Review

International Biospecimen Sourcing Platform: A Key Player in Advancing Health Research and Drug Discovery

Zahraa Qusairy and Miran Rada *

Posted Date: 18 December 2023

doi: 10.20944/preprints202312.1256.v1

Keywords: Biobanking; human biospecimens; drug discovery; health research

Review

International Biospecimen Sourcing Platform: A Key Player in Advancing Health Research and Drug Discovery

Zahraa Qusairy [1] and Miran Rada [2,*]

[1] Cancer Research Program, Research Institute of the McGill University Health Centre, Montreal, QC H4A 3J1, Canada.
[2] Zlal Bioconsulting, Sulaimani, Kurdistan-Region, Iraq
* Correspondence: miranm.rada@gmail.com

Abstract: The field of biobanking human biospecimens has evolved significantly, transitioning from the basic, often poorly documented collection of clinical leftovers kept privately to well-organized and extensively documented collections overseen by both commercial and non-profit platforms. The increasing demand for high-quality and clinically annotated biospecimens is propelled by unprecedented levels of health research activities. Meeting this growing demand presents both new opportunities and challenges, particularly in developing strategies to establish international biospecimen sourcing (IBS) platforms. These platforms aim to facilitate collaboration among biobanks to address future biospecimen needs. In this manuscript, we delve into the advantages and challenges of establishing IBS platforms to provide high-quality and cost-effective biospecimens to drive drug discovery research, ultimately leading to improved health and quality of life for everyone.

Keywords: biobanking; human biospecimens; drug discovery; health research

1. Introduction

Healthcare systems worldwide are facing significant challenges due to the increasing elderly population and a growing number of common chronic diseases[1,2]. Addressing these healthcare challenges necessitates remarkable scientific progress, involving new technologies and tools that offer great potential for enhancing disease diagnosis, prevention, treatment, and personalized medicine. The success of these technologies is heavily reliant on access to comprehensive and well-organized collections of human biological samples and associated clinical and research data, typically curated by biobanks[3]. A biobank is a specialized repository that receives, processes, stores, and distributes biological specimens along with their relevant clinical and research information[4]. Biobanks play a crucial role in driving advancements in biotechnology, scientific and medical research, and have a positive impact on both public health and individual patient care[5].

Over the years, biospecimens have been collected and preserved alongside clinical and epidemiological studies. What sets current biobanks apart from traditional biobanking initiatives is their sheer scale and scope[5,6]. These initiatives not only prioritize the collection of biological samples but also emphasize acquiring a broad range of phenotypic information. This phenotypic information includes various elements, including medical diagnoses, risk factors, physical and metabolic measurements (such as blood pressure and insulin resistance), other pertinent clinical data, and details pertaining to behavior and social factors[1,3,5].

According to the International Agency for Research on Cancer (IARC), biobanks play a pivotal role in the advancement of three rapidly expanding fields within biomedical science[4,7,8]: a.) Molecular and genetic epidemiology; which investigate the genetic and environmental factors contributing to cancer causation in the general population and within families. Biobanks provide the essential resources for studying these factors. b.) Molecular Pathology; which focuses on the development of molecular-based classifications and diagnostic procedures for various types of cancers. Biobanks are

 doi:10.20944/preprints202312.1256.v1

instrumental in providing the biological samples and data required for these diagnostic advancements. c.) Pharmacogenomics/Pharmacoproteomics; which studies the relationship between an individual patient's genetic makeup (genotype) or observable characteristics (phenotype) and their response to drug treatments. Biobanks offer a wealth of data and samples for investigating these correlations, leading to more personalized and effective drug therapies[9].

The significance of biobanking as a groundbreaking opportunity for scientists to gain valuable insights for their research has been highlighted in both Forbes[10] and Time magazine[11]. Time Magazine specifically recognized the importance of biobanks in its 2009 feature titled "10 Ideas Changing the World Right Now"[11]. In light of this acknowledgment, modern biobanks are now considered vital infrastructure platforms for sharing specimens and data, expanding their role beyond merely supporting individual research projects. Nevertheless, the establishment of modern international biospecimen sourcing (IBS) platforms face significant challenges related to science, logistics, ethics, legality, economy, and politics[4–6]. In this manuscript, we will explore the advantages of creating IBS to advance research and the hurdles that these efforts encounter.

2. The Advantages of the International Biospecimen Sourcing Platform

The value of IBS in advancing medical research, improving healthcare, and addressing global health challenges is underscored by the following benefits.

2.1. Diverse and Representative

Diversity in study participants allows for greater exploration of variation in the overall effectiveness of a particular intervention[12]. Exploring the heterogeneity of treatment effects becomes crucial, not only for comprehending variations that impact the safety and effectiveness of interventions in underrepresented populations but also for identifying novel biological processes. These discoveries, in turn, may lead to new insights crucial for all populations[13–15].

The lack of representation has been recognized as a crucial challenge that hinder innovation and drug development, and costs hundreds of billions of dollars[12]. Over the past decades, various randomized controlled clinical trials conducted in small population were largely considered to be generalizable to all patient populations and were regarded by the medical community as the gold standard in evidence-based medicine for determining the safety and efficacy of investigational medical therapies[16]. However, growing evidence has surfaced to challenge that assumption[17]. Research has specifically demonstrated that many groups underrepresented and excluded in clinical research may distinct disease presentations or health circumstances, influencing their response to investigational drugs or therapies[18–21]. Indeed, such differences contribute to variable therapeutic responses, highlighting the need for targeted efficacy and safety evaluation. One notable case illustrating the significance of diversity in research involves the proprotein convertase subtilisin-like kexin type 9 (PCSK9) on understanding cholesterol homeostasis and the subsequent development of crucial therapeutics for preventing and treating atherosclerotic cardiovascular disease[12]. PCSK9 is a protein that controls the levels of LDL in the blood[22,23]. The identification of PCSK9 occurred during an examination of cholesterol metabolism differences in the Atherosclerotic Risk in Communities (ARIC) Study, which researchers observed that 2 percent of Black subjects in the ARIC cohort possessed one of two mutations in PCSK9 associated with a 40 percent reduction in low-density lipoprotein (LDL) cholesterol[24]. These mutations are infrequent among white individuals[24], emphasizing that PCSK9 might not have been explored without the presence of diversity in the ARIC study[12]. Another example is the discrepancy in the response to tricyclic antidepressants among men and women, which suggests that men are more likely to respond to tricyclic antidepressants and women to selective serotonin reuptake inhibitors as a treatment for depression[25–27]. Indeed, initiatives like IBS platforms could be helpful in providing biospecimens from diverse races, ethnicities, and nationalities to ensure a more representative sample of the whole population. These data allow researchers to better understand the correlation between genetic information and various health factors.

 doi:10.20944/preprints202312.1256.v1

2.2. Larger Sample Size

Using large numbers of samples become the critical component for translational research[28]. The size of the sample used in a study profoundly impacts both the hypothesis and study design[29]. Determining the appropriate sample size is not always straightforward, and using an incorrect sample size can result in inconclusive or unreliable results in both clinical and laboratory research[30]. One of the main challenges for that investigators face is employing adequate numbers of biospecimens to address their research questions[31]. Indeed, the emergence of IBS platform can address this issue by pooling resources from multiple sources, allowing researchers access to larger sample sizes. Access to a wide variety of biospecimens expedites research in areas such as drug discovery, disease understanding, and precision medicine.

2.3. Rare Disease Research

A rare disease is characterized by its predominantly impact on a relatively small percentage of the population[32]. Addressing the unique challenges presented by rare diseases requires the adoption of cutting-edge methods for diagnosis and treatment. A significant impediment to progress in this field is the scarcity of biospecimens available for research, a global issue that persists[33,34]. Given the limited number of patients with rare diseases in local regions, the pursuit of international collaborations becomes essential to amplify the size of patient cohorts for robust research endeavors. Therefore, the establishment of IBS platforms has become imperative to offer access to a broader range of samples and data from individuals with rare diseases.

2.4. Enhanced Public Health

The establishment of a biobank demands meticulous attention to ethical, legal, and social issues[1,35,36]. In certain countries, particularly those with low- and middle-income economies, inadequate legislative structures and governance frameworks may pose challenges in safeguarding research participants and communities from the unfair distribution of risks and benefits[35,37–39]. This leads to diminished benefits for low- and middle-income countries compared to their high-income counterparts in the realms of epidemiological and genetic research[35]. Indeed, the e creation of IBS platform plays a crucial role in supporting the creation and effective operation of biobanks in low- and middle-income countries. This approach is specifically designed to address existing disparities and promote ethical and equitable utilization of patient data and samples in both in retrospective and prospective research endeavors[39–41]. Ultimately, the establishment of IBS platforms hold the potential to make a significant contribution to global public health by maximizing the benefits derived from collaborative research efforts.

3. Challenges Involved in Establishing the International Biospecimen Sourcing Platform

The establishment of an IBS platform involves a myriad of challenges, involving legal, ethical, technical, and logistic considerations. The intricacies of these challenges are further explained below

3.1. Legal Challenges

The establishment of an IBS platform ntroduces a spectrum of legal concerns that necessitate careful consideration[42,43]. A primary legal challenge arises from navigating diverse data protection and privacy laws across different countries, as compliance with these regulations is crucial when handling sensitive information linked to biospecimen[44]. Another significant hurdle is ensuring alignment of informed consent procedures with the regulations of multiple jurisdictions, necessitating clear and legally compliant consent documentation for each participating country[45,46]. Intellectual property rights present a distinct legal challenge, involving the determination of ownership for biospecimen and the associated data, potentially leading to legal disputes[47,48]. Additionally, complying with the legal requirements of various international and local research governance frameworks proves to be challenging[49,50]. Lastly, adherence to international treaties and agreements covering aspects, such as data sharing, sample ownership, publication rights, and dispute

 doi:10.20944/preprints202312.1256.v1

resolution becomes crucial for successful international collaborations[46,49–51]. Effectively addressing these legal challenges demands a collaborative approach involving legal experts, ethicists, and regulatory professionals. The establishment of clear protocols, agreements, and communication channels is essential to navigate the intricate legal landscape associated with an IBS platform.

3.2. Ethical Challenges

The collection, storage, and sharing of biospecimens and related data for research purposes pose numerous ethical challenges including informed consent, privacy, confidentiality, respect for community values, stewardship, sustainability, and considerations of public perception and trust[50,52]. Obtaining informed consent from participants is an ethical cornerstone of biobanking and research, specifically for the biospecimens that are collected for IBS platforms to prevent biopiracy or exploitation of vulnerable participants[9,28,53]. It is crucial to ensure that participants fully understand the extent to which their data will be shared internationally, especially in cases where biobanking involves collaboration with entities outside their own country[54,55]. Sometimes, the waiver of consent may be justified by potential public health benefits, and this must be carefully weighed against respecting individual patient autonomy[53]. However, having material transfer agreements (MTAs) and data transfer agreements (DTAs) between biobank and end users would be crucial for samples that are collected under a waiver of consent[56,57].

Privacy and confidentiality are paramount considerations in IBS platforms, and several challenges must be addressed to maintain the trust of donors, comply with regulations, and ensure the ethical use of biospecimens[58,59]. Consequently, negotiating the diverse data protection laws and regulations across countries involved in the biobanking initiative and harmonizing privacy practices to meet the requirements of multiple jurisdictions can be a complex endeavor. Moreover, complying with restrictions on cross-border data transfer imposed by various countries poses a significant challenge[60]. Some countries have stringent regulations specifying where data can be stored and processed, introducing hurdles for international collaboration[61].

Respecting community values emerges as a significant challenge in the context of IBS platform, considering the diverse cultural norms and values prevalent across communities in different countries and regions[42,62,63]. Understanding and honoring this diversity is crucial to avoid unintentional cultural insensitivity. Many religious traditions emphasize the sacredness of the human body[64], and obtaining consent for biospecimen collection may conflict with beliefs concerning bodily integrity and the sanctity of remains[63,64]. Ensuring that the goals of the biobanking initiative align with religious principles, particularly regarding the ethical use of biospecimen for the greater good and the equitable distribution of benefits, is crucial. Consultation with religious leaders to provide ethical oversight, along with the implementation of education and outreach programs that include religious sensitivity training for those involved in biospecimen collection, data management, and community engagement, can be instrumental in addressing these challenges[64,65].

3.3. Technical Challenges

The development and implementation of standardized operating procedures (SOPs) across different locations and organizations pose a significant technical challenge in achieving reliability in sample collection, processing, and storage protocols[4,7,28]. Ensuring that samples meet the required standards necessitates regular audits, proficiency testing, and the validation of methods[4,56]. Moreover, the development of interoperable systems for sharing information among participating organizations, and track sample collection, storage and shipment to facilitate seamless collaboration is crucial. However, managing this software requires robust cybersecurity, and can be challenging[66,67]. Engaging and coordinating efforts among various stakeholders, including researchers, healthcare institutions, and regulatory bodies, demands effective communication and relationship management, presenting an additional potential challenge.

3.4. Logistic Challenges

Coordinating the transportation of biological samples across international borders involves navigating complex shipping regulations to ensure the samples reach their destination[68]. This necessitates the implementation of robust documentation and tracking systems to prevent loss, misidentification, or compromising the integrity of the samples[56,68]. Moreover, monitoring shipment conditions, such as temperature is critical to preserving the viability of the samples[28,68].

Overcoming these challenges requires careful planning, collaboration, and the development of robust infrastructure and processes to ensure the success of an IBS platform.

4. Conclusions

Despite the challenges, the establishment of IBS platforms represents a crucial step forward in fostering collaborative research efforts that transcend geographical boundaries and holds immense potential for advancing medical research, improving healthcare, and addressing global health challenges.

Author Contributions: Z.Q. and M.R. conceptualization, writing and preparation of the manuscript. M.R. reviewing the final draft. Both authors have read and agreed to the published version of the manuscript.

Conflicts of interest: The authors declare no conflict of interest.

References

1. Lu, T.-P., Kamatani, Y., Belbin, G., Park, T. & Hsiao, C. K. Current Status and Future Challenges of Biobank Data Analysis. *Front Genet* **13**, (2022).
2. Humphreys, G. The health-care challenges posed by population ageing. *Bull World Health Organ* **90**, 82–83 (2012).
3. De Souza, Y. G. & Greenspan, J. S. Biobanking past, present and future. *AIDS* **27**, 303–312 (2013).
4. Annaratone, L. *et al.* Basic principles of biobanking: from biological samples to precision medicine for patients. *Virchows Archiv* **479**, 233–246 (2021).
5. Harris, J. R. *et al.* Toward a roadmap in global biobanking for health. *European Journal of Human Genetics* **20**, 1105–1111 (2012).
6. Coppola, L. *et al.* Biobanking in health care: evolution and future directions. *J Transl Med* **17**, 172 (2019).
7. Mendy, M., Caboux, E., Lawlor, R., Wright, J. & Wild, C. *Common Minimum Technical Standards and Protocols for Biobanks Dedicated to Cancer Research*. (2017).
8. Frascarelli, C. *et al.* Revolutionizing Cancer Research: The Impact of Artificial Intelligence in Digital Biobanking. *J Pers Med* **13**, 1390 (2023).
9. Olson, J. E. *et al.* Biobanks and personalized medicine. *Clin Genet* **86**, 50–55 (2014).
10. Marr, B. Biobanking Is Changing The World. *Forbes* (2019).
11. Park, A. 10 Ideas Changing the World Right Now. *Time* (2009).
12. Bibbins-Domingo, K. & Helman, A. *Improving Representation in Clinical Trials and Research*. (National Academies Press, 2022). doi:10.17226/26479.
13. Kravitz, R. L., Duan, N. & Braslow, J. Evidence-based medicine, heterogeneity of treatment effects, and the trouble with averages. *Milbank Q* **82**, 661–87 (2004).
14. Xu, Z. M. & Burgess, S. Polygenic modelling of treatment effect heterogeneity. *Genet Epidemiol* **44**, 868–879 (2020).
15. Duan, N. & Wang, Y. Heterogeneity of treatment effects. *Shanghai Arch Psychiatry* **24**, 50–1 (2012).
16. Bothwell, L. E., Greene, J. A., Podolsky, S. H. & Jones, D. S. Assessing the Gold Standard — Lessons from the History of RCTs. *New England Journal of Medicine* **374**, 2175–2181 (2016).
17. Sirugo, G., Williams, S. M. & Tishkoff, S. A. The Missing Diversity in Human Genetic Studies. *Cell* **177**, 26–31 (2019).
18. Beglinger, C. Ethics Related to Drug Therapy in the Elderly. *Digestive Diseases* **26**, 28–31 (2008).
19. Crawley, F., Kurz, R. & Nakamura, H. Testing Medications in Children. *New England Journal of Medicine* **348**, 763–764 (2003).
20. Garcia, M., Mulvagh, S. L., Bairey Merz, C. N., Buring, J. E. & Manson, J. E. Cardiovascular Disease in Women. *Circ Res* **118**, 1273–1293 (2016).
21. Ramamoorthy, A., Pacanowski, M., Bull, J. & Zhang, L. Racial/ethnic differences in drug disposition and response: Review of recently approved drugs. *Clin Pharmacol Ther* **97**, 263–273 (2015).

22. Rada, M., Reynolds, A. R., Lazaris, A., Seidah, N. & Metrakos, P. Inhibition of proprotein convertase subtilisin-like kexin type 9 (PCSK9) potentiates anti-angiogenic therapy in colorectal cancer liver metastases. *BioRxiv* 1–12 (2023).
23. Rada, M. *et al.* High levels of serum cholesterol positively correlate with the risk of the development of vessel co-opting tumours in colorectal cancer liver metastases. *MedRxiv* (2022).
24. Cohen, J. C., Boerwinkle, E., Mosley, T. H. & Hobbs, H. H. Sequence variations in PCSK9, low LDL, and protection against coronary heart disease. *New England Journal of Medicine* **354**, 1264–1272 (2006).
25. Baca, E., Garcia-Garcia, M. & Porras-Chavarino, A. Gender differences in treatment response to sertraline versus imipramine in patients with nonmelancholic depressive disorders. *Prog Neuropsychopharmacol Biol Psychiatry* **28**, 57–65 (2004).
26. Bano, S., Akhter, S. & Afridi, M. I. Gender based response to fluoxetine hydrochloride medication in endogenous depression. *J Coll Physicians Surg Pak.* **14**, (2004).
27. Kornstein, S. G. *et al.* Gender Differences in Treatment Response to Sertraline Versus Imipramine in Chronic Depression. *American Journal of Psychiatry* **157**, 1445–1452 (2000).
28. Cicek, M. S. & Olson, J. E. Mini-Review of Laboratory Operations in Biobanking: Building Biobanking Resources for Translational Research. *Front Public Health* **8**, (2020).
29. Faber, J. & Fonseca, L. M. How sample size influences research outcomes. *Dental Press J Orthod* **19**, 27–29 (2014).
30. Serdar, C. C., Cihan, M., Yücel, D. & Serdar, M. A. Sample size, power and effect size revisited: simplified and practical approaches in pre-clinical, clinical and laboratory studies. *Biochem Med (Zagreb)* **31**, 27–53 (2021).
31. Baer, A. R., Smith, M. Lou, Collyar, D. & Peppercorn, J. Issues Surrounding Biospecimen Collection and Use in Clinical Trials. *J Oncol Pract* **6**, 206–209 (2010).
32. Julkowska, D. *et al.* The importance of international collaboration for rare diseases research: a European perspective. *Gene Ther* **24**, 562–571 (2017).
33. Mascalzoni, D., Paradiso, A. & Hansson, M. Rare disease research: Breaking the privacy barrier. *Appl Transl Genom* **3**, 23–29 (2014).
34. Thorogood, A. International Data Sharing and Rare Disease: The Importance of Ethics and Patient Involvement. in *Rare Diseases* (IntechOpen, 2020). doi:10.5772/intechopen.91237.
35. Chen, H. & Pang, T. A call for global governance of biobanks. *Bull World Health Organ* **93**, 113–117 (2015).
36. De Souza, Y. G. & Greenspan, J. S. Biobanking past, present and future. *AIDS* **27**, 303–312 (2013).
37. Dal-Re, R., Ndebele, P., Higgs, E., Sewankambo, N. & Wendler, D. Protections for clinical trials in low and middle income countries need strengthening not weakening. *BMJ* **349**, g4254–g4254 (2014).
38. Sulaieva, O. N. *et al.* Ethical navigation of biobanking establishment in Ukraine: learning from the experience of developing countries. *J Med Ethics* jme-2023-109129 (2023) doi:10.1136/jme-2023-109129.
39. Vodosin, P. *et al.* A Review of Regulatory Frameworks Governing Biobanking in the Low and Middle Income Member Countries of BCNet. *Biopreserv Biobank* **19**, 444–452 (2021).
40. Lu, T.-P., Kamatani, Y., Belbin, G., Park, T. & Hsiao, C. K. Editorial: Current Status and Future Challenges of Biobank Data Analysis. *Front Genet* **13**, (2022).
41. Coppola, L. *et al.* Biobanking in health care: evolution and future directions. *J Transl Med* **17**, 172 (2019).
42. Haga, S. B. & Beskow, L. M. Ethical, Legal, and Social Implications of Biobanks for Genetics Research. in 505–544 (2008). doi:10.1016/S0065-2660(07)00418-X.
43. Tzortzatou-Nanopoulou, O. *et al.* Ethical, legal, and social implications in research biobanking: A checklist for navigating complexity. *Dev World Bioeth* (2023) doi:10.1111/dewb.12411.
44. Rothstein, M. A. & Knoppers, B. M. Harmonizing Privacy Laws to Enable International Biobank Research. *Journal of Law, Medicine & Ethics* **43**, 673–674 (2015).
45. Master, Z., Campo-Engelstein, L. & Caulfield, T. Scientists' perspectives on consent in the context of biobanking research. *European Journal of Human Genetics* **23**, 569–574 (2015).
46. Zawati, M. H., Knoppers, B. & Thorogood, A. Population Biobanking and International Collaboration. *Pathobiology* **81**, 276–285 (2014).
47. Policiuc, L. *et al.* Current aspects in biobanking for personalised oncology investigations and treatments. *Med Pharm Rep* **96**, 235–245 (2023).
48. Jordan, M., Liddicoat, J. & Liddell, K. An empirical study of large, human biobanks: intellectual property policies and financial conditions for access. *J Law Biosci* **8**, (2021).
49. Yip, C., Han, N.-L. & Sng, B. Legal and ethical issues in research. *Indian J Anaesth* **60**, 684 (2016).
50. Slowther, A. Research governance: ethical issues. *J R Soc Med* **99**, 65–72 (2006).
51. Mascalzoni, D. *et al.* International Charter of principles for sharing bio-specimens and data. *European Journal of Human Genetics* **23**, 721–728 (2015).

52. Tulchinsky, T. H. Ethical Issues in Public Health. in *Case Studies in Public Health* 277–316 (Elsevier, 2018). doi:10.1016/B978-0-12-804571-8.00027-5.
53. Singh, S., Cadigan, R. J. & Moodley, K. Challenges to biobanking in LMICs during COVID-19: time to reconceptualise research ethics guidance for pandemics and public health emergencies? *J Med Ethics* **48**, 466–471 (2022).
54. Maloy, J. W. & Bass, P. F. Understanding Broad Consent. *Ochsner journal* **20**, 81–86 (2020).
55. Milanovic, F., Pontille, D. & Cambon-Thomsen, A. Biobanking and data sharing: a plurality of exchange regimes. *Genom Soc Policy* **3**, 17 (2007).
56. Mendy, M., Caboux, E., Lawlor, R., Wright, J. & Wild, C. *Common Minimum Technical Standards and Protocols for Biobanks Dedicated to Cancer Research*. vol. 44 (2017).
57. Akyüz, K. *et al.* Biobanking and risk assessment: a comprehensive typology of risks for an adaptive risk governance. *Life Sci Soc Policy* **17**, 10 (2021).
58. Abdul Aziz, M. F. & Mohd Yusof, A. N. Can dynamic consent facilitate the protection of biomedical big data in biobanking in Malaysia? *Asian Bioeth Rev* **11**, 209–222 (2019).
59. Ursin, L. O. Privacy and Property in the Biobank Context. *HEC Forum* **22**, 211–224 (2010).
60. Mwaka, E. & Munabi, G. Trans-border transfer of human biological materials in collaborative biobanking research: Perceptions and experiences of researchers in Uganda. *medRxiv* (2022).
61. Thompson, R. & McNamee, M. J. Consent, ethics and genetic biobanks: the case of the Athlome project. *BMC Genomics* **18**, 830 (2017).
62. Vaz, M., Warrier, P., Wai-Loon Ho, C. & Bull, S. Respecting values and perspectives in biobanking and genetic research governance: Outcomes of a qualitative study in Bengaluru, India. *Wellcome Open Res* **7**, 78 (2023).
63. Haldeman, K. M. *et al.* Community Engagement in US Biobanking: Multiplicity of Meaning and Method. *Public Health Genomics* **17**, 84–94 (2014).
64. Domaradzki, J. & Walkowiak, D. When Biobanks Meet Religion: Association Between Religiosity and Attitudes of Polish Medical Students Toward Biobanking of Human Biological Material for Research Purposes. *J Relig Health* (2023) doi:10.1007/s10943-023-01932-2.
65. Modell, S. M. *et al.* When Genetics Meets Religion: What Scientists and Religious Leaders Can Learn from Each Other. *Public Health Genomics* **22**, 174–188 (2019).
66. Cremer, F. *et al.* Cyber risk and cybersecurity: a systematic review of data availability. *Geneva Pap Risk Insur Issues Pract* **47**, 698–736 (2022).
67. Rychnovská, D. Anticipatory Governance in Biobanking: Security and Risk Management in Digital Health. *Sci Eng Ethics* **27**, 30 (2021).
68. Gordy, D., Tashjian, R. S., Lee, H., Movassaghi, M. & Yong, W. H. Domestic and International Shipping of Biospecimens. in 433–443 (2019). doi:10.1007/978-1-4939-8935-5_35.