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Demographic, psychosocial and health disparities between living and deceased renal allograft recipients in Switzerland

Achermann Rita[a*], Koller Michael[a*], De Geest Sabina[bc], Hadaya Karine[d], Müller Thomas F.[e], Huynh-Do Uyen[f], Pascual Manuel[g], Steiger Jürg[a], Kiss Alexander[h], Binet Isabelle[i] for the Psychosocial Interest Group and the Swiss Transplant Cohort Study

[a] Transplantation Immunology and Nephrology, University Hospital Basel, Switzerland
[b] Institute of Nursing Science, University of Basel, Switzerland
[c] Department of Public Health and Primary Care, Academic Centre for Nursing and Midwifery, KU Leuven, Belgium
[d] Division of Transplantation and Nephrology, University of Geneva Hospitals, Switzerland
[e] Division of Nephrology, University Hospital Zurich, Switzerland
[f] Division of Nephrology and Hypertension, University Hospital Bern Inselspital, Bern, Switzerland
[g] Transplantation Centre, Centre Hospitalier Universitaire Vaudois and University of Lausanne, Switzerland
[h] Department of Psychosomatic Medicine, University Hospital Basel, Switzerland
[i] Nephrologie/Transplantationsmedizin, Kantonsspital St. Gallen, Switzerland

Summary

BACKGROUND: Living donor renal transplantation is widely performed in Switzerland with a superior long-term outcome and lower waiting time compared with deceased renal transplantation. However the chances of receiving a living donor kidney transplant are not the same for all transplant candidates. The current study aimed to identify psychosocial and demographic characteristics that predict lower access to living kidney donation in Switzerland.

METHODS: The study was a nationwide multicentre study nested within the Swiss Transplant Cohort Study. Pre-transplant demographic, psychosocial and health characteristics of 1126 deceased and 859 living renal transplant recipients were compared using logistic regression analysis.

RESULTS: Transplant candidates with higher age (odds ratio [OR] per 10 years 0.67, 95% confidence interval [CI] 0.60–0.74), lower education (OR 0.46, 95% CI 0.36–0.59), a work capacity of less than 50% (OR 0.48, 95% CI 0.35–0.66), single or formerly married (OR 0.38, 95% CI 0.26–0.53 / OR 0.37, 95% CI 0.26–0.53) or with a higher hospital depression score (OR per 5 points 0.61, 95% CI 0.50–0.74) were less likely to receive an allograft from a living donor. In some regions of Switzerland candidates were more likely to undergo living transplantation than in other regions. No association was found with gender or income.

CONCLUSIONS: Interventions to increase access to kidney transplantation from living donors should target transplant candidates of older age, lower education, lower working capacity and not living in a committed relationship. The observed regional differences suggest that additional determinants of living donation may play a role such as population and health professional attitudes toward living donation.

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Joint first authors

Correspondence:
Rita Achermann, Msc Biostatistics, University Hospital Basel, Universitatsspital Basel, Petersgraben 4, CH-4056 Basel, rita.achermann[at]usb.ch Author contributions
AK and MK designed the study proposal. AK, MK, IB, SdG and the psychosocial group of interest of the STCS designed the PSQ questionnaire. RA and IB drafted the manuscript. RA conducted the statistical analysis. All authors provided intellectual input, reviewed the article and approved the final version.

Background

Living donor renal transplantation (LDRT) was introduced in Switzerland in the 1960s [1] and accounted for 32% of all renal transplantations in 2018; 47% of all kidney donors in 2018 were living donors [2], corresponding to 11.3 donations per million population (pmp) [3]. Northern European countries and the United Kingdom have similar rates, the Netherlands is much higher at 29.0 ppm, but most other European countries have lower rates of between 5 and 10 pmp [3]. LDRT has been shown to result in a lower allograft failure rate than transplantation from deceased donors (DDRT) [4–6] and a long-term systematic follow-up of donors from the Swiss Living Donor Health Registry [7] showed that the risks for a qualified donor are acceptable [1, 8]. The latter result is also supported by a British study that showed that medium-term morbidity and mortality outcomes of live donors in comparison with a healthy cohort suggest that live donation is not associated with excess mortality, end-stage renal disease or morbidity in at least 10 years of follow-up [9].

According to the Swiss transplantation law, living donors must fulfil the following criteria: at least 18 years old, fully informed, free of coercion and capable of giving written consent. Furthermore, a thorough somatic and psychological health assessment must show no serious health risk and a global health assessment compatible with kidney donation. There is no constraint in the law about the relationship between the living donor and the transplant candidate. The principles dealing with various issues of living donation assessment are discussed in depth by the Swiss Academy

of Medical Science and published as medical guidelines [10]. These guidelines are binding for certified doctors in Switzerland. The law forbids any financial gain through living donation. However, the costs for the donors' investigations before donation and for the health follow up after donation are covered by the mandatory health insurance of the recipient.

Transplant candidates who qualify as potential kidney recipients have to be registered on a national waiting list. Transplant candidates without a suitable living donor have to wait for a deceased donation. In 2018, median waiting time was 896 days, the annual mortality of candidates on the waiting list was 1.6% [2]. The waiting list encompassed 1518 candidates, 4.3 times the number of kidney transplantations performed in 2018 (n = 352). If more candidates could benefit from a living donor, the waiting list and waiting time could be reduced. Therefore analysing the psychosocial and demographic characteristics of transplant candidates who have not undergone LDRT in Switzerland could bring insight into the access to LDRT.

Several studies showed that candidates of older age [8, 11–13], lower education [11, 14, 15], lower income [11], not living in a committed relationship [14, 16] and not working [17] are less likely to undergo LDRT. These results do not necessarily hold for Switzerland as they possibly depend on the healthcare system, cultural beliefs and organisation of transplantation at a national level. The aim of this study was to verify whether these findings also apply to Switzerland. In addition, we examined whether further characteristics collected within the Swiss Transplant Cohort Study [18], a nationwide mandatory register for all solid organ transplantations in Switzerland, were associated with a lower incidence of LDRT. This includes the region of the transplant centre as a proxy for cultural attitudes towards LDRT and the way healthcare professionals in- and outside the transplant centres advocate living transplantation and the health status of the transplant candidate at the time of registering on the waiting list operationalized as quality of life and symptoms of depression.

Materials and methods

Study population

The present study was a nationwide multi-centre study nested within the Swiss Transplant Cohort Study (STCS). Since May 2008, the STCS prospectively has enrolled and followed up all solid organ recipients undergoing transplants in Switzerland. For consenting patients, the STCS collects a large variety of clinical, psychosocial, infectious disease and bio-banking data. For non-consenting recipients, the STCS collects a minimal set of transplant outcome data by legal mandate. Recipients are prospectively followed up until death or drop out. Further details regarding data collection and cohort design can be found in Koller et al. [18, 19]. For the present study, 1985 patients with any first single or double kidney transplantation performed between May 2008 and December 2017 were eligible. Patients were excluded if they had transplantation of any organ other than kidney, a re-transplantation within the observation period or were aged less than 18 years. A total of 176 patients who met the inclusion criteria could not be included because they did not consent.

Data collection

Transplant candidates are asked to fill in the STCS psychosocial questionnaire (PSQ) before transplantation, usually at the time of registering on the waiting list. The PSQ covers the EuroQuol EQ-5D-3L questionnaire [20], quality of life measured by visual analogue scale (EQ-VAS) [20], seven items of the hospital anxiety and depression scale related to symptoms of depression (HADS-Depression) [21] and further questions about education, relationship status, work capacity and, since August 2012, household income in CHF per month. These variables are further described by De Geest et al. [22]. Scores for EQ-5D-3L were calculated based on the time-trade-off (TTO) value set of France and on the EQ-5D VAS value set of Europe, as there was no value set available for Switzerland. Individuals showing depressive symptoms were identified based on the cut off values defined in the HADS-Depression scale manual [21]. Higher education was defined as having a qualification to enter university. Additional information such as the cause of the native kidney disease, comorbidities and results of standard clinical examinations were collected at the time of transplantation. For the region, the geographical location of the transplant centre was taken, thus four regions (German 1–4) represented the German- and two regions (French 1, 2) the French-speaking parts of Switzerland. There is no transplant centre in the Italian-speaking region of Switzerland, an area that accounts for 4.2% of the Swiss population. Thus candidates from the Italian region are sent to any of the German or French regions. Reference level for the analysis was set to German 1, the centre with the highest number of total renal transplantations.

Ethics approval

The data collection and their further use for research purposes is covered by the Ethics approval of the STCS by the 'Ethik Kommission beider Basel' (EKBB 351/07).

Statistical analysis

The primary outcome of the study was the type of donation operationalised as living or deceased. Logistic regression was performed to find associations between a set of predefined covariates. This predefined set was then further reduced based on likelihood ratio chi-square tests, and an interaction term between covariate age and work capacity and a transformation of age to a categorical variable was assessed. Multi-collinearity was assessed by inspecting the design matrix and variance inflation factor $GVIF^{(1/2Df)}$ adjusted for the degree of freedom [23]. Confidence intervals (CIs) are based on the profile likelihood method and were compared with bootstrapped intervals (sample size 80% of total number of observations, sampling with replacement). Deviance residuals were inspected visually (R-library arm::binnedplot).

As 428 (21.6%) patients had at least one missing covariate, we used multiple imputation assuming a missing at random mechanism. Pooled estimates from 10 imputed data sets were generated using multivariate imputation by chained equation algorithm (R-library::mice) and Rubin's method and compared with estimates using the complete dataset.

Some patients completed the PSQ questionnaire close to the transplant event. In some LDRT candidates, the transplant event might have already been scheduled at that time,

which could influence the self-assessment of EQ-VAS or HADS-Depression score. Therefore, to assess reliability of the results, we repeated the logistic regression on two subgroups: one with candidates who had completed the questionnaire at least 6 months before transplantation and a second group with candidates who had completed the questionnaire at least 30 days before transplantation. In another sensitivity analysis, we examined whether the estimates for the covariate work capacity change when only working-age individuals were included, hence restricting the analysis to candidates of age between 18 and 65 years.

All analysis were performed using R Statistical Software Version 3.3.3 [24].

Results

In Switzerland, between May 2008 and December 2017, 2161 adults of age 18 or older underwent a first kidney only transplantation. A total of 1985 patients (91.9%) gave informed consent and were included in the present study. Of those, 1126 (56.7%) kidney transplants were from a deceased donor and 859 (43.3%) from a living donor (table 1, fig. 1). Among living donors, unrelated donors (not first-degree relatives) were slightly overrepresented (55.6%) compared with first-degree related donors (44.4%).

Table 1: Socioeconomic, demographic and health characteristics of renal transplant candidates by deceased (DDRT) and living (LDRT) donation.

	DDRT	LDRT
Number of recipients	1126	859
Number of males (%)	694 (61.6%)	579 (67.4%)
Age at transplantation in years, median (IQR)	58 (48–65.75)	52 (40–61)
Region		
German 1	344 (64.5%)	189 (35.5%)
German 2	143 (60.3%)	94 (39.7%)
German 3	101 (65.2%)	54 (34.8%)
German 4	255 (51.6%)	239 (48.4%)
French 1	174 (49.7%)	176 (50.3%)
French 2	109 (50.5%)	107 (49.5%)
Quality of life		
Visual analogue scale (EQ-VAS), mean ± SD	62.8 ± 20.73	62.04 ± 20.28
EQ-5D-3L index score (TTO France), mean ± SD	72.29 ± 28.57	76.11 ± 25.8
EQ-5D-3L index score (VAS Europe), mean ± SD	67.09 ± 20.77	70.46 ± 18.61
HADS-Depression score, mean ± SD	4.71 ± 3.83	3.85 ± 3.06
No cases (score 0–7)	777 (69%)	653 (76%)
Mild cases (score 8–10)	121 (10.7%)	57 (6.6%)
Moderate cases (score 11–14)	63 (5.6%)	25 (2.9%)
Severe cases (score 15–21)	24 (2.1%)	4 (0.5%)
Missing	141 (12.5%)	120 (14%)
Higher education		
Yes	206 (18.3%)	300 (34.9%)
No	811 (72%)	456 (53.1%)
Unknown	109 (9.7%)	103 (12%)
Relationship status		
Living in a relationship	634 (56.3%)	574 (66.8%)
Formerly married	209 (18.6%)	71 (8.3%)
Single	180 (16%)	116 (13.5%)
Unknown	103 (9.1%)	98 (11.4%)
Income (CHF)		
>9000	31 (2.8%)	72 (8.4%)
6001–9000	52 (4.6%)	68 (7.9%)
4501–6000	123 (10.9%)	104 (12.1%)
<4500	301 (26.7%)	132 (15.4%)
Refused	78 (6.9%)	60 (7%)
Unknown	73 (6.5%)	54 (6.3%)
Not recorded*	468 (41.6%)	369 (43%)
Work capacity of individuals aged 18-65 years		
Number of individuals (% of all patients)	828 (73.5%)	721 (83.9%)
– Not working	322 (28.6%)	196 (22.8%)
– 1–50%	207 (18.4%)	126 (14.7%)
– >50	205 (18.2%)	300 (34.9%)
– Missing	94 (8.3%)	99 (11.5%)
Reason for not working		
– Housewife/man	49 (15.2%)	40 (20.4%)
– Illness/invalidity	188 (58.4%)	104 (53.1%)
– Other	61 (18.9%)	30 (15.3%)

HADS = hospital anxiety and depression scale; IQR = interquartile range; SD = standard deviation * Income was recorded only since August 2012.

Demographic characteristics

Older candidates were less likely to undergo LDRT. In the multivariable logistic regression model including 1557 candidates with no missing values, the odds ratio (OR) for age per 10 years increase was 0.67 (95% CI 0.60–0.74, p <0.0001) (table 2). The proportion of LDRT recipients was highest in the age group 26–30 years (65.6%) and decreased steadily with increasing age (fig. 1). At younger age, living donors were most often first-degree relatives, whereas unrelated living donors were more prevalent in older patients. No difference was observed for gender (OR 1.06, 95% CI 0.83–1.35). The proportion of living donation recipients by region varied between 34.8% and 50.3%. In the logistic regression, the overall p-value for the covariate region was <0.0001. Odds ratios for the French regions and one German region, the transplant centres with the highest proportion of living donor transplantations, ranged between 1.86 and 1.96, compared with the reference category, German 1, the region with the highest number of transplantations.

Socioeconomic status

The relationship status was a significant factor for having a LDRT. Not living in a relationship compared with living in a relationship decreased the odds for LDRT, for recipients formerly married to 0.37 (95% CI 0.26–0.53, p <0.0001) and for singles to 0.38 (95% CI 0.26–0.53, p <0.0001). Re-

Figure 1: Number (left) and percentage (right) of deceased and living donors by age group of recipients, n = 1985. The group of living donors is further split into donor related (first-degree relatives) and unrelated donors.

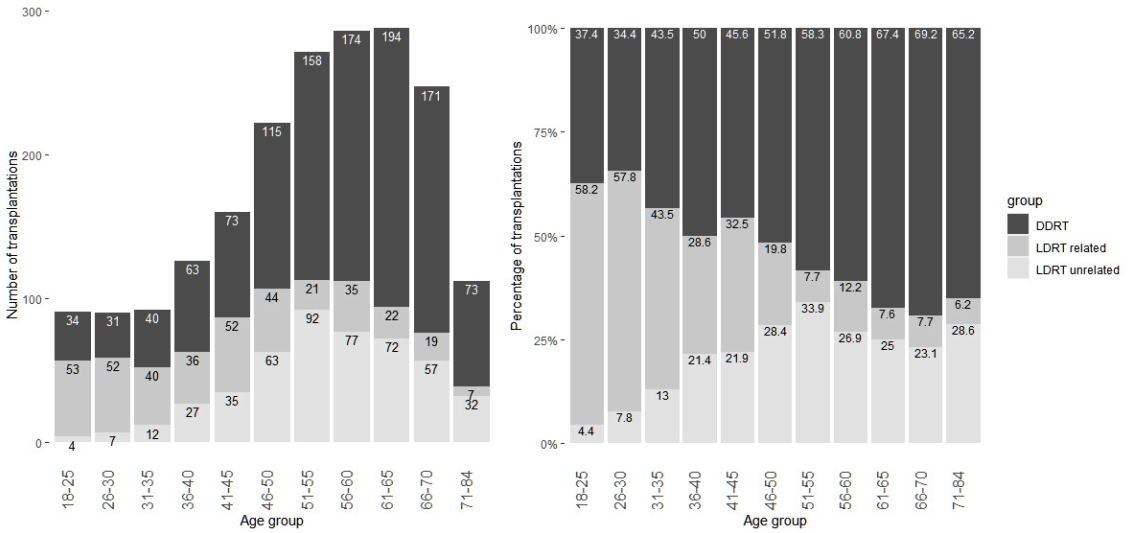


Table 2: Odds ratios, 95% confidence intervals (CIs) of multivariable and univariate logistic regression with outcome living donor renal transplant on complete data set (n = 1558).

Covariate	Level	Multivariable		Univariate
		Odds ratio (95% CI)	p-value	Odds ratio (95% CI)
Intercept		70.28 (29.25–172.52)	<0.0001	
Age at time of transplant (per 10 years)		**0.67 (0.60–0.74)**	**<0.0001**	0.73 (0.67–0.79)
Gender	Male vs female	1.06 (0.83–1.35)	**0.6442**	1.27 (1.03–1.57)
Relationship status	**Formerly married vs living relationship**	**0.37 (0.26–0.53)**	**<0.0001**	0.37 (0.26–0.5)
	Single vs living relationship	**0.38 (0.26–0.53)**	**<0.0001**	0.73 (0.55–0.96)
Higher education	**No vs yes**	**0.46 (0.36–0.59)**	**<0.0001**	0.41 (0.33–0.52)
Working capacity	**1–50% vs >50%**	**0.48 (0.35–0.66)**	**<0.0001**	0.43 (0.32–0.57)
	0% vs >50%	**0.51 (0.38–0.67)**	**<0.0001**	0.39 (0.31–0.5)
Income CHF >6000 per month	No vs yes	0.81 (0.57–1.14)	0.2261	0.66 (0.49–0.9)
	Unknown / not recorded vs yes	0.87 (0.62–1.23)	0.4269	0.74 (0.54–1)
HADS-Depression score (per 5 points)		**0.61 (0.50–0.74)**	**<0.0001**	0.68 (0.59–0.79)
EQ-VAS (per 10 points)		**0.87 (0.81–0.93)**	**<0.0001**	0.98 (0.93–1.03)
Cardiopulmonary disease	Yes vs no	0.95 (0.74–1.21)	0.6572	0.61 (0.5–0.74)
Diabetes	Yes vs no	0.98 (0.7–1.36)	0.8829	0.64 (0.48–0.86)
Region			**<0.0001**	
	German 2 vs German 1	1.28 (0.84–1.95)		1.01 (0.69–1.47)
	German 3 vs German 1	1.07 (0.69–1.66)		1.02 (0.68–1.52)
	German 4 vs German 1	**1.96 (1.43–2.69)**		1.73 (1.31–2.28)
	French 1 vs German 1	**1.86 (1.32–2.62)**		1.66 (1.22–2.27)
	French 2 vs German 1	**1.89 (1.25–2.86)**		1.73 (1.2–2.49)

HADS = hospital anxiety and depression scale For the multivariable model p-values are provided, for the categorical covariate region only the overall p-value.

cipients without higher education, defined as not having a qualification to enter university, were less likely to undergo living donor transplantation (OR 0.46, 95% CI 0.36-0.59; p <0.0001). Work capacity was also a significant factor, recipients not working or working less than 50% were less likely to undergo living donor transplantation compared with recipients working more than 50% (OR 0.51, 95% CI 0.38–0.67; p <0.0001 and OR 0.48, 95% CI 0.35–0.66, respectively, p <0.0001). When the analysis was restricted to working-age recipients between the ages of 18 and 65, the OR decreased only slightly (ORs of 0.41 and 0.45, respectively) (supplementary table S1 in the appendix). Lower household income below CHF 6000 per month was not significantly associated with the likelihood of a LDRT (OR 0.81, 95% CI 0.57–1.14, p = 0.4269).

Health-related characteristics

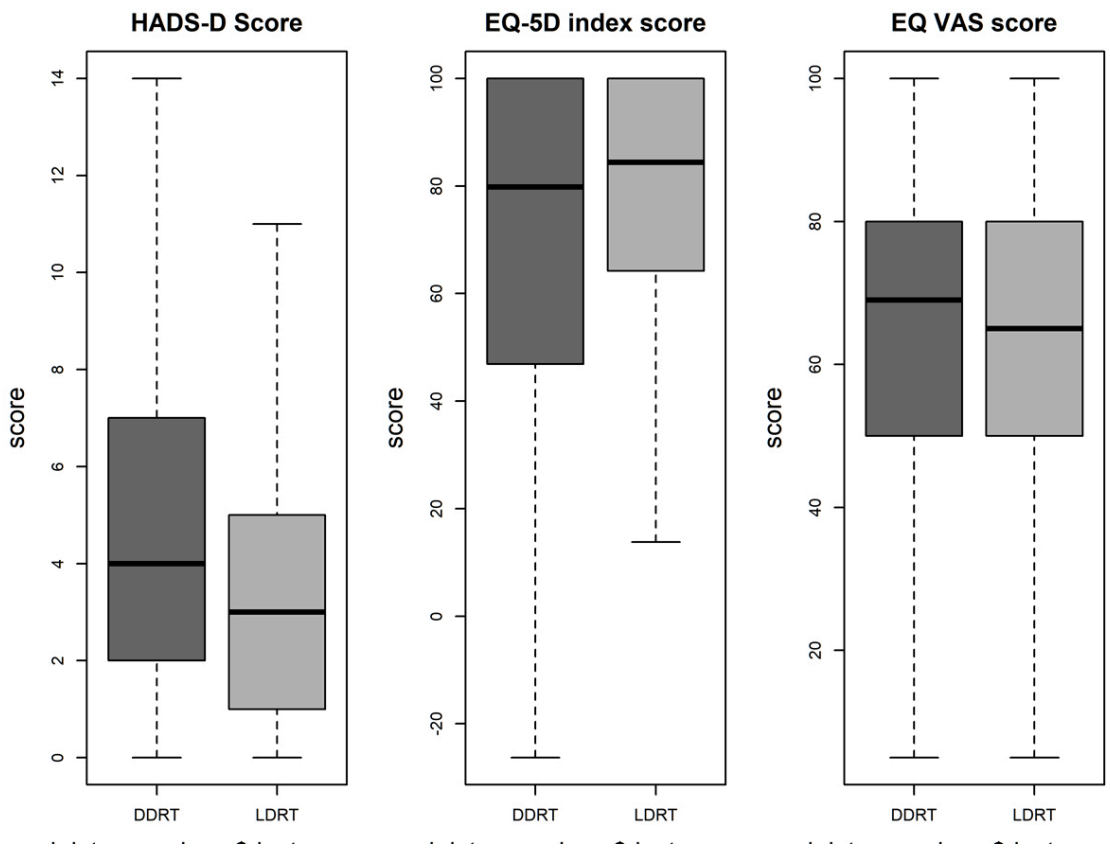
An elevated level of symptoms of depression, defined as a score above 7 on the HADS-Depression scale, was observed in 20.2% of DDRT recipients who answered the questionnaire, but only in 11.5% of the LDRT recipients (table 1); the median and interquartile range were correspondingly higher (fig. 2). In the multivariable logistic regression, the score was associated with a lower chance of having a living donor, the OR per 5 point increase was 0.61 (95% CI 0.50–0.74, p <0.0001).

Self-perceived health measured by visual analogue scale (EQ-VAS) was similar in both groups, with a mean value of 62.04 (standard deviation [SD] 20.28) for LDRT and 62.80 (SD 20.73) for DDRT candidates (fig. 2). A value of 100 indicates 'Best imaginable health state' and 0 'Worst imaginable health state'. In the multivariable logistic regression, a higher EQ-VAS was associated with a lower chance of LDRT, the OR per 10 points increase was 0.87 (95%, CI 0.81–0.93, p <0.0001). However, this association was not significant when restricted to candidates who filled in the PSQ at least 30 days before the transplant (table S1), or after removal of HADS-Depression score and work capacity from the logistic regression model. An alternative measurement for the state of health, the EQ-5D index score based on the French time-trade-off value set, showed higher mean score for LDRT (76.11, SD 25.08) compared with DDRT (72.29, SD 28.57), mainly due to the fact that LDRT recipients reported less mobility problems (fig. 3). The fit of the logistic regression model did not improve when the EQ-5D index score was included, therefore this score was not included in the final model. Regarding other indicators that reflect the state of health, the proportion of candidates with diabetes or cardiopulmonary disease was lower in the LDRT group (12.1% vs 17.9%; 45.3% vs 56.0%), but not significantly in the multivariable analysis (table 2).

Donor characteristics

Living donors were rarely more than 20 years younger than the recipient (3.4%), most donors were within 10 years (63.2%) or between 20 and 40 years older (18.5%). In the DDRT group 20.1% of donors were at least 20 years younger than the recipient, 44.4% at a similar age and

Figure 2: Boxplot for HADS–Depression score, quality of life EQ-5D-3L index score (value set time-trade-off France) and self-perceived quality of life measured by visual analogue scale EQ-VAS for DDRT and LDRT. The solid line represents the median, the hinges of the box the inter-quartile range.HADS-Depression 0: no problems. EQ-5D and EQ VAS score 100: best possible state of health. DDRT = deceased donor renal transplant; HADS = hospital anxiety and depression scale; LDRT = living donor renal transplant



8.1% at least 20 years older. Regarding gender, 37.0% of LDRT donors were males, 40.1% of the related and 34.5% of the unrelated donors. In the DDRT group, male donors were more prevalent with 56.2%.

Model assessment and sensitivity analysis

Accuracy for the final model rose from 56.5% for a model with no covariates to 70.2% after inclusion of the covariates, the area under the curve (c-index) was 74.5. Neither tests for multicollinearity of the covariates nor the binned Pearson residual plots to assess the assumptions for the logistic regression indicated a problem with the estimators of the model.

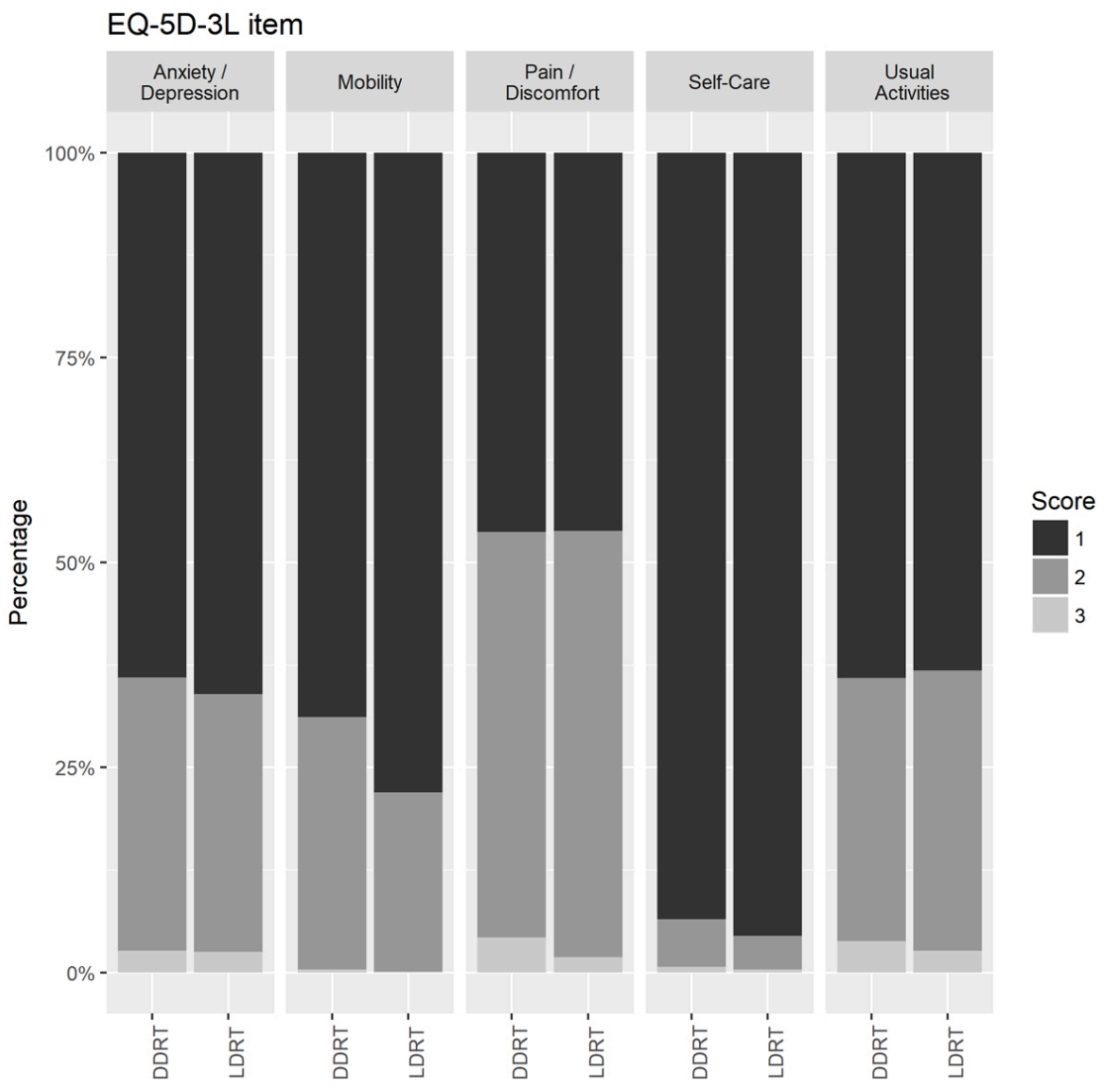
LDRT recipients filled in the PSQ much closer in time to the transplant event; the median was 15 days (IQR 3–157) versus 573 days (IQR 158–1091) for DDRT recipients. To assess whether this circumstance influenced the estimators, we applied the multivariable logistic regression on a subgroup of candidates who filled in the questionnaire at least 30 days or at least 180 days before transplantation. Results were similar except for EQ-VAS with OR close to 1 (fig. S3, table S1). Regarding missing information, the results based on an imputed dataset (table S1) did not contradict our findings on the complete dataset.

Discussion

Transplant candidates who were older, less educated, less able to work and not in a committed relationship were less likely to undergo LDRT. Also, regional differences were observed. Income and gender were not associated with the type of donor. Candidates with higher symptoms of depression (HADS-Depression) or, unexpectedly, higher quality of life (EQ-VAS) were less likely to undergo LDRT.

Living donation is less frequent in recipients of older age, as already shown by several studies [11, 12, 14, 17]. With increasing age, potential donors such as siblings, parents and partners become older and their health decreases, thus fewer meet the criteria to donate. In addition, older transplant candidates are less in favour of accepting living donation [25], in particular from much younger donors such

Figure 3: Bar plot of percentages of transplant recipients of EQ-5D-3L scores by item for 1780 DDRT and LDRT transplant candidates before transplantation. For 205 recipients response was missing. Score 1 = no problems, 2 = some problems, 3 = severe problems. DDRT = deceased donor renal transplant; LDRT = living donor renal transplant



as their children [26]. This attitude is reflected in our data, as only 2.9% of living donors were more than 20 years younger than the recipient.

Since partners account for 33% of the living donations [7], living in a stable relationship increases the chance of having a living donor, as confirmed by our study. It also explains why females were more prominent among living donors (table 3). Most often, female spouses or partners are the living donors of male candidates and males are more frequent in the LDRT group (67.4%). Furthermore, HLA incompatibility can arise when a male living donor wants to donate to a female partner/spouse, as previous pregnancies may have immunised the female transplant candidate, further skewing the gender distribution. Female donors were also more common among first-degree relatives (58.8%), hence donation to a sibling, child or parent. However, the gender of the transplant candidates was not associated with LDRT; men were not more likely to receive a transplant from a living donor.

Recipients with lower education were less likely to undergo living transplantation. Although transplant candidates are informed about the possibility of a living donation, we speculate that recipients with a higher education appraise the benefit of a living donation and the risk for the donor differently from candidates with lower education. Hence, recipients with higher education might be less reluctant to initiate a conversation about live donor kidney transplantation. Not knowing how to initiate a conversation about living donation or being embarrassed to ask others for a donation was identified by several studies [27–29] as a major obstacle to finding a donor.

Transplant candidates were not overly depressed prior to transplantation. The mean score for both groups (4.71 DDRT, 3.85 LDRT) was comparable to the mean HADS-Depression score of 3.68 from a normative sample of the adult British population [30], three samples from the Dutch population with a mean score between 3.4 and 4.6 [31] and the German population with a mean score of 4.8 for men

Table 3: Characteristics related to the transplant event of recipients by deceased (DDRT) and living (LDRT) donation.

	DDRT	LDRT
Graft function		
Delayed graft function	209 (18.6%)	15 (1.75%)
Primary non function	13 (1.2%)	0 (0%)
Dialysis		
Days on dialysis, median (IQR)	1238 (794–1794)	377 (182–716)
Dialysis type		
– Haemodialysis	903 (80.2%)	433 (50.41%)
– Peritoneal dialysis	163 (14.5%)	101 (11.76%)
– Pre-emptive	58 (5.2%)	324 (37.72%)
– Unknown	0 (0%)	0 (0%)
Donor		
Number of mismatches, mean (IQR)	3.97 (3–5)	3.66 (3–5)
Number of ABO compatible patients (%)	1126 (100%)	719 (83.7%)
Age years, median (IQR)	56 (43–65)	54 (46, 61)
Number of males (%)	633 (56.2%)	318 (37.02%)
Number of patients with same sex as donor, (%)	607 (53.9%)	268 (31.2%)
Physiology		
Systolic blood pressure (mmHg), mean ± SD	142.01 ± 21.66	139 ± 19.51
Diastolic blood pressure (mm Hg), mean ± SD	80.89 ± 13.71	81.73 ± 13.03
LDL cholesterol (mmol/l), mean ± SD	2.36 ± 0.99	2.35 ± 1.03
HDL cholesterol (mmol/l), mean ± SD	1.31 ± 0.55	1.33 ± 0.55
BMI (kg/m^2), mean ± SD	27.55 ± 19.43	26.36 ± 15.53
Aetiology		
Glomerulonephritis/vasculitis	235 (20.9%)	238 (27.7%)
Polycystic kidney disease	230 (20.4%)	195 (22.7%)
Hypertensive/renovascular nephrosclerosis	164 (14.6%)	97 (11.3%)
Diabetic nephropathy	122 (10.8%)	56 (6.5%)
Obstructive nephropathy / reflux / pyelonephritis	45 (4%)	47 (5.5%)
Hereditary kidney disease other than polycystic kidney disease	33 (2.9%)	34 (4%)
Interstitial nephritis, not hereditary	41 (3.6%)	32 (3.7%)
Congenital disease/malformation	19 (1.7%)	23 (2.7%)
Other	233 (20.7%)	137 (15.9%)
Comorbidity/diseases at time of transplantation*		
Cancer other than skin	131 (11.6%)	90 (10.5%)
Cardiopulmonary diseases	630 (56%)	389 (45.3%)
Infectious diseases	281 (25%)	176 (20.5%)
Metabolic, endocrine or kidney diseases	1115 (99%)	850 (99%)
– Diabetes	202 (17.9%)	104 (12.1%)
Other events and diseases	348 (30.9%)	234 (27.2%)
Skin cancer	46 (4.1%)	33 (3.8%)

HDL = high-density lipoprotein; IQR = interquartile range; LDL = low-density lipoprotein; SD = standard deviation * Multiple answers possible.

and 5.1 for women [32]. However, recipients with a higher HADS-Depression score were less likely to undergo living donor transplantation (table 2). Like lower education, this could be related to the ability to actively seek a living donor. However, it cannot be ruled out that the higher HADS-Depression score of the DDRT recipients could also be a consequence of not finding a living donor and being on dialysis for a long time, as described by other studies [33, 34].

In terms of physical health, we have little evidence of differences between the LDRT and DDRT. Although EQ-VAS was associated with the type of donor, this association disappeared when the analysis was restricted to recipients who filled in the PSQ questionnaire at least 30 days before the transplant event. The EQ-5D index score, another instrument measuring health-related quality of life, did not differ significantly between LDRT and DDRT. Cardiopulmonary disease or diabetes as comorbidities occurred more frequently in the DDRT group but were not significant factors in the multivariable model. Health parameters such as blood pressure, body mass index (BMI) or cholesterol measured at the time of transplantation were similar in both groups (table 3).

Individuals working more than 50% had higher odds for having a living donor. When the analysis was restricted to candidates aged 20 to 65 and pre-emptive transplantations were excluded the results did not change significantly. A possible explanation for our finding is that candidates fully integrated into the labour market do not want to impair their work and therefore have a higher motivation to search actively for a living donor. To remain on dialysis treatment can limit the ability and flexibility to work and increases the risk of dropping out of the labour market. Also, candidates integrated into the labour market usually have a more active social net that fosters living transplantation.

Higher household income of the recipient was not associated with a living donation in the logistic regression model. This result is in line with our expectations, as healthcare costs related to dialysis and transplantations for donor and recipient are covered by health insurance, which is mandatory in Switzerland. Although donor income was not part of the information collected, we expect only a marginal influence on the decision to donate. Health insurance compensates for any loss of income or other unavoidable expenses resulting from kidney donation [35]. Other studies found that economic factors such as the household income of the donor [36], or car or house ownership as a proxy for household income [14] are associated with the decision to donate. In this context, a country's healthcare system can influence living donation and studies may come to a different conclusion regarding income. Also, income may increase with age, education and ability to work; study results depend on whether the analysis has been adjusted for such confounders. Our results may also be biased by the high number of missing values. Household income has only been recorded since 2012.

The two centres located in the French-speaking part of Switzerland had a higher proportion of LDRT than the centres located in the German-speaking area, with one exception. According to a 2015 survey [37], the French-speaking regions have a higher proportion of respondents with a positive attitude towards organ donation after death (99%) compared with respondents in the German-speaking region (89%), and therefore presumably also towards living donation [37]. However, one centre in the German-speaking part with a long history of performing and promoting living kidney transplantations had a similarly high proportion of LDRT. We assume that the way healthcare professionals in and outside the transplant centres advocate living transplantation, as well as experiences shared between patients, also influence the willingness of living donations.

The present study includes almost all (91.9%) first kidney only transplant recipients of Switzerland within the observation period. Therefore, our analysis does not suffer from selection bias regarding the population of transplanted patients. As only candidates effectively transplanted were included, the transplant event is not hypothetical. However, we cannot exclude any selection bias for being accepted on the waiting list, a prerequisite for both LDRT and DDRT candidates. Although only candidates effectively transplanted are included, the information was collected at the time of registering on the waiting list, hence before the transplant event was assured. The strength of our study is that we collected characteristics of LDRT and DDRT recipients before transplantation, unlike many other studies that compare characteristics between LDRT and DDRT recipients after transplantation, which may be influenced by the transplant event.

Our model explains only moderately which candidate characteristics were associated with having a living donor; accuracy of the statistical model rose from 56.5% to 70.2%.To gain more insight into the driving factors of living donation, further research is needed. In particular, whether DDRT candidates had potential living donors who were not accepted and if so what were the reasons for declining, about candidate's beliefs and knowledge regarding living donation and most importantly understand difficulties about looking for a living donor. The challenge to undertake is to promote living donation among older transplant candidates, among those without higher education, not living in a committed relationship and not fully integrated into the labour market, as these candidates are currently underserved. Also paired donation approved by the Swiss transplantation law 2019 has become an option and may increase access to living donation by rescuing living donor-transplant candidate pairs which previously would not have been accepted at least due to HLA incompatibility.

The members of the Psychosocial Interest Group are: Sabina De Geest, Kris Denhaerynck, Remon Helmy, Lynn Leppla, Oliver Mauthner, Marian Struker (University of Basel); Annette Boehler, Sabine Gerull, Michael Koller, Lut Berben (University Hospital Basel); Uyen Huynh-Do (University Hospital Inselspital Bern); Emmanuelle Catana (University Hospital Lausanne); Annina Seiler, Richard Klaghofer (University Hospital Zurich); Isabelle Binet (Cantonal Hospital St. Gallen); Patrizia Künzler-Heule (University of Basel, Cantonal Hospital St. Gallen); Hanna Burkhalter (Sleepmed Hirslanden), Sonja Beckmann (University of Basel, University Hospital Zurich)

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Potential competing interests

None declared. The results presented in this article have not been published previously in whole or part, except in abstract/poster form.

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Appendix

Supplementary material

Model assessment and sensitivity analysis

We assessed whether multi-collinearity of the covariates influenced estimates of the regression coefficients. Correlations above 0.4 were observed between age and relationship status single (-0.43) and between HADS-Depression and EQ-VAS (-0.53). However, the variance inflation factors (GVIF $^{1/(2*df)}$ [23]) was below the critical threshold of 4 for all covariates, and therefore should not affect the estimates on a larger scale.

Restricting the analysis to transplant candidates who filled in the PSQ at least 30 days or 180 days before transplantation did not contradict our findings (fig. S3 and table S1) except for EQ-VAS. For EQ-VAS the odds ratio was around 1 indicating no difference when restricting the analysis to candidates who filled in the questionnaire at least 30 respectively 180 days before transplantation.

Figure S1: Bar plot of percentages of scores for hospital anxiety and depression score by DDRT and LDRT renal transplant candidates for items related to depression. n = 1766. Score 0 indicates no impairment, score 3 severe impairment. DDRT = deceased donor renal transplant; HADS = hospital anxiety and depression scale; LDRT = living donor renal transplant

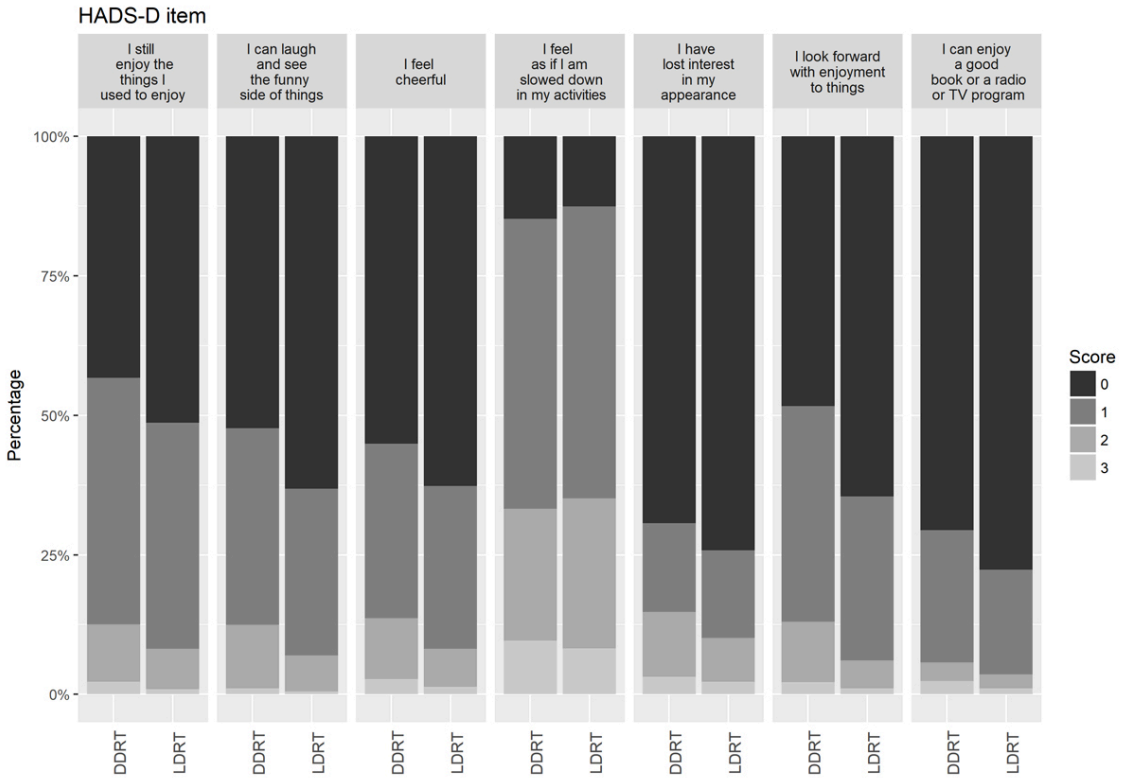

Figure S2: Effect plots for the estimates of the covariates of the logistic regression for outcome live donor renal transplant (LDRT). Covariates not shown in a single graph are standardised as described by Fox [38].

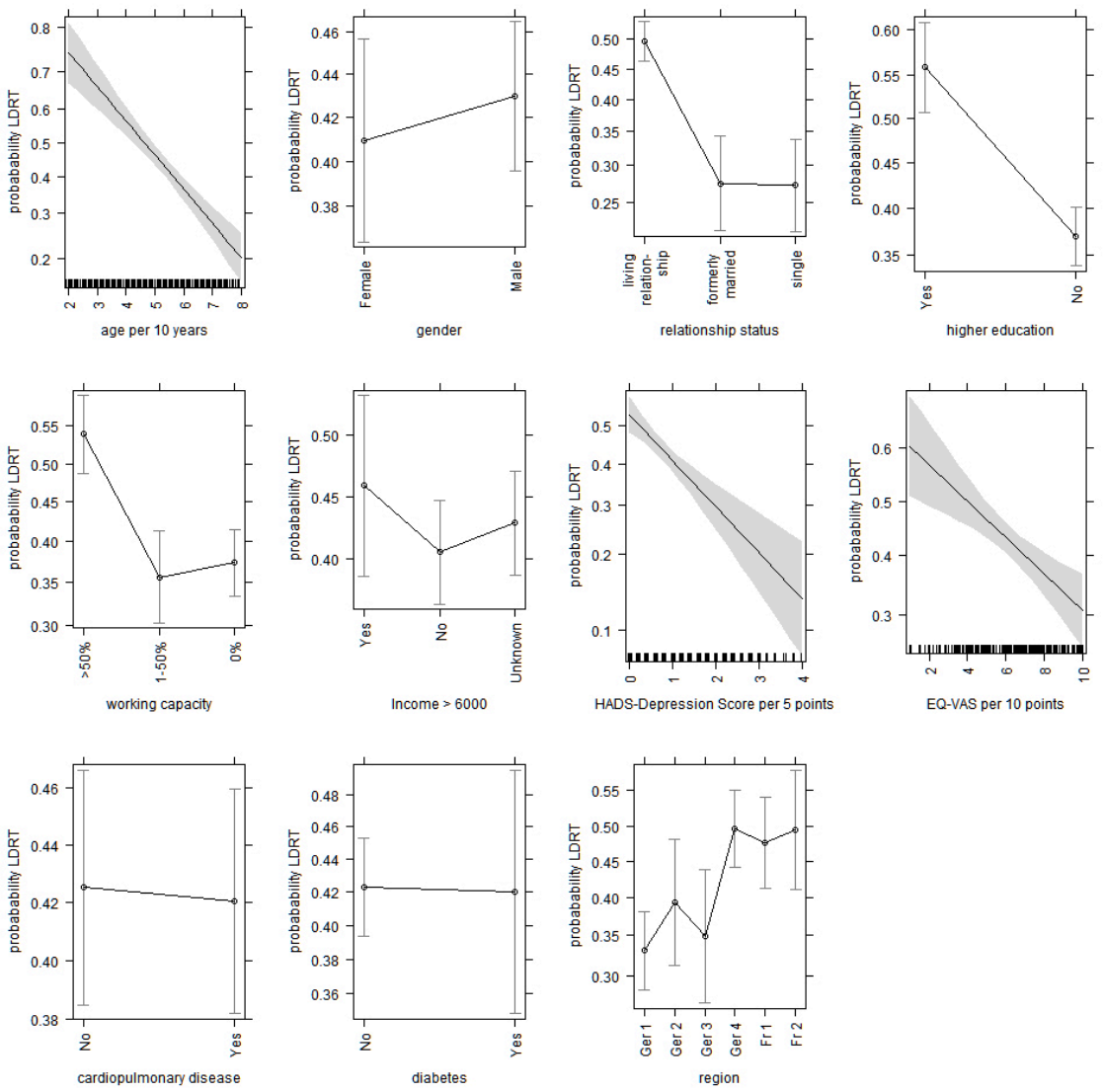

Figure S3: Odds ratio and 95% confidence intervals for covariates for the logistic regression model for outcome LDRT. In addition, regression coefficients for two subgroups are shown: Δ with candidates filled in PSQ at least 30 days (n: DDRT 867, LDRT 315); O with candidates filled in PSQ at least 180 days (n: DDRT 767, LDRT 166) before transplant event. Only estimates for covariates that might change over time are shown for the subgroup analysis. DDRT = deceased donor renal transplant; HADS = hospital anxiety and depression scale; LDRT = living donor renal transplant; PSQ = Swiss Transplant Cohort Study psychosocial questionnaire

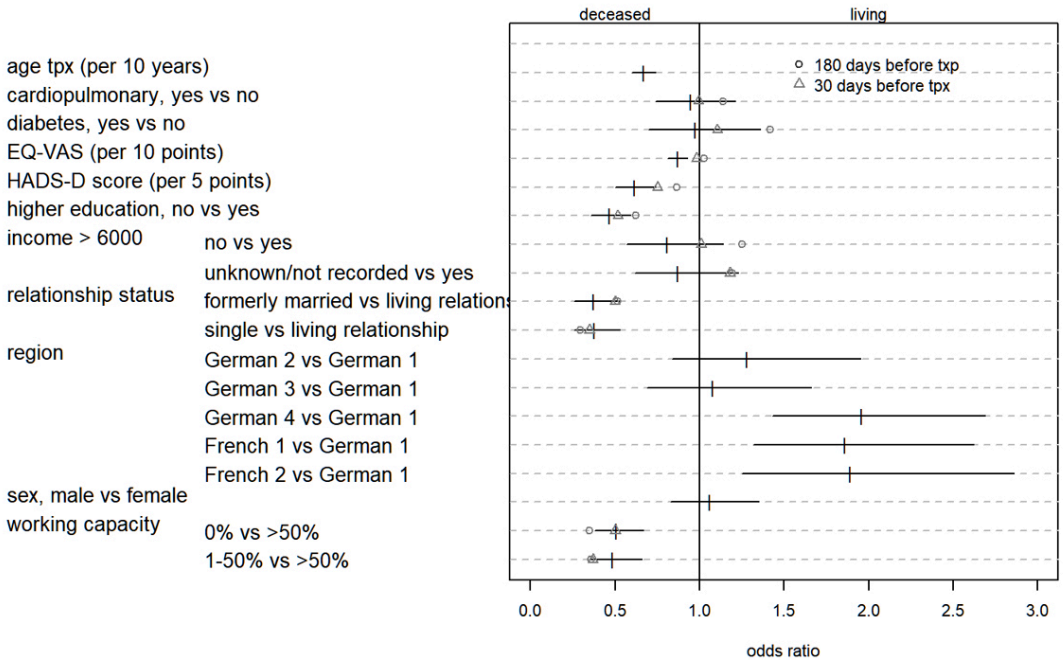

Table S1: Results of the logistic regression model for the imputed data set, subgroup restricted to recipients of working age 18–65, and subgroup of recipients who filled in the PSQ questionnaire at least 30 days or at least 180 days before the transplant event.

Logistic regression model with imputed data set				
Covariate	**Estimate**	**p-value**	**0.025**	**0.975**
(Intercept)	44.48	<0.0001	20.42	96.89
Age at time of transplant (per 10 years)	0.69	<0.0001	0.63	0.75
Gender male vs female	1.06	0.5686	0.86	1.32
Relationship status, formerly married vs living relationship	0.40	<0.0001	0.29	0.55
Relationship status, formerly married vs single	0.38	<0.0001	0.28	0.53
Higher education	0.44	<0.0001	0.35	0.56
Working capacity 0% vs >50%	0.48	<0.0001	0.36	0.65
Working capacity 1–50% vs >50%	0.53	<0.0001	0.41	0.69
Income CHF >6000 per month, no vs yes	0.84	0.287	0.61	1.16
Income unknown vs high income	0.95	0.7285	0.70	1.29
HADS-Depression score (per 5 points)	0.68	<0.0001	0.57	0.81
EQ-VAS (per 10 points)	0.89	0.0002	0.83	0.94
Cardiopulmonary disease, no vs yes	1.01	0.9214	0.81	1.25
Diabetes	0.89	0.4425	0.67	1.19
German 2 vs German 1	1.48	0.0266	1.05	2.09
German 3 vs German 1	1.02	0.9401	0.68	1.53
German 4 vs German 1	2.01	<0.0001	1.52	2.66
French 1 vs German 1	2.02	<0.0001	1.50	2.73
French 2 vs German 1	1.88	0.0006	1.31	2.69
Logistic regression model restricted to patients of working age (18 to 65 years)				
Covariate	**Estimate**	**p-value**	**0.025**	**0.975**
(Intercept)	101.74	<0.0001	36.51	292.19
Age at time of transplant (per 10 years)	0.63	<0.0001	0.55	0.71
Gender male vs female	0.99	0.9598	0.76	1.30
Relationship status, formerly married vs living relationship	0.37	<0.0001	0.25	0.55
Relationship status, formerly married vs single	0.34	<0.0001	0.23	0.50
Higher education	0.43	<0.0001	0.32	0.56
Working capacity 0% vs >50%	0.45	<0.0001	0.32	0.62
Working capacity 1–50% vs >50%	0.41	<0.0001	0.30	0.57
Income CHF >6000 per month, no vs yes	0.84	0.3876	0.57	1.24
Income unknown vs high income	0.92	0.6661	0.62	1.35
HADS-Depression score (per 5 points)	0.67	0.0002	0.54	0.82
EQ-VAS (per 10 points)	0.86	0.0002	0.80	0.93
Cardiopulmonary disease, no vs yes	1.00	0.9717	0.77	1.32
Diabetes	0.99	0.9549	0.66	1.47
German 2 vs German 1	1.28	0.2944	0.80	2.05
German 3 vs German 1	1.07	0.7969	0.66	1.72
German 4 vs German 1	2.13	<0.0001	1.50	3.03
French 1 vs German 1	1.76	0.0037	1.20	2.59
French 2 vs German 1	2.11	0.0024	1.31	3.41
Model restricted to patients who filled in the PSQ questionnaire at least 30 days before transplant event				
Covariate	**Estimate**	**p-value**	**0.025**	**0.975**
(Intercept)	21.37	<0.0001	6.49	71.89
Age at time of transplant (per 10 years)	0.63	<0.0001	0.55	0.73
Gender male vs female	1.29	0.1421	0.92	1.82
Relationship status, formerly married vs living relationship	0.50	0.0039	0.31	0.79
Relationship status, formerly married vs single	0.35	<0.0001	0.21	0.57
Higher education	0.52	0.0001	0.37	0.72
Working capacity 0% vs >50%	0.37	<0.0001	0.24	0.57
Working capacity 1–50% vs >50%	0.50	0.0003	0.35	0.73
Income CHF >6000 per month, no vs yes	1.01	0.9633	0.63	1.63
Income unknown vs high income	1.18	0.4909	0.74	1.90
HADS-Depression score (per 5 points)	0.75	0.0342	0.58	0.98
EQ-VAS (per 10 points)	0.98	0.7464	0.90	1.08
Cardiopulmonary disease, no vs yes	0.99	0.9718	0.72	1.38
Diabetes	1.11	0.6821	0.68	1.77
German 2 vs German 1	0.28	0.0062	0.10	0.65
German 3 vs German 1	0.74	0.2457	0.44	1.22
German 4 vs German 1	0.34	<0.0001	0.21	0.54
French 1 vs German 1	0.63	0.0619	0.38	1.01

French 2 vs German 1	1.67	0.0322	1.04	2.67
Model restricted to patients who filled in the PSQ questionnaire at least 180 days before the transplant event				
Covariate	**Estimate**	**p-value**	**0.025**	**0.975**
(Intercept)	8.93	0.007651	1.80	45.21
Age at time of transplant (per 10 years)	0.62	<0.0001	0.51	0.74
Gender male vs female	1.26	0.301051	0.82	1.96
Relationship status, formerly married vs living relationship	0.52	0.031977	0.27	0.92
Relationship status, formerly married vs single	0.29	0.000243	0.15	0.55
Higher education	0.62	0.033131	0.40	0.97
Working capacity 0% vs >50%	0.36	0.000243	0.20	0.61
Working capacity 1–50% vs >50%	0.35	<0.0001	0.21	0.57
Income CHF >6000 per month, no vs yes	1.25	0.473301	0.69	2.35
Income unknown vs high income	1.19	0.585895	0.64	2.28
HADS-Depression score (per 5 points)	0.86	0.409509	0.61	1.22
EQ-VAS (per 10 points)	1.03	0.689229	0.91	1.16
Cardiopulmonary disease, no vs yes	1.14	0.544059	0.75	1.74
Diabetes	1.42	0.240849	0.78	2.51
German 2 vs German 1	0.17	0.01743	0.03	0.59
German 3 vs German 1	0.76	0.394019	0.39	1.41
German 4 vs German 1	0.28	0.0003	0.14	0.55
French 1 vs German 1	0.72	0.268824	0.39	1.27
French 2 vs German 1	1.54	0.169877	0.82	2.81