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Canadian Kidney Transplant Professionals' Perspectives on Precision Medicine and Molecular Matching in Kidney Allocation

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Background. Antibody-mediated rejection is an important cause of kidney transplant loss. A new strategy requiring application of precision medicine tools in transplantation considers molecular compatibility between donors and recipients and holds the promise of improved immunologic risk, preventing rejection and premature graft loss. The objective of this study was to gather Canadian transplant professionals' perspectives on molecular compatibility in kidney transplantation. **Methods.** Seventeen Canadian transplant professionals (14 nephrologists, 2 nurses, and 1 surgeon) participated in semistructured interviews in 2021. The interviews were digitally recorded, transcribed, and analyzed using the qualitative description approach. **Results.** Participants identified fair access to transplantation as the most important principle in kidney allocation. Molecular compatibility was viewed as a promising innovation. However, participants were concerned about increased waiting times, negative impact on some patients, and potential problems related to the adequacy of information explaining this new technology. To mitigate the challenges associated with molecular matching, participants suggested integrating a maximum waiting time for molecular-matched kidneys and expanding the program nationally/internationally. **Conclusions.** Molecular matching in kidney transplantation is viewed as a promising technology for decreasing the incidence of antibody-mediated rejection and improving graft survival. Further studies are needed to determine how to ethically integrate this technology into the kidney allocation algorithm.

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Kidney transplantation is the optimal treatment for chronic kidney failure. Unfortunately, graft loss is commonly seen in kidney transplantation. For a deceased donor kidney transplantation, the 10-y graft survival rate is 62% and for a living donor kidney transplantation, the 10-y graft survival rate is 74%.[1] Although many factors may jeopardize the transplanted organ, the overwhelming cause of graft loss remains rejection.[2] One type of rejection is antibody-mediated rejection (AMR),[3] which remains the most serious and destructive form. It may occur early or late in the transplant course, and presentation may range from the less common acute AMR with rapid and fulminant graft injury to the more common chronic AMR with

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progressive graft destruction.[3-6] AMR is now the major cause of this chronic graft loss, and because we have virtually no effective therapies for AMR, measures to prevent this complication are vital. AMR is associated with the development of donor-specific antibodies, which occur when there is an immune recognition by the recipient of non-self-HLA of the organ donor.[7]

When allocating organs, organ donation organizations (ODOs) try to balance justice and utility.[8] In Canada, provincial ODOs are responsible for recovering and allocating deceased donor kidneys using various allocation criteria. The allocation scores vary across provinces, but time spent on dialysis, medical urgency, HLA compatibility, and pediatric priority are important factors in all provincial ODOs.[9-13] Deceased donor kidneys can be shared across provinces for highly sensitized patients (ie, cPRA >95%) through a national registry managed by Canadian Blood Services.[14] In recent years, a more precise method of HLA compatibility assessment was proposed: molecular-based matching (previously referred to as epitope matching). This considers each HLA molecule as a combination of amino acid polymorphisms informing cellular and/or antibody responses (T-cell and B-cell epitopes, respectively).[15] Securing molecular compatibility could decrease the development of donor-specific antibodies by the recipient and, therefore, the incidence of AMR. The Genome Canada Transplant Consortium has set itself the objective of developing a national molecular-based matching program in kidney transplantation to decrease the incidence of rejection.[16] Given concerns that molecular matching at the time of organ allocation might improve long-term outcomes for some kidney recipients, it could also decrease access to kidney transplantation, for other concerns around fairness are often raised.[8,17] However, the ever-growing gap between organ supply and demand and current allocation rules make some patients more vulnerable than others (eg, because of high anti-HLA antibody burden and/or blood group).

This study is part of a larger research project, CanPREVENT AMR, whose objective is to use genetic technologies to improve donor–recipient matching and reduce the risks of AMR.[16] The CanPREVENT AMR project also aims to document various stakeholders' perspectives on the ethical issues related to molecular matching in deceased kidney allocation. When implementing a new kidney allocation algorithm, it is important to consider the perspectives of key stakeholders, such as transplant professionals, because they are stewards of scarce resources and also have a duty to benefit transplant candidates.[8] This study aimed to gather Canadian transplant professionals' perspectives on precision medicine and molecular matching in kidney transplantation. The results will contribute to the development of future allocation rules that could incorporate precision medicine in deceased donor kidney transplantation in Canada.

MATERIAL AND METHODS

This study was exploratory in nature and used semistructured interviews with kidney transplant professionals. We used the consolidated criteria for reporting qualitative research checklist.[18] We conducted individual semistructured interviews to gather kidney transplant professionals' perspectives on molecular compatibility in kidney transplantation. The Centre Hospitalier de l'Université de Montréal research ethics board approved the study, and all participants provided informed consent (CHUM CE20.054, MP-02-2021-9021).

The recruitment and interviews were performed between January and December 2021. Convenience and purposive sampling[19] were used to recruit transplant professionals across Canada. An email invitation was sent to the directors of 14 kidney transplant centers in Canada. The invitation asked directors to disseminate the invitation to participate and to refer other professionals working in their centers who were willing to participate. We used a snowball and convenience sampling strategy.[19] Three reminders were sent and those interested were contacted by phone by a research team member (F.B.). Twenty-one transplant professionals replied to the invitation and were interested in participating. Four could not be reached to schedule an interview, meaning 17 transplant professionals participated in the study.

All participants took part in an individual interview. Two interviews were conducted by phone and 15 by videoconference, 12 in English and 5 in French, by a research team member (F.B.). The interviews lasted around 40 (28–58) min and were digitally recorded and transcribed. Participants did not receive any compensation. The interview transcripts were sent for review and approval to all the participants.

Interviews began with a brief presentation of the objectives of the study. Participants had the opportunity to ask questions about the study before the interview started. The issues covered during the interviews were outlined in an interview guide with open-ended questions that were developed by the research team and pretested by 2 transplant professionals for question length and clarity in both English and French. The questions addressed the following themes: (1) the knowledge and perspectives on the current organ allocation system; (2) the role of molecular matching in deceased organ and living kidney donation; (3) informed consent and molecular compatibility; and (4) sociodemographic data. Consistent with qualitative methodology, the interview guide was modified during the study as new topics emerged from the interviews. The interview guide can be found in the Supplemental Material (SDC, http://links.lww.com/TXD/A597).

We used a qualitative description approach to describe the perspectives of transplant professionals on molecular matching in kidney transplantation.[20,21] The goal of this pragmatic approach was to stay close to the data and provide a comprehensive summary of the topic studied,[21] using thematic analysis.[22] The latest version of NVivo (QSR International) software was used to facilitate the analysis. Before coding the verbatim, the research team created the initial coding frame based on the interview grid and a review of the literature. New codes were added to the coding frame based on the interview content. The research team met frequently to discuss the coding frame and data analysis. A research team member with expertise in qualitative methodology (F.B.) coded the interviews, and no new codes were created after the 11th interview. The number of participants allowed for data saturation.[23,24] An independent researcher (A.A.) with experience in qualitative methods coded 41% of the raw data, with the rate of coding agreement assessed at 97% and disagreements discussed. Coded quotes were then organized by themes and subthemes.

RESULTS

Participant Characteristics

Seventeen transplant professionals participated in the study. The majority were adult nephrologists, White and from the Canadian province of Québec. Table 1 summarizes participant characteristics.

TABLE 1.

Transplant professional characteristics

Characteristics	N = 17, n (%)
Sex	
Female/male	9 (52.9)/8 (47.1)
Age, y, mean ± SD) (range, 34–73)	47.6 ± 10
Ethnic group	
White	9 (52.9)
Asian/South Asian	5 (29.4)
Other	3 (17.7)
Type of job	
Transplant nephrologist—adult	12 (70.5)
Transplant	2 (11.8)
nephrologist—pediatric	2 (11.8)
Nurse	1 (5.9)
Surgeon	
Province of practice	
Québec	7 (41.1)
Manitoba	3 (17.6)
Ontario	2 (11.8)
British Columbia	2 (11.8)
Alberta	2 (11.8)
Saskatchewan	1 (5.9)
Years of experience in nephrology	
Average in years (range, 2–40)	15.7 (±9.4)

Qualitative Interviews

Kidney transplant professionals believe that fairness and equity are the principles that should guide kidney allocation. They viewed precision medicine using molecular matching in kidney transplantation as an important innovation. However, they were concerned about increased waiting times, decreased access to transplantation, and informed consent issues. They also provided some recommendations to promote ethical allocation in this context.

Importance of Fairness and Equity in Organ Allocation

In general, participants prioritized fairness and equity in organ allocation over medical utility (Table 2). More than half of them considered fair access to kidney transplantation as one of the most important principles. They also highlighted the importance of maintaining trust in the allocation system. Some participants underlined that the allocation algorithm should strive to increase the number of patients transplanted and improve access to transplantation to improve patients' quality of life. For one participant, deciding to wait for a better-matched kidney or receiving a kidney as soon as possible should be the patient's decision and not the result of the allocation rules.

For other participants, fairness and utility principles should be equally balanced to be able to offer kidney transplantation to patients who have less optimal medical outcomes, such as older patients. Others highlighted the difficulty in balancing equity and medical utility and identified this situation as an ethical conundrum:

> And so, at a health system level, trying to maximize life here, then that becomes a bit of a conundrum, right? […] at the end of the day, a lot of the times, we're going to have to just make some decisions that are not entirely based on evidence, because there isn't any evidence here, but we at least follow ethical principles that ensure that we are allocating fairly, as fairly as possible, and we revisit these issues over time, because the conditions and circumstances change around these issues. (Transplant nephrologist 1)

Precision Medicine in Organ Allocation is a Promising Alternative

Molecular matching and precision medicine in renal transplantation are perceived as promising avenue (Table 3). First, compared with serological typing of HLA antigens, molecular matching could increase the medical utility of the existing limited pool of organs. Moreover, participants were enthusiastic about molecular matching if it could reduce the incidence of AMR and the need for immunosuppression in transplant patients. This would improve patients' lives, which is why they believed that molecular matching should be incorporated into deceased kidney allocation. Another interesting aspect of molecular compatibility is that it can be used for both short- and long-term patient monitoring. For instance, one participant mentioned that she would be more prone to personalize immunosuppression according to the molecular matching between the donor and the recipient. Thus, if the donor and the recipient were not well matched at the epitope level, this participant would warrant more potent immunosuppression. In living kidney donation, molecular matching could help when choosing from many potential donors. Finally, one pediatric transplant nephrologist highlighted the potential benefits of molecular compatibility for young recipients. Therefore, having a perfectly matched kidney could decrease the risk of rejection among nonadherent adolescents.

Concerns With Precision Medicine, Molecular Matching, and Transplantation

The main concerns expressed by participants toward precision medicine and molecular matching in kidney transplantation were related to the potential for increased waiting times for transplant candidates and inequitable access to an organ (Table 4). For example, some participants were concerned that molecular matching could increase the gap between patients' transplantation access, resulting in negative consequences for patients from disadvantaged populations, such as ethnic communities.

Informing transplant candidates and obtaining their informed consent was also mentioned as an important concern related to molecular matching in kidney transplantation for participants. Because precision medicine and molecular matching are complex issues, it is of paramount importance to develop educational tools with lay information. The educational tools should be adapted to individual patients' needs. Many participants viewed it as a transplant professional's responsibility to ensure that patients are well informed and educated. Educational tools could take the form of information sessions, videos, comics, and standardized scripts and should be designed with patient partners and knowledge translation experts. For 2 participants, transplant professionals needed to be able to answer patients' questions related to molecular matching, increased waiting times, and fair access to kidney transplantation. One participant also emphasized the need for more accurate information about waiting time numbers and percentages and the benefits of molecular matching in terms of graft rejection to properly inform patients and answer their

TABLE 2.

Importance of fairness and equity in organ allocation

Themes and interview excerpts	N = 17
Equity in access to organ transplantation	12
"So for me, maximizing access to transplantation outweighs maximizing the longevity of transplanted kidneys. It's more important." (Transplant nephrologist 5)	
"I think access to transplantation needs to be prioritized." (Nurse 1)	
"I think from a programmatic perspective, the health system needs to be biased toward fairness, and so you know as it relates to the default position, it should be to ensure that everyone has similar access to transplantation and that the choice to wait longer for a better matched kidney or a better quality kidney should be the choice of the transplant candidate not of the system." (Pediatric transplant nephrologist 1)	
"I think probably the most important thing is equity, making sure that people feel that their system can be trusted, to ensure that it's fair. That's probably it, and whatever the fairness criteria are about." (Transplant nephrologist 1)	
"I think one of the principles of transplantation should be that everyone has the opportunity to receive a kidney transplant." (Transplant nephrologist 3)	
Balance between equity and utility	6
"For sure it can't be an either/or. In my view, there's a certain balance, a middle ground. […] I think it's important that the principles of justice carry a bit more weight than the principles of utility." (Transplant nephrologist 5)	
"I think ideally, you would do both and they kind of go hand in hand. I think we probably try, we probably put a bit more weight, I mean we certainly try to get as many people transplanted as possible. We don't want to waste organs." (Transplant nephrologist 6)	
"But it's trying to ideally strike a balance between equity and utility, as they say, and the nuances are challenging as to, you know, where you put those cut offs. So yes, expected survival has some weight, but it is hard to predict on an individual basis somebody's anticipated survival and quality of life post-transplant." (Transplant nephrologist 9)	
"I honestly can't pick because the thing is, I'd like to say maximizing graft survival, but if we say that, then we are going to contribute to the disparity. So I can't pick one. I think it should be a balance of both." (Transplant nephrologist 10)	
"I think a balance needs to be maintained, because if we just consider graft survival, we'll no longer transplant, we'll no longer transplant older people, and older people have the right to transplants as well. If we expect to have results that are nevertheless satisfying, we don't want to transplant for the sake of transplanting. But we won't transplant a 70-y-old from the same perspective as a 22-y-old. So I don't think we can answer. In my opinion, there's no single answer to this question." (Transplant nephrologist 11)	

TABLE 3.

Precision medicine in organ allocation is a promising alternative

Themes and interview excerpts	N = 17
"The promise of it is fantastic. The trick is, of course, how you actually operationalize it and how it's actually applied. […] very positive, but it's really about the specifics." (Transplant nephrologist 1) "Basically, I think it's great, especially if we can have a kidney that can be better matched, meaning fewer rejections, fewer immunosuppressants. I'm happy with that." (Transplant nephrologist 4) "I think it's wonderful. I think it's a great idea to consider integrating it into the systems. And you have two ways you can integrate it. You can integrate it based on allocation criteria, meaning award points in a scoring system to people who would have a better donor-recipient match in terms of epitopes. So yes, I think this should be part of an allocation score. I think it's worth considering that this could be part of an allocation score." (Transplant nephrologist 5) "I think that the concept is obviously very attractive. So, and if we back it up, so the premise here is that unlike serological typing of HLA antigens that matching on epitope load or epitope mismatch may allow us to increase the utility from the available organ's supply, and here's the key, without exacerbating disparities that are linked to genetics which are ultimately linked to race. And so, that's really the issue. If we can achieve that, then I think the system is potentially useful." (Transplant nephrologist 7) "So, I'm waiting for the very best possible kidney so that even if my patient isn't completely adherent, because we know that teenagers aren't, it's still going to be OK, and then hopefully that kidney lasts them 20–25 years. That's good for the system too, because then the one kidney that we gave them does last a long time, and so giving them the pediatric priority and allowing me to pick fairly actually benefits the system as a whole too, because they are only taking one kidney from that system as opposed to if I don't have a really good match and take whatever I can get, they are non-adherent and are back on the transplant list in, you know, 3 or 5 years." (Pediatric transplant nephrologist 2) "Yes, so again I think it can be helpful in trying to figure out, I think it can be helpful in living donation to figure out who among several qualified candidates might be the best donor, and we've certainly been using it in that way. It's always been surprising to me how well somebody can be HLA matched and how bad of an eplet match they can have, or sometimes the other way, that somebody who, when you look at their HLA mismatch you think, oh, that's not going to be great, but then their total eplet load is very high. So, I think that for living donors, it's been very helpful. Again, I think looking at it down the road, for deceased donor allocation it might be helpful, I think it could." (Pediatric transplant nephrologist 2)	8

questions. That being said, some participants mentioned that transplant professionals should respect transplant candidates who trust the medical team and do not want more information about this type of kidney allocation.

A participant also voiced concerns about the operationalization of this new allocation scheme. She wondered how it would be applied in practice, specifically, how laboratories would be able to add additional tests when they already had a lot of work to do.

Recommendations for Including Molecular Matching in Kidney Transplantation

Some participants suggested strategies to mitigate the potential increased waiting time associated with molecular matching (Table 5). The first strategy involved a maximum waiting time for a molecular-matched kidney. For instance, if after 5 y of waiting for a molecular-matched kidney, a transplant candidate has still not received a kidney transplantation, this patient should receive a nonmolecular-matched kidney. However, a maximum waiting time for a molecular-matched kidney could be hard to incorporate into an allocation algorithm. Second, to improve access to a molecularly matched kidney, some participants suggested that allocation should be implemented at a national and even international level, such as kidney-paired donation or highly sensitized programs. This could increase the chances of transplant candidates being matched with a donor. Indeed, "the way to implement epitope matching is to increase that donor pool and this would be one way to do that" (Transplant nephrologist 10). Finally, it is also paramount to get patients' and all stakeholders' input on how to present and implement molecular matching, and the modification in the allocation rules should be made transparent and publicly debated.

DISCUSSION

This is the first study describing Canadian transplant professionals' perspectives on the use of molecular matching in kidney allocation. The participants' interview excerpts reflect their opinions and attitudes on the use of molecular compatibility. As the state of knowledge on molecular compatibility is in flux, the perspectives expressed may not represent the most up-to-date state of knowledge in this field. Yet, understanding participants' views and values in this domain is imperative because they provide important insights into the acceptability of integrating molecular compatibility into future kidney allocation systems.

We found that for participants in this study, precision medicine and molecular matching will be an important innovation in transplant medicine because it could decrease AMR, improve patients' survival, and help to personalize the medical management of immunosuppression. A pan-Canadian public deliberation also showed a consensus supporting the addition of epitope compatibility to the criteria for allocating deceased donor kidneys.[25,26] However, the transplant professionals interviewed were concerned about the possibility of disadvantaging patients with rare epitopes, of increasing waiting times, and the issue of adequately informing patients on this complex issue. To mitigate the challenges, they recommended implementing a maximum waiting time for a molecularly matched kidney and developing educational tools based on patients' needs. In the case of highly sensitized patients, for

TABLE 4.

Concerns with precision medicine, molecular matching, and transplantation

Themes and interview excerpts	N = 17
Molecular compatibility could disadvantage some populations	11
"Where the donor pool is very skewed in terms of its racial and genetic distributions, it's going to significantly disadvantage other subpopulations of recipients, and so the questions we then have to ask ourselves is how do we prioritize these things? And is there a balance that we can achieve where we can try, even if there is some iniquity, we can actually try to reduce it to an acceptable extent while optimizing, maybe not maximizing, but optimizing outcomes as a result of the improvement in epitope matching, for example? So, and these are partly scientific questions, but driven much more so by the ethics and the societal norms that we sort of currently embrace." (Transplant nephrologist 1)	
"[…] And we know for a variety of sort of socio-economic and cultural reasons, that there are certain minority groups that are underrepresented in the donor population. And that means that certain minority group recipients will be disadvantaged if we prioritize too much." (Transplant nephrologist 2)	
Informing patients and informed consent	8
"I think that when they register, when, (…) that would be the time to check their comprehension and re-explain everything. This would allow them to make a more informed decision and have a better understanding, at the time of registration." (Nurse 1)	
"[…] we can still quantify the differences in terms of number of different epitopes. I think we'll need to come back to these types of discussions with numbers so that it is much, much clearer." (Transplant nephrologist 11)	
Educational tools	8
"I think that maybe a standardized script or a standardized approach to how it's explained to all patients, preferably designed with patients' input, would be a good start." (Transplant nephrologist 2)	
"I think it would have to be put into extremely easy-to-understand lay terms, because no one is going to know what we're talking about if we mention epitope matching." (Transplant nephrologist 4)	
"I would need tools to explain epitopes, because it's not going to be easy to understand." (Nurse 1)	
"I think if we are going to provide them with too much complex information, they will get confused and maybe a little scared, to the point that they may actually run away from transplantation. So, I hope that someone will be able to maybe create a cartoon on HLA." (Transplant nephrologist 8)	
"An accessible explanation, in lay terms that the patient can understand and with diagrams and examples, would undoubtedly be useful. Because we do that, we did it in a DVD that we recorded, but I think there could be other things that are perhaps better done. […] I think that having a written document and audiovisual material is important, because there are a lot of patients who aren't necessarily highly literate. I think they need to be able to watch and then have someone explain it clearly. […]But if we do that and then we want to inform patients that we're doing it, we're going to have to show some imagination and use technological tools to reach all patients." (Transplant nephrologist 11)	
Operationalization of this new allocation scheme	1
"I think we will get there, but I think there is, as I said, when the labs are already struggling financially to do the testing we are doing just now, it's tough to see us getting there in the next year or two, and the technology is still evolving." (Transplant nephrologist 9)	

TABLE 5.

Recommendations for including molecular compatibility in kidney transplantation

Themes and interview excerpts	N = 17
Maximum waiting time	6
"If your wait time exceeds, you know, several years beyond the person who is better matched, it will still go to you. But if your wait time is pretty close, then it will go to the better matched person, and maybe there's some time trade off for the wait time, boost it out, and then you know?" (Transplant nephrologist 2)	
"I think that for people who have waited five years, it's their turn. So I think that could be integrated, but with an eye to ensuring that there is a maximum number of points they can collect, and that this doesn't hinder people who have been waiting a long time for a kidney, even if it's not as well matched. Because it still works and it's still going to improve their quality of life, even if they aren't matched and they have a higher risk of rejection. […] I think that if we can help, without adversely affecting certain patients, respect a reasonable wait time while better matching kidneys for others, I think that could be acceptable." (Transplant nephrologist 4)	
"There is this concern of how long they are going to wait if they are going to be very hard to match and knowing that they are going to wait longer, so there should be some kind of frame or limit for that waiting time. […] I'm just not clear how it could be incorporated into our algorithm or, operationally speaking, how we would do that." (Transplant nephrologist 6)	
Expand donor pool with national/international program	3
"Yes, so I think that maybe that is where something like the highly successful programs that we have had nationally, like the highly sensitized program, the kidney paired donor exchange program, and then the upcoming pediatric matching program, those could be good models for a national program. Because again, absolutely that is a risk that if you don't have, or you are going to wait longer and longer and longer and not get your match, but if you could expand the donor pool to the entire country, then you are just increasing the number of lottery tickets everybody has to potentially get those epitopes matched." (Pediatric transplant nephrologist 2)	
"And you know, I think one of the best ways to implement matching is if we make some kind of a huge waiting list that we share with the US and we share with Europe. I don't know if it's possible, I really don't, but especially when it comes to living donation, it could be done. [...] that I can think of is create this sort of universal registry, which I mean is impossible to create, it's impossible to navigate the laws in different countries, but that would be the one recommendation, to expand the deceased donor pool." (Transplant nephrologist 10)	
Stakeholders' engagement and transparency	3
"Yes, bringing all the relevant science and data to the discussion, plus having all the relevant stakeholders at the table, plus making sure all the relevant information is intelligible and can be used by all stakeholders effectively, because if I, if the physicians are the only ones who understood that part, then we failed. We have to make sure the patients also understand, at least at a reasonable level, what this information or what these data are telling us about, for example, the effectiveness of epitope matching and so forth. And then again, using guiding principles, frameworks that allow us to think clearly about the problem and the issue of resource allocations and a scarce resource." (Transplant nephrologist 1)	
"I think that they want transparency on how kidneys are allocated though, so I think, you know, I think transparency on this risk, you know?" (Transplant nephrologist 2)	

example, Canadian province-based organ allocation schemes already prioritize access to transplantation and promote national organ sharing for this vulnerable group of transplant candidates. As donor-specific anti-HLA antibodies are informed by molecular incompatibility, striving for molecular compatibility is unlikely to further extend the waiting times of highly sensitized patients; rather, it is likely to facilitate the identification of compatible donors. Importantly, simulations are underway to illustrate the implication on waiting times for various vulnerable populations and to inform on how molecular compatibility may be incorporated into Canadian organ allocation schemes in an equitable manner.

Most allocation algorithms try to balance equity with medical utility.[27-29] A previous qualitative study conducted with Australian nephrologists about deceased kidney allocation showed that nephrologists were divided on how to reconcile equity and medical utility. They believed that it was the role of policymakers and the community to balance equity and maximize medical utility.[30] A literature review on healthcare providers' preferences on how to allocate deceased organs also showed the difficulty in balancing equity and medical utility. Quality-of-life gains, patient survival, and graft survival were used to determine how to maximize medical utility, whereas waiting times and medical urgency were criteria that could be used to achieve equity.[31] Finally, in a recent survey, Australian healthcare professionals expressed preferences for maximizing the overall benefit in deceased donor allocation.[32] These results differ from our results, where participants expressed a preference for achieving equity, as evidenced by their concerns with increasing waiting times for some patients and disadvantaging other patients. Participants acknowledged the benefits of precision medicine and molecular matching because these improve medical utility by decreasing the incidence of AMR and improving patients' lives.

Increased waiting times potentially associated with molecular matching in kidney allocation for some patients was a concern frequently voiced by participants. Participants were also concerned about the possibility of discriminating and disadvantaging certain patients if molecular matching is implemented in deceased kidney allocation. In the United States, Black patients have decreased access to transplantation as well as an increased incidence of graft loss compared with White patients. Previous studies have shown that HLA matching is harder for Black transplant patients.[27,33] Lemieux et al[7] have outlined strategies to improve utility and equity in access to transplantation when incorporating molecular compatibility in organ allocation schemes for nonsensitized and sensitized patients, respectively. In the case of sensitized patients, this strategy aligns with the Eurotransplant Acceptable Mismatch program.[34] Also, in a recent simulation study, including 2000 ethnically diverse Canadian transplant recipients and donors, Tran et al[35] showed that molecular compatibility could be improved when prioritizing organ allocation.[35] The implications of optimizing molecular compatibility on disparities in access to transplantation can be assessed not only by simulations relying on retrospective data sets but also prospectively, as informed by a recent Canadian public deliberation study, which supported the reevaluation of policies incorporating molecular compatibility prospectively.[26]

Molecular matching could positively impact young transplant recipients who are more likely to need future retransplantation. Any procedures such as molecular matching that could reduce the odds of a young recipient developing donor-specific antibodies will facilitate access to retransplantation and improve medical outcomes.[36] The only experience of molecular matching was conducted among the pediatric transplantation community.[37] One of our participants who was working with the pediatric population mentioned the potential benefits of using molecular matching for young transplant recipients because it could reduce the risk of rejection among nonadherent recipients.

Molecular matching could also be used in living kidney donation. Transplant professionals mentioned that it could be helpful to differentiate between potential living kidney donors. We could also foresee that molecular matching would be an advantage for compatible pairs who are considering participating in kidney-paired exchanges. For instance, the recipient in the compatible pair could have access to a better-matched kidney. In a previous study conducted with potential living kidney donors and transplant candidates, the possibility of having access to a better-matched kidney was a factor that increased the willingness to participate as a compatible pair in kidney-paired donation.[38] Further studies are needed to explore key stakeholders' perspectives on molecular matching and living kidney donation.

Molecular matching is part of the precision medicine approach in transplantation. A key paradox of precision medicine is the uncertainty related to its clinical application.[39] That being said, precision medicine and molecular matching aim to bring more certainty to organ allocation through a more tailored allocation. For instance, a recent scoping review identified different sources of uncertainty. One of them is the complexity of the system, which could apply to kidney allocation because molecular matching is only one component of this complex system.[40] Although uncertainty was not explicitly mentioned during the interviews, the issue was raised when participants voiced concerns about the need for accurate information on graft survival and increased waiting times with molecular matching and accessing technology that will allow this new allocation scheme.

The limitations of our study include its small sample size, even if the number of participants allowed for data saturation,[23] and no new codes were created after the 11th interview. Also, we have participants from every Canadian province except the Atlantic provinces. Moreover, most of the participants were Canadian nephrologists, and thus, the results may not reflect the perspectives of other stakeholders. There is also a limitation in terms of external validity. The results of this study are not necessarily representative of all Canadian transplant professionals' views on molecular matching. As kidney allocation and clinical practices vary by country, our results may not be applicable to other parts of the world. Nevertheless, questions regarding the ethical issues related to molecular matching and kidney allocation are universal. Learning the perspectives of additional stakeholders, such as HLA experts, patients and policymakers, and scanning practices in other countries, may trigger reflections that could help improve kidney allocation. Finally, this work concerns the collection of perspectives expressed by transplant physicians based on their previously acquired knowledge in this domain; we have made no attempt to check the factual accuracy of the knowledge and how it may affect any of the responses.

CONCLUSION

Molecular matching and precision medicine are viewed as promising technologies in kidney transplantation because they could improve graft survival and patients' lives. However, participants were concerned about the risks of increasing waiting times and disadvantaging certain populations. In the process of integrating molecular compatibility into kidney allocation in Canada, there is a need to engage more diverse stakeholders, adopt a transparent approach to policy development, and develop an evidence-based simulation framework to guide changes to allocation schemes.

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