Transplantation Publish Ahead of Print

DOI: 10.1097/TP.0000000000003256

Disparity in accessibility to and prognosis of kidney transplantation according to economic inequality in South Korea: a widening gap after expansion of insurance coverage

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Acknowledgements

This study used the database from the NHIS of Korea, and the approach was approved by the organization (NHIS-2018-1-399).

Disclosure: There is no competing interest to be declared.

Authorship page

Authors' Contributions

The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted. SP, GCP, MYY, KSK, MP, DKK, KWJ, YSK, and HL contributed to the conception and design of the study. SP, JEK, MYY, KSK, MP, YCK, DKK, KWJ, YSK, and HL advised on statistical aspects and interpreted the data. SP, GCP, JP performed the main statistical analysis, assisted by JEK, MYY, KSK, MP. DKK, KWJ, YSK, and HL advised the data interpretation. SP, GCP, and HL had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. All authors participated in drafting the manuscript. All authors reviewed the manuscript and approved the final version to be published.

Conflict of Interest Disclosure: The authors declare no conflicts of interests.

Funding: This study was supported by a grant from the Ministry of Health and Welfare, Republic of Korea (grant number: HI18C1604). The funder did not have any role in the study design; collection, analysis, and interpretation of data; writing the report; or the decision to submit the report for publication.

Abbreviation page

ESRD = end-stage renal disease

IRB = institutional review board

NHIS = National Health Insurance Service

DCGF = death-censored graft failure

MPR = medication possession ratio

Abstract

Background

Nationwide studies on the effects of wealth inequality on kidney transplantation are rare, particularly in a country with an expanded national health insurance service and in Asian countries.

Methods

In this nationwide, population-based cohort study, we reviewed the national claims database of Korea in which details of nationwide health insurance are provided. From 2007 to 2015, 9 annual cohorts of end-stage renal disease (ESRD) patients were included. The annual financial statuses were collected and stratified into five subgroups in each year: the aided group in which insurance fee was waived and the 4 groups divided by quartiles of their medical insurance fee. Time trends of incidence proportion of kidney transplantation among ESRD patients in each year was initially assessed. The risk of graft failure, both including death-censored graft failure and death with functioning graft, was analyzed as prognostic outcome within the transplant recipients.

Results

Significant disparity in accessibility of kidney transplantation was present and it was further widening, particularly from 2009 in which the national health insurance service started to cover desensitized kidney transplantation. Desensitized or preemptive transplantation was less common in the poorest group who were more frequently receiving transplantation after 5 years of dialysis in the latter years. The prognosis of kidney transplantation was significantly worse in the poorer people, and this disparity also worsened during the study period.

Conclusions

Prominent disparity regarding accessibility to and prognosis of kidney transplantation was observed in Korea according to wealth inequality and this disparity was worsening.

Introduction

Kidney transplantation is the best treatment option in terms of patient prognosis for end-stage renal disease (ESRD).[1,2] Although the prognosis of kidney transplantation has improved simultaneously with increased prevalence of ESRD, limited accessibility to transplantation remains a concern.[3] The financial burden of kidney transplantation has consistently remained an important issue in health care. Desensitization therapy for mismatched donors has expanded the donor pool for living kidneys; however, disparities may still be present according to the economic status of patients.[4-7] Post-transplant prognosis may also be affected by socioeconomic deprivation,[4,8-12] but there are also reports indicating that prognosis does not differ significantly among those with low income levels.[13,14] The financial hurdles that potential kidney transplant recipients may face are closely related to the socioeconomic environment of a nation. Therefore, understanding time trends is essential when investigating this issue, and longitudinal nationwide studies which assess the accessibility to and prognosis of kidney transplantation according to economic inequality are necessary. Still, evidences lacked among kidney transplantation in Asian countries, and even fewer studies were present with nationwide information.

The Republic of Korea (hereafter, South Korea) provides universal health insurance coverage. This service has a wealth redistribution adjustment, as additional coverage is provided for the those with lower economic status. Using the National Health Insurance Database of Korea, the present study aimed to investigate whether a disparity exists in kidney transplantation accessibility or prognosis according to economic inequality of patients with ESRD. We hypothesized that patients with ESRD with poor financial status would have worse accessibility to kidney transplantation and worse post-transplant prognosis, and that the trend would change with the expansion of insurance coverage.

Materials and Methods

Ethical approval

This study was approved by the institutional review board (IRB) of Seoul National University Hospital (IRB No. E-1801-027-913). The IRB waived the requirement for informed consent as the study analyzed an anonymous database provided by the National Health Insurance Service (NHIS) of the Republic of Korea. The study was conducted in accordance with the Declaration of Helsinki. The study was consistent with the Principles of the Declaration of Istanbul.

Study setting

South Korea is one of the nations in which an aging population is a present concern and the prevalence of ESRD is rapidly increasing.[15] South Korea provides nationwide health insurance through NHIS. The National Health Insurance Database of South Korea is a public data resource that has collected complete information of the claims database in the nation since 2002.[16] Unique codes given for maintenance dialysis or transplantation can be used to identify information on kidney replacement therapy. In addition, "annual financial percentiles" of the recipients of medical care are also included in the database, as the health insurance fee is based on subscribers' economic status. This status is determined by annual income and estates or property possessed. The dependent subscribers' economic percentiles were determined by the supporters' financial status. South Korea also provides special medical coverage for individuals who have no income or near loss of working ability (i.e., the aided group); people in this group receive insured medical services at almost no cost, with the NHIS covering the fee, while non-insured costs are still paid by the patient. During the study period, the number of those who received this additional support (the aided group) ranged from 1.44–1.85 million people, accounting for 2.9%–3.4% of the total population during the study period. The relatively high

prevalence of CKD or ESRD in this low-income group in South Korea has been previously reported.[15,17]

Kidney transplantation surgery, induction and maintenance immunosuppressants are lifetime insured medical services in South Korea, for all people with Korean nationality, regardless of the medication types. The insured medical fee is 90% covered by the NHIS and completely covered for the aided group. Therefore, the choice of immunosuppressants is mostly based on the patients' immunologic risk versus benefit, rather than on their financial status.

The NHIS has covered desensitization therapy from 2009; initially, a single session rituximab was insured, with multiple plasmapheresis treatments insured since then. The desensitization therapies following the standard protocol suggested by the NHIS have been universally covered for patients regardless of their financial status, and for the aided group, the fee is even waived. The standard protocol is as below; those who had panel reactive antibody greater than 50% can receive desensitization therapies, including plasmapheresis, until it reaches less than 20%; when targeting cross match results, cases with CDC (-) but flow cytometry (+) are eligible for desensitization until negative conversion; for ABO mismatch cases, titer for mismatch antibody below 1:8 is the usually accepted cutoff-value targets. A few extreme cases have been rejected by the NHIS; however, most transplantation centers follow the protocol, as non-insured medical fee due to violation of the protocol, which is known as "arbitrarily non-insured service", is burdened by the hospitals.

There are certain accepted non-insured medical services which are not identifiable in the NHIS database, including some surgical materials or ward charges. The non-insured medical transplantation fee varies according to center or patient demographics. The median non-insured costs during admission for transplantation from 2007–2015 was approximately $6,550 in one of the main transplantation centers in Korea.

In Korea, kidney donations from living donors are mostly performed with confirmed relatives, because transplantation from non-relatives are mostly disapproved to prevent organ sale issues. Regarding the decision to receive deceased donor allograft while on the waiting list, there is no priority according to economic status, and the decision is mostly based on age, blood types, and waited duration. Regarding the costs for pre-transplant donor work-up, the fees of the potential living donors are initially non-insured, and the NHIS refunds approximately 80% (100% for the aided group) of the work-up costs after the actual donor nephrectomy is performed. The hospitalization and surgery for living donor nephrectomy are covered by the NHIS, and as the recipients, the insured fees are 90% covered by the NHIS and 100% for the aided group. The deceased donor transplantation-related fees are totally burdened by the recipients, receiving same insurance coverage as the recipients themselves. In contrast, as the claims for the donor nephrectomy-related costs are administratively issued to the recipients' bill, the direct donor claims information is unidentifiable in the claims database.

There were also other subtle changes in the NHIS within the study period, and the overall insurance coverage rate for the disease category that ESRD was included in continuously increased from 74.6%–79.9% from 2010–2015; no statistics were available prior to this period.[18]

Study population

We included nine annual cohorts of ESRD patients who received kidney replacement therapy, including maintenance dialysis or transplantation, from 2007–2015. The exclusion criteria included: 1) a transplantation history prior to the study period, 2) those who were > 70 years old in each annual cohort, as they would less likely be potential candidates for kidney transplantation, and 3) those who received multi-organ transplantation. As wealth status is reported annually, financial status of patients with ESRD was collected and stratified into five

subgroups in each year: the aided group and four other groups according to the percentiles of their medical insurance fee: < 25th percentile, ≥ 25th to < 50th percentile, ≥ 50th to < 75th percentile, and ≥ 75th percentile, which was the group with the highest wealth.

Study outcomes

The financial status of the study population was identified each year; thus, kidney transplant recipients could have a different economic status at the time of ESRD diagnosis and the time of receiving the kidney transplant. Therefore, to assess kidney transplantation accessibility, incidence proportions and odds ratios of transplant among prevalent ESRD patients in each year cohort were presented to represent the kidney accessibility in the year, rather than using a time-to-event analysis. In addition, to account the effect of patients who have significant comorbidities that preclude transplant, as they would remain in the prevalent ESRD population, we additionally investigated the ratios of number of incident transplantation to number of incident ESRD cases in each year.

The post-transplant prognosis according to income level was also analyzed among those who received kidney transplantation during the study period. The main study outcome was death-censored graft failure (DCGF). Patient mortality and graft failure, which was determined from DCGF and mortality, were also extracted. As inclusion into the study was limited to 2007–2015, the last follow-up date was December 31, 2016, to include at least 1 year of follow-up. Follow-up was censored at the date of death or DCGF.

Data collection

Characteristics of patients with ESRD or transplant recipients were collected in each year cohort. Patients' wealth status and number of household members were collected. The following clinical characteristics were also collected; age, sex, previous/current main dialysis method, duration of dialysis. Region of residence and hospitals has been categorized as urban

or rural, and the urban region included the capital area and metropolitan cities of the nation. Preemptive transplantation was determined when the total dialysis duration before transplantation was less than 3 months or there was no dialysis history before receiving kidney transplant. Previous comorbidities, including hypertension and diabetes mellitus, were identified with the specific ICD-10 diagnostic codes and usage of relevant medications. We considered that history to be present if multiple diagnostic codes or medication prescriptions figured within 3 years prior to each year. Peri-transplant insured medical costs are collected, and the costs included donors' burden for hospitalization during donor nephrectomy as the fees are administratively issued to the recipients' bill.

For transplant recipients, the region in the nation they received renal transplantation and whether they received desensitization therapy, rituximab treatment or plasmapheresis, were additionally collected. The compliance with maintenance immunosuppressants—cyclosporine, tacrolimus, corticosteroids, and mycophenolic acid—was assessed by medication possession ratio (MPR) within 1 year, which was calculated as below.

$$\text{MPR} = \frac{Total\ medication\ supplied\ days}{Last\ fill\ date\ -\ first\ fill\ date\ +\ last, fill\ day's\ supply}$$

An MPR below 95% was defined as poor compliance state, and as MPR is a time-dependent variable that decreases with a longer follow-up duration, one-year MPR was used.

Statistical analysis

Continuous variables are presented as median [interquartile ranges] values and categorical variables are presented as numbers (percentage). Kaplan-Meier survival curves were plotted with P values calculated with the log-rank method. Multivariable regression analysis was used to investigate the study outcomes with adjustment for other clinical characteristics. The logistic regression analysis to assess kidney transplantation accessibility was were adjusted for age,

sex, region of residence (urban or rural), baseline hypertension, and diabetes mellitus. When analyzing post-transplant prognosis outcomes, Cox regression analysis was adjusted for age, sex, region of residence (urban or rural), comorbidity of hypertension, diabetes mellitus, duration of dialysis before transplantation, previous dialysis method, and desensitization treatment history. Supplemental multivariable models were adjusted for some of the variables included in the above full-adjusted model, considering the statistical powers, and at least for age and sex. There was no missing information in the studied data. All statistical analyses were performed using the R program (the R foundation, version 3.4.2), and two-sided P values <0.05 were considered to indicate statistical significance.

Results

Study population

Approximately 30,000–40,000 patients with ESRD aged < 70 years were identified each year from 2007–2015 in the national claims database of Korea, which includes information for all insured medical fees among the total Korean population (Figure 1). The trend in the number of patients with ESRD steadily increased (Supplementary Table 1, SDC, http://links.lww.com/TP/B921). The aided group, the poorest group who received government aid for their medical insurance fee, comprised 22.8%–29.9% of the total participants. The number of new kidney transplantation cases was 820 in 2007; this increased until it reached 1,755 cases in 2015. A total of 12,564 kidney transplantation cases were included in the study.

Demographic and clinical characteristics of the transplant recipients

Among the transplant recipients (Table 1), the most common age decile was the 40s, with 58.9% being male patients. The proportion of recipients with past history of diabetes mellitus prior to transplantation was 33.1% and that with hypertension was 92.1%. The aided group had the lowest median age, and they comprised the largest proportion of one-person households

and rural residence. Preemptive transplantation was more common in those with wealthier economic status, whereas transplantation after ≥ 5 years was more common in the poorer group.

Accessibility to transplantation in ESRD patients

The incidence proportion of kidney transplantation was 25.48/1,000 ESRD patients in 2007, and an increasing trend was observed until 2015 (Figure 2). The incidence proportion was in the same sequence as the wealth hierarchy. The incidence proportion of transplantation in the richest group was 63.72/1,000 ESRD patients in 2015, which was more than triple the incidence in the aided group (18.53/1,000 ESRD patients). When the ratios of number of incident transplantation to ESRD cases were investigated, the richest population had the highest ratios among the studied subgroups throughout the year, and the gap was even widened from the year 2011. These results remained similar when adjusted for age, sex, region of residence, hypertension, and diabetes mellitus, and the odds ratio for kidney transplantation progressively decreased in the poorer group when compared to the richest group (Supplementary Figure 1, SDC, http://links.lww.com/TP/B921). Moreover, this inequality was even more evident when only preemptive transplantation was considered; the aided group showed the least accessibility to preemptive transplantation.

Types of transplantation

The proportion of patients with preemptive transplantation was similar among those in the ≥ 26th wealth percentile, but it prominently decreased in those in the 1st–25th percentile (Figure 3). The aided group had the lowest proportion of preemptive transplantation during the study period, and this gap increased in the latter years in the study period. Desensitized transplantation was introduced in South Korea in earnest in 2010, and its frequency prominently increased in those with higher wealth status. The number of transplantations with previous dialysis duration ≥ 5 years increased in all subgroups, but when proportions were

considered, the aided group showed a clearly higher proportion of patients who received transplantation after prolonged previous dialysis than the other subgroups. After 2013, more than 70% of the transplantation cases in the aided group were performed after ≥ 5 years of dialysis; this proportion was more than double the rate among the richest transplant recipients.

Apart from the economic inequality, transplantation within 1 year from initiation of dialysis or preemptive transplantation was associated with better prognosis, while transplantation after ≥ 5 years of dialysis was associated with poor prognosis (Supplementary Table 2, SDC, http://links.lww.com/TP/B921).

Post-transplant prognosis according to wealth status

The risk of DCGF was highly associated with the economic gradient, as patients in the richer groups had better post-transplant prognosis (Table 2 and Figure 4). The aided group had approximately > 30% increased adjusted hazards with respect to the DCGF and graft failure outcomes and > 60% higher death hazards when compared to the highest income group. When we assessed the time trends (Supplementary Figure 2, SDC, http://links.lww.com/TP/B921), the disparity of DCGF outcome according to economic hierarchy existed in the earlier years of the study period but showed an increasing trend; a similar finding was observed when analysis was limited to preemptive transplantation. Within the aided group, a significantly worsening trend of prognosis through the study period was shown. In contrast, among those with better economic status, recent prognoses improved over the study period (Supplementary Table 3, SDC, http://links.lww.com/TP/B921).

Medication compliance

Median one-year MPR was > 100% in all study subgroups regarding major immunosuppressants; however, the proportion of kidney transplant recipients achieving one-year MPR ≥ 95% was smaller in the aided group with respect to cyclosporine, tacrolimus,

corticosteroids, and mycophenolic acid (Supplementary Table 4, SDC, http://links.lww.com/TP/B921). However, when time trends of 1-year compliance with maintenance immunosuppressive agents was examined, possible poor compliance was not observed in the aided group during the later years of the study period, and the overall improvement reached MPR ≥ 95% in the recent years (Supplementary Figure 3, SDC, http://links.lww.com/TP/B921).

Transplant-related fee

With respect to insured medical fees, the median costs borne by the NHIS during the peri-transplant period steadily increased during the study period (Figure 5). The median insured medical fee paid by each patient showed a decreasing tendency from 2007 before slightly increasing in the latter years. For the aided group, the fee was waived among the insured costs during the peri-transplantation periods.

Discussion

Using national data from a country with universal health insurance, the present study identified that poor patients with ESRD had lower accessibility to kidney transplantation. Compared to patients with better economic status, patients with ESRD and poorer economic status received less benefit overall from the expansion of the donor pool that resulted from the newly introduced desensitization strategy. Furthermore, the aided group had worse post-transplant prognosis than the richest group, and the disparity became prominent in the latter years of the study period.

Socioeconomic inequalities in accessibility to or prognosis of kidney transplantation has been previously recognized as an important issue.[4,7,8,10,19] Studies in the United States or European countries have shown that the socioeconomic gradient was a critical factor in determining the accessibility to transplantation and the likelihood of being on a waiting list.[4,7,20,21] Post-

transplant prognosis was also suggested to be poor among those with socioeconomic deprivation, and wealth disparity has been found to be a more strongly associated factor than educational levels for post-transplant prognosis [8-12]. Although some findings are controversial,[13,14] there is some consensus that difficulty in paying the required fee, poor medical compliance, or relatively low educational attainment are the underlying factors responsible for socioeconomic inequality in the kidney transplant era. However, rare previous studies have assessed changes in time trends of disparities.

Strengths of the present study include the following: 1) the study data was comprised of complete nationwide kidney transplantation events; 2) the study was conducted in South Korea, where universal health insurance is provided with additional support for the poorest group; and 3) the findings demonstrate a widening gap in accessibility and prognosis after desensitization therapy was introduced and insurance coverage had been expanded. Additionally, the results show that economic inequality, which itself has been reported to be widening in South Korea,[22,23] is also an important issue in kidney transplantation in one of the most developed Asian countries. Moreover, the increased gap in accessibility to and prognosis of kidney transplantation during the latter years suggests that limited access to safer transplantation could hinder patients with ESRD and poor financial status from enjoying the health benefits of kidney transplantation.

The study showed that poor ESRD patients have a lower possibility of receiving transplantation compared with rich ESRD patients, and this may be explained by several reasons. First, availability of potential living donors might have been limited in the poor group, [24] which is largely affected by socioeconomic factors.[4,6,7,20,24] In our study, after the desensitization therapy has been widely introduced, the number of desensitized kidney transplantation, which would be mostly transplantation from living donors, was prominently

increased in the richer groups. However, the aided group received lower number of desensitized transplantation although they were waived for the related financial burden than the other groups. This may be related to the limited number of potential living donors, who are most likely to be household members, among the poor, as more than 50% of the aided group consisted of one-person households and a lower number of household members were identified among the poor.

The above hypothesis can be supported by the data from KONOS (KOrean Network for Organ sharing),[25] as the trends of living donor transplantation resembled the trends of preemptive transplantation cases in our study. Second, the financial burden might have been still a significant hurdle for kidney transplantation. Namely, although the approximate median non-insured fee for transplantation was $ 6,000, which consists a small portion of the total cost, even this burden could not have been affordable for the aided group. In addition, donor-related costs might have prohibited poor donors to actively participate in kidney donation. As the disparity has been worsening, an expansion of coverage for essential non-insured services or reimbursement for donors may be considered to prevent further aggravation in Korea. Third, the medical behavior of the patients and clinicians might different according to patients' economic status. Possibly because of their poor education level, the poor ESRD patients may less likely to actively seek the possibility of kidney transplantation. In addition, it is also possible that clinicians may hesitate to recommend kidney transplantation for those with poor economic status, worrying for medication compliances and post-transplant care. As the disparity was prominent, additional efforts to educate or inform the poor patients may be considered.

The present study also found that kidney transplant recipients with poorer economic status showed worse post-transplant prognosis than those with better financial status. This gap widened in the latter years of the study period, after the desensitized transplantation had been actively introduced in Korea. This may imply that different accesses to safer living donors also resulted in disparities in post-transplant prognosis because after the desensitization therapy introduction, living donor transplantation, or preemptive transplantation, became more available to rich patients as they had higher number of household members. However, as the difference remained significant even after adjusting for previous dialysis duration or method, including whether the transplantation was preemptive, transplantation patients who have lower income might carry additional distinct risks.[4,10,11,26] The larger proportion of patients in the aided group who showed poor medication compliance, which might be related to education level or other social factors, cannot solely explain this result, as differences in regard to compliance lessened in the latter years of the study period. South Korea is one of the few countries globally that provides maintenance immunosuppressive agents or insured medical services nearly free of cost for the poorest aided group. Therefore, financial hurdles, even if present, would have had minimal effects on post-transplant prognosis. In contrast, other medical behaviors, such as understanding of post-transplant care, hygiene, or early visit to clinics when complication occurred might have played a certain role in this disparity of prognosis. Future studies should investigate this finding of worse post-transplantation prognoses among the poor; in particular, importance may need to be given to the education level or medical behavior of patients.

There are several limitations of this study. Firstly, non-insured medical services are not included in the NHIS database; therefore, exact "out-of-pocket" spending or medical services performed outside of the insurance system could not be analyzed. Secondly, although the social

trends of economic disparity in kidney transplantation in South Korea were demonstrated, detailed health status, waiting list data, or other socioeconomic variables, including education, were not collected. Additionally, detailed donor information was unidentifiable in the NHIS data, as expenses from the donors' side were covered in the recipients' bill. A further study including additional information, particularly donor types, may reveal additional disparity in the transplantation field. Thirdly, issues of economic disparity differ according to national medical insurance systems and social environments; therefore, the findings of the present study may not be generalizable to other countries. Potential changes to policy to manage the increasing gap identified in this study are warranted, but policies will vary according to the available medical resources and economic situation of individual countries.

In conclusion, economic disparities regarding accessibility to and prognosis of kidney transplantation were identified and found to be increasing in South Korea. Although the introduction of desensitization strategy would have expanded the potential donor pool, disparities in accessibility still became a major issue. Patients with ESRD and lower economic status may receive less benefit from medical advances in kidney transplantation.

References

1. Wolfe RA, Ashby VB, Milford EL, et al. Comparison of mortality in all patients on dialysis, patients on dialysis awaiting transplantation, and recipients of a first cadaveric transplant. *N Engl J Med.* 1999;341:1725-1730.
2. Mange KC, Weir MR. Preemptive renal transplantation: why not? *Am J Transplant.* 2003;3:1336-1340.
3. Lamb KE, Lodhi S, Meier-Kriesche HU. Long-term renal allograft survival in the United States: a critical reappraisal. *Am J Transplant.* 2011;11:450-462.
4. Axelrod DA, Dzebisashvili N, Schnitzler MA, et al. The interplay of socioeconomic status, distance to center, and interdonor service area travel on kidney transplant access and outcomes. *Clin J Am Soc Nephrol.* 2010;5:2276-2288.
5. Gill J, Dong J, Gill J. Population income and longitudinal trends in living kidney donation in the United States. *J Am Soc Nephrol.* 2015;26:201-207.
6. Gill J, Dong J, Rose C, Johnston O, Landsberg D, Gill J. The effect of race and income on living kidney donation in the United States. *J Am Soc Nephrol.* 2013;24:1872-1879.
7. Kasiske BL, London W, Ellison MD. Race and socioeconomic factors influencing early placement on the kidney transplant waiting list. *J Am Soc Nephrol.* 1998;9:2142-2147.
8. Tjaden LA, Noordzij M, van Stralen KJ, et al. Racial Disparities in Access to and Outcomes of Kidney Transplantation in Children, Adolescents, and Young Adults: Results From the ESPN/ERA-EDTA (European Society of Pediatric Nephrology/European Renal Association-European Dialysis and Transplant Association) Registry. *Am J Kidney Dis.* 2016;67:293-301.
9. Goldfarb-Rumyantzev AS, Koford JK, Baird BC, et al. Role of socioeconomic status in kidney transplant outcome. *Clin J Am Soc Nephrol.* 2006;1:313-322.

10. Begaj I, Khosla S, Ray D, Sharif A. Socioeconomic deprivation is independently associated with mortality post kidney transplantation. *Kidney Int.* 2013;84:803-809.

11. Butkus DE, Dottes AL, Meydrech EF, Barber WH. Effect of poverty and other socioeconomic variables on renal allograft survival. *Transplantation.* 2001;72:261-266.

12. Nee R, Jindal RM, Little D, et al. Racial differences and income disparities are associated with poor outcomes in kidney transplant recipients with lupus nephritis. *Transplantation.* 2013;95:1471-1478.

13. Ward FL, O'Kelly P, Donohue F, et al. Influence of socioeconomic status on allograft and patient survival following kidney transplantation. *Nephrology (Carlton).* 2015;20:426-433.

14. Laging M, Kal-van Gestel JA, van de Wetering J, JN IJ, Weimar W, Roodnat JI. Understanding the influence of ethnicity and socioeconomic factors on graft and patient survival after kidney transplantation. *Transplantation.* 2014;98:974-978.

15. Jin DC, Yun SR, Lee SW, et al. Current characteristics of dialysis therapy in Korea: 2016 registry data focusing on diabetic patients. *Kidney Res Clin Pract.* 2018;37:20-29.

16. Cheol Seong S, Kim YY, Khang YH, et al. Data Resource Profile: The National Health Information Database of the National Health Insurance Service in South Korea. *Int J Epidemiol.* 2017;46:799-800.

17. Park JI, Baek H, Jung HH. Prevalence of Chronic Kidney Disease in Korea: the Korean National Health and Nutritional Examination Survey 2011-2013. *J Korean Med Sci.* 2016;31:915-923.

18. National Health Insurance Service. National Health Insurance System Survey for Medical Expenses. Republic of Korea 2010, 2011, 2012, 2013, 2015.

19. Choi Y, Shin J, Park JT, Cho KH, Park EC, Kim TH. Disparities in Kidney Transplantation Access among Korean Patients Initiating Dialysis: A Population-Based Cohort Study Using National Health Insurance Data (2003-2013). *Am J Nephrol.* 2017;45:32-39.

20. Zhang Y, Gerdtham UG, Rydell H, Jarl J. Socioeconomic Inequalities in the Kidney Transplantation Process: A Registry-Based Study in Sweden. *Transplant Direct.* 2018;4:e346.

21. Roodnat JI, Laging M, Massey EK, et al. Accumulation of unfavorable clinical and socioeconomic factors precludes living donor kidney transplantation. *Transplantation.* 2012;93:518-523.

22. Chesters J. Trends in economic growth and levels of wealth inequality in G20 nations: 2001–2013. *Contemporary Social Science.* 2016;11:270-281.

23. An C-B, Bosworth B. *Income Inequality in Korea - An Analysis of Trends, Causes, and Answers.* Vol 354. 1 ed: Harvard University Asia Center; 2013.

24. Kasiske BL, Snyder JJ, Matas AJ, Ellison MD, Gill JS, Kausz AT. Preemptive kidney transplantation: the advantage and the advantaged. *J Am Soc Nephrol.* 2002;13:1358-1364.

25. KONOS (Korean Network for Organ Sharing). 2017 annual report for organ transplantation and human tissue donation (Korean). 2017.

26. Woodward RS, Page TF, Soares R, Schnitzler MA, Lentine KL, Brennan DC. Income-related disparities in kidney transplant graft failures are eliminated by Medicare's immunosuppression coverage. *Am J Transplant.* 2008;8:2636-2646.

Figure legends

Figure 1. Study population. The cohorts that assessed accessibility to transplantation was constructed in each year, as wealth status changed every year. Each cohort included prevalent ESRD patients including those who received dialysis or transplantation. The transplant recipients were separately analyzed for their prognosis. ESRD = end-stage renal disease.

Figure 2. Incidence proportion according to wealth hierarchy. Incidence proportion was calculated as incident transplantation among prevalent ESRD patients (including dialysis and transplantation) in each year. The aided group was the poorest subgroup, while the 76-100th percentile was the richest subgroup.

Figure 3. Types of transplantation according to wealth hierarchy. Numbers and proportions of desensitized, preemptive, and after 5 years of dialysis-transplantation are shown. The aided group was the poorest subgroup, while the 76-100th percentile was the richest subgroup.

Figure 4. Graft survival according to wealth hierarchy. Kaplan-Meier survival curve showing the graft failure outcome is presented. The y-axis indicates the cumulative graft survival, and the x-axis indicates the time (years). The aided group was the poorest subgroup, while the 76-100th percentile was the richest subgroup.

Figure 5. Median costs burdened by the national health insurance service (NHIS) or by the patients during peri-transplant period. The y-axes indicate the median fee. The aided group was mostly waived for patient burden. Non-insured medical service expenses were not included in the current data. NHIS = national health insurance system.

Table 1. Baseline characteristics of the kidney transplant recipients included in the study.

	Total	Aided (the poorest)	1-25th	26-50th	51-75th	76-100th (the richest)
Number of patients	12,564	1,618	1,929	2,053	2,819	4,145
Age (years)	47 (37-54)	44 (37-50)	46 (35-54)	46 (34-54)	46 (36-54)	49 (41-56)
< 10	82 (0.7)	10 (0.62)	13 (0.7)	10 (0.5)	21 (0.7)	28 (0.68)
≥ 10 and < 20	322 (2.6)	52 (3.2)	49 (2.5)	34 (1.7)	72 (2.6)	115 (2.8)
≥ 20 and < 30	984 (7.8)	98 (6.1)	229 (11.9)	242 (11.8)	194 (6.9)	221 (5.3)
≥ 30 and < 40	2,399 (19.1)	375 (23.2)	367 (19.0)	472 (23.0)	668 (23.7)	517 (12.5)
≥ 40 and < 50	3,582 (28.5)	644 (39.8)	496 (25.7)	491 (23.9)	736 (26.1)	1,215 (29.3)
≥ 50 and < 60	3,818 (30.4)	376 (23.2)	583 (30.2)	622 (30.4)	780 (27.7)	1,457 (35.2)
≥ 60 and < 70	1,377 (11.0)	63 (3.9)	192 (10.0)	182 (8.8)	348 (12.3)	592 (14.3)
Male sex	7,420 (59.1)	952 (58.8)	1,134 (58.8)	1,183 (57.6)	1,626 (57.7)	2,525 (60.9)
Region of residence						
Urban	8968 (71.4)	1083 (66.9)	1351 (70.0)	1463 (71.3)	2075 (73.6)	2996 (72.3)
Rural	3596 (28.6)	535 (33.1)	578 (30.0)	590 (28.7)	744 (26.4)	1149 (27.7)
Region of hospital						
Urban	12032 (95.8)	1500 (92.7)	1841 (95.4)	1961 (95.5)	2704 (95.9)	4026 (97.1)
Rural	532 (4.2)	118 (7.3)	88 (4.6)	92 (4.5)	115 (4.1)	119 (2.9)
Number of household member						
1	3,020 (24.0)	885 (54.7)	880 (45.6)	519 (25.3)	418 (14.8)	318 (7.7)
2	2,084 (16.67)	274 (16.9)	283 (14.7)	402 (19.6)	489 (17.3)	636 (15.3)
3	2,857 (22.7)	211 (13.0)	323 (16.7)	505 (24.6)	755 (26.8)	1,063 (25.6)
≥ 4	4,603 (36.6)	248 (15.3)	443 (23.0)	627 (30.5)	1,157 (41.0)	2,128 (51.3)
Comorbidity						
Hypertension	11,582 (92.1)	1,231 (76.0)	1,806 (93.6)	1937 (94.4)	2,655 (94.2)	3,953 (95.4)
Diabetes mellitus	4,258 (33.9)	481 (29.7)	713 (37.0)	694 (33.8)	915 (32.5)	1,455 (35.1)
Previous dialysis						
Preemptive	4,181 (33.3)	102 (6.3)	559 (29.0)	768 (37.4)	1,075 (38.1)	1,677 (40.5)
Hemodialysis	5,335 (42.5)	995 (61.5)	873 (45.3)	844 (41.1)	1,103 (39.1)	1,520 (36.7)
Peritoneal dialysis	1,956 (15.6)	315 (19.5)	316 (16.4)	285 (13.9)	407 (14.4)	633 (15.3)
Mixed	1,092 (8.7)	206 (12.7)	181 (9.4)	156 (7.6)	234 (8.3)	315 (7.6)
Dialysis duration (years)						
< 1	5,393 (42.9)	196 (12.1)	731 (37.9)	973 (47.4)	1,373 (48.7)	2,120 (51.1)
≥ 1 and < 2	1,100 (8.8)	173 (10.7)	175 (9.1)	175 (8.5)	231 (8.2)	346 (8.3)
≥ 2 and < 3	872 (6.9)	171 (10.6)	130 (6.7)	145 (7.0)	155 (5.5)	271 (6.5)
≥ 3 and < 4	859 (6.8)	189 (11.7)	147 (7.6)	106 (5.2)	196 (7.0)	221 (5.3)
≥ 4 and < 5	925 (7.4)	176 (10.9)	149 (7.7)	134 (6.5)	180 (6.4)	286 (6.9)
≥ 5	3,415 (27.2)	713 (44.1)	597 (30.9)	520 (25.3)	684 (24.3)	901 (21.7)
Desensitization	790 (6.3)	46 (2.8)	111 (5.8)	138 (6.7)	189 (6.7)	306 (7.4)
Plasmapheresis	310 (2.5)	17 (1.1)	50 (2.6)	59 (2.9)	67 (2.4)	117 (2.8)
Rituximab	744 (5.9)	44 (2.7)	102 (5.3)	133 (6.5)	179 (6.4)	286 (6.9)

The continuous variables are described as median (interquartile range) values, and the categorical variables are shown as number (percentage) values. The study population was stratified into 5 subgroups; the aided group, those received government aid for their health insurance fee, and 4 subgroups graded by their insurance fee percentiles. There was no missing information in the collected data.

Table 2. Post-transplant prognosis according to wealth hierarchy.

	Outcome N (%)	HR (95% CI)	P	[a]Adjusted HR (95% CI)	P
DCGF					
Aided (the poorest)	415 (25.6)	1.62 (1.43-1.83)	< 0.001	1.31 (1.15-1.49)	< 0.001
1-25th	364 (18.9)	1.25 (1.10-1.42)	< 0.001	1.14 (1.00-1.30)	0.04
26-50th	393 (19.1)	1.24 (1.10-1.41)	< 0.001	1.20 (1.06-1.36)	0.004
51-75th	512 (18.2)	1.17 (1.04-1.31)	0.009	1.14 (1.02-1.28)	0.02
76-100th (the richest)	659 (15.9)	Reference		Reference	
Mortality					
Aided (the poorest)	112 (6.9)	1.41 (1.12-1.78)	0.001	1.62 (1.26-2.08)	< 0.001
1-25th	108 (5.6)	1.26 (1.00-1.60)	0.05	1.39 (1.10-1.76)	0.007
26-50th	81 (3.9)	0.85 (0.66-1.11)	0.23	1.01 (0.78-1.31)	0.94
51-75th	124 (4.4)	0.95 (0.76-1.19)	0.65	1.08 (0.87-1.36)	0.48
76-100th (the richest)	194 (4.7)	Reference		Reference	
Graft failure					
Aided (the poorest)	496 (30.7)	1.61 (1.44-1.80)	< 0.001	1.33 (1.18-1.50)	< 0.001
1-25th	447 (23.2)	1.27 (1.13-1.43)	< 0.001	1.19 (1.06-1.34)	0.003
26-50th	452 (22.0)	1.18 (1.05-1.32)	0.005	1.18 (1.05-1.32)	0.006
51-75th	610 (21.6)	1.15 (1.04-1.28)	0.009	1.16 (1.04-1.29)	0.007
76-100th (the richest)	797 (19.2)	Reference		Reference	

HR = hazard ratio, CI = confidence interval, DCGF = death-censored graft failure
The study population was stratified into 5 subgroups; the aided group, those received government aid for their health insurance fee, and 4 subgroups graded by their insurance fee percentiles.
[a]Adjusted with age, sex, region of residence (urban or rural), comorbidity of hypertension, diabetes mellitus, duration of dialysis before transplantation, previous dialysis method, and desensitization treatment history.

Figure 1

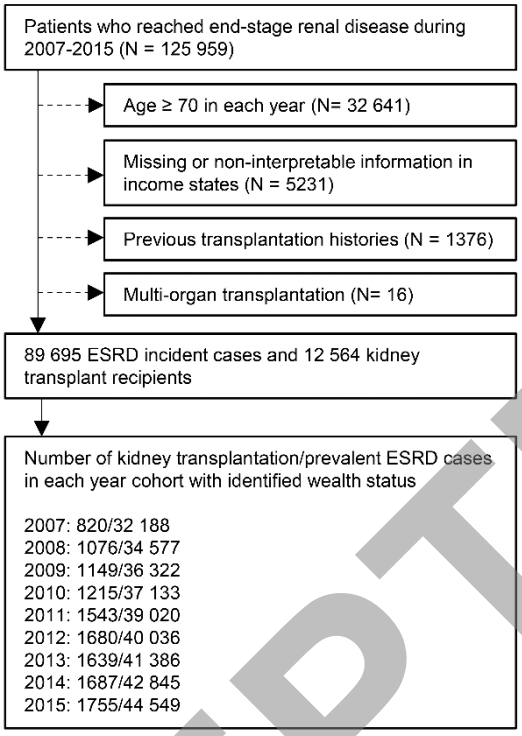

Figure 2

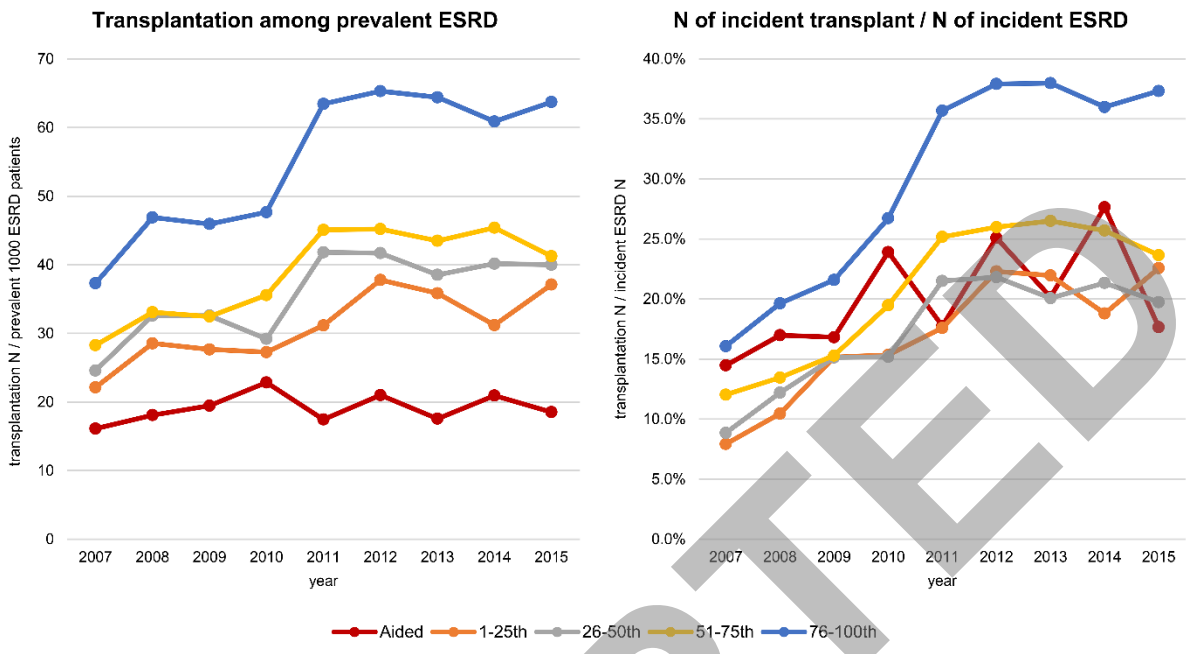

Figure 3

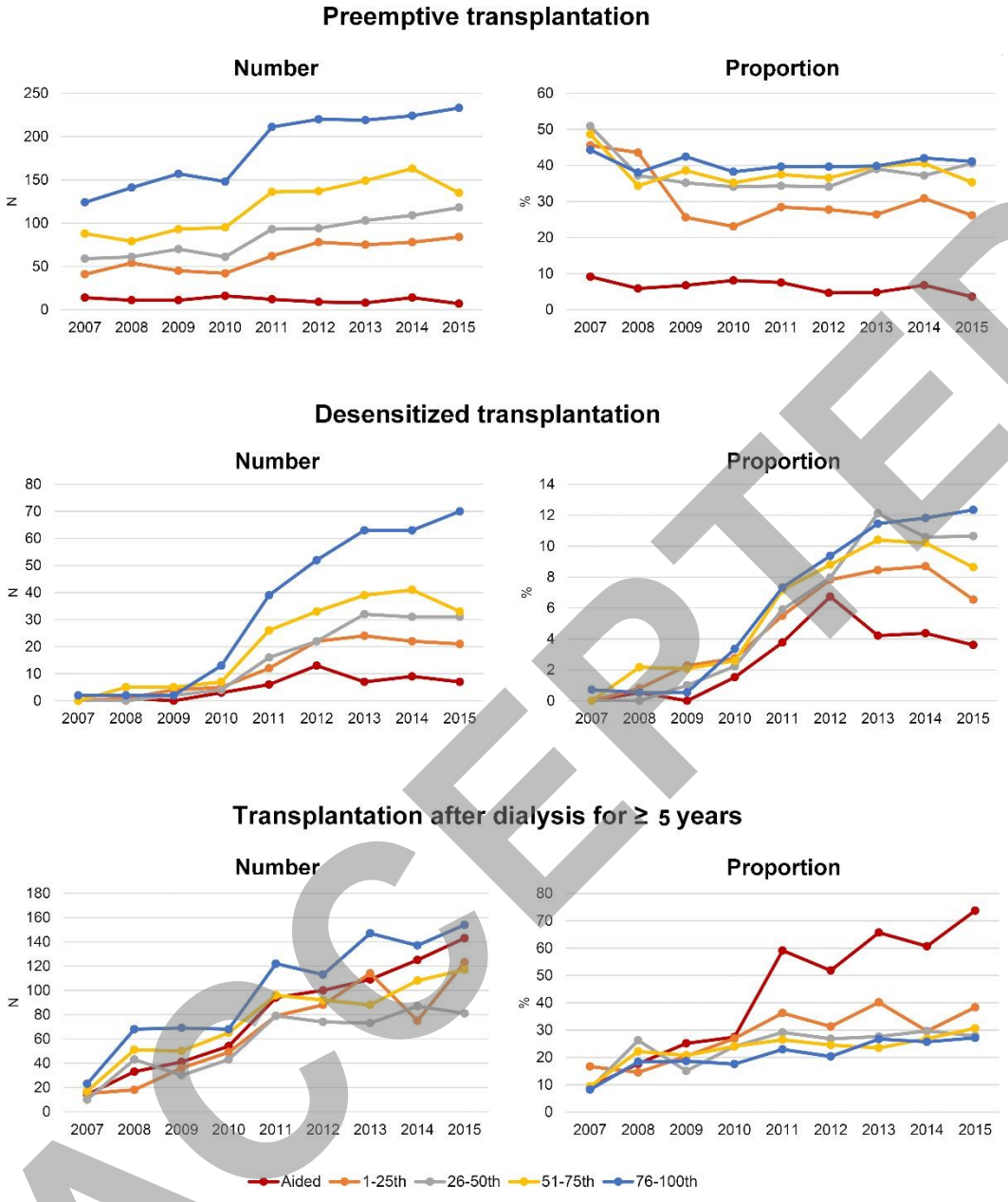

Figure 4

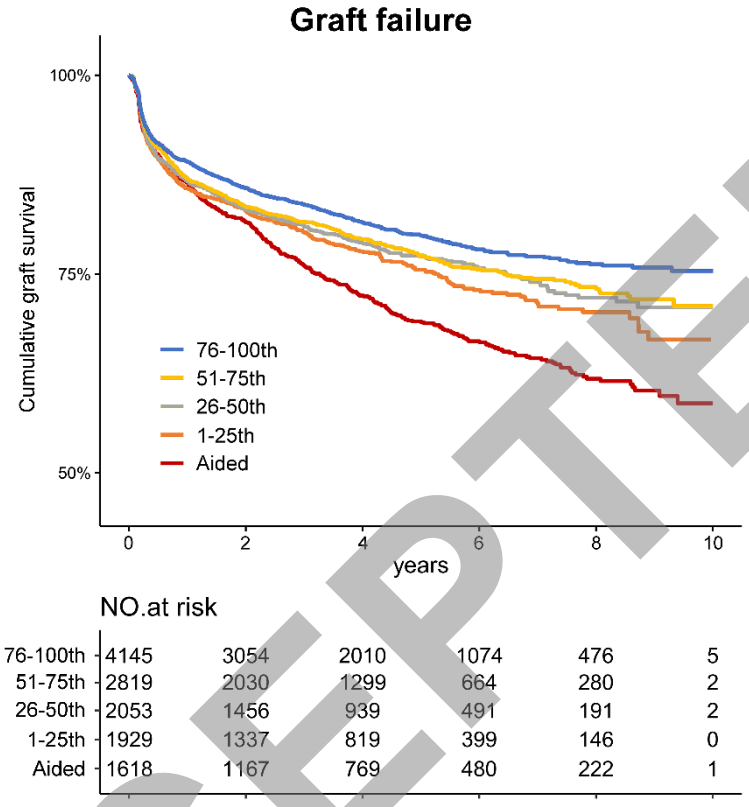

Figure 5