Review
High-Resource Users among Renal Transplant Recipients

Aleksandra Maciejczyk 1, Anna Łabuś 2 and Mariusz Niemczyk 2,*

1 Faculty of Medicine, Medical University of Warsaw, 02-091 Warsaw, Poland; aleksandramaciejczyk99@gmail.com
2 Department of Transplantology, Immunology, Nephrology and Internal Diseases, Medical University of Warsaw, Nowogrodzka 59, 02-006 Warsaw, Poland; a.labus@poczta.onet.pl
* Correspondence: mariusz.niemczyk@wum.edu.pl; Tel.: +48-22-502-1076

Abstract: Chronic kidney disease (CKD) represents a significant global epidemiological challenge, demanding considerable financial resources for treatment. Renal transplantation is the optimal approach for end-stage renal failure, being the most cost-effective option among renal replacement therapies. This narrative review aims to explore clinical conditions associated with excessive healthcare costs among renal transplant recipients, particularly focusing on high-resource users (HRU). We reviewed literature examining conditions generating high costs in kidney transplant patients, including infections, sepsis, pneumonia, antibody-mediated rejection (AMR), graft failure, advanced recipient age, heart failure, and fractures. Immunosuppressive therapies heighten the risk of infections, with sepsis and pneumonia posing significant costs. AMR is a major contributor to healthcare costs, but effective treatment of AMR can extend graft longevity and improve patient outcomes. Graft failure significantly increases medical expenses and adversely affects patient outcomes. Older recipients face higher post-transplant morbidity and mortality rates, though transplantation still offers better long-term survival compared to dialysis. Heart failure and fractures further elevate post-transplant costs and underscore the necessity of targeted interventions to mitigate associated risks. Ensuring kidney transplant care is sustainable and accessible requires a comprehensive strategy. This approach aims to improve patient outcomes while keeping costs reasonable.

Keywords: chronic kidney disease; renal transplantation; high-resource users; antibody-mediated rejection; graft failure; healthcare costs; infections

1. Introduction

Chronic kidney disease (CKD) poses a significant epidemiological challenge globally, with its treatment entailing considerable financial resources. Renal transplantation emerges as the optimal approach for end-stage renal failure. Not only does it prolong patients’ lives but it also enhances their overall well-being, while representing the most cost-effective option among renal replacement therapies. Individuals diagnosed with end-stage kidney disease (ESKD) who undergo kidney transplantation (KT) usually experience enhanced quality of life and increased length of life compared to those who do not. Research confirms renal transplantation as the financially sound choice, even over extended periods. Renal transplantation is the most economically viable option, even in long-term perspectives. Nevertheless, within this sphere, the term high-resource users (HRU) is employed to denote patients whose healthcare expenses exceed the 90th percentile for a given year, which means that these individuals incur higher healthcare costs than 90% of other patients, often due to complications or comorbidities. HRUs require more frequent hospitalizations, treatment in intensive care units, and extended medical attention. Understanding the dynamics of HRUs is crucial for healthcare systems aiming to manage costs while providing optimal care for CKD patients [1].

In healthcare management, high-resource users (HRU) are crucial for balancing cost and quality in renal transplant care. These patients, with expenses in the top 10%, pose
challenges to traditional care models. Preventing HRU emergence is vital for population health management. Predictive tools like HRUPoRT help identify at-risk patients, guiding resource allocation. Analyzing HRU expenditure patterns informs cost-saving strategies, improving resource distribution. Recognizing HRUs' importance is key to building sustainable, patient-focused healthcare systems [2,3].

This narrative review aims to explore clinical conditions associated with excessive healthcare costs among renal transplant recipients.

2. Identification of Related Studies

To comprehensively understand the subject of HRUs among renal transplant recipients, a thorough review of 52 scientific papers was conducted. This process involved systematically searching for and analyzing studies that explore healthcare utilization patterns, cost implications, and outcomes for patients undergoing renal transplantation. The literature search was carried out using major electronic databases, including PubMed and Google Scholar. Keywords and phrases such as “high-resource users”, “renal transplant recipients”, “healthcare costs”, “resource utilization”, and “kidney transplantation” were employed to identify relevant studies. The search was limited to peer-reviewed articles published in English over the last 25 years to ensure the inclusion of contemporary and relevant research findings. Studies were included if they met the criteria of focusing on renal transplant recipients, examined healthcare costs and provided data on healthcare expenditures and resource use. Studies were excluded if they were not peer-reviewed, focused on non-renal transplant populations, or were case reports or opinion pieces. Full-text reviews were conducted for articles that appeared to meet the inclusion criteria. Reference lists of the selected articles were also examined to identify additional relevant studies.

3. Conditions Generating Excessive Expenses

The escalation of economic burdens associated with expenditure on treating kidney diseases, particularly end-stage kidney disease (ESKD), is increasingly evident worldwide. In a study encompassing data from 1.2 million type 2 diabetes patients across 12 countries, the progression of kidney disease, akin to heart disease, correlates with a significant surge in treatment costs [4]. Additionally, research illustrates a direct correlation between the advancement of chronic kidney disease stages and heightened care expenses. The most substantial costs were linked to the necessity of renal replacement therapy [5]. Notably, in developed countries, renal replacement therapy accounts for 3% of the annual healthcare budget [6].

Given this context, individuals classified as high-resource users (HRUs) become focal points for health system enhancements. Preventing HRU designation emerges as a pivotal aspect of population health management, particularly recognizing the historical inadequacy of healthcare systems in addressing patients with such needs. Notably, costs within the HRU group exceed those of the general population ten times. Therefore, it is crucial for managed care pharmacy to understand why these expenses are elevated [1,3,7]. In the upcoming parts of this article, conditions generating high costs in kidney transplant patients will be analyzed.

The identified conditions, including infection, heart failure, fracture, and advanced age, are not exclusive to kidney transplantation. These conditions are frequently linked with increased costs and demonstrate comparable patterns across various chronic medical conditions. However, it is important to note that different comorbidities (e.g., hypertension or diabetes mellitus) may present distinct conditions that drive higher healthcare expenditures [8,9]. This study aims to enhance our comprehension of the precise cost dynamics within kidney transplant care and offer insights into broader strategies for healthcare management.

Post-transplant care for kidney transplant recipients in the United States demonstrates significant variability in terms of length of stay and healthcare costs, both regionally and by type of healthcare facility. Data from studies conducted across several notable centers, including Johns Hopkins University, the universities of California and San Francisco, and
NYU Langone Medical Center, reveal that kidney transplant recipients typically experience a median length of stay of 3 days compared to 2 days for non-kidney transplant recipients. This prolonged stay contributes to increased costs, with the average expense for procedures like appendectomies being USD 9175 for kidney transplant recipients versus USD 6806 for non-kidney transplant recipients, a 1.17-fold increase \[10\].

The financial burden is further underscored by findings from the Chronic Disease Research Group at the Hennepin Healthcare Research Institute and the University of Minnesota Medical School in Minneapolis. Their research highlights that the mean healthcare costs attributable to antibody-mediated rejection in kidney transplant recipients are four times higher than those of matched controls, amounting to an additional USD 13,066 per patient in the 60 days prior to antibody-mediated rejection diagnosis and USD 35,740 per patient per year in the two years following the diagnosis \[11\].

4. Infections

Regarding infectious complications, the increase in costs due to infections seems unquestionable. Immunosuppressive therapies, while crucial for preventing acute kidney rejection post-transplantation, heighten the vulnerability to infections and subsequent sepsis.

4.1. Prevalence

Studies underscore the gravity of infectious complications in renal transplant recipients, with infection emerging as the most common non-cardiac cause of death post-transplantation. Approximately 70% of renal transplant recipients experience at least one infection episode within three years of transplantation, with urinary tract infections prevailing as the most frequent \[12\].

Sepsis, a severe systemic response to infection, poses a significant challenge to kidney transplant patients. The occurrence and severity of sepsis after transplantation are alarming, with one study finding sepsis occurring in 62% of transplant patients after six months, with urinary tract infections being the primary source in 38% of cases. The most common pathogen responsible for sepsis is Escherichia coli, further emphasizing the significant burden of bacterial infections in this population \[13\].

Pneumonia poses a significant threat to kidney transplant recipients, often leading to severe respiratory complications that may necessitate ICU hospitalization, resulting in substantial healthcare expenses. One of the analyzed studies revealed that among 406 kidney transplant recipients, 20% experienced 111 episodes of pneumonia, with respiratory tract infections accounting for 8.9% of all infectious episodes post-transplantation. Notably, community-acquired pneumonia episodes were more frequent than nosocomial ones, with bacterial infections, including Haemophilus influenzae, Stenotrophomonas maltophilia, and Pseudomonas aeruginosa, being the primary culprits. Furthermore, comorbidities, history of acute graft rejection, and older age emerged as risk factors for pneumonia development in kidney transplant recipients \[14\].

4.2. Impact on Costs and Preventive Measures

In one of the analyzed studies, it was shown that infectious disease consultation in transplant recipients is linked with longer hospital stays and higher hospitalization costs. Nevertheless, it was associated with lower mortality rates and decreased readmission rates. Unique opportunistic infections in immunocompromised individuals, such as cytomegalovirus and invasive fungal infections, may be challenging to diagnose and treat appropriately, leading to increased costs. Additionally, drug-resistant infections are more expensive to treat due to longer hospital stays, higher readmission rates, increased medication costs, post-discharge care, lost workdays, and mortality. While infectious disease consultation improves patient survival, it also increases resource utilization. However, infectious disease consultation may facilitate care transition, as patients who receive it are less likely to be readmitted within 30 days of hospital discharge \[15\].
Sepsis significantly elevates the risk of graft rejection and loss by triggering pro-inflammatory responses and exacerbating immune dysfunction, leading to the loss of the transplanted kidney, and generating high costs. Furthermore, specific comorbidities, such as viral infections (CMV, HSV, and HCV), coagulopathies, and glomerulonephritis, exacerbate the risk of complications and graft failure, further increasing unnecessary expenses. Despite ongoing research into potential interventions such as metformin and statin use, managing sepsis in this patient group remains complex due to the interactions between infections, comorbidities, and transplant outcomes [12]. We analyzed the study that compared costs associated with sepsis and pneumonia before and after kidney transplantation in 44,916 patients from the USRDS database. The costs for sepsis-free patients were USD 50,000 and USD 51,100 for the first and second years post-transplantation, respectively. Patients with post-transplant sepsis incurred an additional USD 48,400 on average [16].

Regarding the costs for pneumonia-free patients, it was USD 13,000 and USD 13,500 for the first and second years post-transplantation. Patients who experienced post-transplant pneumonia incurred an additional average cost of USD 38,400 [16]. Dizdar et al. highlight the essential requirement for vigilant monitoring and personalized interventions to reduce pneumonia-related risks and minimize unnecessary expenses [14].

5. Antibody-Mediated Rejection

5.1. Prevalence

Antibody-mediated rejection (AMR), predominantly observed in highly sensitized individuals, poses a formidable challenge in kidney transplant recipients, impacting graft longevity and treatment expenses significantly. AMR is the leading cause of late-stage allograft failure following kidney transplantation [17].

5.2. Impact on Costs and Preventive Measures

The analyzed studies indicate that the treatment costs for kidney transplant patients with acute AMR in the first year following diagnosis are substantially higher compared to patients without acute AMR [1,11,18]. Some of the analyzed papers suggest that there might be additional costs if more expensive treatments are used, such as rituximab [19].

Treating acute AMR is believed to potentially extend the lifespan of the transplanted organ. Despite not functioning at optimal levels, a transplanted kidney offers patients a longer lifespan compared to undergoing hemodialysis [20]. However, it is important to acknowledge that while treatment for acute AMR may prolong kidney graft survival in some cases, it also entails increased financial burden. The economic burden associated with treating acute AMR is substantial and given the still suboptimal clinical outcomes of this treatment, there is a need for cost-utility analyses to justify expenditures. Therefore, it is crucial to prevent acute AMR by improving the selection of tissue compatibility antigens and ensuring patients follow recommendations, especially regarding immunosuppressive therapy. Results of the analyzed simulation held in United States have shown that interventions aimed at improving medication adherence among young kidney transplant recipients lead to at least a 3% reduction in rejection risk. The result was cost-effective procedural outcomes [21].

Moreover, it is crucial to consider that focusing solely on cost reduction may not always yield favorable outcomes. Fusfeld et al. conducted a study estimating the healthcare expenses for kidney transplant recipients suspected of antibody-mediated rejection [22]. The study compared healthcare costs over a 5-year period following diagnosis. Patients who underwent kidney biopsy combined with molecular biopsy, specifically mRNA panel determination of 1494 genes using microarray technology on fresh biopsy samples (MMDx-Kidney), were more likely to be diagnosed with rejection requiring treatment compared to those diagnosed solely by kidney biopsy. This resulted in higher initial costs in the study group, attributed to MMDx-Kidney and treatment expenses for patients diagnosed with rejection. However, starting from the second year post-biopsy, costs in this group decreased as a higher percentage of patients avoided expenses associated with graft failure.
and loss [22]. Labuś et al. carried out research that analyzed the direct costs of treating 11 kidney transplant recipients with acute antibody-mediated rejection (AMR) diagnosed between September 2016 and August 2019 [23]. The average cost of treatment was nearly double the cost of hemodialysis, with intravenous immunoglobulin accounting for 55% of the expenses. The study concluded that acute AMR treatment significantly increases post-transplant care costs, highlighting the need for strategies to reduce AMR risk and further cost-effectiveness analyses to optimize treatment regimens [23].

6. Graft Failure
6.1. Prevalence

The lifespan of a transplanted kidney is inherently limited. After the first-year post-transplantation, up to 4% of patients experience graft loss and must return to dialysis. In the United States, the overall graft failure rates within three years following transplantation in 2016 were 2.3 per 100 patients for living donor transplants and 4.8 per 100 patients for deceased donor transplants [17].

6.2. Impact on Costs and Preventive Measures

Labuś et al. analyzed 20 renal transplant recipients who lost their transplants in 2017 or 2018, all of whom had functioning grafts for at least five years [24]. The researchers retrospectively assessed the direct costs of inpatient and outpatient care post-transplant. The group included 8 men (40%) and 12 women (60%). Results showed a significant cost increase in the final year of graft function, regardless of whether the graft failed or the patient died with a functioning graft. However, the average costs of post-transplant care over the last six years of graft function were still lower than the costs of hemodialysis. The study concluded that despite the increased costs near the end of graft function, renal transplantation remains more cost-effective than hemodialysis [24]. Another study by Labuś et al. demonstrated that the costs remained relatively stable in the years preceding graft failure, but increased significantly in the year of graft loss, which is presented in Figure 1 [1].

![Median costs (in PLN) in years preceding graft failure.](image-url)
Cooper et al. underscore the significant impact of graft failure on both medical expenses and patient outcomes following kidney transplantation [25]. Their analysis drew from a substantial cohort of 24,000 deceased donor kidney transplant recipients in the United States between 2012 and 2015. It showed a compelling correlation between renal function, graft failure, and healthcare costs during the first-year post-transplant. The study reveals that the total medical costs during this crucial period are intricately tied to renal function, whether measured by graft failure or estimated glomerular filtration rate (eGFR) among those with surviving grafts. Notably, the research highlights that the economic burden escalates even before the actual occurrence of graft failure, becoming discernible as early as 3–4 months prior. While the expenses associated with post-transplantation care rise with the progression of graft dysfunction, the costs remain markedly lower compared to those incurred during hemodialysis therapy. It underscores the enduring importance of mitigating early graft failures to enhance both patient outcomes and healthcare economics [1,25].

7. Advanced Age of the Recipient

7.1. Prevalence

During the early post-operative phase, elderly may face higher morbidity and mortality rates, successful kidney transplantation in those with end-stage renal disease enhances their chances of long-term survival compared to prolonged dialysis. Older transplant recipients report better health-related quality of life compared to those awaiting transplantation [26].

7.2. Impact on Costs and Preventive Measures

Kidney transplantation in older recipients presents a complex scenario, characterized by both potential health benefits and increased economic burdens. Despite the initial rise in costs during the first-year post-transplantation compared to remaining on the waiting list, the long-term cost-effectiveness of transplantation in older individuals requires further investigation over extended observation periods [27–29]. Offering kidney transplantation to older adults may prolong waiting times for younger candidates, potentially exacerbating societal costs. Using organs from older deceased donors for elderly recipients could help alleviate this issue, since these organs are frequently not suitable for younger patients [30–32]. The results of Heldal et al. support absence of a formal upper age limit for transplant waiting list acceptance is supported by findings suggesting comparable survival outcomes between older transplant recipients and those remaining on the waiting list [33]. Cost–utility analyses demonstrating the superior health outcomes of kidney transplantation over dialysis serve as pivotal arguments in discussions surrounding acceptance criteria for transplantation, particularly in the context of older recipients [33].

8. Heart Failure

8.1. Prevalence

Heart failure (HF) emerges as a significant concern among kidney transplant recipients, constituting 16% of all post-transplant admissions [34]. Weeda et al. conducted a study involving 1731 kidney transplant recipients. Their research revealed a notable increase in the prevalence of HF, rising from 31.8% in the first-year post-transplantation to 48.1% by the tenth year [35].

8.2. Impact on Costs and Preventive Measures

Patients with HF incurred substantially higher median expenses, with costs reaching USD 75,837 compared to USD 42,940 for those without HF. This observed trend of high and escalating HF prevalence is concerning, particularly due to its association with doubled healthcare costs. Given these findings, interventions aimed at mitigating HF risk factors represent a promising avenue for improving outcomes among kidney transplant recipients [35].
9. Fractures

9.1. Prevalence

The prevalence of chronic kidney disease–mineral and bone disorders (CKD-MBD) among patients progressing to chronic kidney failure significantly impacts morbidity and mortality, with up to 66% experiencing clinically evident osteoporosis [36–39]. This condition leads to various complications, including long-bone fractures and vertebral compression fractures [40,41]. There are numerous factors that impact bone health. Notably, the long-term use of glucocorticoids post-transplantation exacerbates osteoporosis, contributing to rapid bone mass loss immediately after kidney transplantation [42–44]. Research indicates that a substantial proportion of kidney transplant recipients, up to 22.5%, experience fractures within five years post-transplantation, surpassing rates in the general population and those on maintenance dialysis. These fractures not only incur increased healthcare costs but also elevate post-transplantation mortality by up to 60% [37].

9.2. Impact on Costs and Preventive Measures

Kuppachi et al. explored the impact of fractures on healthcare spending post-kidney transplantation [45]. Fractures within the first year incurred an additional cost of USD 5122, with subsequent years showing higher expenses for both new and prior fractures. These findings emphasize the need for preventive measures to reduce healthcare costs and patient morbidity. Such findings underscore the imperative for preventive measures aimed at reducing the incidence of fractures to alleviate healthcare burdens and enhance patient outcomes following kidney transplantation [45].

10. Future Directions

Exploring future directions in lowering the costs of renal transplant recipients’ care requires a forward-thinking and proactive approach to enhance health system efficiency. Among the most promising strategies are innovative care models led by pharmacists, optimizing medical regimens. Another effective strategy involves adopting cost-effective alternatives to IVIG for AMR and therapies with lower financial implications. Successful implementations include the utilization of tools like HRUPoRT for risk assessment and predictive analytics, as well as the implementation of vaccination protocols and strict adherence to immunosuppressive therapy.

This involves targeting interventions towards individuals who are at the highest risk of becoming new healthcare resource utilization (HRU) cases in the future. Research underscores the increased impact and efficiency of intervention programs that are designed to improve patient outcomes while minimizing costs. Containing healthcare spending identified as a top priority by governments across multiple health systems, innovative tools such as population risk assessment tools like the HRUPoRT play a pivotal role in health planning. By considering the upstream determinants of HRUs, these tools can help explore the impact of various prevention strategies and associated cost savings up to five years into the future. Moreover, predictive analytics provided by tools like the HRUPoRT offer valuable insights into identifying optimal population subgroups for intervention and determining the extent of strategy implementation needed to achieve desired risk reduction in new HRU cases [7].

In the pursuit of lowering the costs of renal transplant recipients’ care, we need to systematically identify and examine the main factors that contribute to increased costs. By understanding these factors, strategies can be developed to enhance the cost-effectiveness of treatment, mainly by focusing on preventive avoidable conditions. This includes not only improving adherence to recommendations to prevent humoral rejection but also avoiding preventable infections. This can be achieved by implementing vaccination protocols to reduce the incidence of infections. Vaccinations are essential in preventing infections following kidney transplantation, thereby reducing treatment costs associated with post-transplant infections. The 2023 Polish vaccination calendar includes mandatory vaccinations for people after transplantations. Specifically, these vaccinations target invasive
infections caused by Streptococcus pneumoniae that can be a cause of pneumonia. Other vaccines mandatory for renal transplant recipients are diphtheria, Haemophilus influenzae type b infections, pertussis, mumps, measles, acute poliomyelitis (polio), rubella, tetanus, and hepatitis B virus infection [46]. Other important factors are ensuring the isolation of patients and strictly following hospital hygiene rules. Additionally, in treating infections, rapid diagnosis and targeted treatment, while avoiding unnecessary empirical antibiotic therapy that is a risk factor for the carriage and selection of resistant strains, are critical components of this strategy. Emphasis should be placed on interventions that not only demonstrate clinical effectiveness but also offer substantial cost savings. By embracing these principles and fostering a culture of evidence-based decision-making, the healthcare system can strive towards achieving sustainable and affordable renal transplant care for all patients.

The key to preventing humoral rejection is for patients to adhere to their recommendations. Antibody-mediated rejection (AMR) appears to be higher in patients who are non-adherent to immunosuppressive therapy. Adherence is improved when renal transplant recipients take immunosuppressive medications once daily, which has also been shown to be cost-effective [47]. Other idea to enhance the adherence is implementation of personalized patient education programs tailored to varying levels of health literacy. Moreover, it is crucial to address the barriers related to access to healthcare services. Socioeconomic disparities also significantly influence adherence, with financial constraints often impeding medication access and compliance. Mitigating these challenges necessitates the implementation of financial assistance programs and personalized healthcare practices that acknowledge diverse socioeconomic backgrounds. By addressing these multifaceted factors, healthcare providers can optimize medication adherence among renal transplant recipients. There are also innovative strategies emerging in post-transplant care. A notable example is a study conducted in the United States that observed kidney transplant recipients between 6 and 36 months post-transplantation for 12 months. This study demonstrated the potential benefits of pharmacist-led care, wherein therapy monitoring and management were facilitated through smartphone applications and teleconsultations [48]. The pivotal role of pharmacists in optimizing medication management continues to be recognized as a cost-effective measure in various healthcare settings. Economic analyses have demonstrated the ability of pharmacists to reduce medication costs and the risk of medication-related toxicities among patients admitted to hospitals, particularly within intensive care units and other high-cost environments. By optimizing medication regimens and providing patient education, pharmacists contribute to overall cost savings, while also reducing lengths of stay and early hospital mortality rates. As healthcare systems navigate the complexities of cost containment and resource optimization, the collaborative efforts of healthcare professionals, policymakers, and researchers remain essential in shaping the future landscape of kidney transplant care [48–51].

Furthermore, another important consideration lies in the omission of components such as intravenous immunoglobulin (IVIG) from post-transplantation care regimens. IVIG often constitutes a substantial portion of treatment expenses, so a comprehensive analysis of both effectiveness and cost is crucial. It would allow for exploring the viability of alternative therapies with comparable efficacy but lower financial implications. This endeavor holds particular significance in the context of acute antibody-mediated rejection (AMR), where choosing the correct treatment is significantly important. Consequently, there is a pressing need to develop universal treatment guidelines that will optimize patient outcomes while concurrently lessening financial burdens [1].

Another future direction, occasionally advocated, involves the implementation of donor compensation for kidney transplantation. In their controversial study, McCormic et al. [52] argue that offering financial compensation to living kidney donors and families of deceased donors could significantly increase the number of kidney transplantations in the United States, potentially saving thousands of individuals with chronic kidney failure from the hardships of dialysis and premature death. They suggest that compensating donors
with an average amount of USD 77,000 could lead to obtaining the necessary additional kidneys for transplantation each year. The study estimates that this compensation could save approximately 47,000 patients annually from the need for dialysis [52]. However, some ethical concerns have been raised about compensating kidney donors. Fisher et al. highlighted these concerns, including worries about undue pressure to donate, exploitation of vulnerable individuals, the commodification of the human body, negative impact on public opinion, and potential decrease in organ donation rates [53]. Nonetheless, McCormic et al. argue for compensation for deceased donors as well, highlighting its importance in recovering organs beyond kidneys and its potential to save lives [52].

11. Conclusions

In conclusion, chronic kidney disease (CKD) poses a significant global epidemiological challenge, necessitating substantial financial resources for its treatment. Renal transplantation stands out as the most optimal approach for end-stage renal failure, offering not only prolonged life expectancy but also enhanced overall well-being, while remaining the most cost-effective option among renal replacement therapies. However, the management of high-resource users (HRUs) within renal transplant care presents unique challenges, emphasizing the need for targeted interventions to prevent their emergence and improve population health management. States generating excessive expenses, such as infections, sepsis, pneumonia, antibody-mediated rejection (AMR), graft failure, advanced recipient age, heart failure, and fractures, significantly contribute to healthcare costs among renal transplant recipients. Future directions in lowering these costs involve proactive strategies targeting at-risk individuals and optimizing post-transplant care through innovative approaches like pharmacist-led interventions and alternative treatment regimens. Additionally, the controversial suggestion of donor compensation for kidney transplantation, advocated by some researchers, poses ethical considerations but offers potential solutions to address the kidney shortage crisis and improve patient outcomes. These multifaceted approaches, informed by scientific evidence and ethical considerations, are essential for shaping the future landscape of kidney transplant care, ensuring its sustainability and accessibility while optimizing patient outcomes.

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References


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