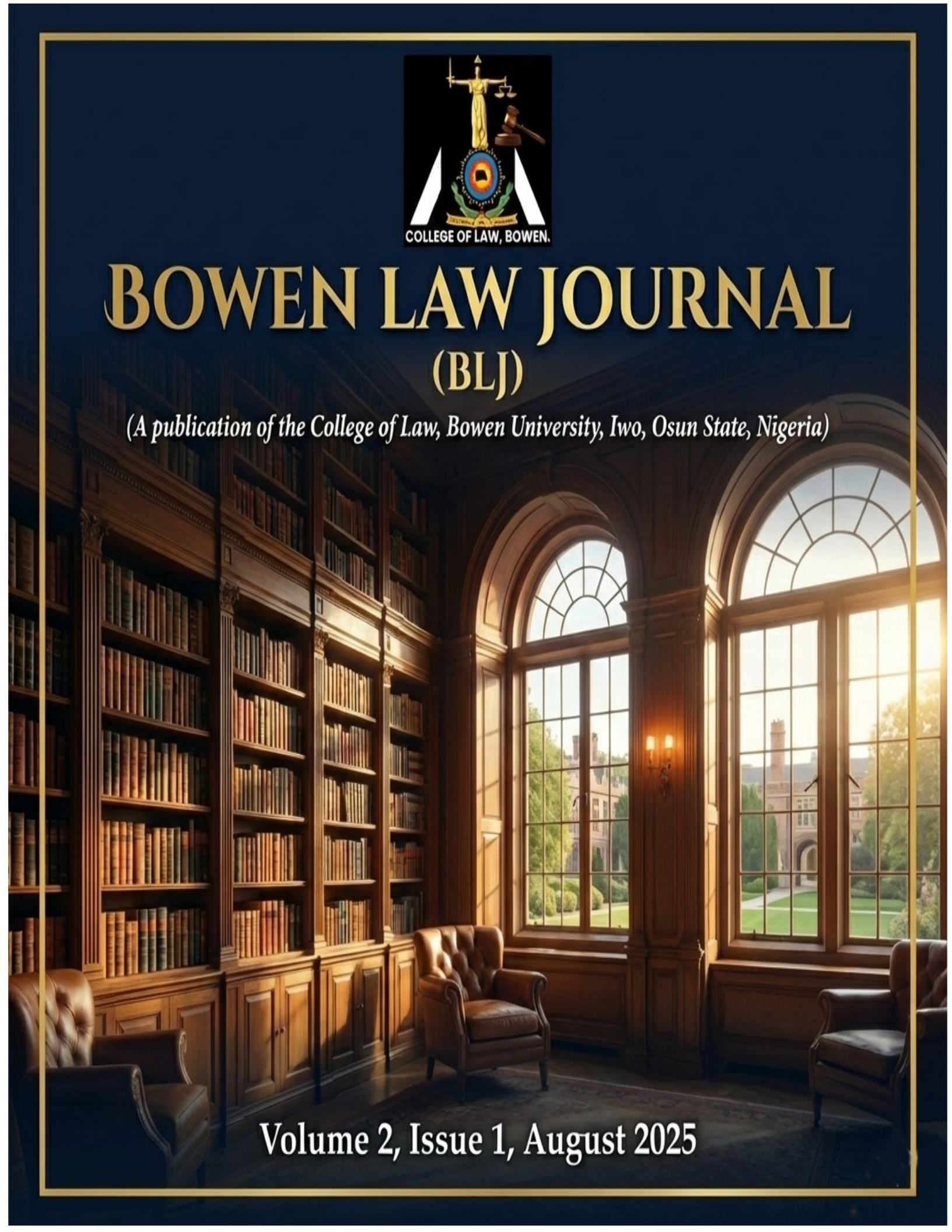
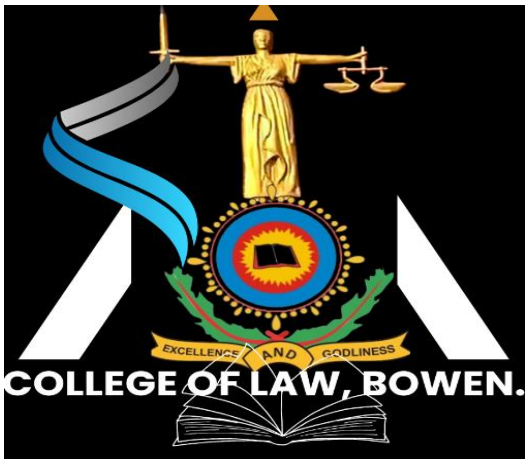

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Editorial

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College of Law, Bowen University, Iwo, Osun State, Nigeria.

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This edition of *Bowen Law Journal* is not only a resuscitation of the publication but its first online edition. It is appearing at a time that the world has become a global village, interconnected and observable by technological means. The journal, the content of which is peer reviewed, is therefore purposed for global impact through the projection of the dignified visibility of its contributors.

The journal accepts contributions on all areas of the law as is apparent from the present contents that span the areas of criminal law and criminology, human rights, employment law, law and medicine, security, peace, and tourism as well as business law generally, including taxation.

The thematic coverage of this journal accommodates impactful and scholarly contributions towards the advancement of the knowledge of law and its application in society. Significantly, the journal is interested in contributions that ensure that law addresses the intricacies of human relations and dealings as well as order in the world we live in.

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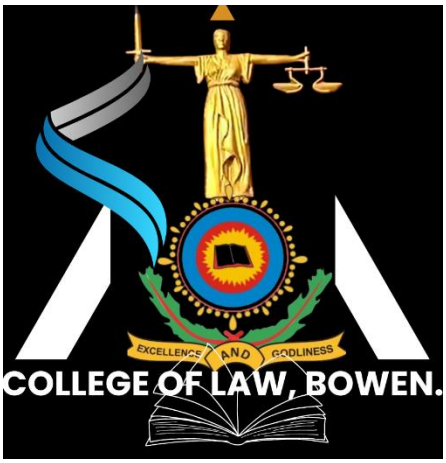
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BOWEN JOURNAL OF LAW

Regulating the Frontiers of Medicine: Ethical, Policy, and Regulatory Frameworks for Xenotransplantation

Onyegbule Kelechi

Abstract

The idea of transferring organs from animals to human's dates back to antiquity, as shown in the fable of Daedalus and Icarus. However, xenotransplantation is a relatively recent phenomenon. That prospect presents a slew of legitimate ethical concerns, as well as bogus ones caused by cultural ignorance of science. As a systematic scientific study, xenotransplantation dates only to the latter half of the 20th century, with episodic xenotransplantation events occurring before that. As the science of xenotransplantation has advanced in the 20th and 21st centuries, the public's awareness of the potential therapy has also increased, leading to shifting ethical stances towards xenotransplantation in important areas, such as public health concerns, animal rights, and religious perspectives on the procedure. This article aims to examine the concept of xenotransplantation in terms of its ethics, policy, and regulatory considerations. The doctrinal research method is adopted to unravel with holistic view modern trends in xenotransplantation and how it has impacted the medical field. The findings reveal there have been numerous attempts to effectively carry out xenotransplantation and most proved abortive and the prosecution violation to that effect is difficult. The article concludes that there is a significant concern for society in general when it comes to xenotransplantation. There are also "bad ethics" issues that arise as a result of scientists' refusal to acknowledge ethical considerations in science. This, combined with public misunderstanding of science, fosters the spread of religious and other non-rational concerns, such as the argument that xenotransplantation is capable of transmitting deadly viral diseases to the human race. These baseless concerns can only be alleviated if public comprehension of science improves and scientific understanding of ethics grows. This paper recommends that a holistic regulatory framework for xenotransplantation is paramount and the need for international harmonization and standardization of regulations should be a serious concern if all issues pertaining to xenotranplantation must be resolved.

1.0. Introduction

In their attempt to assign a definition to xenotransplantation, Mohiuddin, Singh, Corcoran, Hoyt, Thomas and Horvath stated that, xenotransplantation, the latest breakthrough in transplantation, involves taking organs, tissues, or cells from one species and transplanting them into another[622]. This innovative technique has long been hailed as a potential solution to the severe shortage of human organs available for transplantation. For decades, the idea of using non-human organs and tissues to meet the overwhelming demand for conventional donors has captivated clinicians, scientists, healthcare providers, and patients alike - and its roots stretch back hundreds of years[623]. In the 1600s, xenotransfusion was the first documented attempt at xenotransplantation. In the 1800s, xenoskin transplants were tried before more ambitious attempts at kidney xenotransplantation. As the possibility of xenotransplantation has become more realistic due to advances in medical science and technology, there has been a

[622] MM Mohiuddin, P Singh, A Corcoran, J Hoyt, J Thomas and K Horvath, 'Genetically Engineered Pigs for Xenotransplantation: A Review of the Recent Progress'. *Journal of Transplantation 2020* [2020] 1-13.
[623] CJ Phelps, C Koike, TD Vaught, J Boone, KD Wells and RL Troyer, 'Production of Alpha-1,3-Galactosyltransferase-Deficient Pigs'. *Science* [2003] (299) (5605) 411-414.

long line of effort[624]. Crucially, the legal and ethical environment around this innovative subject has received fresh and growing attention, although it still has to be updated on a regular basis[625]. The World Health Organisation (WHO), the Transplantation Society (TTS), and the International Xenotransplantation Association (IXA) have made significant efforts in this area, but as the field develops, more work must be done from a wider international and national regulatory perspective.

Xenotransplantation has the potential to save countless lives by providing an abundant supply of organs, tissues, and cells, drastically lowering transplant wait times, and lessening the suffering of patients on transplant waiting lists. It is also a significant means of actively eradicating the trade in trafficked organs and organ transplant tourism. However, this promise is accompanied by a complicated web of ethical considerations and legal frameworks that must be carefully traversed to ensure that xenotransplantation is carried out responsibly and ethically from the laboratory to the clinic. With this, we must make sure that xenotransplantation does not have the same widespread problems that have plagued human organ transplantation, such as xenotransplant tourism[626] and unethical practices that profit from the use of animals and patients who might be duped into undergoing unapproved procedures[627].

Concerns about animal welfare (during the breeding and production of the donor animals)[628], the perceived or potential for the spread of diseases from animals to humans (xenozoonosis)[629], and cultural and religious issues, particularly the idea of crossing species boundaries in the use of their tissues for transplantation[630], have all been major obstacles to xenotransplantation in the past. These difficulties resulted in the implementation of stringent rules, embargoes, and a complex ethical discussion that still influences the field's course. The development of genetically modified pigs with organs designed to be compatible with the human immune system has advanced significantly in recent years due to groundbreaking developments in genetic engineering, which has given the field fresh hope[631]. In addition to xeno-hearts and kidneys being studied clinically in a new model using "Brain Dead"[632] recipients, these advancements have opened the door for the start of human trials involving xeno-hearts

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[624] TC Communiqué, 'First WHO Global Consultation on Regulatory Requirements for Xenotransplantation Clinical Trials: Changsha, China 19-21 November 2008'. *The Changsha Communiqué . Xenotransplantation* [2009] 16(2): 61-63. doi: 10.1111/j.1399- 3089.2009.00520.x

[625] World Health Organization, Second WHO Global Consultation on Regulatory Requirements for Xenotransplantation Clinical Trials (2011). Geneva, Switzerland: World Health Organization. Available at https://iris.who.int/bitstream/handle/10665/341817/WHO-HTP-EHT-CPR-2011.01-eng.pdf?sequence=1&isAllowed=y accessed 1 December 2024.

[626] I Kwon and H Mo, 'Xenotransplantation'. In H Ten Have (editor) *Encyclopedia of Global Bioethics* (Cham: Springer International Publishing, 2014) 1-14.

[627] WJ Hawthorne, A Thomas and RN Pierson, 'Ethics and Theoretical Issues in Kidney Xenotransplantation'. *Semin Nephrol* [2022] 42(4): 151288. Doi: 10.1016/ j.semnephrol.2022.151288.

[628] T Schiff, B Parent, I Dittmer, WJ Hawthorne, I Kwon and MM Mohiuddin, 'Next Steps for Clinical Xenotransplantation in the United States'. *Ann Internal Med* [2023] 176: 1538-153. Doi: 10.7326/m23-1823%m37903363.

[629] WJ Hawthorne, PJ Cowan , L Buhler and E Wolf, 'International Standards and Guidelines for Xenotransplantation'. *Nat Biotechnol* [2021] 39(12): 1501-1502. Doi: 10.1038/s41587-021-01148-3

[630] *Ibid* (n 5).

[631] EJ Salvaris, N Fisicaro, S McIlfatrick, A Thomas, E Fuller, AM Lew AM, et al., 'Characterisation of Transgenic Pigs Expressing a Human T Cell-Depleting Anti-CD2 Monoclonal Antibody'. *Xenotransplantation* [2023] 13(n/a): e12836. Doi: 10.1111/ xen.12836

[632] PM Porrett, BJ Orandi, V Kumar, J Houp, D Anderson, A Cozette Killian, et al. 'First Clinical-Grade Porcine Kidney Xenotransplant Using a Human Decedent Model'. *Am J Transplant Off J Am Soc Transplant Am Soc Transplant Surgeons* [2022] 22(4): 1037–10 53. Doi: 10.1111/ajt.16930

approved under "compassionate use" for live patients[633] and highly successful preclinical trials using transgenic pig islet cells[634].

In this study, we examine the xenotransplantation in line with its definition and the principles supporting xenotransplantation as it approaches widely recognised clinical translation. We explore the evolution of Xenotransplantation in the lens of its historical perspective. We also examine the ethical issues of Xenotransplantation, looking at issues relating to balancing individual and collective interests, animal rights, their use, the public's opinion of this novel medical technique, and the possible risks of xenozoonotic disease transmission. Other subject matters of this study are the public policy debate surrounding Xenotransplantation, Xenotransplantation and public health risks, regulatory challenges and concerns in Xenotransplantation and the regulatory frameworks for Xenotransplantation and the need for international harmonization and standardization of regulations, with an emphasis on the actions taken by the IXA, TTS, and WHO's top governing bodies[635]. A new era in organ transplantation is unfolding[636], and as the first clinical trials of xeno-kidneys[637] and hearts bring us closer to making xenotransplantation a reality[638], it's essential to reflect on the remarkable progress that has led us to this critical moment[639]. The delicate balance of scientific innovation, human health, and ethical responsibility has been at the heart of this journey. To move forward with confidence, we must fully understand these advances and their ethical, policy and regulatory implications[640].

2.0. Xenotransplantation: Definition and Principles

The simplest form of xenotransplantation, however far from basic, is the removal of organs from an animal and transplanting them into a human organ. The term is defined as "any procedure involving the transplantation, implantation, or infusion into a human recipient of either live tissues or organs retrieved from animals, or human body fluids, cells, tissue, or organs that have undergone ex vivo contact with live non-human animal cells, tissues, or organs"[641]. When xenotransplantation was first attempted in the 1960s, the most important

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[633] BP Griffith, CE Goerlich, AK Singh, M Rothblatt, CL Lau, A Shah, et al. 'Genetically Modified Porcine-to-Human Cardiac Xenotransplantation'. *New Engl J Med* [2022] 387(1): 35–44. Doi: 10.1056/NEJMoa2201422

[634] WJ Hawthorne, EJ Salvaris, YV Chew, H Burns, J Hawkes, H Barlow, et al., 'Xenotransplantation of Genetically Modified Neonatal pig Islets Cures Diabetes in Baboons'. *Front Immunol* [2022] 13: 898948. Doi: 10.3389/fimmu.2022.898948

[635] WJ Hawthorne, PJ Cowan, LH Bühler, S Yi, R Bottino, RN3rd Pierson, et al., Third WHO Global Consultation on Regulatory Requirements for Xenotransplantation Clinical Trials, Changsha, Hunan, China December 12-14, 2018: 'The 2018 Changsha Communiqué' The 10-Year Anniversary of the International Consultation on Xenotransplantation. Xenotransplantation (2019) 26(2): e12513. Doi: 10.1111/xen.12513

[636] JS Logan and DKC Cooper, 'Xenotransplantation: A New Era in Transplantation'. *Journal of Heart and Lung Transplantation* [1998] (17) (10) 1026-1032.

[637] RA Montgomery, JM Stern, BE Lonze, VS Tatapudi, M Mangiola, M Wu, et al. 'Results of Two Cases of Pig-to-Human Kidney Xenotransplantation'. *New Engl J Med* [2022] 386(20):1889–98. Doi: 10.1056/NEJMoa2120238

[638] MM Mohiuddin, AK Singh, L Scobie, CE Goerlich, A Grazioli, K Saharia K, et al., 'Graft Dysfunction in Compassionate Use of Genetically Engineered Pig-to-Human Cardiac Xenotransplantation: A Case Report'. *Lancet* [2023] 402(10399): 397–410. oi: 10.1016/ S0140-6736(23)00775-4

[639] Ibid (n 13).

[640] WJ Hawthorne, A Thomas and RN Pierson, 'Ethics and Theoretical Issues in Kidney Xenotransplantation'. *Semin Nephrol* [2022] 42(4): 151288. Doi: 10.1016/ j.semnephrol.2022.151288

[641] United Kingdom Department of Health (2006). – Xenotransplantation Guidance. Department of Health, London, 1–7. Available at: http://webarchive.nationalarchives.gov.uk/20090503114534/; http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicy AndGuidance/DH_063075 accessed 1 December 2024.

ethical concern became clear: organs from animals are more likely to be rejected than those donated by people. The recipient's immune system will nearly always react badly to the new transplant or organs and try to reject them since donor organs, regardless of their source, are foreign to the recipient's body. Even organ transplant recipients will need to take immunosuppressive medications for the remainder of their lives. However, because the organ comes from a different species, immunosuppressants are unlikely to work when it is removed (or "donated" barely seems suitable) from an animal.

Animal organs are rapidly rejected when transplanted into humans, as was quickly found in the early attempts at xenotransplantation. In 1964, six patients in the United States received kidney transplants from chimpanzees, a species selected due to its near genetic resemblance to humans. However, the organs were rejected, and all but one patient passed away within days (although the latter lived for nine months). Six patients received kidney transplants from baboons that same year, but none of them lived for more than two months. In three previous examples (a baboon heart and two baboon livers) from the 1980s and 1990s, the recipients died within 100 days of the transplant. In terms of transplantation from other animals, one patient received a sheep heart in 1968 and died instantly, while another received a pig heart in 1992 and died within a day[642]. These gloomy figures prompted the first attempts to genetically modify animals in order to reduce the likelihood of rejection. Since the risk of death associated with receiving a transplant would be too great for people who can afford to wait longer in the hopes of receiving an organ from a human donor, xenotransplantation of solid organs would only ever be considered for patients who "super-urgently" needed an organ. Naturally, patients will be drawn to the extremely low possibility of a successful transplant without rejection if the alternative to attempting xenotransplantation is death from organ failure. However, as will be covered below, there is another reason why xenotransplantation could be difficult, even for this tiny set of patients.

The other major ethical concern with xenotransplantation is the potential consequences if the organ is not rejected: the transplant could result in the transmission of an existing animal virus to its human host, or (worse), interaction between the animal organ and its human host could create a new virus, causing a pandemic of infection. The risk of 'zoonosis' makes xenotransplantation a matter of not only individual permission and risk, but also of public health ethics. This means that the repercussions of xenotransplantation affect not only the recipient (and the animal from which the organ is derived), but also the whole public. As Sheila McLean and Laura Williamson describe: 'The hazards of infectious disease potentially connected with xenotransplantation mean that the decision of one patient could endanger the health of third parties: their close contacts, healthcare providers, or others'[643]. Because of these concerns, monitoring for infectious disease following xenotransplantation may include not just the recipient of the organ, but also anybody in close touch with him or her, in order to avoid the modest but possibly catastrophic possibility of a pandemic. This in turn brings up some ethical concerns about the potentially coercive character of any such monitoring; although an individual may desire a xenotransplant, family members' consent should also be obtained if they are required to participate in ongoing monitoring for any zoonosis. Any xenotransplantation research would have to exclude any patient who refused to consent to such

[642] Nuffield Council on Bioethics (1996). – Animal-to-Human Transplants: The Ethics of Xenotransplantation. Nuffield Council on Bioethics, London, 168 pp. Available at: http://nuffieldbioethics.org/wp-content/uploads/xenotransplantation.pdf accessed 30 November 2024.

[643] S McLean and L Williamson, 'The Demise of UKXIRA and the Regulation of Solid-Organ Xenotransplantation in the UK'. *J. Med. Ethics* [2007] 33(7), 373-375. Doi:10.1136/jme.2007.020768.

monitoring, as well as any family members or other close relatives who did not agree to be monitored.

Finally, some conservative pundits opposed the early attempts at xenotransplantation because they saw it as a violation of human dignity to introduce animal parts into human bodies, even if it meant saving lives. This is because many religious beliefs argue that humans are a distinct type of animal (or not an animal at all), and that any form of cross-species mixing should not obscure this distinction. This view is well illustrated by the official Catholic Church statement on xenotransplantation: 'From our point of view, supported by the biblical perspective that asserts, as stated above, that man is created "in the image and likeness of God" (cf. Gen 1: 26-27), we reaffirm that humans have a unique and higher dignity'[644]. However, even the Catholic Church today recognises that xenotransplantation is ethically justifiable[645], despite some reservations about recent breakthroughs in the field. It is crucial to remember that solid organs are not the only animal parts that can be transplanted into humans, even though the early attempts at xenotransplantation were comparatively unsuccessful. Although solid organ xenotransplantation has not been successful, there has been some success with transplanting other animal parts. Many patients suffering from cardiac illness have had pig heart valves transplanted into their chests, with excellent results. Pigskin has also been used successfully in burn victims, with no signs of zoonosis.

3.0. The Historical Trajectory of Xenotransplantation: A Retrospective Perspective

For decades, humanity has witnessed xenotransplantation as having held promise as a lifeline for thousands of people waiting for organ transplants[646]. The prospect of using animal organs, tissues, and cells to save human lives has captivated the imagination of scientists, doctors, and patients. As breakthroughs bring this innovative field closer to reality, the spotlight is shifting to the complex policy, ethical and regulatory questions surrounding xenotransplantation[647]. This is especially true given the rapid progress made in recent years, which has led to the beginning of life-saving heart and kidney xenotransplantation. In cases where patients face immediate life-threatening conditions, special compassionate use authorization has been granted, allowing access to experimental treatments outside of clinical trials. This authorization, approved by the FDA, is reserved for situations where no alternative treatments are available to address the patient's life-threatening condition[648].

The history of xenotransplantation has been characterised by both optimism and difficulty. From fairly strange early conceptions and therapies to now being a clinical reality, xenotransplantation has been explored in many and varied settings. In June of 1667, xenotransfusion was tried for the first time in Paris, marking the first documented attempt at xenotransplantation in the early 17th century. A 15-year-old boy[649] received what we presume

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[644] Pontifical Academy for Life (2001). – Prospects for Xenotransplantation: Scientific Aspects and Ethical Considerations. Pontifical Academy for Life, Vatican City. Available at: www.vatican.va/roman_curia/pontifical_academies/acdlife/documents/rc_pa_acdlife_doc_20010926_xenotrapianti_en.html accessed 1 December 2024.

[645] *Ibid*

[646] *Ibid* (n 1).

[647] KC Cooper David K and P Robert Lanza, *Xenotransplantation: The Transplantation of Organs and Tissues Between Species* (Springer, 2000).

[648] JL Estrada, E Martens, AD Li, PS Patel, JR Butler and JL Platt, 'Evaluation of Human Immune Responses to Pig Cellular Antigens'. *Xenotransplantation* [2018] (25) (3) e12413.

[649] JB Denys, Lettre Escrite à Monsieur de Montmor ... Touchant une Nouvelle Maniere de Guerir Plusieurs Maladies par la Transfusion du Sang, Confirmée Par deux Experiences Faites sur des Hommes (1667). Available at: https://gallica.bnf.fr/ark:/12148/bpt6k326277d accessed 2 December 2024.

to be a modest amount of lamb blood by transfusion from French physician Jean-Baptiste Denis, who served as King Louis XIV's physician, and surgeon Paul Emmerez. Unfortunately, the second effort at xeno-transfusion failed and resulted in the patient's death, prompting the French government to criminalise it[650].

Mathieu Jaboulay performed the first documented successful kidney xenotransplant in 1906, after perfecting the vascular anastomosis procedure with Alexis Carrel. In an underlying effort, Dr. Jaboulay made an attempt to transplant a pig kidney into a 48-year-old woman, connecting it to her blood vessels in her arm. Initially, the procedure showed signs of success, with the transplanted kidney producing urine for a day and a half. Unfortunately, tragedy struck on the third day, as the kidney's blood vessels began to clot, forcing Dr. Jaboulay to remove the transplanted organ[651]. Despite the enthusiasm and pioneering spirit of these early attempts, they were ultimately hindered by a fundamental lack of understanding of the intricate complexities of transplantation, particularly when crossing species boundaries. The risks and consequences of such procedures were often underestimated, and the scientific, ethical and regulatory frameworks that guide modern medical research were not yet in place[652].

The position of Thomas, Hawthorne and Burlak is clear as they stated that in the centuries that followed, sporadic attempts at xenotransplantation were met with limited success[653], as patients struggled with infections and graft rejection[654]. As medical ethics evolved, the scientific community was compelled to confront the profound ethical concerns surrounding these practices, particularly with regards to animal welfare and the use of animals in research and as a source of organs, tissues, and cells for human transplantation[655]. The introduction of organ transplantation in the mid-20th century, coupled with a growing shortage of donor organs, reignited interest in xenotransplantation. A major breakthrough came with the discovery of alpha Gal, the key driver of hyperacute rejection (HAR)[656]. This finding led to the development of genetically modified pigs[657], designed to produce organs that would be less likely to trigger an immune response in humans. Cascalho Marilia and Jeffrey Platt revealed that these advancements enabled the first clinical trials of xeno-kidney transplants and paved the way for islet cell xenotransplantation[658]. As a result, new possibilities emerged for patients in dire need of organ transplants, offering a glimmer of hope for improved treatment options.

As we push the boundaries of xenotransplantation, let's not forget the lessons of history. By learning from the past, we can build a stronger, more compassionate foundation for the future of this life-changing field, as ethical considerations and the historical context of early, ill-

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[650] *Ibid*

[651] M Jaboulay, Greffe de Reins Au pli du coude par soudures arterielles et veineuses (1906) accessed 30 November 2024.

[652] L Platt Jeffrey, *Xenotransplantation* (American Society of Nephrology, 1998).

[653] A Thomas, WJ Hawthorne, C Burlak, 'Xenotransplantation Literature Update, November/December 2019. *Xenotransplantation* [2020] 27(1): e12582. Doi: 10.1111/ xen.12582.

[654] M Hu, WJ Hawthorne, S Yi and PJ O'Connell, 'Cellular Immune Responses in Islet Xenograft Rejection'. *Front Immunol* [2022] 13: 893985. Doi: 10.3389/fimmu.2022.893985

[655] WJ Hawthorne, A Thomas and RN Pierson, 'Ethics and Theoretical Issues in Kidney Xenotransplantation'. *Semin Nephrol* [2022 42(4): 151288. Doi: 10.1016/ j.semnephrol.2022.151288.

[656] DKC Cooper, B Ekser and AJ Tector, 'Immunobiological Barriers to Xenotransplantation'. *Int J Surg (London England)* [2015] 23(Pt B):211–216. Doi: 10.1016/j.ijsu.2015.06.068

[657] M Sykes, 'Developing Pig-to-Human Organ Transplants'. *Sci (New York NY)* [2022] 378(6616):135-136. Doi: 10.1126/science.abo7935

[658] Cascalho Marilia and Jeffrey Platt, 'Xenoreactive Natural Antibodies and the Future of Xenotransplantation'. *American Journal of Transplantation* [2001] (1) (2) 134-141.

informed endeavours have greatly influenced the ethical and legal frameworks that exist today[659]. At the core of this transformative journey is the careful balancing act between scientific innovation, human health, and ethical duty. Understanding these historical obstacles helps us to recognise the importance of the ethical and legal developments covered in this study, as they bring us one step closer to the long-awaited reality of xenotransplantation, which appears to be happening right now[660].

4.0. The Ethics of Xenotransplantation: Balancing Individual and Collective Interests

The challenges of applying core biological ethical principles such as beneficence, nonmaleficence, autonomy, and fairness to both individuals and communities are evident. Ethical thinkers have battled with the potential conflict between a dying patient's right to the sole accessible treatment and the community's right to avoid being exposed to an unknown and potentially nonexistent risk of infection[661]. Much attention has been paid to individual patients' responsibilities to the community, including debates over whether compliance with post-transplantation surveillance could be coerced and whether contracts that bind patients in advance to follow up should be considered, regardless of any subsequent wavering on the part of the individuals[662]. Others have emphasised on the community's responsibility to each individual patient. The National Academy of Sciences, Institute of Medicine Workshop on Xenotransplantation, for example, argued that if we as a community are unwilling to accept some level of risk for the sake of those among us whose suffering is obvious and potentially alleviatable, we diminish our own humanity[663]. At least one ethicist has made an effort to examine the advantages and disadvantages of xenotransplantation using logic informed by an understanding of Darwin's evolutionary theories. According to Donnelley[664], ethical reasoning in the field of evolutionary biology should reject the idea of perfection as well as the inherent drawbacks of attempts at ethical reasoning that presume linear cause and effect. Instead, it should strive to operate with an understanding of complex cascades of multiplying cause and effect.

Ultimately, the obligations and interests of the individuals and the broader community they are a part of are entwined. Although there is a chance of risk associated with xenotransplantation, there are also advantages for both the patients and society at large. Even a cursory analysis of one proposed use of xenotransplantation—trials to functionally cure juvenile onset type 1 diabetes mellitus using pig pancreatic islets—can demonstrate that the benefit may go beyond the individual recipient, a fact that is all too frequently overlooked or unacknowledged in discussions of this subject. Society is greatly impacted by the illness burden of diabetes mellitus in young people. Diabetes mellitus was the sixth most common cause of mortality in the United States in 1998. According to Eberhardt and others[665], diabetes caused 176.8 years of lost productive life before the age of 75 and 24.7 fatalities per 100,000 people. This influence hasn't

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[659] DKC Cooper, B Ekser and AJ Tector, 'A Brief History of Clinical Xenotransplantation'. *Int J Surg (London England)* [2015] 23(Pt B): 205-210. Doi: 10.1016/j.ijsu.2015.06.060.

[660] MM Mohiuddin, AK Singh, L Scobie, CE Goerlich, A Grazioli and K Saharia, et al., 'Graft Dysfunction in Compassionate Use of Genetically Engineered Pig-to-Human Cardiac Xenotransplantation: A Case Report'. *Lancet* [2023] 402(10399): 397–410. Doi: 10.1016/ S0140-6736(23)00775-4

[661] APR Aluwihare, 'New Problems Beget New Solutions'. Bull of the WHO [1999] 77: 64–5.

[662] AS Daar, 'Xenotransplantation: Informed Consent/Contract and Patient Surveillance'. Biomedical Ethics [1999] 4: 87-91.

[663] Institute of Medicine (1996) Xenotransplantation: Science, Ethics, and Public Policy. National Academy Press, Washington, D.C.

[664] S Donnelley, (1999) The Moral Landscape of Xenotransplantation. Presented at Cold Spring Harbor, New York on May 12, 1999 and University College, Oxford University, United Kingdom on September 17, 1999.

[665] MS Eberhardt, DD Ingram, DM Makuc, et al (2001) Urban and Rural Health Chartbook. Health, United States, 2001. Hyatesville, Maryland: National Center for Health Statistics.

changed much since 1950, despite continuous study and innovative treatment initiatives. Diabetes caused 96,000 hospitalisations in the USA in 1999, with an average stay of six days[666]. Intermittent injections of pig insulin have long been used to treat diabetes in humans. Porcine pancreatic islets could be used to functionally treat early-onset diabetes, which would save society a substantial amount of money and years of productive life.

5.0. The Public Policy Debate Surrounding Xenotransplantation

Both scientists and laypeople are quite concerned about the biohazards that may be connected to xenotransplantation[667]. A ban on clinical trials has previously been demanded by the Council of Europe, certain well-known scientists, and laypeople. In order to ban xenotransplantation in the United States, the global Campaign for Responsible Transplantation petitioned the Secretary of the US Department of Health and Human Services for rulemaking in December 1998. In December 1999, that petition was turned down.

The lessons learnt from zoonotic illness in general, and the AIDS pandemic in particular, suggest that there are enough infectious dangers inherent in xenotransplantation to warrant a reasonable level of concern. Scientists and policymakers in this field are caught in a conundrum caused by the inextricable marriage of unclear collective risk and potential benefit for both individuals and society, as mentioned below. In contrast to safeguarding the public from the risk of meningococcal disease, protecting the human population from infectious risks associated with xenotransplantation is more akin to the experience of gene therapy: a possible benefit is accompanied with the need for public precautions. Any clinical strategy that involves the use of xenogenetic tissue in humans should include planning ahead of time for these infectious hazards which may result later on.

5.1. Xenotransplantation and Public Health Risks

Concerns regarding the possible threats that Xenotransplantation poses to public health around the world have existed for many decades[668]. The possibility of xenozoonosis—an infectious disease that spreads from an animal to a human recipient and then to the community after xenotransplantation—has been the main focus of these. An epidemic or even a pandemic could be brought on by a xenozoonosis in the worst situation. This issue grew starting in the mid-1990s when the US Food and Drug Administration (FDA) temporarily halted plans for a clinical trial of xenotransplantation to see if baboon bone marrow could strengthen AIDS patients' immune systems[669]. The FDA imposed a de facto restriction on xenotransplantation from NHPs to humans due to the possibility of an infectious disease arising, which was regarded higher than that of more phylogenetically distant animals, such as pigs[670].

A Working Party was formed by the UK's Nuffield Council on Bioethics in 1995, and it released a study titled "*Animal-to-Human Transplants: The Ethics of Xenotransplantation*" in 1996[671]. The apparent ethical, safety, financial, and public health concerns that xenotransplantation raise are prevailing. A number of issues persist, including the possibility

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[666] MS Eberhardt, DD Ingram and DM Makuc, et al., *Urban and Rural Health Chartbook. Health, United States, 2001* (Hyatesville, Maryland: National Center for Health Statistics, 2001).

[667] LE Chapman, TM Folks, DR Salomon, AP Patterson, TL Eggerman and PD Noguichi, 'Xenotransplantation and Xenogeneic Infections'. *New England Journal of Medicine* [1995] 333: 1498-1501.

[668] Y Ye, M Niekrasz, S Kosanke, et al., 'The Pig as a Potential Organ Donor for Man: A Study of Potentially Transferable Disease from Donor Pig to Recipient Man'. *Transplantation* [1994] 57(5): 694-702.

[669] J Brown, AL Matthews, PA Sandstrom and LE Chapman, 'Xenotransplantation and the Risk of Retroviral Zoonosis'. *Trends Microbiol.* [1998] 6(10): 411-415. Doi:10.1016/S0966-842X(98)01347-X; JS Allan, 'Xenograft Transplantation of the Infectious Disease Conundrum'. *ILAR J.* [1995] 37(1): 37-48. Doi:10.1093/ilar.37.1.37.

[670] D Butler, 'FDA Warns on Primate Xenotransplants'. *Nature* [1999] 398(6728): 549-549. Doi:10.1038/19144.

[671] Nuffield Council on Bioethics, Animal-to-Human Transplants: The Ethics of Xenotransplantation. Nuffield Council on Bioethics; 1996.

of a xenozoonotic infection, even if it came to the ethically acceptable conclusion that using genetically modified pigs for xenotransplantation is acceptable. It is ascertainable that unless this risk is sufficiently managed, formal clinical studies would not be ethically acceptable. After the COVID-19 pandemic, there were increased worries about the possibility of xenozoonosis, and these worries are not unjustified. Zoonotic disease is widespread, and it is predicted that three out of every four new or emerging diseases in humans begin in nonhuman animals[672]. Furthermore, there is no shortage of well-known zoonotic diseases that have collectively contributed to large and widespread human suffering, only 13 zoonotic diseases are responsible for 2.2 million human deaths and 2.4 billion cases of illness annually[673].

A 57-year-old man with nonischemic cardiomyopathy who was not a candidate for cardiac allotransplantation received a heart transplant in January 2022 from a genetically modified pig that had ten distinct gene alterations. Although the xenograft performed admirably for over 40 days, the patient sadly passed away on day 60[674]. Graft rejection was probably the reason for the failure[675], but since the xenograft recipient tested positive for porcine cytomegalovirus, it has been hypothesised that this might have played a role in his demise. The argument that a xenozoonosis is more than just theoretically possible is supported by it. Crucially, a recipient of a xenograft may offer the "perfect" conditions for a virus to adapt in a new host because immunosuppressive therapy is required.

Since the 1990s, there have been three primary perspectives on clinical trials and the hazards of xenozoonosis:

(i) The pandemic danger associated with xenozoonosis is significant enough to exclude formal clinical studies[676].

(ii) The danger of xenozoonosis to public health is significant enough that clinical trials should not begin until there has been an adequately informed public debate to determine whether or not they desire to accept the risks and allow clinical trials, and under what conditions[677].

(iii) The absolute pandemic risk provided by XTx is low enough to allow clinical trials if adequate public health surveillance and lifelong monitoring are implemented[678].

Given any worldwide risk, no matter how minor, prudence is undoubtedly necessary, and the requirements listed in the second and third viewpoints appear to be reasonable on the surface but are nevertheless unfulfilled. It would be challenging to conclude that there has been an adequately informed public debate over the risks of formal clinical trials based just on the increasing number of studies that have been undertaken and some international media attention. Furthermore, while there is consensus that some level of health monitoring and surveillance is appropriate, there is disagreement about the extent of this and what a participant can be

[672] U.S. Centers for Disease Control and Prevention. Zoonotic Diseases. Available at https://www.cdc.gov/onehealth/basics/zoonotic-diseases.html accessed 1 December 2024.

[673] D Grace, F Mutua, P Ochungo, et al., Mapping of Poverty and Likely Zoonoses Hotspots. Zoonoses Project 4. Report to the UK Department for International Development. ILRI; 2012.

[674] BP Griffith, CE Goerlich, AK Singh AK, et al., 'Genetically Modified Porcineto-Human Cardiac Xenotransplantation'. *N Engl J Med.* [2022] 387(1): 35-44. Doi: 10.1056/NEJMoa2201422.

[675] DKC Cooper, T Yamamoto, H Hara, and RN 3rd Pierson, The First Clinical Pig Heart Transplant: Was IVIg or Pig Cytomegalovirus Detrimental to the Outcome?' *Xenotransplantation* [2022] 29(4): e12771. Doi: 10.1111/xen.12771.

[676] S Fovargue, and S Ost, 'When Should Precaution Prevail? Interests in (Public) Health, the Risk of Harm and Xenotransplantation'. *Med Law Rev.* [2010] 18(3): 302-329.

[677] FH Bach an HV Fineberg, 'Call for Moratorium on Xenotransplants'. *Nature* [1998] 391(6665): 326-326. Doi:10.1038/34766.

[678] JA Fishman, L Scobie and Y Takeuchi, 'Xenotransplantation-Associated Infectious Risk: A WHO Consultation'. *Xenotransplantation* [2012] 19(2): 72-81. Doi:10.1111/j.1399-3089.2012.00693.x.

expected to commit to in a reasonable and practical manner[679]. As a result, there is ongoing debate about how severe and realistic post-transplant surveillance should be, as well as what is legally and ethically permissible. For example, such questions as these may be raised: Is it necessary to monitor someone for the rest of their lives? Is monitoring the recipient's social and sexual relationships required? If so, how long? Considerable investment would be necessary to carefully monitor xenograft recipients and any bystanders who may be at greater risk. Coherent plans for accounting for this have not been proposed. Finally, the advantage of xenotransplantation is limited to a tiny fraction of people in need of an organ transplant, whereas the costs and risks associated with it could be universal[680]. Overall, the trajectory appears to be that the public health risk has been judged to be low enough that formal clinical trials can be regarded sufficiently safe and hence permitted. However, it is still required to exercise due caution and take efforts to limit the potential for harm. In the end, until official clinical studies start, the infection risk posed by xenotransplantation is unknown.

6.0. Regulatory Challenges and Concerns in Xenotransplantation

Potential harm from xenotransplantation zoonoses could affect the porcine organ recipient's family, friends, and other contacts, and it could also spread far beyond the borders of regional and national jurisdictions in the event of a pandemic. International regulation is extremely desirable for a number of reasons, including the inadequacies of lower-level regulation and the prospect that a patchwork of regulations could increase some of the risks of xenotransplantation.

Since it appears doubtful that institutional animal regulators and local IRBs will possess the level of experience required to handle extremely complex issues, local regulation is insufficient. A patchwork of solutions with differing levels of rigour may result from national legislation. By 2010, for instance, there were at least 29 xenotransplant therapies accessible in 12 different nations, with 9 of those 12 without any laws pertaining to the practice[681]. Since many jurisdictions have not established the legal framework to oversee human-animal chimaeras or animals with numerous genetic alterations, monitoring of xenotransplantation is unclear[682]. In the United States, regulation is overseen by the Food and Drug Administration[683], but separate branches govern distinct parts; for example, one branch manages animal genetic changes while another regulates the use of the resulting organs as medical therapies.

Efforts to govern xenotransplantation have been made at the international level over the years. The World Health Organisation and the International Xenotransplantation Association have created criteria that member governments must enforce[684]. However, without uniform regulations and enforcement, there is still a risk of inappropriate tracking and exploitation. A lack of regulatory consistency enhances the likelihood of xenotransplant tourism, in which patients fly to other countries for less expensive or quicker treatment. Transplant tourism has been a reality for many years, and it exploits local communities for financial benefit by those at the top, to the cost of the less fortunate who make the sacrifices required to give services to foreigners, such as organ donors. Xenotourism may thrive in nations with lax rules, employing

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[679] D Rodger, DJ Hurst and DKC Cooper, 'Xenotransplantation: A Historical–Ethical Account of Viewpoints'. *Xenotransplantation* [2023]: e12797. Avaialble at https://doi.org/10.1111/xen.12797 accessed 2 December 2024.
[680] *Ibid*
[681] DK Cooper, 'Clinical Trials of Xenotransplantation: The Need for a Worldwide Registry'. *Xenotransplantation* [2020] 27(3): e12598.
[682] K Kwisda, T Cantz and N Hoppe, 'Regulatory and Intellectual Property Conundrums Surrounding Xenotransplantation'. *Nat Biotechnol.* [2021] 39(7): 796-798.
[683] P Marks and S Solomon, 'Clarifying US Regulations on Xenotransplantation'. *Nat Biotechnol.* [2021] 39(12): 1500-1501.
[684] World Health Organization, Fifty-seventh World Health Assembly. Resolutions and Decisions, Annexes — Document WHA57/2004/REC/1 (WHO, 2004).

pig organs with less robust genetic manipulation and husbandry, raising the danger of zoonotic illnesses[685]. These worries are heightened by recent instances, such as an individual engaging in clandestine genetic editing to develop offspring resistant to HIV, despite the fact that the practice violated host nation legislation[686].

Several firms that seek to generate organs for xenotransplantation make their own genetic changes to donor organs. Revivicor has developed hearts with ten genetic changes, while eGenesis and Qihan Biotech collaborated to create pigs with deactivated PERVs. NZeno has created pigs with kidneys that do not expand following implantation[687]. The degree of PERV inactivation in each model, as well as other mitigation techniques, is uncertain. Each company's technique to gene editing contains proprietary information; therefore details may not be readily available for an independent risk assessment. These concerns highlight the importance of rigorous oversight for the safety of patients, donor animals, and the larger society.

7.0. Regulatory Frameworks for Xenotransplantation and the Need for International Harmonization and Standardization of Regulations

The regulatory landscape that regulates xenotransplantation is riddled by pronounced juridical heterogeneity, with diverse national and local legislative frameworks governing the practice globally. In the United States, for example, the Food and Drug Administration (FDA) and the Centers for Medicare and Medicaid Services (CMS) constitute the primary regulatory agencies responsible for overseeing xenotransplantation research and clinical trials[688]. Similarly, other jurisdictions, including Australia, China (Chinese FDA), South Korea (Korean FDA), Argentina (AFDA), and the European Union (European Medicines Agency, EMA), as well as the Therapeutic Goods Administration (TGA) in Australia[689], have established regulatory frameworks and legislative mechanisms to govern xenotransplantation.

These current frameworks usually include some modifications to its legislation, such as oversight of research and clinical trials, safety evaluations, informed consent, and xenozoonotic disease monitoring. With a foundation in preclinical trials, it becomes necessary that laws ideally aim to strike a balance between driving scientific progress and ensuring that risks are carefully weighed and minimized. Some of these laws may require or suggest conducting trials in non-human primates as a stepping stone to testing in humans[690]. International harmonisation and standardisation of legislation is one of the most urgent demands in the field of xenotransplantation. At the moment, several nations have varied legal systems, which can provide difficulties for researchers and medical professionals. These discrepancies have the potential to impede clinical trial advancement and erect needless obstacles to the advancement of this exciting technology. Simplifying the process from research to clinical application requires harmonisation and standardisation. By embracing universal laws and standards, scientists worldwide can collaborate seamlessly, share knowledge, and build on each other's

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[685] N Cengiz and CS Wareham, 'Ethical Considerations in Xenotransplantation: A Review'. *Curr Opin Organ Transplant* [2020] 25(5): 483-488.

[686] VL Raposo, The First Chinese Edited Babies: A Leap of Faith in Science'. *JBRA Assist Reprod.* [2019] 22;23(3): 197-199.

[687] When will xenotransplantation of pig organs be possible? Nanalyze. Available at https://www.nanalyze.com/2021/03/when-xenotransplantation-pig-organs-possible/ accessed 2 December 2024.

[688] JR Butler, MA Williams, JA Butler and JL Platt, 'Xenotransplantation: A Review of the Current Status'. *Journal of Surgical Research* [2016] (202) (2) 241-253.

[689] (EMA) EMA. Guideline On Xenogeneic Cell-Based Medicinal Products (2009). Accessed 30 November 2024.

[690] FDA. Source Animal, Product, Preclinical, and Clinical Issues Concerning the Use of Xenotransplantation Products in Humans (2016). Available at: https://www.fda.gov/files/vaccines,%20blood%20&%20biologics/published/Source-Animal–Product–Preclinical–and-Clinical-Issues-Concerning-the-Use-of-XenotransplantationProducts-in-Humans–Guidance-for-Industry.pdf accessed 1 December 2024.

discoveries. This harmony would not only accelerate progress but also pave the way for global acceptance of clinical trials and their life-changing outcomes, and a world where xenotransplantation knows no borders will be made feasible[691]. And because of this, the IXA in partnership with the Transplantation Society (TTS) and in collaboration with the World Health Organization (WHO) has been engaged in fruit-yielding efforts for decades, beginning with the establishment of guidelines and a xenotransplant registry[692]. These organisations have put forth a great deal of effort to guarantee that there has been international expert consultation. Through numerous high-level discussions and collaborations, the international community has been able to come together to establish and publish widely accepted guidelines under the auspices of the IXA, TTS, and WHO[693]. The first of these was released in 2008, when the "Changsha Communique" was draughted, and the guidelines have since been updated by numerous panels of international experts[694].

8.0. Conclusions

Since the first documented xenograft in the 17th century, some attitudes towards xenotransplantation have changed. According to what is currently known, three of the major religions are generally open to the prospect of xenotransplantation, which represents a significant shift. Furthermore, as the likelihood of xenotransplantation has grown, more powerful theological perspectives have emerged, such as those supplied by the Catholic Church's Pontifical Academy for Life. However, it is evident that additional research is required in this area to gain a fully thorough understanding.

Since the 1990s, the pig has replaced the NHP as the species used to harvest organs. The utilisation of pigs as a source of xenografts is probably more acceptable to the public than NHPs. But there is still an unknown danger of xenozoonotic infection, which raises ethical questions about whether and how clinical trials should be conducted in addition to scientific ones. The genetic engineering techniques currently used on source pigs have somewhat resolved this ethical dilemma. As demonstrated by the recent clinical pig heart transplant in 2022, there is still some risk to the patient, and there may be a minor but credible risk at the community level. Finally, despite decades of research on public opinions towards xenotransplantation, additional data points are required to guarantee a deeper comprehension.

Many of the ethical questions surrounding xenotransplantation have been debated for decades in one form or another. As the science of xenotransplantation has improved, some headway has been made in resolving certain ethical issues. However, some ethical difficulties have lasted and continue to exist today, hence, the need for international harmonization and standardization in regulations.

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[691] J Denner, 'Recent Progress in Xenotransplantation, with Emphasis on Virological Safety'. *Ann Transplant* [2016 21: 717-27. Doi: 10.12659/aot.900531.

[692] L Buhler and WJ Hawthorne, 'International Xenotransplantation Association (IXA) 25th Anniversary'. *Xenotransplantation* [2023] 30(4): e12821. Doi: 10.1111/xen.12821.

[693] World Health Organization, Second WHO Global Consultation on Regulatory Requirements for Xenotransplantation Clinical Trials (2011). Geneva, Switzerland: World Health Organization. Available at: https://iris.who.int/bitstream/handle/10665/341817/WHO-HTP-EHT-CPR-2011.01-eng.pdf?sequence=1&isAllowed=y accessed 2 December 2024.

[694] CommuniquéTC. First WHO Global Consultation on Regulatory Requirements for Xenotransplantation Clinical Trials: Changsha, China, 19-21 November 2008. The Changsha Communiqué. *Xenotransplantation* [2009] 16(2): 61-63. Doi: 10.1111/j.1399- 3089.2009.00520.x