existing laws are sufficient are also more likely to think that training in gene-environment processes is not needed. The results of correlational and ANOVA analyses (available from the authors) revealed no significant association between the two variables.

It is possible that endorsement for gene-environment training depends on the area of practice. For example, many participants in the present study were commercial court judges. For them, information on gene-environment processes may seem too far removed to be relevant, as they rarely need to judge people's behavior in their day-to-day work. Indeed, previous research found much greater endorsement for such training in a sample of Romanian Supreme Court judges whose work includes criminal cases where knowledge about individual differences may be particularly relevant (Selita *et al*. 2020)

In the present study we further explored potential reasons for not endorsing gene-environment training by analysing responses of the Seminar participants (reported in SOM). Participants commented that the field of genetics "is highly complex" and "technical" and that they have "never considered genetics". Some also expressed that they "do not know anything about genes", but this "is nothing to be ashamed of – as the field is complex and new". In light of these complexities, participants may feel that one would need a prohibitively long time to acquire the necessary knowledge.

However, the danger of not including genetic knowledge in lawyers' training is that without such knowledge they are not able to identify and protect against the risks of misuses of genetic information. Without training, understanding of genetic concepts is often superficial and misses the ethical complexities; potential consequences; details of how technologies (e.g. gene editing) work; and how such technologies can be used (O'Keefe *et al*. 2015). For example, various metaphors and simple descriptions used for gene editing techniques present them in a way that may lead to wrong decisions across the public, political, and scientific sectors (O'Keefe *et al*. 2015). The nuanced presentation of information must capture the limitations of the current knowledge and challenges of using predictive polygenic information; as well as dispel some of the deterministic myths, and warn against over-optimistic views of genetic information as bio-truth (Robert 2019). Evidence suggests that incorporating modules on gene-environment processes in medical and social sciences degrees, such as psychology, may lead to less biased views (Jacko *et al*. 2023; Jamieson and Radick 2017).

5. Conclusions and future directions

The study found overall low genetic literacy and wide variability in views on genetics among legal professionals in the same jurisdiction. Further research is needed to understand the reasons and practical implications of this variability, as well as to clarify the sources of differences found across jurisdictions. For example, the agreement among Russian judges and lawyers in the current study was overall lower than the agreement found in the Romanian sample; and Romanian participants showed overall stronger endorsement for genetic applications in medicine, crime prevention, personalization of the legal system, as well as amending existing laws and incorporating genetics in judges' training. With information available only from two jurisdictions, explanations for these differences are currently speculative.

For example, differences in opinions may stem from media coverage of the ongoing genetic research, including focus of the coverage on potential benefits vs. ethical dilemmas and issues of access to advances. Views may also be influenced by popular culture, such as books, movies and games that often portray an anti-utopian image of gene editing. The differences may also stem from the way information is presented to participants in research, as previous research has demonstrated that the way genetic information is presented may impact important justice related decisions (Selita, Chapman, and Kovas 2019). For example, presentation of the question about the "use of genetic information for crime prevention by the State" may have led to the observed difference: endorsement by 60% of the Russian vs. 91% of the Romanian judges and lawyers. The introductory information for participants in the Romanian sample read: "If we find that people with certain genetic mutations have a propensity for violence … ". Therefore, the information was hypothetical ("if we find") and vague ("people with certain mutations have a propensity for violence"). In contrast, in our study the item read: "Over 40 markers in the human genome have been linked to aggressiveness. The State should use this information for prevention of crime". These facts may have appeared more salient (markers already linked to aggressiveness) and more nuanced (many genes are involved), but at the same time potentially less informative or usable. The observed difference may therefore reflect complex processes through which opinions are influenced by interaction between genetic knowledge, how information is presented, personal values and societal influences.

Other factors, such as participants' jurisdiction, area of practice and experience may have also contributed to the observed differences across the studies. Further research is also needed to explore any potential differences in views of professionals from civil law vs. common law jurisdictions. Both Russia and Romania are civil law jurisdictions, where the laws are codified; views may be different in common law jurisdictions, where laws include case/judge-made law. Research is also needed to establish to what extent the views of judges and lawyers correspond to those of the general public and other groups of professionals. Several studies to date have suggested similar trends in views of

judges, lawyers, and other groups e.g. (McCaughey *et al*. 2016; Selita *et al*. 2023; Selita, Chapman, and Kovas 2019).

To conclude, genetic advances have brought many new opportunities to societies, with new powers of polygenic prediction, genetic engineering and gene-based environmental interventions. Judges and lawyers have the power to influence society through influencing interpretations and attitudes towards complex societal issues (Amsterdam and Bruner 2011). Therefore, their understanding and views towards genetics can shape how societies view and use genetic advances. The results of our study highlight the need for improving readiness of the legal workforce for the genomic era. This is a shared responsibility and will require efforts of legal professionals, geneticists, educators, forensic scientists, psychologists and other key stakeholders to how the relevant knowledge can be communicated more effectively. Moreover, reducing knowledge "deficit" is only one of the many steps that need to be taken, including increasing opportunities for cross-disciplinary research and discussions, debates, sharing values, perspectives and views (Nadkarni *et al*. 2019; National Academy of Sciences *et al*. 2017).

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Data availability statement

All data are available upon request from the corresponding author (fatos.selita@gold.ac.uk). The datasets generated and/or analysed during the current study are not publicly available due to being part of a larger dataset, but are available from the corresponding author on reasonable request.

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