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Review Article

Transforming organ donation and transplantation: Strategies for increasing donor participation and system efficiency

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ABSTRACT

Organ transplantation is a critical medical procedure that saves and improves lives, yet the system faces significant challenges that result in many missed opportunities. This comprehensive review examines the factors contributing to these missed opportunities and the concerns of potential donors. The shortage of donors remains a major issue, exacerbated by low registration rates, family consent refusals, and strict medical and health criteria. Inefficiencies within the organ procurement and transplantation process, including logistical delays and suboptimal matching systems, further hinder the availability of organs. Public misconceptions and cultural and religious beliefs also negatively impact donor willingness. Moreover, potential donors and their families face ethical, psychological, and procedural concerns. Ethical dilemmas revolve around issues of autonomy and informed consent, while psychological concerns include fear and anxiety about the donation process and its impact on families. Procedural issues, such as transparency, legal hurdles, and post-donation follow-up, add to the complexities of organ donation. This review explores potential solutions to address these challenges, such as enhancing public education campaigns to dispel myths, and providing incentives for proactive registration. It also recommends improving the performance of organ procurement organizations, optimizing logistics for organ transport, and developing advanced matching algorithms to ensure equitable organ allocation. Addressing donor concerns through robust ethical standards, comprehensive psychological support, and clear communication strategies is essential. By adopting these multifaceted strategies, the organ transplantation system can be made more efficient and supportive, increasing the availability of organs and ultimately saving more lives. This review underscores the need for integrated and targeted approaches to overcome the existing barriers in organ transplantation.

1. Introduction

Organ transplantation stands as one of the most significant advancements in modern medicine, providing life-saving solutions for patients with end-stage organ failure [1]. From the first successful kidney transplant in 1954 to today's complex multi-organ transplants, the field has evolved remarkably, extending the lives of countless individuals and improving their quality of life. These medical milestones are testament to the progress in surgical techniques, immunosuppressive therapies, and overall patient care. Despite these advancements, the demand for transplantable organs far exceeds the supply, leading to a critical and persistent shortage [2].

The disparity between the number of patients needing transplants and the availability of suitable organs has profound implications [3]. According to the World Health Organization, thousands of patients globally are on waiting lists for organs such as kidneys, livers, hearts, and lungs. In the United States alone, over 100,000 people are on the national transplant waiting list [4], and an average of 17 people die each day waiting for an organ that never comes [5]. In England 5100 people are waiting for an organ transplant. Three people die waiting for an organ each day [6]. This gap not only highlights the urgency of addressing organ shortages but also emphasizes the need for optimizing

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the existing organ transplantation system to ensure that no viable organ is wasted.

Missed opportunities in organ transplantation occur at multiple levels, from the point of potential donor identification to the final stages of organ allocation and transplantation [7]. Systemic inefficiencies, logistical challenges, and inadequate public awareness contribute to these missed opportunities [8]. For instance, organ procurement organizations (OPOs) often face challenges related to timely identification and retrieval of organs. Moreover, the logistics of organ transport can be fraught with delays, particularly in geographically vast regions. These delays can render otherwise viable organs unsuitable for transplantation [9].

Potential organ donors and their families also harbor various concerns that can affect their willingness to donate. Ethical and moral considerations, fears about the donation process, and concerns about the handling of their loved one's body are significant barriers [10]. Ensuring that potential donors and their families feel supported and informed throughout the process and training of healthcare professional is crucial in addressing these concerns and increasing donation rates [11].

Public perception and awareness of organ donation also play a crucial role in this issue. Misconceptions about the organ donation process, cultural and religious beliefs, distrust in the healthcare system and general lack of knowledge are significant challenges in societal acceptance and willingness to participate in organ donation [12]. The Department of Health and Social Care, have shown that many people support organ donation in principle, yet a significant proportion do not take the necessary steps to register [6]. In the United Kingdom a change in the law to an opt-out system in line with what the majority wants bridge this disconnect [13]. However, the importance of effective education and awareness campaigns that can address common myths and encourage more people to consider donation actively needs to be emphasized [14].

The novelty of this review lies in its comprehensive examination of the multi-faceted issues surrounding missed opportunities in organ transplantation and the concerns of potential donors. By synthesizing current knowledge and identifying gaps in practice, this review aims to provide a thorough understanding of the systemic, logistical, and ethical challenges in organ transplantation. The rationale for this study is to highlight areas where improvements can be made, thereby increasing the efficiency of the transplantation system and addressing the critical shortage of organs. The primary objectives are to explore the reasons behind missed opportunities in organ procurement and transplantation, to understand the concerns and barriers faced by potential donors, and to suggest evidence-based strategies to enhance the overall process of organ donation and transplantation. By achieving these objectives, this review contributes to the ongoing efforts to save more lives through improved organ donation and transplantation practices.

2. Methodology

2.1. Study design

This review employs a narrative review methodology, aimed at providing a comprehensive synthesis of the existing literature on missed opportunities in organ transplantation and the concerns of potential organ donors. The narrative review approach allows for a detailed examination of diverse studies, reports, and articles, offering a broad perspective on the topic.

2.2. Literature search strategy

The literature search was conducted across multiple electronic databases, including PubMed, MEDLINE, Google Scholar, and Cochrane Library. The search terms included combinations of keywords such as "organ transplantation," "organ donation," "missed opportunities," "donor concerns," "organ procurement," "transplant logistics," and "public awareness." Both peer-reviewed articles and grey literature, such as reports from health organizations and government publications, were included to ensure a comprehensive collection of relevant information.

2.3. Inclusion and exclusion criteria

The inclusion criteria for selecting articles were as follows:

- **Time Frame**: Publications from 2000 to 2023 were included to ensure the review covers the most recent and relevant developments.
- **Language**: Only articles published in English were considered.
- **Type of Study**: Both qualitative and quantitative studies, as well as systematic reviews, meta-analyses, and narrative reviews, were included.
- **Relevance**: Articles specifically addressing the aspects of missed opportunities in organ transplantation, systemic inefficiencies, logistical challenges, donor registration, public awareness, ethical concerns, and psychological factors affecting donors were included.

Exclusion criteria included:

- Articles not directly related to organ transplantation or donation.
- Studies focusing solely on medical or surgical techniques without addressing broader systemic or societal issues.
- Publications in languages other than English.

2.4. Data extraction and synthesis

Data extraction was performed manually by reviewing the abstracts and full texts of the selected articles. Key information was extracted and categorized into thematic areas such as systemic inefficiencies, logistical challenges, public awareness, and donor concerns. The synthesis process involved summarizing and integrating findings from different studies to construct a coherent narrative that highlights the main issues and potential solutions.

3. Missed opportunities in organ transplantation

Organ transplantation has the potential to save and improve countless lives, but the system is fraught with missed opportunities that hinder its effectiveness [7]. These missed opportunities manifest at various stages, from donor registration to the final allocation of organs. Systemic inefficiencies, logistical challenges,public misconceptions, organ and tissue extraction losses including procedural technicalities. These create significant barriers to the optimal use of available organs [15]. By identifying and addressing these missed opportunities, the transplantation system can be made more efficient, increasing the number of successful transplants and reducing the number of patients who die waiting for an organ [7]. This section delves into the primary missed opportunities, starting with the shortage of donors. Table 1 provides a detailed overview of the various missed opportunities in organ transplantation, highlighting the contributing factors and potential solutions for each issue.

3.1. Shortage of donors

The shortage of donors is arguably the most critical missed opportunity in organ transplantation [25]. This persistent gap between the supply of and demand for transplantable organs is influenced by several factors. One of the main contributors to the shortage of donors is the low registration rate among the general population. Despite widespread support for organ donation in principle, a significant proportion of individuals do not register as donors. The opt-out or deemed consent law which came to force in England, 2020 aims to address this discrepancy [14]. However, many people are still unaware of how to register as

Table 1
Missed Opportunities in Organ Transplantation.

Missed Opportunity	Description	Contributing Factors	Potential Solutions
Shortage of Donors [2]	Insufficient number of registered organ donors to meet the demand	- Low registration rates - Family consent refusals - Medical exclusions - Strict age and health criteria	- Enhance public education - Further expansion of the donor criteria including relaxed health and age restrictions - Consideration of donors in maastricht category I and II
Inefficiencies in OPOs [16]	Variability and inadequacies in the performance of Organ Procurement Organizations	- Inconsistent protocols - Insufficient training - Staff and resource limitations	- Standardize protocols - Improve training programs and increase pool of competent organ retrieval service team - Adequate resources allocation
Transport Logistics [17]	Delays and challenges in the timely transport of organs	-Inadequate transport infrastructure - Poor coordination - Geographical disparities	- Upgrade transport infrastructure - Establish robust coordination mechanisms - Prioritize organ transport
Matching Systems [18]	Suboptimal organ matching leading to inefficient allocation	- Inadequate matching algorithms - Regional disparities in organ allocation	- Develop advanced matching algorithms - Implement equitable allocation policies
Public Misconceptions [12]	Misunderstandings about organ donation preventing registration	- Fear of compromised medical care - Concerns about bodily integrity - Financial misconceptions	- Launch targeted education campaigns - Provide clear, accurate information - Engage in community outreach
Cultural and Religious Beliefs [19]	Cultural and religious reservations hindering donor registration	- Beliefs about body sanctity - Lack of clear religious guidance	- Engage with cultural and religious leaders - Provide culturally sensitive information
Family Dynamics [20]	Conflicting views among family members creating barriers	- Emotional distress - Lack of communication about donor wishes	- Encourage open family discussions - Provide mediation and support services
Legal and Bureaucratic Hurdles [21,22]	Complex legal and administrative processes deterring donation	- Extensive documentation requirements - Legal criteria for death declaration - Administrative complexity	- Streamline legal processes - Simplify documentation - Provide assistance through coordinators
Psychological Concerns [23]	Emotional and mental health issues affecting donors and families	- Anxiety about the donation process - Fear of surgery - Grief and loss among family members	- Offer counseling services - Provide support groups - Ensure ongoing psychological support
Procedural Transparency [24]	Lack of clarity and communication during the donation process	- Insufficient information provided - Lack of transparent procedures	- Enhance communication strategies - Ensure transparent and consistent processes
Post-Donation Follow-Up [23]	Inadequate support for living donors after donation	- Lack of medical follow-up - Insufficient psychological support	- Implement comprehensive follow-up care - Provide mental health resources - Maintain ongoing communication

organ donors or the importance of doing so. Public education campaigns often fail to reach or convince a large segment of the population. Additionally, even those who intend to register may procrastinate, delaying the process indefinitely. Misunderstandings about organ donation, such as fears of receiving substandard medical care if identified as a donor and so, and a good number of people plan to opt-out of the new opt-out system in England and Scotland [13]

Another significant barrier arises from the necessity of family consultation at the time of death. Family members may refuse consent due to emotional distress, religious beliefs, or lack of awareness of the deceased's wishes [20]. This can result in many potential donations being lost. Families grieving the loss of a loved one may be too distraught to consider organ donation, and often, the deceased's intentions regarding organ donation were not communicated to their family, leaving the family uncertain and hesitant to consent. The potential donor may have appointed a representative or relative to decide for them after their death, family of the deceased often share cultural and religious belief which may potentially influence the information provided on their loved one's wishes to have their organs donated [26].

Medical exclusions represent another significant factor in the donor shortage [27] Potential donors may be excluded due to their medical history, even if some of their organs are still suitable for transplantation. This overly cautious approach can lead to the unnecessary loss of viable organs. Individuals with certain diseases or medical conditions may be excluded from donating, even if those conditions do not affect all their organs. The risk-averse nature of organ procurement protocols sometimes leads to the rejection of donors who might otherwise be suitable [28].

Strict age and health criteria further reduce the pool of potential donors [29] While these criteria are intended to ensure the safety and success of transplants, they can also exclude viable organs from older donors or donors who fall outside the standard criteria. Many transplant programs have upper age limits for donors, excluding older adults even if their organs are in good condition. Health assessments can be overly stringent, disqualifying donors for relatively minor health issues that may not affect the transplant outcome [30].

Addressing the shortage of donors requires a multifaceted approach. Increasing public awareness and simplifying the registration process can help boost donor registration rates [31]. Encouraging open discussions about organ donation within families and implementing policies that respect the donor's wishes can reduce the barriers related to family consent. Reevaluating medical exclusions and relaxing age and health criteria, where appropriate, can expand the pool of potential donors [32] By tackling these issues, we can make significant strides toward closing the gap between the supply of and demand for transplantable organs.

3.2. Inefficiencies in the transplant system

Systemic inefficiencies further exacerbate the shortage of available organs, leading to missed opportunities in organ transplantation. These inefficiencies are present at various stages of the organ procurement and transplantation process, from the initial identification of potential donors to the final allocation and transplantation of organs [7] Inefficiencies in organ procurement organizations (OPOs) are a significant source of missed opportunities. OPOs are responsible for identifying potential donors, coordinating the retrieval of organs, and facilitating the transplant process. However, variations in the performance of OPOs can lead to inconsistent outcomes. Some OPOs may have inadequate protocols for timely identification and referral of potential donors, leading to delays or missed donations. Additionally, limited resources and staffing shortages can hinder the ability of OPOs to operate efficiently. These inefficiencies can result in a significant number of potential donors not being utilized, thereby reducing the overall availability of organs for transplantation [33]

Transport logistics represent another critical area where inefficiencies can lead to missed opportunities. The process of transporting organs from donors to recipients is time-sensitive, as organs have a limited viability period outside the body [34]. Delays in transport due to logistical challenges, such as flight cancellations, traffic congestion, or inadequate coordination between hospitals and transport services, can render viable organs unsuitable for transplantation. Furthermore, geographical disparities can exacerbate these issues, with organs from rural or remote areas facing additional hurdles in reaching transplant centers promptly [35]. Improving logistical coordination and investing in better transport infrastructure are essential steps to minimize organ wastage and ensure timely delivery.

Inadequate matching algorithms and regional disparities in organ allocation further prevent optimal organ utilization [18]. The process of matching donors with recipients is complex, involving considerations of blood type, tissue compatibility, and urgency of need. However, current matching systems may not always prioritize these factors effectively, leading to suboptimal matches and potential rejections. Additionally, regional disparities in organ allocation policies can result in inequitable distribution of organs [35]. For instance, organs procured in one region may be allocated primarily within that region, even if there are more suitable or urgent recipients elsewhere. This regional bias can lead to scenarios where organs are not utilized to their fullest potential, thereby contributing to the overall shortage.

3.3. Lack of public awareness and education

Public misunderstanding and lack of awareness about organ donation significantly hinder donor registration, creating a substantial barrier to addressing the organ shortage crisis. Despite efforts to promote organ donation, various misconceptions, cultural and religious beliefs, and inadequate education campaigns continue to impede progress in increasing donor numbers. Common misconceptions about organ donation are a major deterrent to registration [12]. Many people harbor fears that if they register as organ donors, their medical care might be compromised. This belief stems from a lack of understanding about medical ethics and the rigorous protocols that healthcare professionals follow to ensure that all patients receive the highest standard of care, regardless of their donor status. Additionally, some individuals believe that organ donation will disfigure their bodies or that their families will be charged for the donation process [36]. These misconceptions can generate fear and reluctance to register as donors, significantly reducing the potential donor pool.

Cultural and religious beliefs also play a crucial role in shaping attitudes toward organ donation. In some cultures, there are deep-seated beliefs about the sanctity of the body after death, which can conflict with the idea of organ donation [37] Similarly, certain religious doctrines may either explicitly oppose organ donation or lack clear guidance, leaving adherents uncertain or hesitant. These beliefs can create substantial barriers to donor registration, particularly in communities where such views are prevalent [38]. Addressing these concerns requires sensitive and respectful engagement with cultural and religious leaders to provide accurate information and reassurance that organ donation can be compatible with their values.

Insufficient and ineffective public education campaigns fail to address the myriad misconceptions and cultural reservations surrounding organ donation. Many campaigns lack the reach or the appeal needed to connect with diverse populations effectively [39,40]. Education efforts often do not adequately convey the importance of organ donation or provide clear, accessible information about how to register as a donor. Moreover, campaigns frequently miss the opportunity to highlight personal stories and testimonies from donors and recipients, which can be powerful tools in changing public attitudes [41] Without robust and targeted education initiatives, potential donors remain uninformed or misinformed, perpetuating the cycle of low registration rates.

4. Concerns of organ donors

Organ donation, while a generous and life-saving act, raises a multitude of concerns for potential donors and their families. These concerns can significantly impact an individual's decision to become an organ donor, contributing to the overall shortage of available organs. Understanding these concerns is critical for developing strategies to address them and encourage more people to consider donation. Donor apprehensions can be broadly categorized into ethical and moral concerns, psychological fears, and procedural worries [42] Each of these categories encompasses a range of issues that need careful consideration and sensitive handling to ensure that potential donors feel informed, respected, and supported throughout the donation process. Table 2 provides a detailed overview of the various concerns of potential organ donors, highlighting the contributing factors and potential solutions for each issue.

4.1. Ethical and moral concerns

Potential donors often grapple with ethical and moral questions that can influence their willingness to donate organs. One of the primary concerns is the issue of autonomy and consent [43]. Ensuring that the donor's autonomy and informed consent are respected is crucial in the organ donation process. Potential donors need to feel confident that their wishes will be honored and that they have the freedom to make informed decisions about their bodies. The process of obtaining consent must be transparent, with clear communication about what organ donation entails and the implications for the donor and their family. Another significant ethical concern is the fear of premature declaration of death. Some potential donors worry that they might be declared dead prematurely to facilitate organ harvesting [44]. This fear is rooted in a lack of understanding about the strict medical and legal criteria that must be met before death is declared and organ retrieval can begin. Educating the public about these protocols can help alleviate such fears and build trust in the organ donation process.

Religious and cultural concerns also play a critical role in shaping attitudes toward organ donation. Various religious and cultural beliefs may conflict with the idea of organ donation, leading individuals to question whether it aligns with their values and traditions [19]. For instance, some religions have specific views on the sanctity of the body after death, while others may have no clear stance on organ donation, leaving followers uncertain about whether it is permissible [46]. Addressing these concerns requires engaging with religious and cultural leaders to provide guidance and support, ensuring that potential donors feel that their beliefs and values are respected in the organ donation process. Fig. 1 below shows concerns of potential donors.

Table 2
Concerns of Organ Donors.

Concern	Description	Contributing Factors	Potential Solutions
Ethical and Moral Concerns [43]	Ethical and moral dilemmas faced by potential donors	- Autonomy and consent issues - Fear of premature declaration of death - Religious and cultural beliefs	- Ensure robust ethical standards - Provide transparent consent processes - Engage with religious leaders
Psychological Concerns [23]	Emotional and mental health issues affecting donors and their families	- Fear and anxiety about the donation process - Family dynamics and conflicts - Grief and loss among families	- Offer counseling and psychological support - Facilitate family discussions and mediation - Provide ongoing support
Procedural Concerns [24]	Concerns related to the procedural aspects of organ donation	- Lack of transparency and communication - Legal and bureaucratic hurdles - Post-donation follow-up	- Enhance communication strategies - Simplify legal and bureaucratic processes - Ensure comprehensive post-donation care
Fear of Compromised Care [44]	Worry that medical care might be compromised if identified as a donor	- Misunderstandings about medical ethics - Lack of trust in the healthcare system	- Educate the public on medical ethics - Build trust through transparent practices
Bodily Integrity Concerns [37]	Concerns about physical handling and appearance after donation	- Fear of disfigurement - Cultural and personal beliefs about the body	- Provide clear information about the handling of the body - Respect cultural and personal preferences
Legal and Bureaucratic Hurdles [21,22]	Complex legal and administrative processes involved in organ donation	- Extensive documentation requirements - Legal criteria for declaring death - Administrative complexity	- Streamline legal processes - Simplify documentation - Provide assistance through coordinators
Lack of Awareness [14]	Limited understanding of the organ donation process and its benefits	- Inadequate public education - Misconceptions and myths	- Launch comprehensive public education campaigns - Provide accurate, accessible information
Family Consent Issues [20]	Family members' refusal to consent to donation at the time of death	- Emotional distress - Lack of communication about donor's wishes	- Encourage open discussions about donation wishes - Provide family mediation and support
Religious and Cultural Concerns [19]	Beliefs that may conflict with the idea of organ donation	- Specific religious doctrines - Cultural practices and traditions	- Engage with religious and cultural leaders - Provide culturally sensitive information and support
Fear of Organ Misuse [45]	Worry that donated organs might not be used appropriately	- Lack of transparency in the allocation process - Mistrust in the system	- Ensure transparent allocation processes - Provide information on the use and impact of donated organs and non-utilization of donated organs in rare or novel transplant except express consent obtained
Post-Donation Care for Living Donors [23]	Concerns about health and well-being after donation	- Lack of medical follow-up - Insufficient psychological support	- Implement comprehensive follow-up care - Provide mental health resources - Maintain ongoing communication

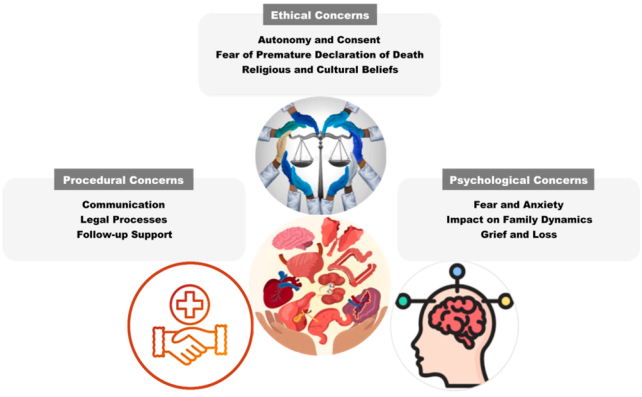

Fig. 1. Ethical, Psychological, and Procedural Concerns Impacting Potential Organ Donors.

4.2. Psychological concerns

The psychological impact of organ donation on donors and their families is significant, often shaping their willingness to participate in the donation process [47]. Understanding and addressing these psychological concerns is crucial to supporting potential donors and their families through what can be an emotionally charged decision. Potential donors may experience fear and anxiety related to the donation process and the impact it will have on their body. Living donors, in particular, may fear the surgical procedures involved, potential complications, and the recovery process. They might also worry about the long-term effects on their health and well-being [23]. For deceased donors, the fear is often centered around the physical handling of their body after death, which can be a distressing thought. Ensuring that potential donors receive comprehensive information about the procedures, risks, and safeguards can help mitigate these fears. Providing opportunities to speak with healthcare professionals and other donors who have undergone the process can also be beneficial in alleviating anxiety.

Family dynamics can significantly influence the decision to donate organs. Family members may have conflicting views on organ donation, leading to stress and anxiety [48]. For example, while one family member may strongly support organ donation, another might oppose it due to personal, cultural, or religious reasons. These conflicting perspectives can create tension and emotional strain, complicating the decision-making process. Open and honest communication within families about their wishes and concerns regarding organ donation is essential. Healthcare providers can facilitate these discussions, helping families navigate their differences and reach a consensus that respects the donor's wishes.

The families of deceased donors often grapple with intense grief and loss, which can complicate the decision to donate organs [49] The period following a loved one's death is emotionally overwhelming, and making decisions about organ donation can add to the burden. Families might struggle with the idea of parting with their loved one's organs, fearing it might affect their grieving process. Relatives' belief about the

deceased's wishes concerning donation are the strongest predictor of family decisions and these can be influenced by emotional response, personal treatment and medical attention [20] Additionally, the decision to donate may trigger feelings of guilt or doubt, particularly if there is uncertainty about the deceased's wishes. Providing bereavement support and counseling can help families process their grief and make informed decisions [50]. It is important to offer compassionate care and clear communication about how organ donation can honor the deceased's legacy and save lives.

4.3. Procedural concerns

The process of organ donation involves several procedural aspects that can be concerning for potential donors and their families. These procedural concerns need to be carefully managed to ensure a smooth and reassuring donation experience [48]. Clear and compassionate communication from medical professionals is essential throughout the organ donation process. Potential donors and their families need to be fully informed about what the donation entails, including the medical procedures involved, the risks and benefits, and what to expect during and after the donation process. Transparent communication helps build trust between donors and healthcare providers, addressing any fears or misconceptions that may exist [45]. Compassionate communication is particularly important during emotionally charged moments, such as when discussing the death of a loved one or the details of organ retrieval. Ensuring that medical professionals are trained in empathetic communication can significantly improve the experience for donors and their families [48].

Legal and bureaucratic processes related to organ donation can be daunting and discouraging for potential donors [51]. These processes include the documentation required to register as a donor, perception of deemed consent, the legal criteria for declaring death, and the administrative steps involved in coordinating the donation. Potential donors and their families may find these procedures complex and overwhelming, which can deter them from proceeding with the donation. Streamlining legal and bureaucratic processes and providing clear, accessible information about the steps involved can help alleviate these concerns [52]. Additionally, offering assistance to navigate these processes, such as dedicated coordinators or helplines, can make the experience less burdensome for donors and their families.

Ensuring proper follow-up and support for living donors is crucial for their long-term well-being [53]. Living donors, who donate organs such as kidneys or portions of their liver, require ongoing medical monitoring to ensure their health remains stable after the donation. They may also need psychological support to cope with any emotional or physical changes resulting from the donation [54]. Comprehensive follow-up care should include regular medical check-ups, access to mental health resources, and clear channels of communication with healthcare providers. This ongoing support helps address any complications early and provides reassurance to living donors that their well-being is a priority.

5. Losses in organ and tissue extraction

Organ and tissue extraction is a critical component in the transplantation process, serving as the bridge between donor identification and successful transplantation. The success of transplants relies heavily on the timeliness and precision of extraction procedures [55]. Any failure or loss during this process can lead to the permanent or premature loss of viable organs and tissues, severely impacting the availability of transplantable material for patients [56]. Tissues such as skin, tendons, bones, corneas, and ligaments are in high demand for various medical procedures, including reconstructive surgeries and burn treatments [57]. Yet, the process of tissue extraction often receives less attention, despite its ability to improve lives on a large scale [58].

5.1. Extraction procedures

The extraction of organs and tissues requires specialized techniques and highly trained multidisciplinary medical teams [59]. The retrieval of solid organs, such as the heart, liver, lungs, and kidneys, is particularly time-sensitive, as these organs must be harvested, preserved, and transplanted within a specific time window to maintain their viability [60]. The steps involved in extraction include meticulous planning, patient monitoring, anaesthesia management, and surgical precision to prevent any damage to the organs. For organ extraction, speed and efficiency are paramount [56]. Once brain death is confirmed, or in cases of cardiac death, the retrieval process must begin immediately. However, some potential donors do not die in a manner or within a timeframe conducive to successful organ extraction or transplantation if they remain alive beyond the retrieval window deemed appropriate by the retrieval surgeon. Due to logistical considerations, it is standard practice that, following the withdrawal of life-supporting treatment (WLST) from a potential controlled DCD (donation after circulatory death) donor, liver and pancreas recipient centers traditionally cancel the retrieval if asystole does not occur within 30 to 60 min post-WLST. Cardio-thoracic NORS teams wait for a minimum of two hours and are advised to discuss the situation with the recipient center for the heart after one hour, while abdominal teams, including those retrieving kidneys, wait at least three hours, regardless of the donor's hemodynamic parameters [61]. Given the extreme variability, transplant centers must decide whether to accept the potential loss of an extraction and transplantation opportunity or consider a case-by-case organ retrieval following withdrawal of life sustaining treatment.

The extraction typically takes place in an operating room where the organ procurement organization (OPO) coordinates with a surgical team. Each organ is removed with precision, following strict protocols for cooling, preservation, and transport to ensure the organ remains in optimal condition until transplantation [62]. In contrast, tissue extraction is less time-sensitive but equally delicate. Tissues such as skin, tendons, ligaments, corneas, and bones can be preserved for longer periods, sometimes up to five years, depending on the preservation method [63]. Nevertheless, the extraction process must be performed under sterile conditions to ensure the integrity of the tissues. Specialized techniques, including cryopreservation, can further extend the life of tissues, making them available for future use in reconstructive surgeries, burn treatments, and other medical interventions [64].

5.2. Factors contributing to losses

Despite the best efforts of medical teams, several factors contribute to losses during organ and tissue extraction. These losses, whether due to procedural errors, logistical issues, or a lack of coordination, can significantly diminish the number or quality of organs and tissues available for transplantation [65]. Technical errors during the extraction process, such as incorrect surgical techniques, inadequate preparation, or mishandling of organs and tissues, can lead to irreversible damage [66]. For instance, prolonged warm ischaemic time, improper cooling during organ extraction, contamination during tissue retrieval, or ischaemia/ reperfusion injury can result in immediate, early or delayed graft loss [67]. Additionally, failure to strictly adhere to sterility protocols may compromise tissue integrity, leading to infections or degradation of the tissues post-extraction.

Consequently, one of the biggest challenges in organ extraction is ensuring optimal coordination between the donor hospital, OPOs, and transplant centers [68]. A breakdown in communication can lead to delays in organ retrieval, particularly when donor hospitals are located far from transplant centers. Timing is critical, especially for heart, lungs, and liver extractions, where prolonged ischemia (lack of blood flow) drastically reduces the viability of the organ. Moreover, scheduling conflicts between surgical teams from different hospitals may result in delays that decrease organ viability [69]. In addition, the type of donor

(living donors vs deceased donors), pattern of death (donation after brain stem death versus deceased donors after circulatory death), certain pre-existing medical conditions, (such as infections, or trauma) can limit the decision to proceed with organ retrieval and the number or quality of organs or tissues that can be retrieved [70,71]. For instance, organs from donors who have had prolonged ICU stays, viral infections or sepsis may be at risk of poor function or outrightly declined [72]. Some tissues may remain viable despite these conditions, factors such as vascular damage or tissue necrosis may limit their usability. Moreso, the categorization of deceased donors after circulatory death (DCD) as either uncontrolled (Maastricht category 1 and 2) and controlled (Maastricht category 3 and 4) plays a crucial role in the decision to be considered for organ donation or extraction and there is a substantial variation world-wide as some countries have no DCD programmes, whilst some countries focus principally on controlled DCD (e.g. UK, Australia) or uncontrolled DCD (e.g. France, Spain) other countries such as Netherlands support both forms DCD [73]. Furthermore, smaller hospitals or those with limited resources may lack the specialized equipment or trained personnel needed for high-quality organ and tissue extraction [74]. This can result in less-than-optimal outcomes, as teams in these facilities may not have the expertise or tools necessary to perform precise extractions. Additionally, insufficient access to preservation tools, such as cold storage units, cryopreservation technologies, or normothermic regional perfusion may further exacerbate losses [75].

6. Potential solutions

Addressing the missed opportunities and concerns in organ transplantation requires a multifaceted approach [7]. By implementing comprehensive strategies, the organ donation system can be optimized to increase donor registration, improve efficiency, and support donors and their families throughout the process. Potential solutions focus on enhancing public awareness, streamlining processes, and providing robust support systems. These solutions aim to bridge the gap between the supply of and demand for transplantable organs, thereby saving more lives and improving the overall efficacy of the organ transplantation system [15]. The following sections explore specific strategies to achieve these goals. Fig. 2 below shows key barriers and potential solutions to addressing missed opportunities in organ transplantation.

6.1. Improving donor registration

Increasing donor registration is a critical step in addressing the organ shortage. Several approaches can be taken to encourage more people to register as organ donors. One effective method is the implementation of opt-out systems, also known as presumed consent systems [76]. In these systems, individuals are presumed to be organ donors unless they explicitly opt out. This approach has been adopted successfully in several countries, resulting in higher donor registration rates. The opt-out system simplifies the decision-making process for individuals and families, reducing the number of missed opportunities due to inaction or uncertainty. Implementing such systems requires careful consideration of ethical and legal implications, as well as public education to ensure that individuals are fully informed about their rights and choices [77].

Enhancing public education campaigns is another crucial strategy for improving donor registration [31]. Effective education campaigns should aim to dispel common myths and misconceptions about organ donation, such as fears about medical care being compromised or concerns about bodily integrity after death. These campaigns should also provide clear, accessible information about how to register as a donor and the impact that organ donation can have on saving lives. Utilizing various media platforms, including social media, television, and community outreach programs, can help reach a wider audience and encourage more people to consider donation [78]. Moreover, providing incentives for registration can also boost donor numbers. Incentives could include priority on transplant lists for registered donors, financial benefits, or other forms of recognition and support. While incentives should be carefully designed to avoid ethical concerns, they can be an effective tool for motivating individuals to take the step to register [79]. Incentives can also help to normalize the idea of organ donation and create a culture of giving within communities.

6.2. Enhancing efficiency in the transplant system

Streamlining processes to reduce inefficiencies within the transplant system is crucial to ensuring that every viable organ reaches a suitable recipient in a timely manner. Enhancing efficiency involves improving the performance of organ procurement organizations (OPOs), optimizing logistical operations, and developing advanced matching

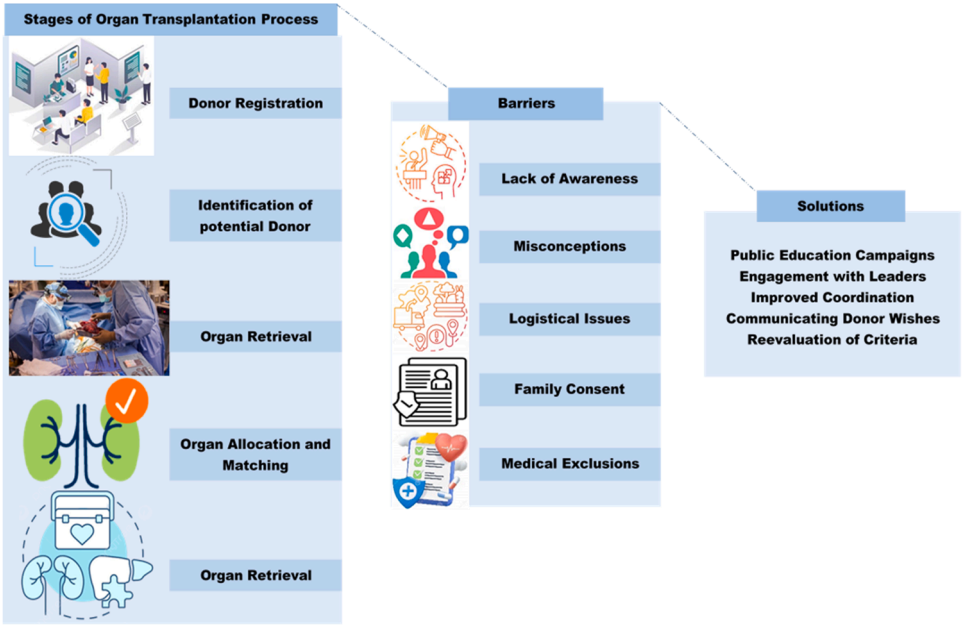

Fig. 2. Key Barriers and Potential Solutions to Addressing Missed Opportunities in Organ Transplantation.

algorithms. These measures aim to reduce organ wastage, increase the number of successful transplants, and ensure that organs are allocated equitably [80].

Organ procurement organizations (OPOs) play a critical role in the identification, retrieval, and allocation of organs. Standardizing and improving the performance of OPOs can address many inefficiencies in the transplant system. This can be achieved through better training and the establishment of rigorous protocols [81]. Comprehensive training programs should focus on best practices in donor identification, family communication, and organ retrieval techniques. Additionally, implementing standardized protocols across all OPOs can ensure consistency in performance and reduce variability in outcomes [16]. Regular audits and performance evaluations can help identify areas for improvement and ensure that OPOs are operating at the highest standards.

Logistics are a crucial component of the organ transplantation process, as organs have a limited window of viability once they are removed from the donor. Investing in better logistics for the rapid transport of organs can significantly reduce delays and improve outcomes [17]. This includes upgrading transportation infrastructure, such as dedicated organ transport vehicles and priority access to air travel for organ transport. Advanced tracking systems can provide real-time updates on the location and condition of organs in transit, allowing for better coordination and faster response times. Collaboration between hospitals, OPOs, and transport agencies is essential to streamline the logistics process and ensure timely delivery of organs to transplant centers [82].

Developing advanced matching algorithms is another vital step in enhancing the efficiency of the transplant system. Current matching systems may not always prioritize the most suitable recipients, leading to suboptimal matches and increased risk of organ rejection [83]. Advanced algorithms can incorporate a broader range of factors, including genetic markers, patient health status, and geographical proximity, to ensure more accurate and equitable matching. Machine learning and artificial intelligence can play a significant role in developing these algorithms, as they can analyze vast amounts of data and identify patterns that may not be apparent through traditional methods [84]. Improved matching can increase the success rates of transplants and ensure that organs are allocated to recipients who are most likely to benefit from them.

6.3. Addressing donor concerns

Mitigating the concerns of potential donors is essential to increasing donor participation and ensuring a supportive environment for both donors and their families [85]. Addressing these concerns through ethical assurance, psychological support, and clear communication can help build trust in the organ donation process and encourage more individuals to consider donation. Ensuring robust ethical standards and transparent processes is crucial for addressing the ethical and moral concerns of potential donors [52]. This involves upholding the highest standards of medical ethics in the donation process, from obtaining consent to organ retrieval and allocation. Donors and their families need to be assured that their autonomy and wishes are respected and that the decision to donate will not compromise their medical care. Transparency in the criteria for declaring death, the process of organ retrieval, and the allocation of organs can help alleviate fears of premature declaration of death or mishandling of organs [86]. Establishing clear, publicly accessible ethical guidelines and protocols can provide potential donors with the confidence that the donation process is conducted with integrity and respect.

Providing psychological support for donors and their families is essential to addressing the emotional and mental health concerns associated with organ donation [23]. Potential donors may experience anxiety and fear about the donation process and its impact on their health and body. Similarly, families of deceased donors may struggle with grief and the emotional burden of making donation decisions during a difficult time. Offering access to counseling services, support groups, and educational resources can help donors and their families navigate these emotional challenges [48]. Psychological support should be available throughout the entire donation process, from the initial decision to donate to post-donation follow-up, ensuring that both donors and their families feel supported and cared for.

Enhancing communication strategies to keep donors and families informed and reassured is a fundamental aspect of addressing donor concerns [87]. Clear and compassionate communication from medical professionals is crucial at every stage of the donation process. Potential donors and their families need detailed information about what organ donation entails, the risks and benefits, and what to expect during and after the donation process. Providing opportunities for donors and families to ask questions and express their concerns can help build trust and reduce anxiety [85]. Additionally, regular updates and transparent communication about the status of the donation and the impact it has had can provide reassurance and a sense of closure for families of deceased donors [88].

6.4. Addressing errors and enhancing coordination

The process of organ extraction plays a pivotal role in determining the success of transplants [89]. The average number of organs extracted from a single donor and the errors that occur during the extraction process are critical aspects that have a direct impact on the availability of transplantable organs [60]. Optimizing these procedures can significantly improve the success rates of organ transplants and reduce organ wastage, making it an essential area of focus for transplant systems worldwide [56]. One of the key challenges in organ extraction is ensuring that the maximum number of viable organs is retrieved without causing damage. Errors in this process, whether technical or procedural, can result in the loss of potentially life-saving organs [55]. These errors can stem from a lack of coordination among medical teams, improper handling of organs, or inadequate preparation and duration of the extraction [90]. Each of these factors can decrease the number of usable organs, negatively affecting the overall efficiency of the organ transplant system. To address these shortcomings, there is a need to implement standardized extraction techniques that can be universally adopted across hospitals and transplant centers [56]. Proper training and certification for medical teams involved in organ retrieval should be prioritized to ensure high-quality extractions. Additionally, the use of advanced technologies and tools, such as precision surgical instruments and real-time monitoring systems, can help reduce errors during the extraction process [91].

Improved coordination between the medical teams involved in donor care, organ procurement, and transplantation is also crucial [92]. Clear communication channels should be established to ensure that all team members are aware of the specific requirements of each extraction and that protocols are followed meticulously. This can help minimize errors and maximize the number of organs successfully retrieved from each donor [93]. Furthermore, ongoing research to expand the DCD categories included in organ retrievals and regular audits of extraction procedures and outcomes to identify areas for improvement. Data-driven analysis of errors and inefficiencies can lead to targeted interventions, such as refining surgical techniques or modifying procedural workflows. Continuous feedback loops between hospitals, organ procurement organizations, and regulatory bodies can help foster a culture of constant improvement in the organ extraction process [94]. By focusing on optimizing extraction techniques and reducing errors, we can increase the availability of viable organs for transplantation. In turn, this will lead to higher success rates for transplants, ultimately saving more lives [95]. Addressing these issues through comprehensive improvement strategies is an essential step toward enhancing the overall effectiveness of the organ transplantation system.

7. Optimizing organ and tissue extraction: reducing losses and enhancing transplant success

This section examines the importance of optimizing organ and tissue extraction procedures and methods to enhance efficiency and safety, with a particular focus on organ and tissue retrieval. While organ donation, particularly of the heart, lungs, liver, and kidneys, garners significant attention, tissue donation is equally vital in improving patients' quality of life [96]. By focusing on refining extraction procedures, enhancing coordination, and ensuring that medical teams have access to the latest technologies and training, significant improvements can be made [58]. Standardized, evidence-based protocols should be implemented across hospitals, OPOs, and transplant centers to ensure consistency in organ and tissue retrieval. This involves establishing detailed guidelines for each stage of the extraction process, including surgical techniques, preservation methods, and transport protocols [97]. Ensuring that all medical personnel follow these protocols can reduce the likelihood of errors and increase the number of organs and tissues successfully retrieved [56]. To prevent logistical and timing issues, effective communication between donor hospitals, OPOs, and transplant centers must be prioritized. Using real-time data-sharing platforms and communication tools, teams can coordinate more effectively, ensuring that surgical teams are on standby when needed and that transport arrangements for organs are in place [98]. Additionally, establishing regional centers of excellence for organ extraction could streamline operations and reduce delays.

Additionally, the use of advanced technologies during extraction can significantly improve outcomes. Robotic-assisted surgeries, for example, allow for greater precision in organ retrieval, minimizing the risk of damage [99]. Additionally, employing more sophisticated preservation technologies such as normothermic machine perfusion (a system that keeps organs functioning and viable outside the body for longer) can extend the window for organ transplantation [100]. Cryopreservation technologies for tissue extraction, particularly for skin, corneas, and bones, can further enhance the shelf-life and quality of tissues for future use. Furthermore, ongoing education and specialized training for medical teams involved in organ and tissue extraction are crucial for maintaining high standards [56]. Regular certification programs, hands-on workshops, and simulation-based learning can help surgeons, nurses, and technicians stay updated on the latest techniques and protocols. Additionally, conducting regular audits of extraction outcomes and implementing a feedback loop can identify areas for improvement and ensure continuous quality control [101].

While organ donation often takes precedence, increasing awareness and infrastructure for tissue donation can greatly expand the transplantation system's reach [8]. Tissue banks should be adequately funded and equipped with the latest preservation technologies to store and distribute tissues effectively. Public awareness campaigns about the benefits of tissue donation, consideration of less stringent laws involving tissue donation along with improved hospital systems for identifying potential tissue donors, can help ensure that this critical resource is not overlooked.

8. Conclusion

Missed opportunities in organ transplantation and the concerns of potential donors present significant challenges that require comprehensive and multifaceted solutions. The persistent shortage of donors, inefficiencies within the transplant system, and public misconceptions all contribute to the organ shortage crisis, while ethical, psychological, and procedural concerns deter potential donors. By implementing strategies to improve donor registration, such as enhanced public education campaigns, and appropriate incentives, we can significantly increase the number of registered donors. Enhancing the efficiency of the transplant system through better performance of organ procurement organizations, optimized logistics, redrawing of the geographic organ distribution boundaries and advanced matching algorithms will ensure that available organs are used effectively and reach suitable recipients in a timely manner. Addressing donor concerns through robust ethical standards, psychological support, and clear communication will help build trust in the organ donation process and encourage more individuals to participate. This comprehensive review highlights the need for a multifaceted approach to bridge the gap in organ transplantation. By addressing these interconnected issues with targeted strategies, we can create a more efficient and supportive organ donation and transplantation system. Ultimately, these efforts will lead to an increase in the availability of organs, saving more lives and improving the overall effectiveness of organ transplantation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] Bezinover D, Saner F. Organ transplantation in the modern era. BMC Anesthesiol. [Internet] 2019;19(1). Mar 4Available from, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6399965/.
[2] Bastani B. The present and future of transplant organ shortage: some potential remedies. J. Nephrol. 2019;33(2):277–88. Aug 9.
[3] Hart A, Lentine K, Smith J, Miller J, Skeans M, Prentice M, et al. OPTN/SRTR 2019 Annual Data Report: kidney. Am. J. Transpl. 2021;21. https://doi.org/10.1111/ajt.16502.
[4] Carrier AN, Verma A, Mohiuddin M, Pascual M, Muller YD, Longchamp A, et al. Xenotransplantation: a New Era. Frontiers Immunology [Internet] 2022;13(13):900594. Available from, https://pubmed.ncbi.nlm.nih.gov/35757701/.
[5] DiBlasi R, Gallo C, González J, Villarreal C, Fasci A, Di D, et al. Evaluating the performance of a nonelectronic, versatile oxygenating perfusion system across viscosities representative of clinical perfusion solutions used for organ preservation. Bioengineering 2022;10.
[6] Department of Health and Social Care. Organs and tissues to be excluded from the opt-out organ donation system – quick read [Internet]. GOV.UK. 2019. Available from: https://www.gov.uk/government/consultations/opt-out-organ-donation-organs-and-tissues-excluded-from-the-new-system/organs-and-tissues-to-be-excluded-from-the-opt-out-organ-donation-system-quick-read.
[7] Lozanovski VJ, Adigozalov Said, Khajeh E, Ghamarnejad Omid, Aminizadeh Ehsan, Schleicher C, et al. Declined organs for liver transplantation: a right decision or a missed opportunity for patients with hepatocellular carcinoma? Cancers (Basel) 2023;15(5). Feb 211365–5.
[8] Vanholder R, Domínguez-Gil B, Bušić M, Cortez-Pinto H, Craig J, Jager K, et al. Organ donation and transplantation: a multi-stakeholder call to action. Nature Reviews Nephrology 2021;17:554–68.
[9] Shaheen FA, Al-Attar Besher, Kamal M, Zakaria H, Follero PM, Santiago DA. Impact of logistics with the cold ischemia time of utilized deceased organs in KSA; Years 2015-2016. Transpl. 2018;102(Supplement 7). Jul 1S770–0.
[10] Muthiah MD, Chua MSH, Griva K, Low I, Lim WH, Ng CH, et al. A multiethnic asian perspective of presumed consent for organ donation: a population-based perception study. Front Public Health 2021;9. Oct 5.
[11] Witjes M, Jansen NE, van der Hoeven JG, Abdo WF. Interventions aimed at healthcare professionals to increase the number of organ donors: a systematic review. Critical Care 2019;23(1). Jun 20.
[12] Abdulrazeq F, Matsumoto MM, Zourob M, Al-Dobai A, Zeyad K, Marwan N, et al. Barriers in knowledge and attitudes regarding organ donation among urban Jordanian population. Saudi J. Kidney Diseases and Transpl. [Internet] 2020;31(3):624 [cited 2024 Apr 7]Available from, https://journals.lww.com/sjkd/fulltext/2020/31030/Barriers_in_Knowledge_and_Attitudes_Regarding.7.aspx.
[13] Miller J, Currie S, McGregor L, O'Carroll R. "It's like being conscripted, one volunteer is better than 10 pressed men": a qualitative study into the views of people who plan to opt-out of organ donation. Br J Health Psychol 2020;25:257–74.
[14] Jansen NE, Williment C, Haase-Kromwijk BJJM, Gardiner D. Changing to an opt out system for organ donation—reflections from England and Netherlands. Transplant Int. 2022:35. Jul 4.
[15] Johnson WR, Kraft K, Chotai PN, Lynch R, Dittus RS, Goldberg DS, et al. Variability in organ procurement organization performance by individual hospital in the United States. JAMA Surg. 2023;158(4). Apr 1404–4.
[16] Scalea JR, Restaino S, Scassero M, Bartlett ST, Wereley N. The final frontier? Exploring organ transportation by drone. Am. J. Transpl. 2018;19(3):962–4. Oct 4.
[17] Faitot F, Michard B, Artzner T. Organ allocation in the age of the algorithm. Curr Opin Organ Transplant 2020;25(3):305–9. Jun.
[18] Doerry K, Oh J, Vincent D, Fischer L, Schulz-Jürgensen S. Religious and cultural aspects of organ donation: narrowing the gap through understanding different

religious beliefs. Pediatric Transpl. [Internet] 2022;26(7). Jun 23Available from, https://onlinelibrary.wiley.com/doi/full/10.1111/petr.14339.
[19] López JS, Martínez JM, Soria-Oliver M, Aramayona B, García-Sánchez R, Martín MJ, et al. Bereaved relatives' decision about deceased organ donation: an integrated psycho-social study conducted in Spain. Soc Sci Med 2018;205:37–47. May.
[20] Cooper J. Organs and organisations: situating ethics in organ donation after circulatory death in the UK. Soc Sci Med 2018;209:104–10. Jul.
[21] Daga S., Patel R., Howard D., Mistry K., Daga V. "Pass it on" - New Organ Donation Law in England May 2020. The Physician. 2020 May 5;6(1).
[22] Ong JQL, Lim LJH, Ho RCM, Ho CSH. Depression, anxiety, and associated psychological outcomes in living organ transplant donors: a systematic review. Gen Hosp Psychiatry 2021;70:51–75. May.
[23] Poppe C, Akum S, Crombez Geert, Rogiers X, Hoste E. Evaluation of the quality of the communication and emotional support during the donation procedure: the use of the donor family questionnaire (DFQ). J Crit Care 2019;53:198–206. Jun 17.
[24] Mckeown D, Bonser R, Kellum J. Management of the heartbeating brain-dead organ donor. Br J Anaesth 2012;108(Suppl 1):96–107.
[25] Carola V, Morale C, Vincenzo C, Cecchi V, Errico L, Nicolais G. Organ donation: psychosocial factors of the decision-making process. Front Psychol 2023.
[26] Jackson WE, Kaplan A, Saben JL, Kriss MS, Cisek J, Samstein B, et al. Practice patterns of the medical evaluation of living liver donors in the United States. Liver Transpl. 2022;29(2):164–71. Sep 16.
[27] Sharif A. Risk aversion, organ utilization and changing behavior. Transplant Int. 2022:35. Apr 7.
[28] Boyarsky BJ, Jackson KR, Kernodle AB, Sakran JV, Garonzik-Wang JM, Segev DL, et al. Estimating the potential pool of uncontrolled DCD donors in the United States. Am. J. Transpl. 2020;20(10):2842–6. May 22.
[29] Proneth A, Schnitzbauer AA, Schenker P, Wunsch A, Rauchfuss F, Arbogast H, et al. Extended pancreas donor program—the EXPAND study. Transpl. 2018;102 (8):1330–7. Feb 6.
[30] Penn-Jones CP, Papadopoulos C, Randhawa G, Asghar Z. Improving access to organ donor registration in general practice: a feasibility study. Br. J. Gen. Pract. [Internet] 2020;70(696). May 4 [cited 2021 Aug 2]e497–504Available from, https://bjgp.org/content/bjgp/70/696/e497.full.pdf.
[31] Hardman G, Hogg R, Rushton S, Booth K, Fisher AJ, Dark JH. Expanding Donor Age Criteria: the UK Experience. J. Heart Lung Transpl. 2020;39(4). Mar 30S377–7.
[32] Concepcion BP, Harhay Meera, Ruterbories J, Finn J, Wiseman A, Cooper M, et al. Current landscape of kidney allocation: organ procurement organization perspectives. Clin. Transpl. Clin. Transpl. 2023;37(4). Feb 12.
[33] Criswell T, Swart C, Stoudemire J, Brockbank KGM, Powell-Palm M, Stilwell R, et al. Freezing biological time: a modern perspective on organ preservation. Stem Cells Translational Med. [Internet] 2022;12(1):17–25. Dec 26 [cited 2023 Oct 24] Available from, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9887086/.
[34] Yilma M, Dalal N, Wadhwani S, Hirose R, V N. Geographic disparities in access to liver transplantation. Liver Transpl. 2023;29:987–97.
[35] Hennawy H, Safar O, Thamer A, Asiri A, Abdullah H, Alhadi W, et al. Knowledge, attitude, and barriers toward deceased organ donation among health care professionals and medical students in southern saudi arabia: A cross-sectional study. Experimental and clinical Transpl.: official J. the Middle East Society for Organ Transpl. 2023;21(9):772–8.
[36] De Gama BZ, Jones DG, Bhengu TT, Satyapal KS. Cultural practices of the Zulu ethnic group on the body and their influence on body donation. Anat Sci Educ 2020;13(6):721–31. Mar 3.
[37] Vincent BP, Randhawa G, Cook E. Barriers towards deceased organ donation among Indians living globally: an integrative systematic review using narrative synthesis. BMJ Open 2022;12(5):e056094. May.
[38] Hansen SL, Eisner MI, Pfaller L, Schicktanz S. "Are you in or are you out?!" Moral appeals to the public in organ donation poster campaigns: a multimodal and ethical analysis. Health Commun 2017;33(8):1020–34. Jun 16.
[39] Hansen SL, Pfaller L, Schicktanz S. Critical analysis of communication strategies in public health promotion: an empirical-ethical study on organ donation in Germany. Bioethics 2020;35(2):161–72. Jun 18.
[40] Tang J. The use of writing strategies to increase organ donation intentions, 2020. 12020BC; https://doi.org/10.32469/10355/88956.
[41] Carmack HJ, DeGroot JM. Communication Apprehension about death, religious group affiliation, and religiosity: predictors of organ and body donation decisions. OMEGA - J. Death and Dying 2018;81:003022281879329. Aug 10.
[42] Katz H, Blekher M, Bosch DA. It Is All About Control: understanding reluctance to register for organ donation. Nonprofit Volunt Sect Q 2018;48(3):665–80. Oct 26.
[43] Sellers MT, McGinnis SH, Alperin M, Sweeney JF, Dodson TF. Deterrents to organ donation: a multivariate analysis of 766 survey respondents. J. Am. Coll. Surg. 2018;226(4):414–22. Apr.
[44] Geissler E, Kirste G, Meade M, Chapman J. Establishing guidelines for organ donation systems. Transplant Direct. 2023;9.
[45] Voyce M. Organ transplants and the medicalisation of death: dilemmas for tibetan buddhists. Contemp. Buddhism 2020;21:1–11. May 5.
[46] Ahmadian S, Khaghanizadeh M, Khaleghi E, Hossein Zarghami M, Ebadi A. Stressors experienced by the family members of brain-dead people during the process of organ donation: a qualitative study. Death Stud 2019;44(12):759–70. May 6.
[47] Dicks SG, Burkolter N, Jackson LC, Northam HL, Boer DP, van Haren FMP. Grief, stress, trauma, and support during the organ donation process. Transplant Direct 2019;6(1). Dec 12e512.
[48] Martínez-López M, Coll E, Cruz-Quintana F, Domínguez-Gil B, Hannikainen I, Rosales R, et al. Family bereavement and organ donation in Spain: a mixed method, prospective cohort study protocol. BMJ Open 2023;13.
[49] Soria-Oliver M, Aramayona B, López JS, Martín MJ, Martínez JM, Sáenz R, et al. Grief reactions of potential organ donors' bereaved relatives: an observational study. Am. J. Critical Care 2020;29(5):358–68. Sep 1.
[50] Miller J, Currie S, O'Carroll R. "If I donate my organs it's a gift, if you take them it's theft": a qualitative study of planned donor decisions under opt-out legislation. BMC Public Health 2019;19.
[51] Smith M, Domínguez-Gil B, Greer D, Manara A, Souter M. Organ donation after circulatory death: current status and future potential. Intensive Care Med 2019; 45:310–21.
[52] Loban K, Robert JT, Alam A, Sandal S. Long-term care of living kidney donors needs a better model of healthcare delivery. Progress Transpl. 2023;33(3):242–6. Jul 20.
[53] Kroencke S. The relevance of donor satisfaction after living kidney donation-a plea for a routine psychosocial follow-up. Transplant Int. 2018;31(12):1330–1. Nov 5.
[54] Dafoe D, Tantisattamo E, Reddy U. Precision medicine and personalized approach to renal transplantation. Semin. Nephrol. 2018;38(4):346–54.
[55] Brustia R, Boleslawski E, Danion J, Savier E, Barrou B, Scatton O. The impact of deceased donor liver extraction time on early allograft function in adult liver transplant recipients. "Vite fait, bien fait". Transpl. 2019;103(8):e218–9. Aug.
[56] Brewin MP, Hijazi Y, Pope-Jones S, Exton RJ, Khan MS. Free tissue transfer for burns reconstruction: a single-site experience. Burns 2020. Apr.
[57] Vaisbuch Yona, Hosseini DK, Wagner A, Hirt B, Mueller M, Ponnusamy Ravikumar, et al. Surgical approach for rapid and minimally traumatic recovery of human inner ear tissues from deceased organ donors. Otol. Neurotol 2022;43(4):e519–25. Mar 2.
[58] Morozova G, Martindale AB, Richards H, Stirling J, McIntyre C, Currie IS. The vanguard study: human performance evaluation of uk national organ retrieval service teams utilizing a single scrub practitioner in multiorgan retrieval. Transpl. 2020;105(5):1082–9. Jun 29.
[59] Lepoittevin Maryne, Giraud S, Kerforne T, Barrou B, Badet L, Bucur P, et al. Preservation of organs to be transplanted: an essential step in the transplant process. Int. J. Mol. Sci. 2022;23(9). Apr 304989–9.
[60] British transplantation society (2023): UK guidelines on transplantation from deceased donors after circulatory death. [Internet]. 2023 [cited 2024 Jul 10]. Available from: Available at: https://bts.org.uk/transplantation-from-deceased-donors-after-circulatory-death.
[61] Petrenko A, Carnevale M, Somov A, Osorio J, Rodríguez J, Guibert E, et al. Organ preservation into the 2020s: the era of dynamic intervention. Transfus. Med. Hemother. 2019;46(3):151–72.
[62] Roy A, Jeng B, Chaurasia S, Das S. Overview of short-term and intermediate-term corneal storage solution: comparison of clinical outcomes and need for future research. Eye Contact Lens 2022;48(4):141–8.
[63] Taylor Michael J, Weegman Bradley P, Baicu Simona C, Giwa Sebastian E. New approaches to cryopreservation of cells, tissues, and organs. Transfus. Med. Hemother. 2019;46(3):197–215.
[64] Viñuela-Prieto JM, Soria-García AM, González-Romero M, Candel FJ. Bacterial contamination rate and associated factors during bone and tendon allograft procurement from Spanish donors: exploring the contamination patterns. J. Hospital Infection 2019;102(3):287–94. Jul.
[65] Hwang H, Kim J, Shin S, Ahn H, Lee S, Joo D, et al. Organ procurement in a deceased donor. Korean J. Transpl. 2020;34:134–50.
[66] Fernández AR, Sánchez-Tarjuelo R, Cravedi P, Ochando J, López-Hoyos M. Review: ischemia Reperfusion Injury—a translational perspective in organ transplantation. Int. J. Mol. Sci. [Internet] 2020;21(22):8549. Jan 1 [cited 2022 Nov 17]Available from, https://www.mdpi.com/1422-0067/21/22/8549.
[67] Mathur AK. New metrics to measure OPO performance are here: how do we ensure organizations receive feedback and improve organ donation? Am. J. Transpl. 2021:22. Nov 16.
[68] Mochi M, Galatà G, Maratea M. Master surgical scheduling via answer set programming. J. Logic Comput. 2023.
[69] Greenberg JW, Kantemneni EC, Kulshrestha K, Clothier JS, Desai MV, Winlaw DS, et al. Later brain death declaration correlates to favorable donor characteristics but decreased heart acceptance. Transpl. 2023 Dec 8.
[70] Mojtabaee Meysam, Ghaffarian Shahrzad, Shahryari Shagin. Farahnaz Sadegh Beigee. causes of deceased donors loss before organ retrieval. PubMed. 2018;17 (3):172–6. Mar 1.
[71] Corman Dincer P, Tore Altun G, Birtan D, Arslantas R, Sarici Mert N, Özdemir I, et al. Incidence and risk factors for systemic infection in deceased donors. Transpl. Proc. [Internet] 2019;51(7):2195–7. Sep 1 [cited 2022 Mar 26]Available from, https://pubmed.ncbi.nlm.nih.gov/31378467/.
[72] Lomero M, Gardiner D, Coll E, Haase-Kromwijk B, Procaccio F, Immer F, et al. Donation after circulatory death today: an updated overview of the European landscape. Transplant Int. [Internet] 2019;33(1):76–88. Oct 7 [cited 2022 Nov 15]Available from, https://www.swisstransplant.org/fileadmin/user_upload/Bilder/Home/Fuer_Fachpersonen/Publikationen/Einsprachige_Dokumente/Lomero_et_al-2020-Transplant_International.pdf.
[73] Kortman VG, Verberne Yinte, Jovanova Jovana, Sakes Aimée. Advancing minimally invasive surgery: a cutting-edge cable-actuated conveying mechanism for reliable tissue transportation. PLoS ONE 2023;18(12). Dec 14e0295585–5.
[74] Rogers NM. Improving donor organ preservation by keeping one's (super)cool. Transpl. 2020;104(9):1774–5. Jan 16.

[75] Lewis A, Koukoura A, Tsianos G, Gargavanis A, Nielsen A, Vassiliadis E. Organ donation in the US and Europe: the supply vs demand imbalance. Transplant Rev 2020:100585.
[76] Hussain N, Soni D. Max and Keira's law: an overview on the advantages, disadvantages and alternatives to an opt-out organ donation system in the UK. Br. Stud. Doc. J. 2020;4:26. https://doi.org/10.18573/bsdj.109.
[77] Dallimore DJ, McLaughlin L, Williams C, Noyes J. Media content analysis of the introduction of a "soft opt-out" system of organ donation in Wales 2015-17. Health Expect. [Internet] 2019;22(3):485–95. Feb 6 [cited 2019 Sep 18]Available from, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6543148/.
[78] Jiang X, Jiang W, Cai J, Su Q, Zhou Z, He L, et al. Characterizing Media content and effects of organ donation on a social media platform: content analysis. J. Med. Internet Res. [Internet] 2019;21(3). Mar 12 [cited 2019 Dec 1]e13058. Available from, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6434401/.
[79] Meng MD, Clarke RN. Filling the organ donor pool by giving priority. J. Health Pol. Policy Law [Internet] 2020;45(1):49–71. Feb 1 [cited 2021 Aug 6]Available from, https://read.dukeupress.edu/jhppl/article/45/1/49/140653/Filling-the-Organ-Donor-Pool-by-Giving-Priority.
[80] Kargar B, Pishvaee MS, Jahani H, Sheu JB. Organ transportation and allocation problem under medical uncertainty: a real case study of liver transplantation. Transp. Res. Part E 2020;134:101841. Feb.
[81] Goldberg D, Karp S, Shah MB, Dubay D, Lynch R. Importance of incorporating standardized, verifiable, objective metrics of organ procurement organization performance into discussions about organ allocation. Am. J. Transpl. 2019;19 (11):2973–8. Jul.
[82] Vail EA, Schaubel DE, Potluri VS, Abt PL, Martin ND, Reese PP, et al. Deceased organ donor management and organ distribution from organ procurement organization-based recovery facilities versus acute-care hospitals. Prog. Transpl. 2023:33. Nov 9.
[83] Rahman MA, Yilmaz I, Albadri ST, Salem FE, Dangott BJ, Taner CB, Nassar A, Akkus Z. Artificial intelligence advances in transplant pathology. Bioengineering 2023;10(9):1041.
[84] Dueñas-Jurado JM, Gutiérrez PA, Casado-Adam A, Santos-Luna F, Salvatierra-Velázquez A, Cárcel S, et al. New models for donor-recipient matching in lung transplantations. PLoS ONE 2021;16(6). Jun 4e0252148–8.
[85] Bahador RS, Farokhzadian J, Mangolian P, Nouhi E. Concerns and challenges of living donors when making decisions on organ donation: a qualitative study. Iranian J. Nurs. Midwifery Res. [Internet] 2022;27(2):149–56. Mar 1 [cited 2022 Jul 4]Available from, https://pubmed.ncbi.nlm.nih.gov/35419258/.
[86] Leal de Moraes E, de Barros e Silva LB, Pilan LASL, de Lima EAA, de Santana AC, da Paixão NCS, et al. My loved one was not an organ donor: ethical dilemmas for family members of deceased potential donors when making the decision on donation. Transplant. Proc. 2019;51(5):1540–4. Jun.
[87] Bjelland S, Jones K. A Systematic Review on Improving the family experience after consent for deceased organ donation. Prog. Transpl. 2022;32:152–66.
[88] Ahmadian S, Rahimi A, Khaleghi E. Outcomes of organ donation in brain-dead patient's families: ethical perspective. Nurs. Ethics 2017;26(1):256–69. Jun 8.
[89] Adelmann D, Roll GR, Kothari R, Syed S, Burdine LJ, Tavakol Mehdi, et al. The impact of deceased donor liver extraction time on early allograft function in adult liver transplant recipients. Transpl. 2018;102(11):e466–71. Jul 26.
[90] Maassen H, Leuvenink HGD, van Goor H, Sanders JSF, Pol RA, Moers C, et al. Prolonged organ extraction time negatively impacts kidney transplantation outcome. Transplant Int. 2021;35:10186 [cited 2023 Feb 18]Available from, https://pubmed.ncbi.nlm.nih.gov/35221788/.
[91] Qui K, Haghiashtiani G, McAlpine M. 3D printed organ models for surgical applications. Ann. Rev. Anal. Chem. 2018;11(1):287–306.
[92] Pahl E, Emery RW, Noce M, Conrad S, Patterson N, Timm B. Mobile Application for communication increases the efficiency of organ procurement and transplantation. Prog. Transpl. 2020;30(2):172–6. Apr 9.
[93] Robba C, Fossi F, Citerio G. Organ donation: from diagnosis to transplant. Curr. Opin. Anaesthesiol. 2019.
[94] Andreoni KA. Now is the time for the Organ Procurement and Transplantation Network to change regulatory policy to effectively increase transplantation in the United States; Carpe Diem. Am. J. Transpl. 2020;20(8):2026–9. Jan 27.
[95] Al-Bahou Raja, Bruner J, Moore H, Zarrinpar A. Quantitative methods for optimizing patient outcomes in liver transplantation. Liver Transpl. 2023;30(3): 311–20. Dec 25.
[96] Oliver K. Overview of organ donation. Mexican J. Med. Res. 2023 ICSA, https://doi.org/10.29057/mjmrv11i2110007.
[97] O'Donoghue K, Reed R, Knight S, O'Callaghan J, Ayaz-Shah A, Hassan S, et al. Critical appraisal of international clinical practice guidelines in kidney transplantation using the appraisal of guidelines for research and education (agree) ii tool: a systematic review. Transp.. Transpl. 2018.
[98] Gracon AD, Foley DP. Strategies to improve liver allocation, distribution, and utilization in a broader sharing climate. Curr Transp. Rep 2021;8(1):1–8. Feb 10.
[99] Bokhari S. Artificial intelligence and robotics in transplant surgery: advancements and future directions. Cureus [Internet] 2023;15. Aug 23 [cited 2024 Jan 24] Available from, https://www.ncbi.nlm.nih.gov/pmc/articles/pmid/37746390/.
[100] Weissenbacher A, Vrakas G, Nasralla D, Ceresa CDL. The future of organ perfusion and re-conditioning. Transplant Int. [Internet] 2019;32. May 8 [cited 2019 Dec 9] Available from, https://onlinelibrary.wiley.com/doi/full/10.1111/tri.13441.
[101] Stanworth S, Lorencatto F, Gould N, Grant-Casey J, Deary A, Hartley S, et al. Can we do better? Bridging the research to practice gap in patient blood management–optimizing "audit & feedback" and the challenges of undertaking a national cluster-randomized controlled trial. ISBT Sci. Ser. 2018;14.