

Review article

Disparities in kidney transplantation accessibility among immigrant populations in Europe: A systematic review and meta-analysis

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ABSTRACT

Background and objectives: Disparities in access to healthcare for patients with an immigration background are well-known. The aim of this study was to determine whether disparities among immigrant populations translate into a relative difference in the number of kidney transplants (KT) performed in documented immigrant patients (first and second generation) relative to native-born patients in Europe.

Methods: A literature search was performed in PubMed from inception to 11-10-2022. Studies were eligible if: (1) written in English, (2) included immigrant and native-born KT patients, (3) performed in countries registered as Council of Europe members, (4) focused on documented first- and second-generation immigrant populations [1]. Systematic reviews, literature reviews, and case reports or articles about emigration, non-KT, and undocumented immigrants were excluded. The outcome measurement was a relative percentage of KT to the total population per 100.000 residents. By dividing the immigrant percentages by the native-born resident percentages, the odds ratio (OR) was calculated in a meta-analysis. The risk of bias was assessed; articles with high risk of bias were excluded in a second meta-analysis.

Results: Out of 109 articles, 5 were included ($n = 24,614$). One Italian study ($n = 24,174$) had a ratio below 1, being 0.910 (95%CI 0.877–0.945). The other four articles ($n = 196$, $n = 283$, $n = 77$, $n = 119$) had ratios above 1: 1.36 (95%CI 0.980–1.87), 2.04 (95%CI 1.56–2.68), 2.23 (95%CI 1.53–3.25) and 2.64 (95%CI 1.68–4.15). After performing a meta-analysis, the OR did not show a significant difference: 1.68 (95%CI 1.03–2.75). After bias correction, this remained unchanged: 1.78 (95%CI 0.961–3.31).

Conclusions: In our meta-analysis we did not find a significant difference in the relative number of KT performed in immigrant versus native-born populations in Europe. However, a lesser likelihood for immigrants to receive a pre-emptive kidney transplantation was found. Large heterogeneity between studies (e.g. different sample size, patient origins, study duration, adult vs children patients) was a shortcoming to our analysis. Nevertheless, our article is the first review in this understudied topic. As important questions (e.g. on ethnicity, living donor rate) remain, future studies are needed to address them.

1. Introduction

Immigration is an ongoing phenomenon worldwide. Over the last

few years, many countries have experienced increased immigration flows due to a variety of factors. These include, but are not limited to, economic, safety and environmental factors [2]. Because these will

Abbreviations: KT, kidney transplant; OR, odds ratio; TFR, total fertility rate; ESKD, end-stage kidney disease; LDKT, living donor kidney transplant.

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probably persist, immigration is likely to increase in the future [3]. In 2020, Europe ranked first as host of international migrants [4]. In 1990, health disparities were thought up to refer to health differences among socially disadvantaged people. Healthy People 2030 defined this more closely as: “a particular type of health difference that is closely linked with social, economic, and/or environmental disadvantage. Health disparities adversely affect groups of people who have systematically experienced greater obstacles to health based on their racial or ethnic group; religion; socioeconomic status; gender; age; mental health; cognitive, sensory, or physical disability; sexual orientation or gender identity; geographic location; or other characteristics historically linked to discrimination or exclusion” [5].

Evidence shows that patients with an immigration background experience disparities in access to healthcare in Europe [6]. The causal mechanisms underlying disparities in these populations are complex. Health disparities are systemic and linked with social disadvantage [7,8]. It is not always clear whether it is social disadvantage that leads to health disparities or the other way around (i.e. a critically ill patient is unable to work and therefore at economic disadvantage compared to a healthy person). Health disparities are unjust as a different quality of care is provided depending on the patient’s background. Since justice is a core ethical principle in organ transplantation, migrant health, and an ethical imperative in healthcare, this is unacceptable [9–11].

Multiple studies have emphasized the need to address disparities in immigrant populations pursuing transplantation (particularly kidney transplantation, KT) in the European area [12–16]. Prior research has shown that, across different European countries, <1% of deceased donor organs are allocated to non-resident patients [17]. However, a systematic review of resident immigrant populations has not yet been done. To fill this gap, we performed a systematic review to determine whether disparities among documented immigrant patients translate into a difference in the number of KTs performed in immigrant relative to native-born populations in Europe.

2. Methods

2.1. Search strategy

This systematic review was performed according to the PRISMA statement [18]. PubMed was searched for case-control studies, prospective and retrospective cohort studies, and cross-sectional studies addressing KT in immigrant populations. The search was performed from inception to 11-10-2022. The following search string was used: (“Transplants”[mj] OR “Transplantation”[Mj:NoExp] OR “Organ Transplantation”[Mj] OR Transplant*[ti] OR graft*[ti] OR donation*[ti] OR donor*[ti]) AND (“Emigrants and Immigrants”[Mj] OR “Emigration and Immigration”[MeSH] OR immigrant*[ti] OR immigration*[ti] OR foreign*[ti] OR alien[ti] OR citizenship-status[ti] OR migration-background[ti] OR history-of-migration*[ti]) AND (Epidemiologic Studies[mesh] OR epidemiolog*[tiab] OR case-control*[tiab] OR cohort*[tiab] OR followup[tiab] OR follow-up[tiab] OR longitudinal*[tiab] OR prospectiv*[tiab] OR retrospectiv*[tiab] OR cross-sectional*[tiab] OR population*[tiab]).

2.2. Definitions

In this research, based on definitions of the European Commission, we defined immigration as “the action by which a person establishes his or her usual residence in the territory of a member state for a period that is, or is expected to be, of at least 12 months, having previously been usually resident in another member state or a third country” [19]. Further, for classification, we distinguished between first-generation immigrants (i.e. foreign-born), second generation immigrants (i.e. native-born with at least one foreign-born parent), and native-born populations with native backgrounds [20].

2.3. Eligibility criteria

Articles were included if they met the following criteria: written in English, including immigrant and native-born patients who received KT, in countries registered as members of the Council of Europe, focused only on documented first- and second-generation immigrant populations [1]. Articles focusing on emigration, non-KT (including tissue, blood or cellular donation) were excluded. Systematic reviews, literature reviews, and case reports were also excluded. If two articles used the same research population, only the article with the longest duration of data collection was to be included. Because KT in undocumented immigrants is rare in Europe, and because this group of migrants may be exposed to additional aspects of vulnerability when compared to regular migrants, studies focusing on undocumented migrants were also excluded [13,21].

2.4. Outcome measurement

The outcome measurement was a relative percentage of KTs relative to the total population per 100.000 residents per year. For example, the total number of immigrants who received KT in each study was divided by the total number of immigrants in the country where the study was performed times 100.000, divided by the total duration of the study. The odds ratio (OR) was calculated by dividing the immigrant percentages by the native-born resident percentages. If the OR was below 1 it meant relatively less immigrants were transplanted compared to the native-born population; if it was higher than 1 the immigrant population was transplanted more often. As a secondary outcome, we identified reasons for the difference in KT between the two populations, if one was found.

2.5. Selection and data collection process

The articles found were divided among two of the authors to be screened on title and abstract. After screening title and abstract, they independently looked at the full text articles to be included. If there was a disagreement, they discussed the article to reach a consensus. If the consensus was not achieved, it was to be resolved by consulting an independent third party consisting of two other authors.

A spreadsheet was developed to extract the following data: publication date, study design, duration of data collection, sample size, study location, patients’ age group (adult vs. pediatric), patients’ country of birth, total number of resident immigrant and native-born patients who received KT. To determine the total native-born and first-generation immigrant populations in each country, the Eurostat database “Population on 1 January by age group, sex and country of birth” was used [22]. The data on second-generation immigrant populations was collected from the national database of the country where the study was performed. If these databases were unavailable, an estimation of second-generation immigrants per country was made based on the first-generation immigrant populations as stated by Eurostat, and the average number of children per family. The usual age for women’s childbearing was estimated to range between 20 and 40 years [23]. Using the database “Population on 1 January by age, sex and broad group of country of birth” the foreign-born female population aged 20–40 years was found for the year 2021 per country [22]. Earlier research stated that the average total fertility rate (TFR) among immigrant women was approximately 2.0. [24]. The rough estimation of second-generation immigrants was found by multiplying the foreign-born female population aged 20–40 years old by 2.

2.6. Quality assessment and risk of bias

The quality of the articles was assessed individually by two authors with a questionnaire based on the New Castle-Ottawa scale and the Study Quality Assessment tools of the NIH (Appendix A) [25,26]. Articles rated as a 5.5 or higher were regarded as low risk of bias (i.e. of

good quality). Articles rated between 4 and 5 were at moderate risk of bias (i.e. of moderate quality). Articles rated below 4 were judged to be at high risk of bias. When this was the case, a second meta-analysis was to be performed without these articles.

2.7. Data synthesis and analysis

First, relative percentages were calculated manually for each group as described previously. The immigrant percentages were divided by the native-born resident percentages to calculate an OR. After the individual analysis, a meta-analysis was performed using the program Open Meta-Analyst. This program was used also to calculate 95% confidence intervals associated with the OR. If the confidence intervals included the number 1, the difference between groups was categorized as non-significant. According to Cochrane, if the I^2 -test statistic for heterogeneity was $>40\%$ a random effects model was used, otherwise a fixed effects model was used [27]. In the meta-analysis, the OR of every article was compared.

3. Results

The search returned 109 articles. After title and abstract screening, 100 articles were discarded, (Fig. 1). Based on full text screening, the remaining 9 articles were assessed for eligibility. Four articles did not match the inclusion criteria. The 5 remaining articles were included in both the systematic review and the meta-analysis.

3.1. Study characteristics

The five included studies are summarized in Table 1. Two studies were performed in Italy [28,29], two in Austria [30,31] and one

combined study in the Netherlands and Belgium [32]. The data collection periods varied with the earliest dating back to 1978 [30] and the latest ending in 2020 [28]. All articles were published between 2010 and 2022. Only studies designed as retrospective cohort were found.

3.2. Patient characteristics

The sample size ranged from $n = 77$ [31] to $n = 24,174$ [28]. One article focused on the adult immigrant patient population [28], while 4 articles focused on pediatric patients [29–32]. Immigrant patients originated from various parts of the world: Europe, Asia, South America, Sub-Saharan Africa, Northern Africa, and the Middle East (Appendix B).

3.3. Risk of bias

Two articles were found to be of good quality and therefore had a low risk of bias (Table 2). Two articles were found to be at moderate risk of bias, the main problem being that outcomes were not adjusted for potential confounders. The last article was found to be at high risk of bias; while also not correcting for confounders, the study population included more male patients than the average in the community.

3.4. Results of individual studies

All five articles spoke about immigrants who underwent a migration. Not all national databases included data on second-generation immigrants. Therefore, for Italy, Belgium and the Netherlands we used the estimation formula described earlier. The number of second-generation immigrants was estimated to be approximately 2.375.432 and 1.712.974 in Italy and the Netherlands/Belgium, respectively. The number of second-generation immigrants in Austria was 363.300 in 2008 and 429.500 in 2013. These data were publicly available on the website of Statistik Austria [34]. The immigrant to native-born resident OR differed between studies (Table 3). One Italian study had an OR below 1, 0.910 (95%CI 0.877–0.945) [28]. The other four articles had ORs above 1: 1.36 (95%CI 0.980–1.87) [30], 2.04 (95%CI 1.56–2.68), 2.23 (95% CI 1.53–3.25) [32] and 2.64 (95%CI 1.68–4.15) [31], respectively.

3.5. Meta-analysis

All studies were included in the first meta-analysis (Fig. 2). The calculated heterogeneity, $I^2 = 94.9$ was above 40% hence a random effects model was used. The calculated OR was 1.68 (95%CI 1.03–2.75), which did not show a significant difference.

Because one article was found to be at high risk of bias, a second meta-analysis was performed excluding this article, (Fig. 3). Since the heterogeneity was $I^2 = 96.0\%$, a random effects model was used. The OR of the corrected analysis was also non-significant: 1.78 (95%CI 0.96–3.31). (See Fig. 4.)

3.6. Explanation of the differences detected in individual studies

The included articles put forward different explanations for the difference in the number of KT in immigrant versus native-born populations. Grossi et al. [28], Paglialonga et al. [29] and Tromp et al. [32] all pointed out that immigrant patients were less likely to receive a kidney from a living donor. Paglialonga et al. [29] also pointed out that immigrant patients were less likely to receive a pre-emptive KT, (13,4% vs. 3,3%; $p = 0.009$). To investigate these differences, the ORs of immigrant to native born patients that received a pre-emptive, living donor kidney transplant (LDKT) and deceased donor kidney transplant (DDKT) were calculated for four studies [29–32] (Table 4). In the studies of Paglialonga et al. [29] and Oztek-Celebi et al. [31] immigrants were significantly less likely to receive pre-emptive KT. This remained significant in the meta-analysis, (OR 0.484; 95%CI 0.262–0.894). The

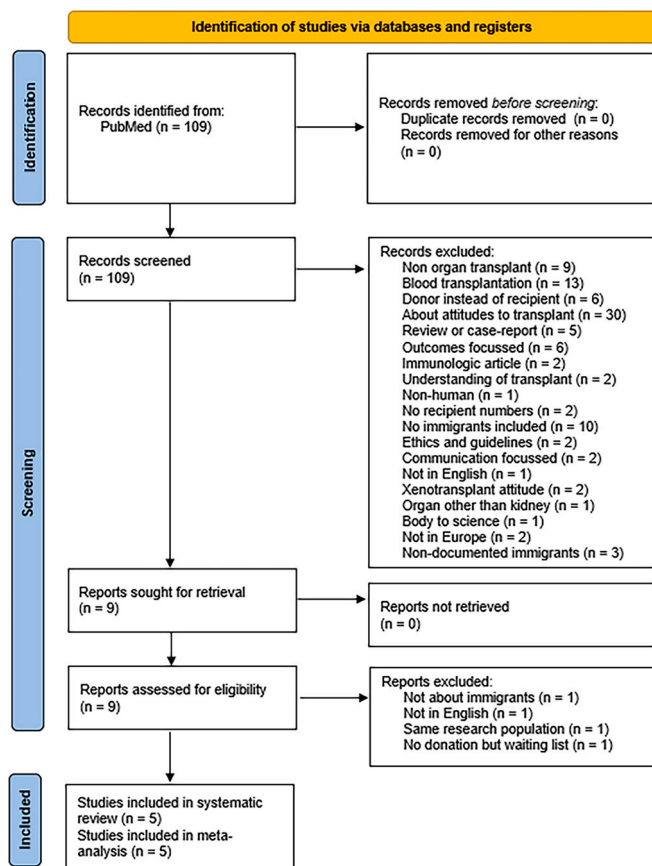


Fig. 1. PRISMA Flowchart of literature search [33].

Table 1
Summary of study characteristics.

Study (years)	Country	Study design	Duration of data collection	Studied group	Sample size	Male gender native born - immigrants in %(P-value)	Mean age native born - immigrants in years (P-value)
A.A. Grossi et al. (2022) [28]	Italy	Retrospective cohort	01/01/2010–31/12/2020	Adults	24.174	64,2–58,6 ((0,001)	51,9–43,3 (<0,001)
F. Paglialonga et al. (2020) [29]	Italy	Retrospective cohort	01/01/2007–21/12/2016	Children	283	57,0–54,2 (0,59)	9,4–6,7 (0,025)
F.Z. Oztek et al. (2008) [30]	Austria	Retrospective cohort	1978–2007	Children	196	50,7–64,6 (0,08)	12,5–11,0 (0,08)
F.Z. Oztek-celebi et al. (2019) [31]	Austria	Retrospective cohort	2008–2013	Children	77	66,6–60,0 (0,69)	9,1–7,5 (0,47)
W.F. Tromp et al. (2012) [32]	Netherlands, Belgium	Retrospective cohort	01/09/2007–01/01/2011	Children	119	53,8–63,4 (NA)	11,7–11,3 (0,907)

Table 2
Risk of bias.

Article	Score	Risk of bias
A. A. Grossi et al.(2022) [28]	5.5	Low
F. Paglialonga et al. (2020) [29]	4.5	Moderate
F. Z. Oztek et al. (2010) [30]	3.5	High
F. Z. Oztek- Celebi et al. (2019) [31]	4.5	Moderate
W. F. Tromp et al. (2012) [32]	5.5	Low

disparities regarding the likelihood of receiving a LDKT were similar, but were not significant in the individual nor meta-analysis (OR 0.957; 95%CI 0.497–1.84). Tromp et al. [32] and Paglialonga et al. [29] found that immigrants were more likely to receive a DDKT. This outcome was not significant in the meta-analysis (OR 1.59; 95%OR 0.686–3.69) (Appendix C). Given the retrospective nature of these studies, most reasons for these findings could only be hypothesized. These included factors potentially related to different levels, i.e. patient-, donor-, provider-, and healthcare system-related. Language barriers, lack of knowledge of living donation, misunderstandings of the procedure,

Table 3
number of immigrants versus native born and odds ratios.

Study (years)	Immigrants included	Native born included	Total immigrants in country	Total native born in country	Transplanted immigrant (per 100.000 immigrant residents per year)	Transplanted native born (per 100.000 residents per year)	Odds ratio immigrant to native born transplanted
A.A. Grossi et al. (2022) [28]	3191	20.983	8.536.823	51.104.665	3,398	3,733	0,910 (95%CI 0,877-0,945)
F. Paglialonga et al. (2020) [29]	69	214	8.282.884	52.382.667	0,08330	0,04085	2,04 (95%CI 1,56-2,68)
F.Z. Oztek et al. (2008) [30]	48	148	1.598.179	6.684.805	0,1001	0,0738	1,36 (95%CI 0,980-1,87)
F.Z. Oztek-celebi et al. (2019) [31]	32	45	1.793.503	6.658.357	0,2973	0,1126	2,64 (95%CI 1,68-4,15)
W.F. Tromp et al. (2012) [32]	41	78	5.376.741	22.791.536	0,1760	0,07897	2,23 (95%CI 1,53-3,25)

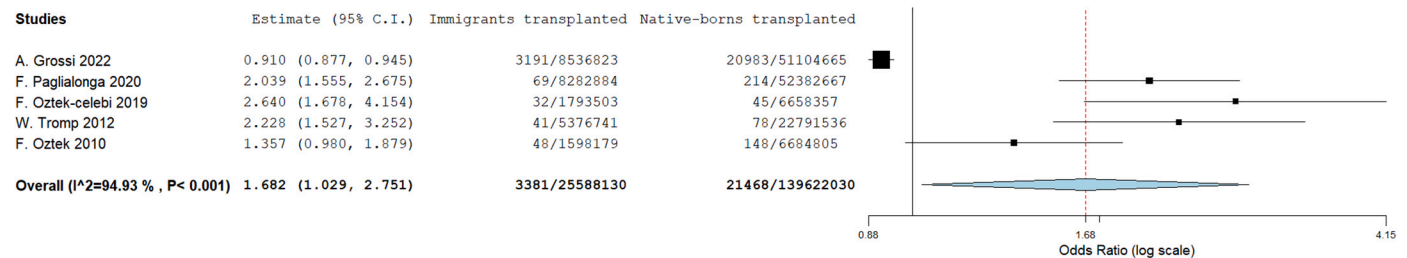


Fig. 2. Meta-analysis with odds ratio between immigrant and native-born population.

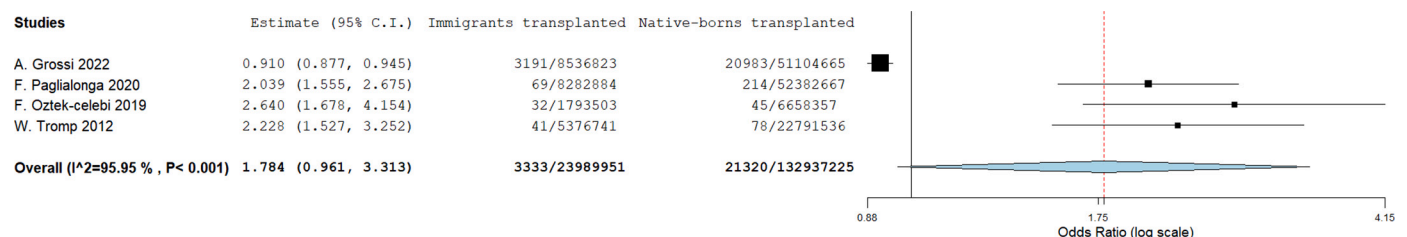


Fig. 3. Meta-analysis with odds ratio between immigrant and native-born population after correction for risk of bias.

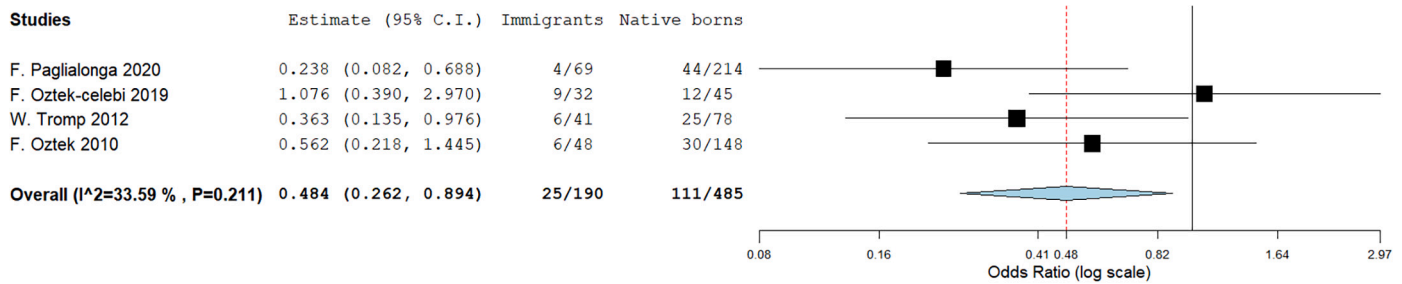


Fig. 4. Meta-analysis with odds ratio pre-emptive transplantation immigrant patients to native born.

Table 4
Transplantation characteristics.

Study (years)	Pre-emptive immigrant patient	Pre-emptive native born patient	Odds ratio pre-emptive immigrant to native born	Living donor immigrant patient	Living donor native born patient	Odds ratio living donor immigrant to native born	Deceased donor immigrant patient	Deceased donor native born patient	Odds ratio deceased donor immigrant to native born
A.A. Grossi et al. (2022) [28]	Unknown	Unknown	–	Unknown	Unknown	–	Unknown	Unknown	–
F. Paglialonga et al. (2020) [29]	4	44	0,238 (95%CI 0,082-0,688)	7	27	0,782 (95%CI 0,324-1,88)	58	143	2,62 (95%CI 1,29-5,30)
F.Z. Oztek et al. (2008) [30]	6	30	0,703 (95%CI 0,270-1,83)	17	46	1,22 (95%CI 0,612-2,42)	25	72	1,15 (95%CI 0,598-2,20)
F.Z. Oztek-celebi et al. (2019) [31]	9	12	0,115 (95%CI 0,039-0,341)	20	20	2,08 (95%CI 0,825-5,26)	12	25	0,480 (95%CI 0,190-1,21)
W.F. Tromp et al. (2012) [32]	6	25	1,55 (95%CI 0,591-4,05)	5	22	0,354 (95%CI 0,123-1,02)	30	31	4,14 (95%CI 1,81-9,45)

personal/cultural/religious beliefs are factors related to the patient- and donor-level. The absence of family members living sufficiently close was also considered a possible factor. Besides, lack of coverage of travel and medical fees for living-donor surgery and follow-up for non-resident donors was also listed among potential reasons.

At the provider-level, factors which were thought to have the potential to negatively affect referral for LDKT included clinicians' personal biases, concerns for risk of compulsion, a higher risk of developing end-stage kidney disease (ESKD) in certain ethnic minority groups, and the lack of healthcare coverage for post-donation care among non-resident living donors. Healthcare-system related factors differ across European countries as each country has its own policies for living donation. In some countries, travel expenses and medical fees are covered for living donation. Moreover, healthcare systems may not be equipped with the resources to provide culturally competent, adequate and understandable education for individual patients.

Problems related to communication and inferior knowledge of living donor KT among immigrants were confirmed by Oztek-Celebi et al., who also ran a survey study to gain a deeper understanding of the outcome under scrutiny [31]. However, the study found no reduction in living donor KTs among immigrants. The authors acknowledged that immigrant populations are more likely exposed to socioeconomic problems, possibly leading to lower living kidney donations among adults. For instance, after living donation, immigrant families more often agreed with the statement that “donating a kidney is a rewarding experience for donors” when compared to their native-born counterparts, which possibly explains the higher OR. Further, the study found that, once starting either hemodialysis or peritoneal dialysis, native-born families were less likely to donate their kidney to their child. Reasons for the differences in deceased donor KT were unexplained. The study also found significantly less immigrant families started communication about organ donation 2 years before KT unlike the families of native-

born residents. In both groups the medical professionals were the main source of information on KT, however in the immigrant group significantly fewer other sources were used. This emphasizes the importance of the communication with families on KT by the medical team.

Grossi et al. [28] stated there was a higher risk of ESKD among first- and second-generation immigrants from various countries, which might explain why KT candidates were younger than their native-born referents. The migration process and ethnicity were assumed to be influencing factors in the development of ESKD. Given the limitations inherent to the retrospective design of the study, the reasons underlying the inferior likelihood to receive a LDKT could only be hypothesized. Besides, the authors stressed that, because they examined the likelihood of KT among wait-listed patients, disparities prior to or at the time of wait-listing could not be explored.

As described by Paglialonga et al. [29], Oztek-celebi et al. [31] and Tromp et al. [32], the primary renal diseases were not different between populations. Paglialonga et al. pose the hypothetical question if children from immigrant families would have received suboptimal conservative care given the difference in age at transplantation without any difference in etiology of the disease. In the study by Oztek et al. [30], congenital diseases were more prevalent among immigrants.

According to Paglialonga et al. [29], children with an immigration background tended to be younger than their native-born counterparts. Besides, they had smaller chances to receive pre-emptive KT compared to native-born patients. This article points out that socioeconomic problems are more prevalent among immigrants and delayed referral could explain this difference. Tromp et al. [32] found that immigrant patients remained longer on dialysis prior to first KT, suggesting other medical or social factors might be at work.

4. Discussion

This study did not find a significant difference in the relative number of KT's performed in immigrant versus native-born populations. This outcome remained unaltered even in the corrected meta-analysis.

The main strength of this systematic review and meta-analysis is that it is the first to explore disparities in access to KT among immigrant populations. Although inequities in access to healthcare for individuals with an immigration background are well-described [6,12,15], our study did not show a significant difference in the number of KT's performed in first- and second-generation immigrant populations relative to their native-born counterparts in Europe. However, our study did show that immigrants were less likely to receive a pre-emptive KT. While the finding that immigrants are less likely to receive a kidney from a living donor was consistent across three studies, we did not find this in our meta-analysis. The explanations for the found differences being the barriers in communication, and the lack of knowledge of the possibility to pursue living donation. The personal, religious and cultural beliefs should also be considered as reasons for a difference.

Another important finding of this review is that very little research has been performed on this topic in the European area, suggesting the need to raise awareness to increase the number of studies in this field. Further, alongside the scarcity of research, the limitations inherent to the retrospective design of existing studies impede the ability to draw any reliable conclusions. While we could provide a subclass analysis regarding the likelihood of receiving pre-emptive KT, LDKT and DDKT for four articles, we were unable to do so for the article of Grossi. et al. [28] due to the way the data was provided. For instance, the inability to distinguish between pre-emptive LDKT and DDKT might introduce bias.

This study has several limitations. First, migrants are not a homogenous group in that there may be great within-group variation depending on multiple factors related to the migration process (pre-migration, movement, arrival/integration in the host country, return) and to cross-cutting socio-economic, demographic, and genetic factors [35,36]. As noted by Grossi et al., immigrants from Europe and other Eastern European countries beyond the EU are less likely to suffer from disparities compared to immigrants originating from non-European countries from beyond the EU [28]. In our study, a considerable number of immigrants originated from the European continent. Therefore, this may have affected our findings. Furthermore, in the study of Paglialonga et al. [29] data concerning the patients' origins was not shown. Because of mixing fathers' and mothers' origin in the article, the origin of immigrants cannot be compared with the other studies. The different origins of patients included in the studies is one of the important causes of heterogeneity among study results.

Further, variation may exist across different countries based on migration history, immigration policies, social security systems, and other societal features [35]. However, little consensus exists on the definition of the term immigrant in Europe [37,38]. Although Eurostat has put together a definition, individual countries vary in how they define these populations, especially regarding the differences between first- and second-generation immigrants. Studies are needed to find consensus on how to best categorize these populations to better enable KT data comparability in immigrant populations across Europe. The European Public Health Association recommends that, because migrants and indigenous ethnic minorities may experience similar disparities, both data on immigrant status and ethnicity should be collected [39]. However, by including only immigration background in our search strategy, studies examining the association of ethnicity- and/or ethnic minority status with disparities in KT accessibility were not included. Therefore, although the United Kingdom (UK) is a part of the Council of Europe, because the UK only differentiates by terms of ethnicity rather than immigrant status, studies from the UK are missing in our review, accounting as an additional limitation of our study [1]. Future systematic reviews and other research should consider the inclusion of ethnicity and/or ethnic minority status together with immigration

background to be more inclusive.

Further, while Eurostat differentiates between first and second-generation immigrants, the Eurostat database used in this review did not contain the exact numbers of second-generation immigrants in Europe. This forced us to use an estimation of second-generation individuals, as described in our methods section. Although this estimation of the number of second-generation immigrants increased the risk of misinterpretation, we do think it is important to have this estimation as first- and second-generation immigrants both have a higher risk of ESKD.

Another limitation of the study is the heterogeneity between the included studies. For example, the sample size or number of participants varied and also the number of participating adults or children differed. Grossi et al. [28] did not include pediatric patients, while the other articles did. As this was the biggest study included, this may distort the results. The origin of immigrants was also different among studies, as was discussed earlier. These variations may distort the results of the meta-analysis. To compensate for the widely different observation periods between studies we showed the number of transplanted immigrant and native-born patients per 100.000 per year in Table 3. While this compensates for the difference in observation periods, it also makes the presumption that KT rates were constant over this period. We know this was not always the case, for example the study of Oztek et al. [30] mentions a difference in KT rates over three decades (53 in the first decade, 107 in the second and 76 in the third).

Subclass analyses for first- and second-generation immigrants are needed to assess whether disparities in KT accessibility are more accentuated in either one or both subgroups when compared to native-born populations. Yet, across Europe, ethnicity is broadly defined by surrogate variables [40]. For example, in Italy, neither racial and/or ethnic statistics are allowed, and, in the Italian Census, they are identified with proxies like citizenship, place of birth, former citizenship for Italians, and, since the 2011 Census, citizenship of parents [41]. Because of the increasing number of acquisitions of citizenship, it is often difficult to derive information of former citizenship from registry data; therefore, country of birth may be considered as the most suitable surrogate to identify ethnic minority individuals among first-generation migrants and build categories [42]. However, the problem remains with ethnicity in second-generation individuals, which are a lot more difficult to identify if ethnicity data are not systematically collected.

Future studies should examine whether disparities in KT accessibility are equally or more associated with immigrant and/or ethnic minority status [36,37].

5. Conclusion

In our meta-analysis we did not find a significant difference in the relative number of KT's performed in the immigrant patient population when compared to the native-born patient population in Europe, meaning that disparities are not present. However, as multiple studies have shown a lesser likelihood for immigrants to receive a pre-emptive KT this outcome should be debatable. More research should be performed to strengthen this conclusion. There is also a need for consensus around immigration and ethnicity among European countries. This is necessary to enable unambiguous research on the topic of disparities in KT for individuals with an immigration background and/or who are from ethnic minorities. Future research should consider the inclusion of ethnicity and/or ethnic minority status together with immigration background to be more inclusive. Prospective studies are equally needed to collect these data along with data of all the potential confounding factors.

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Interests in relation to this manuscript

There are no interests to declare related to this manuscript.

Interests unrelated to this manuscript

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Martijn W.F. van den Hoogen reports honoraria with Alnylam, Astellas, Astra-Zeneca, Boehringer Ingelheim, Chiesi, Fresenius, GSK, Mundipharma, NovoNordisk, Sanofi / Genzyme, Vifor.

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Declaration of Competing Interest

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Martijn W.F. van den Hoogen reports a relationship with Alnylam that includes: honoraria.

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Martijn W.F. van den Hoogen reports a relationship with Vifor that includes: honoraria.

Appendix A. Quality assessment questionnaire

1. Is the research question/objective clear? Yes/no
2. Is the cohort representative of the average in the community? Yes/no/cannot determine (CD)
3. Was the participation rate of eligible persons at least 50%? Yes/no/CD
4. Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants? Yes/no/CD
5. Were the outcome assessors blinded to the exposure status of participants? Yes/no/CD
6. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)? Yes/no/CD

A.1. Points

Yes equals one point.

Every “cannot determine” counts as half a point.

No equals no points.

- o 0–3.5 Bad quality
- o 4–5 Moderate quality
- o 5.5–6 Good quality

Appendix B. Table of patients’ origins

Table S1

Origin of patients per study.

	European	Asian	North American & Oceania	South American	Sub-Saharan African	Northern Africa & Middle-East	Other
A.A Grossi et al. (2022) [28]	Albania: 265 Belgium: 22 Bosnia & Herzegovina: 25 Bulgaria: 15 Former Yugoslavia: 51 France: 35 Germany: 80 Italy: 20983 Macedonia: 42 Moldavia: 72 Poland: 28 Romania: 293 Switzerland: 90 UK: 23	Bangladesh: 55 China: 139 Philippines: 195 India: 86 Pakistan: 75 Sri Lanka: 31 Other North-East and South-East Asian: 33	–	Argentina: 32 Brazil: 30 Colombia: 19 Cuba: 13 Dominican Rep: 20 Ecuador: 58 El Salvador: 17 Other Latin American: 32 Peru: 54 Venezuela: 22	Burkina Faso: 15 Congo: 15 Ethiopia: 28 Ghana: 95 Ivory Coast: 40 Mauritius Islands: 15 Nigeria: 112 Senegal: 121 Other Sub-Saharan African: 84	Egypt: 64 Lybia: 24 Morocco: 315 Tunisia: 69 Other North-African and Middle-Eastern: 36	–

(continued on next page)

Table S1 (continued)

	European	Asian	North American & Oceania	South American	Sub-Saharan African	Northern Africa & Middle-East	Other
	Ukraine: 112 Other: 94						
F. Paglialonga et al. (2020) [29]*	Italian: 4 mothers, 8 fathers Other European: 41 mothers, 37 fathers	18 mothers, 17 fathers	–	12 mothers, 9 fathers	12 mothers, 12 fathers	31 mothers, 33 fathers	–
F.Z. Oztek et al. (2008) [30]	Austria: 45 Former Yugoslavia: 12 Turkey: 10	–	–	–	–	–	Other**:
F.Z. Oztek-celebi et al. (2019) [31]	Austria: 148 Former Yugoslavia: 22 Turkey: 9	–	–	–	–	Lybia: 9	Other: 8
W.F. Tromp et al. (2012) [32]	Belgium: 18 Germany: 1 Luxembourg: 1 Netherlands: 58 Turkey: 9	Other: 4	–	Dutch Antilles/ Caribbean: 2 Surinam: 7	Other: 7	Morocco: 8 Other: 4	–

* Only the continent from which the parents of the patients originated was mentioned, except for Italy.

** 10 participants originated from Romania, Bulgaria, Spain, Hungary, Jordan, Nigeria, Sudan and Thailand. Exact numbers per country were not provided.

Appendix C. Analysis of living donor kidney transplantations and deceased donor kidney transplantations

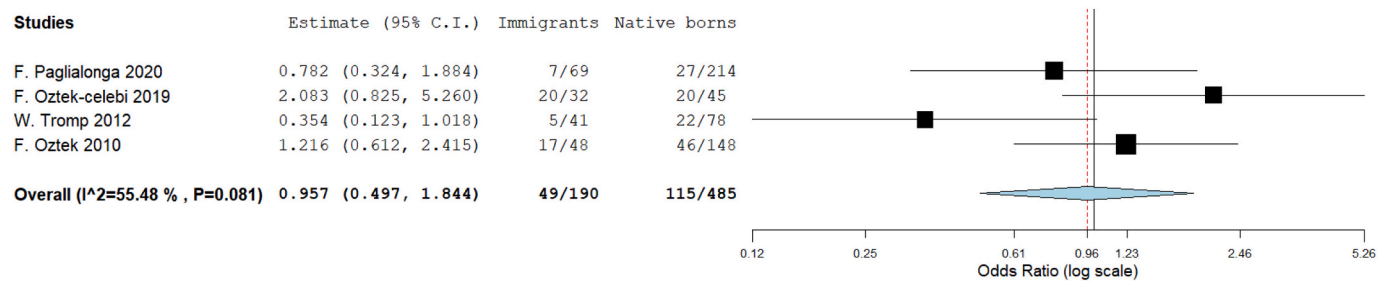


Fig S2. Meta-analysis with odds ratio living donor kidney transplantation between immigrant and native born patients.

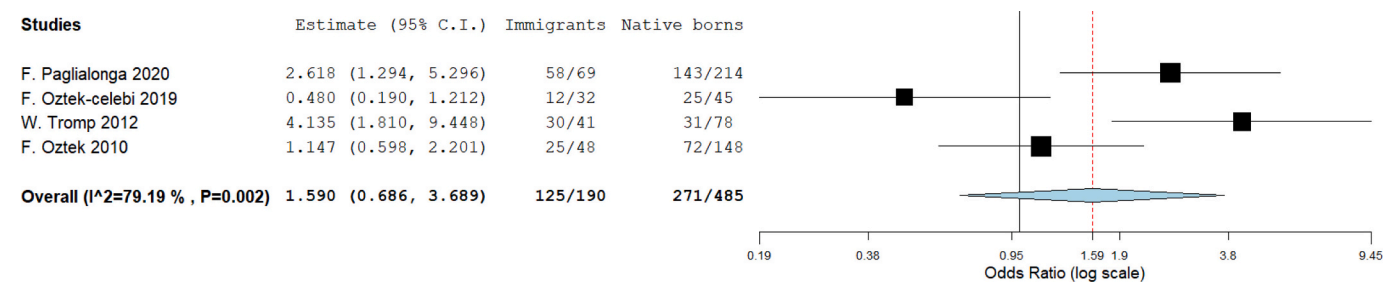


Fig. s3. Meta-analysis with odds ratio deceased donor kidney transplantation between immigrants and native born patients.

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