Supplemental Digital Contents

Table of Contents

Supplemental S0: Technical Appendix

Section A:

Derivation of Model Inputs for Outcomes after Initial (Index) Transplant

This section summarizes the methodologies by which the following probabilities were obtained:

- death, liver re-transplant, and kidney graft failure after simultaneous liver-kidney (SLK) transplantation;
- death, liver re-transplant, and native kidney failure after liver transplantation;
- death and liver re-transplant after kidney graft / native kidney failure;
- death after liver re-transplant.

As discussed in methods, we obtained an empiric cohort of adult, first-time SLK or liver transplant recipients from Scientific Registry of Transplant Recipients (SRTR) data. We analyzed SLK and liver transplant outcomes separately. For each transplant type, we divided the cohort into 4 strata based on kidney function at the time of transplant (**Table 1** in main text) and analyzed the following outcomes by stratum:

- death;
- liver graft failure, defined as liver re-transplant;
- kidney graft failure after SLK transplant, defined as initiation of dialysis or kidney re-transplant by the SRTR;
- native kidney failure after liver transplant, defined in two ways: 1) dialysis initiation or kidney transplant, from Sharma *et al.*'s published registry analysis which linked Center of Medicare & Medicaid Services data with SRTR[1]; 2) follow-up creatinine value >4 mg/dl (captured by SRTR on an annual basis after liver transplant). We used definition 1 in

calibration, since it provided better temporal resolution within the first year of liver transplant. We used definition 2 for cross-validation in the validation step (see **Supplemental S1**).

The calibration approach differed in the three period post-transplant: first month post-transplant, 1 month to 10 years, and 10+ years.

Combining data from Sharma et al. *with SRTR data*

In a registry analysis of 43,514 liver transplant recipients not on maintenance dialysis at the time of liver transplantation, Sharma *et al.* reported the cumulative incidence of developing native kidney failure (accounting for the competing risk of death) within 5 years based on deciles of a Renal Risk Index they developed[1]. The following Renal Risk Index deciles best corresponded to each of our stratum, based on the baseline characteristics (**Table S1**).

Table S1. Correspondence between strata of our study cohort and deciles of Renal Risk Index in Sharma *et al.*'s work.

Patient Stratum in Our Study Cohort	***Proportion of Total***	***Decile of Renal Risk Index***
1: No kidney failure	56.1%	1-6
2: Kidney failure (OPTN-)	29.0%	7-8
3: Kidney failure (OPTN+)	4.3%	9-10
4: Kidney failure (OPTN-unknown)	10.6%	9-10

We approximated the cumulative incidence of native kidney failure in each of our study stratum as a range, with the lower bound being the predicted cumulative incidence in the lowest decile and the upper bound the predicted cumulative incidence in the highest decile (**Table S2**).

Table S2. Cumulative incidences of native kidney failure after liver transplant by Renal Risk Index.

Month Post-Transplant	***Corresponding RRI Deciles***	***Cumulative Incidence of Native Kidney Failure***	
		Lowest RRI Decile	***Highest RRI Decile***

Stratum 1: No kidney failure			
1	1-6	0.0013	0.0054
3	1-6	0.0008	0.0046
12	1-6	0.0033	0.0105
36	1-6	0.0067	0.0205
60	1-6	0.0092	0.0411
Stratum 2: Kidney failure (OPTN-)			
1	7-8	0.0054	0.0071
3	7-8	0.0029	0.0046
12	7-8	0.0113	0.0143
36	7-8	0.0264	0.0399
60	7-8	0.0411	0.0608
Stratum 3: Kidney failure (OPTN+) *Stratum 4: Kidney failure (OPTN-unknown)*			
1	9-10	0.0192	0.0463
3	9-10	0.0081	0.0236
12	9-10	0.0263	0.0542
36	9-10	0.0548	0.0974
60	9-10	0.0837	0.1407

The cumulative incidences are combined with cumulative incidences of death and liver re-transplant after liver transplants from SRTR (see later sections) to form calibration targets.

Outcomes at 1 Month Post-Transplant

We tabulated the mutually exclusive occurrences of death, liver re-transplant, and kidney graft failure (SLK only) at 1 month (**Table S3**). Dual graft failure (SLK re-transplantation) was so rare (<0.1%) that it was excluded from the decision model and collapsed with the liver re-transplant category. We represented probability of each type event at 1 month as a beta distribution, where α = number of events and β = number of non-events. For the probability of native kidney failure after liver transplant at 1 month, we obtained the upper and lower limits from Figure 3 of Sharma *et al.*, as described in the preceding section, and fit these to beta distributions.

Table S3. One-month SLK and liver transplant outcomes in empiric cohort.

Stratum	***Events in First Month***	
	Liver Transplant	***SLK Transplant***

	Total	*Death*	*Liver Re-Transplant*	*Native Kidney Failure*[a]	*Total*	*Death*	*Liver Re-Transplant*	*Kidney Graft Failure*
1: No kidney failure	33655	759 (2.3%) [2.1-2.4%]	722 (2.2%) [2.0-2.3%]	0.3% [0.1-0.5%]	na[b]			
2: Kidney failure (OPTN-)	17064	609 (3.6%) [3.3-3.8%]	306 (1.8%) [1.6-2.0%]	0.6% [0.5-0.7%]	338	8 (2.4%) [1.0-4.2%]	1 (0.3%) [0.0-1.0%]	4 (1.2%) [0.3-2.6%]
3: Kidney failure (OPTN+)	1891	84 (4.4%) [3.6-5.4%]	25 (1.3%) [0.9-2.0%]	3.3% [1.9-4.6%]	700	14 (2.0%) [1.1-3.2%]	9 (1.3%) [0.6-2.2%]	13 (1.9%) [1.0-3.0%]

a: See preceding section and Table S2.
b: Only 13 SLK transplants occurred in this patient stratum. Hence it was excluded from the decision model and further analysis.

Outcomes from 1 Month to 10 Years Post-Transplant

SLK transplant outcomes: Conditional on being event-free in the first month, we used a proportional sub-distribution hazards model[2] to estimate the cumulative incidence of death, liver re-transplant, and kidney graft failure over the next 119 months. We used the cumulative incidences at 6 time points (3-, 12-, 36-, 60-, 84- and 120-months post-transplant) for patients age 55 years at the time of transplant, and these formed the calibration targets ("actual" cumulative incidences).

Liver transplant outcomes: We used the same approach as above to obtain the cumulative incidences of death and liver re-transplant after liver transplantation. We then combined these estimates with the cumulative incidence of native kidney failure from Sharma *et al.* (**Table S2**). Of note, the rates of death and liver graft failure did not account for the competing risk of native kidney failure. This would lead to a slightly higher estimate for death after liver transplant. Nonetheless, our model still performed well in the validation step.

To arrive at the transition probability of death, liver re-transplant, and kidney graft / native kidney failure for our Markov model, we modelled them as 3 separate step-functions, holding probabilities constant between months 1-3, 3-12, 12-36, 36-60, 60-84, and 84-120 post-

transplant. We made this decision by examining the cumulative incidence function plot and based on clinical experience. Because data for native kidney failure beyond year 5 after liver transplant were unavailable, we assumed a constant rate of native kidney failure from year 5 onwards. We randomly generated 5,000,000 sets of probabilities and calculated cumulative incidences based on these probability sets for the 6 time points ("model" cumulative incidences). Only the probability sets that generated model cumulative incidences within the 95% confidence interval of the "actual" cumulative incidences were retained. The retained probabilities formed the distribution of the transition probabilities in the Markov model (**Table S4**).

Table S4. Summary of transition probabilities for death, liver graft failure and kidney failure post-liver or SLK transplantation. N refers to the number of sets of probabilities retained in the calibration process.

	Transition Probability, Cycle Length of 1 Month Mean (Range)					
	Month 1-2	Month 3-12	Month 13-36	Month 37-60	Month 61-84	Month 85-120
Liver Transplant						
Stratum 1: No kidney failure (N=722)						
Death	0.0080 (0.0073-0.087)	0.0056 (0.0051-0.0061)	0.0050 (0.0046-0.0054)	0.0033 (0.0028-0.0038)	0.0034 (0.0027-0.0041)	0.0045 (0.0036-0.0055)
Liver re-transplant	0.0028 (0.0023-0.0031)	0.0013 (0.0011-0.0015)	0.0006 (0.0004-0.0007)	0.0003 (0.0001-0.0005)	0.0003 (0.0000-0.0005)	0.0002 (0.0000-0.0004)
Native kidney failure	0.0013 (0.0003-0.0023)	0.0005 (0.0000-0.0011)	0.0004 (0.0000-0.0010)	0.0008 (0.0000-0.0018)	0.0008 (0.0000-0.0018)	0.0008 (0.0000-0.0018)
Stratum 2: Kidney failure (OPTN-) (N=445)						
Death	0.0141 (0.0127-0.0153)	0.0073 (0.0065-0.0080)	0.0041 (0.0035-0.0045)	0.0036 (0.0028-0.0043)	0.0037 (0.0026-0.0046)	0.0057 (0.0044-0.0073)
Liver re-transplant	0.0030 (0.0024-0.0036)	0.0013 (0.0009-0.0017)	0.0004 (0.0002-0.0007)	0.0003 (0.0000-0.0006)	0.0002 (0.0000-0.0006)	0.0002 (0.0000-0.0005)
Native kidney failure	0.0019 (0.0017-0.0021)	0.0011 (0.0009-0.0013)	0.0013 (0.0008-0.0018)	0.0013 (0.0002-0.0024)	0.0013 (0.0002-0.0024)	0.0013 (0.0002-0.0024)
Stratum 3: Kidney failure (OPTN+) (N=580)						
Death	0.0156 (0.0115-0.0197)	0.0111 (0.0084-0.0142)	0.0055 (0.0034-0.0075)	0.0039 (0.0009-0.0070)	0.0056 (0.0016-0.0104)	0.0068 (0.0019-0.0134)

Liver re-transplant	0.0042 (0.0019-0.0065)	0.0014 (0.0003-0.0027)	0.0003 (0.0000-0.0009)	0.0002 (0.0000-0.0007)	0.0003 (0.0000-0.0010)	0.0002 (0.0000-0.0008)
Native kidney failure	0.0087 (0.0041-0.0129)	0.0030 (0.0003-0.0058)	0.0020 (0.0001-0.0039)	0.0028 (0.0000-0.0058)	0.0028 (0.0000-0.0058)	0.0028 (0.0000-0.0058)
SLK Transplant						
Stratum 2: Kidney failure (OPTN-) (N=691)						
Death	0.0146 (0.0051-0.0240)	0.0095 (0.0032-0.0153)	0.0048 (0.0007-0.0087)	0.0036 (0.0000-0.0095)	0.0036 (0.0000-0.0101)	0.0095 (0.0001-0.0179)
Liver re-transplant	0.0029 (0.0000-0.0100)	0.0007 (0.0000-0.0025)	0.0003 (0.0000-0.0014)	0.0004 (0.0000-0.0015)	0.0004 (0.0000-0.0016)	0.0004 (0.0000-0.0015)
Kidney graft failure	0.0031 (0.0000-0.0080)	0.0009 (0.0000-0.0026)	0.0008 (0.0000-0.0026)	0.0008 (0.0000-0.0027)	0.0010 (0.0000-0.0032)	0.0010 (0.0000-0.0033)
Stratum 3: Kidney failure (OPTN+) (N=1274)						
Death	0.0120 (0.0107-0.0291)	0.0071 (0.0016-0.0125)	0.0052 (0.0018-0.0084)	0.0048 (0.0001-0.0100)	0.0051 (0.0000-0.0116)	0.0072 (0.0002-0.0155)
Liver re-transplant	0.0019 (0.0000-0.0039)	0.0010 (0.0000-0.0027)	0.0003 (0.0000-0.0011)	0.0004 (0.0000-0.0016)	0.0005 (0.0000-0.0017)	0.0004 (0.0000-0.0014)
Kidney graft failure	0.0030 (0.0000-0.0063)	0.0011 (0.0000-0.0029)	0.0007 (0.0000-0.0019)	0.0011 (0.0000-0.0033)	0.0016 (0.0000-0.0045)	0.0012 (0.0000-0.0037)

a: This stratum was only used in sensitivity analysis.

Outcomes after 10 Years Post-Transplant

We assumed constant rates for liver re-transplant and kidney graft failure / native kidney failure from year 10 onwards. We calculated the rate of death by assuming a constant disease-specific death rate from year 10 onwards and adding to this disease-specific death rate the age-specific, gender-weighted background death rate in the United States in 2011[3] to arrive at the overall death rate at each age. We chose this additive approach, rather than the multiplicative approach of applying a proportional hazard, based on examining a plot of the actual versus background death rate in the first 10 years post-transplant. The plot suggested that the additive approach was more constant for extrapolating the total risk of death as the cohort continued to age[4].

Outcomes after Kidney Graft / Native Kidney Failure

We calculated death rate after kidney failure by applying to the death rate without kidney failure a rate ratio of 3.32 (95% confidence interval 2.96-3.71)[5]. This ratio was modelled as a log-normal distribution.

We calculated liver re-transplant rate after kidney failure as follows: Mindikoglu *et al.*[6] reported that SLK results in a reduction in the rate of liver graft failure compared to liver transplant alone (hazard ratio 0.67, 95% confidence interval 0.49-0.91). We assumed that most of this clinical benefit stemmed from improved kidney function and avoidance of dialysis. We therefore took the reciprocal of this hazard ratio to represent the increase in liver re-transplant risk after kidney failure, and applied this new hazard ratio to the basal liver re-transplant rate.

Outcomes after Liver Re-Transplant

The liver re-transplant tree was identical to the main tree except in two respects:

1) A second liver re-transplant was not permitted, so any liver graft failure was presumed to lead to death.
2) Death rate in the re-transplant tree was increased by a factor of 1.70 (95% confidence interval 1.56-1.84)[7]. This ratio was modelled as a log-normal distribution.

All analysis was done in SAS 9.4 (Cary, NC). The proportional subdistribution hazards model was done using a peer-reviewed SAS macro function[8].

Section B:

Derivation of Model Inputs Relevant to Non-Index Kidney Transplant

We defined the index kidney transplant as the kidney transplant in SLK. The non-index kidney transplant was therefore the first kidney transplant, when the patient received a liver transplant initially, or the kidney re-transplant, when the patient received a SLK initially.

The section summarizes the methodologies by which the following probabilities were obtained from published literature:

- Time to non-index kidney transplant;
- Death and kidney graft failure after non-index kidney transplant;
- Probability of living donation;
- Safety Net impact.

Time to Non-Index Kidney Transplant

Time to transplant on the kidney transplant waitlist is a dynamic measure. The "median wait time", although flawed in its failure to account for the competing risk of death and waitlist removal[9], is nonetheless still the most commonly used measure to indicate waitlist movement in different geographic regions. We therefore used this measure to model the movement from the kidney transplant waitlist to non-index kidney transplant. Wait time is modelled by a tracker variable that "tracks" the amount of time a patient has been dialysis-dependent. When wait time equals the median wait time, the patient undergoes a transplant.

Prior to the implementation of the Kidney Allocation System (KAS) in December 2014, the mean time to kidney transplant for a liver transplant was 401 days (standard deviation: 466 days)[10].

As such, we modelled it as a gamma distribution covering 50-300% of the mean to allow for a thick right tail. We used this time to transplant in model validation, to verify that we were able to replicate the post-liver transplant outcomes from 2002-2013 using data from the same time period.

For the actual decision model in which we compared prospective strategies, we wished to use a wait time that reflected the current wait times across all regions in the country. The United Network of Organ Sharing (UNOS) website lists median times to transplant, stratified by UNOS region and blood type, for patients listed in 2003-2004. We built our base model based on the median time to transplant for blood type O in all UNOS regions (**1601 days**). In the sensitivity analyses, we ran our model under two additional extreme wait times: 292 days (most favorable blood type [AB] in the speediest UNOS region) and 2891 days (least favorable blood type [B] in the slowest UNOS region).

Rates of Death and Graft Failure after Non-Index Kidney Transplant

Cassuto *et al.*[10] reported outcomes for 689 patients who received a kidney transplant after an initial liver transplant. The 10-year survival and death-censored graft survival were reported in Figure 5 of that paper. We calculated the cumulative incidence of event as 1 – survival (**Table S5**).

Table S5. Cumulative incidence of outcomes after a non-index kidney transplant.

Time Post-Kidney Transplant	***Death***		***Death-Censored Graft Failure***	
	Survival[a]	***Cumulative Incidence***	***Survival[a]***	***Cumulative Incidence***
90 days	0.964-0.987	0.013-0.036	0.951-0.979	0.021-0.049
1 year	0.929-0.964	0.036-0.071	0.932-0.966	0.034-0.068
3 year	0.856-0.905	0.095-0.144	0.877-0.923	0.077-0.123
5 year	0.776-0.836	0.164-0.224	0.817-0.873	0.127-0.183
7 year	0.686-0.755	0.245-0.314	0.755-0.817	0.183-0.245
10 year	0.541-0.616	0.384-0.459	0.657-0.727	0.273-0.343

a. From Cassuto *et al*, Figure 5.

We modelled the transition probabilities for death, liver re-transplant, and kidney graft / native kidney failure as 3 separate step-functions, holding constant between months 1-3, 3-12, 12-36, 36-60, 60-84, and 84-120 months post-transplant. We randomly generated 5,000,000 sets of probabilities and calculated cumulative incidences based on these probability sets for the 6 time points ("model" cumulative incidences). Only the probability sets which generated model cumulative incidences within the 95% confidence interval of the actual were retained (**Table S6**).

Table S6. Summary of transition probabilities for death and kidney graft failure after non-index kidney transplantation. Statistics are obtained from the 193 sets of probabilities generated in the calibration process.

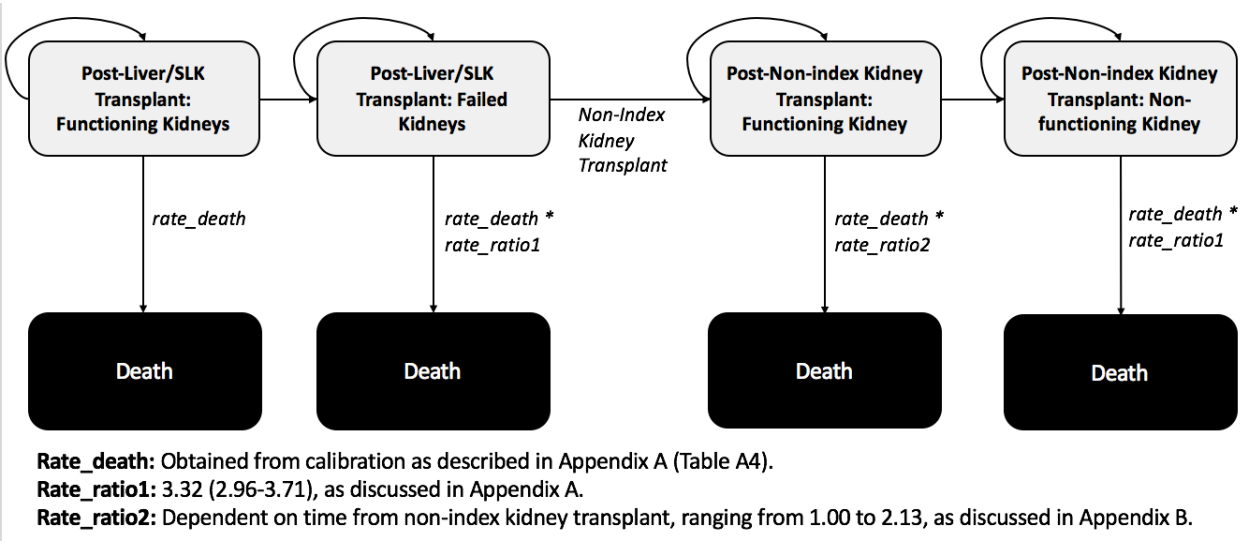
	Transition Probability, Cycle Length of 1 Month Mean (Range)					
	Month 0-2	Month 3-12	Month 13-36	Month 37-60	Month 61-84	Month 85-120
Death	0.0083 (0.0044-0.0124)	0.0035 (0.0004-0.0070)	0.0033 (0.0014-0.0053)	0.0044 (0.0013-0.0073)	0.0062 (0.0017-0.0110)	0.0108 (0.0056-0.0170)
Kidney graft failure	0.0116 (0.0070-0.0166)	0.0023 (0.0000-0.0054)	0.0023 (0.0006-0.0043)	0.0034 (0.0006-0.0060)	0.0043 (0.0003-0.0084)	0.0071 (0.0021-0.0119)

For kidney graft failure, we used the transition probabilities in row 2 directly. We did not use the probabilities of death from Table S6 directly, because few patients in Cassuto *et al.*'s cohort received kidney transplants within one year of liver transplant, when the mortality risk would be the highest. Using those probabilities directly would therefore grossly overestimate the benefit of the subsequent kidney transplant performed within one year of liver transplant. We thus applied a time-dependent rate ratio to the basal death rate for liver transplant recipients as follows:

The patients in Cassuto *et al.*'s cohort received kidney transplants approximately 4 years after their liver transplant, at age 55.0±9.5 years. Compared to the basal death rates of liver transplant recipients in our SRTR cohort who did not develop kidney failure ("baseline") at the same age, we noted that a kidney after liver transplant increased the risk of death in the first year,

returned it to baseline (*i.e.* the death rate if kidney failure never developed) after year 1, and increased again at year 7. This pattern is concordant with clinical intuition. We therefore chose to calculate the rate of death after the non-index kidney transplant as the rate of death in liver transplant recipients who did not develop kidney failure multiplied by a rate ratio that varied based on time after non-index kidney transplant: 2.13 (1-12 months), 1.00 (13-84 months), and 1.57 (85 months and beyond) (**Figure S1**).

Figure S1. A schematic showing the differential rates of death as a patient moves through stages of kidney failure after liver transplant in our model. For simplicity sake, the pathways of liver re-transplant are not shown.



Rate_death: Obtained from calibration as described in Appendix A (Table A4).
Rate_ratio1: 3.32 (2.96-3.71), as discussed in Appendix A.
Rate_ratio2: Dependent on time from non-index kidney transplant, ranging from 1.00 to 2.13, as discussed in Appendix B.

Probability of Living Donation

Cassuto *et al.*[10] reported 132 living kidney donations amongst the 2237 liver transplant recipients who were added to the kidney transplant waitlist: 5.9%. We used this proportion as the probability of having a living donor. In our model, patients who had a living donor underwent kidney transplant at 3 months after the development of kidney failure.

In the OPTN proposal and stringent strategy pathways, we shared the concern that a Safety Net provision may decrease the incentive for living donation for liver transplant recipients who are Safety Net-eligible[11]. In our base model, we assumed the worst case scenario (100% reduction in living donation rate in patients who are Safety Net eligible). We tested a less extreme scenario (50% reduction) in sensitivity analysis.

Safety Net Impact

The actual effectiveness whereby Safety Net reduces wait time to transplant is not known. As the previous liver transplant may have a immunologically sensitizing effect, wait time to a subsequent kidney transplant may be longer than otherwise predicted[12]. Subsequently, we assumed a more modest reduction in wait time (75%) in the base model and tested a more effective reduction (90%) in sensitivity analysis.

Appendix C:

Correlation between Model Parameters

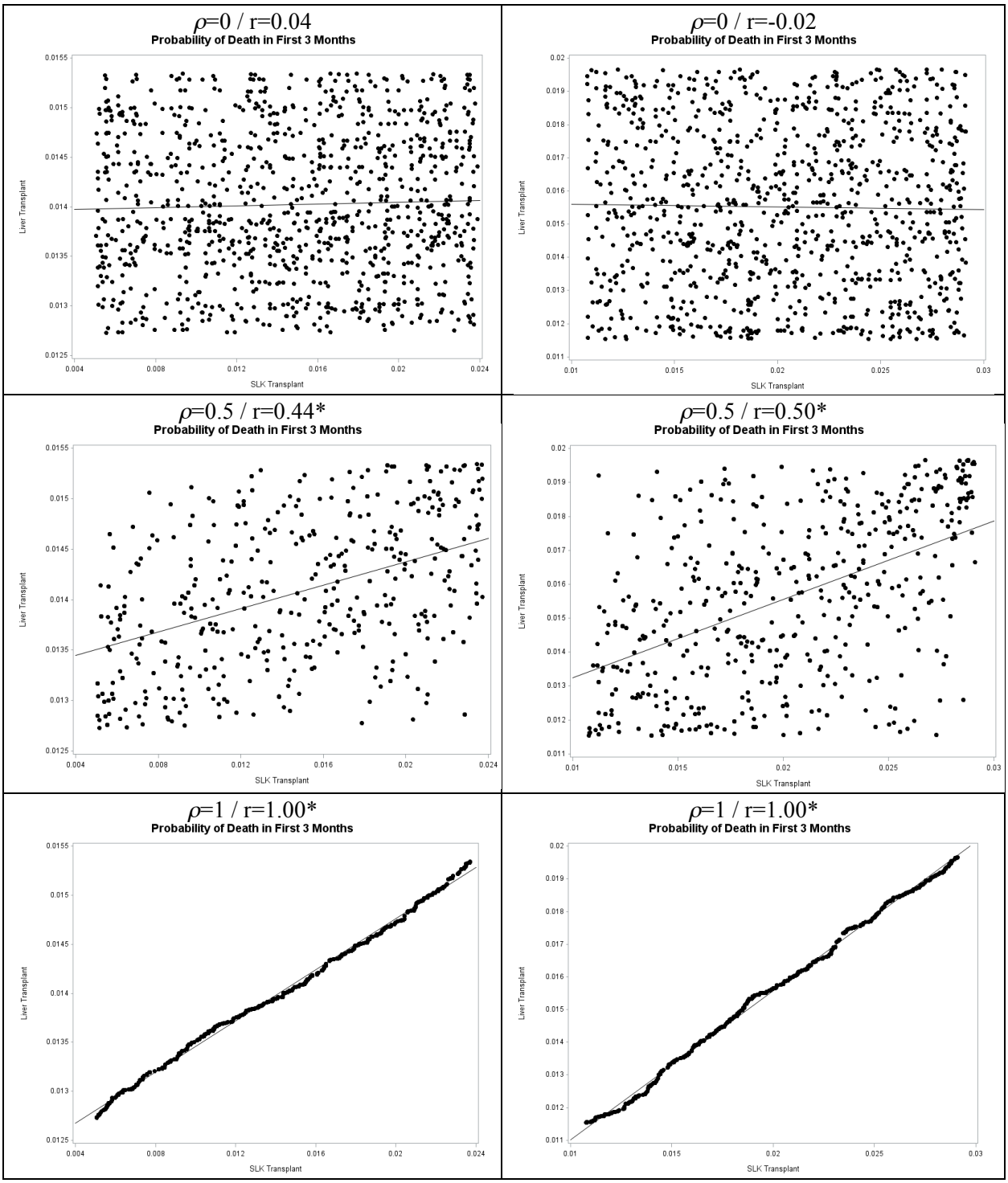
Probability sensitivity analyses (PSAs) enable us to model how uncertain our result is. However, estimates of uncertainty from PSAs rely on our assumption about the joint uncertainty of a model's inputs. In modelling the natural history of a population after receiving liver or simultaneous liver-kidney (SLK) transplantation, outcomes after each type of transplant are almost certainly correlated, *i.e.* in a world where outcomes after liver transplantation is good, one would expect that outcomes after SLK transplantation to also be good, and vice versa. The extent of this correlation, however, is not known, given the absence of randomized studies.

We tested three extents of correlation: no correlation (ρ=0), moderate correlation (ρ=0.5), and perfect correlation (ρ=1), between probability of death in the first 3 months after liver and after SLK transplantation. We used a sorting algorithm to "induce" a desired degree of correlation as described in Goldhaber et al.[13]. We ran a PSA for each condition of correlation.

Figure S2 displays the relation between the correlated parameters. **Table S7** displays key model results. Increasing the degree of correlation from none (ρ=0) to partial (ρ=0.5) and to perfect (ρ=1) did not lead to an appreciable change in model results. We ran the base model with moderate correlation (ρ=0.5).

Figure S2. Correlation in probability of death in the first 3 months after transplant, between liver transplant (y-axis) and SLK transplant (x-axis), in the probabilistic sensitivities analyses. ρ represents the desired degree of correlation and r represents actual Spearman's coefficient. R is not statistically significant unless specified by *.

Patients with kidney failure, OPTN- (do not meet proposed criteria for SLK transplant)	Patients with kidney failure, OPTN+ (meet proposed criteria for SLK transplant



* $p<0.0001$

Table S7. Difference in life year (LY), qualify-adjusted life year (QALY) and kidney usage, all discounted, between strategies (mean [95% confidence interval]), when different correlation

coefficients are used. Strategy 1: Pre-OPTN. Strategy 2: OPTN proposal ("pessimistic scenario"). Status 3: Safety net strategy.

	Correlation Coefficient (ρ)		
	0.0	**0.5**	**1.0**
Difference in LY per person			
Strategy 2 – strategy 1	0.047 (0.045-0.050)	0.046 (0.044-0.049)	0.050 (0.047-0.053)
Strategy 1 – strategy 3	0.018 (0.016-0.019)	0.019 (0.017-0.020)	0.019 (0.017-0.020)
Strategy 2 – strategy 3	0.065 (0.061-0.069)	0.065 (0.061-0.069)	0.068 (0.064-0.072)
Difference in QALY per person			
Strategy 2 – strategy 1	0.040 (0.038-0.042)	0.040 (0.037-0.042)	0.042 (0.040-0.044)
Strategy 1 – strategy 3	0.011 (0.009-0.011)	0.011 (0.010-0.013)	0.011 (0.010-0.012)
Strategy 2 – strategy 3	0.051 (0.048-0.054)	0.051 (0.048-0.054)	0.053 (0.050-0.057)
Difference in deceased donor kidneys per liver transplant			
Strategy 2 – strategy 1	0.037 (0.037-0.037)	0.036 (0.035-0.036)	0.036 (0.035-0.036)
Strategy 1 – strategy 3	0.021 (0.021-0.021)	0.021 (0.020-0.021)	0.021 (0.021-0.021)
Strategy 2 – strategy 3	0.058 (0.058-0.058)	0.056 (0.056-0.056)	0.056 (0.056-0.056)

Section D:

Quality-of-Life Weights

Studies to date reported quality of life in patients with end-stage kidney disease (ESKD) or with liver disease, but not together. A meta-analysis[14] reported the quality-of-life weight for dialysis-dependent patients as 0.70 (0.62-0.78). A prospective multi-center study[15] placed quality-of-life weight of liver transplant recipients at 2 years at 0.747 (0.720-0.774), compared to 0.823 (0.799-0.847) for the "population norm". We assumed that liver transplant recipients who developed ESKD would have a worse quality of life than patients with either condition alone.

All health states in our model correspond to liver transplant recipients. We separated health states into having one of two quality-of-life weights, based on the objective of our study:

1) No kidney failure: Weight = 0.747 (0.720-0.774).
2) With kidney failure. We try two accepted methods: 1) additive disability approach, where we took the quality-of-life weight for dialysis patients and subtracted the decrement that liver transplant recipients have compared to "population norm", *i.e.* 0.70 – (0.823-0.747) = 0.624; 2) multiplicative approach, where quality-of-life weight was the product of the weights of dialysis patients and liver transplant recipients, *i.e.* 0.70 * 0.747 = 0.523. The base model was selected to be the mean of these two results, *i.e.* 0.573, and the two results were set as the upper and lower bounds of the beta distribution.

We verified that in all sets of probabilistic sensitivity analyses, the quality-of-life weight for the health state of no kidney failure was higher than for the health state of kidney failure.

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Supplemental S1: Sensitivity Analyses

Table S8. "Cost"-effectiveness of each kidney allocation strategy, with and without discounting. LY: Life year. DDK: Deceased donor kidney. Dom: Dominated completely. DomEx: Dominated by extension. Highlighted cells indicate the dominated strategy.

	Without Discounting			**With Discounting (base model)**		
Optimistic Scenario for OPTN Implementation						
Strategy	*LY (year)*	*# DDK*	*Incremental LY per DDK**	*LY (year)*	*# DDK*	*Incremental LY per DDK**
Stringent	12.49 (12.47-12.53)	0.050 (0.050-0.051)	-	9.56 (9.55-9.57)	0.036 (0.036-0.037)	-
Safety Net	12.51 (12.48-12.53)	0.056 (0.055-0.056)	2.37 (2.23-2.50)	9.57 (9.56-9.59)	0.042 (0.041-0.042)	1.85 (1.77-1.94)
OPTN	12.55 (12.52-12.57)	0.074 (0.074-0.075)	2.17 (2.05-2.28)	9.61 (9.59-9.61)	0.061 (0.060-0.061)	1.59 (1.52-1.66)
Pre-OPTN	12.54 (12.51-12.55)	0.077 (0.076-0.077)	Dom	9.59 (9.57-9.60)	0.062 (0.062-0.063)	Dom
Pessimistic Scenario for OPTN Implementation						
Strategy	*LY (year)*	*# DDK*	*Incremental LY per DDK**	*LY (year)*	*# DDK*	*Incremental LY per DDK**
Stringent	12.49 (12.47-12.53)	0.050 (0.050-0.051)	-	9.56 (9.55-9.57)	0.036 (0.036-0.037)	-

Safety Net	12.51 (12.48-12.53)	0.056 (0.055-0.056)	2.37 (2.23-2.50)	9.57 (9.56-9.59)	0.042 (0.041-0.042)	1.85 (1.77-1.94)
Pre-OPTN	12.54 (12.51-12.55)	0.077 (0.076-0.077	ExDom: 1.22 (1.09-1.36)	9.59 (9.57-9.60)	0.062 (0.062-0.063)	ExDom: 0.89 (0.81-0.98)
OPTN	9.64 (9.62-9.65)	0.111 (0.110-0.112)	1.88 (1.73-2.02)	9.64 (9.62-9.65)	0.098 (0.098-0.099)	1.30 (1.21-1.38)

Table S9. "Cost" effectiveness of each kidney allocation strategy, varying adjustment for liver transplant counterfactual*. LY: Life year. DDK: Deceased donor kidney. HR: Hazard ratio. Dom: Dominated completely. DomEx: Dominated by extension. Highlighted cells indicate the dominated strategy.

	HR = 1.3			HR = 1.5			HR = 2.0		
Optimistic Scenario for OPTN Implementation									
Strategy	*LY (year)*	*# DDK*	*Incremental LY per DDK**	*LY (year)*	*# DDK*	*Incremental LY per DDK**	*LY (year)*	*# DDK*	*Incremental LY per DDK**
Stringent	9.57 (9.55-9.58)	0.036 (0.036-0.037)	-	9.56 (9.55-9.57)	0.036 (0.036-0.037)	-	9.54 (9.53-9.56)	0.036 (0.035-0.036)	-
Safety Net	9.58 (9.56-9.59)	0.042 (0.041-0.042)	1.85 (1.76-1.93)	9.57 (9.56-9.59)	0.042 (0.041-0.042)	1.85 (1.77-1.94)	9.55 (9.54-9.57)	0.042 (0.041-0.042)	ExDom: 1.85 (1.77-1.94)
OPTN	9.60 (9.59-9.62)	0.061 (0.060-0.061)	1.32 (1.26-1.40)	9.61 (9.59-9.61)	0.061 (0.060-0.061)	1.59 (1.52-1.66)	9.60 (9.58-9.61)	0.061 (0.060-0.061)	2.18 (2.11-2.24)
Pre-OPTN	9.59 (9.57-9.60)	0.062 (0.062-0.063)	Dom	9.59 (9.57-9.60)	0.062 (0.062-0.063)	Dom	9.59 (9.57-9.60)	0.062 (0.062-0.063)	Dom
Pessimistic Scenario for OPTN Implementation									
Strategy	*LY (year)*	*# DDK*	*Incremental LY per DDK**	*LY (year)*	*# DDK*	*Incremental LY per DDK**	*LY (year)*	*# DDK*	*Incremental LY per DDK**
Stringent	9.57 (9.55-9.58)	0.036 (0.036-0.037)	-	9.56 (9.55-9.57)	0.036 (0.036-0.037)	-	9.54 (9.53-9.56)	0.036 (0.035-0.036)	-

Safety Net	9.58 (9.56-9.59)	0.042 (0.041-0.042)	1.85 (1.76-1.93)	9.57 (9.56-9.59)	0.042 (0.041-0.042)	1.85 (1.77-1.94)	9.55 (9.54-9.57)	0.042 (0.041-0.042)	1.85 (1.77-1.94)
Pre-OPTN	9.59 (9.57-9.60)	0.062 (0.062-0.063)	ExDom: 0.57 (0.48-0.65)	9.59 (9.57-9.60)	0.062 (0.062-0.063)	ExDom: 0.89 (0.81-0.98)	9.59 (9.57-9.60)	0.062 (0.062-0.063)	1.64 (1.56-1.72)
OPTN	9.64 (9.62-9.65)	0.098 (0.098-0.099)	1.35 (1.26-1.43)	9.64 (9.62-9.65)	0.098 (0.098-0.099)	1.30 (1.21-1.38)	9.63 (9.62-9.65)	0.098 (0.098-0.099)	1.19 (1.10-1.27)

*Adjustment for liver transplant counterfactual: We added an adjustment to the the probability of death after liver transplants. Given the observational nature of the survival data underlying model, patients who received SLK transplants are probably sicker than similar-appearing patients who received liver transplants only. If these patients received a liver transplant under alternative allocation strategies in our model, their outcomes would likely be worse. As the current hypothesis stands that SLK transplants ameliorate the risk of death early after transplant, we apply to the death rate a hazard ratio that inflates the first-year risk of death in the subset of patients who are offered SLK transplants in real life, but who receive liver transplants under alternative allocation strategies in our model.

Table S10. "Cost" effectiveness of each kidney allocation strategy, varying wait time for deceased donor kidney transplant*. LY: Life year. DDK: Deceased donor kidney. HR: Hazard ratio. Dom: Dominated completely. DomEx: Dominated by extension. Highlighted cells indicate the dominated strategy.

	Wait time = 292 days			**Wait time = 1601 days (base model)**			**Wait time = 2891 days**		
Optimistic Scenario for OPTN Implementation									
Strategy	*LY (year)*	*# DDK*	*Incremental LY per DDK**	*LY (year)*	*# DDK*	*Incremental LY per DDK**	*LY (year)*	*# DDK*	*Incremental LY per DDK**
Stringent	9.67 (9.66-9.68)	0.083 (0.082-0.084)	-	9.56 (9.55-9.57)	0.036 (0.036-0.037)	-	9.51 (9.50-9.53)	0.016 (0.016-0.016)	-
Safety Net	9.67 (9.66-9.68)	0.085 (0.084-0.086)	ExDom: 1.54 (1.30-1.75)	9.57 (9.56-9.59)	0.042 (0.041-0.042)	1.85 (1.77-1.94)	9.53 (9.51-9.54)	0.022 (0.022-0.023)	1.99 (1.91-2.06)
OPTN	9.70 (9.69-9.61)	0.103 (0.102-0.105)	1.57 (1.51-1.64)	9.61 (9.59-9.61)	0.061 (0.060-0.061)	1.59 (1.52-1.66)	9.56 (9.54-9.57)	0.042 (0.041-0.042)	1.60 (1.53-1.67)
Pre-OPTN	9.69 (9.68-9.71)	0.109 (0.107-0.110)	Dom	9.59 (9.57-9.60)	0.062 (0.062-0.063)	Dom	9.54 (9.53-9.56)	0.042 (0.042-0.043)	Dom
Pessimistic Scenario for OPTN Implementation									
Strategy	*LY (year)*	*# DDK*	*Incremental LY per DDK**	*LY (year)*	*# DDK*	*Incremental LY per DDK**	*LY (year)*	*# DDK*	*Incremental LY per DDK**
Stringent	9.67 (9.66-9.68)	0.083 (0.082-0.084)	-	9.56 (9.55-9.57)	0.036 (0.036-0.037)	-	9.51 (9.50-9.53)	0.016 (0.016-0.016)	-

Safety Net	9.67 (9.66-9.68)	0.085 (0.084-0.086)	1.54 (1.30-1.75)	9.57 (9.56-9.59)	0.042 (0.041-0.042)	1.85 (1.77-1.94)	9.53 (9.51-9.54)	0.022 (0.022-0.023)	1.99 (1.91-2.06)
Pre-OPTN	9.69 (9.68-9.71)	0.109 (0.107-0.110)	ExDom: 1.04 (0.98-1.11)	9.59 (9.57-9.60)	0.062 (0.062-0.063)	ExDom: 0.89 (0.81-0.98)	9.54 (9.53-9.56)	0.042 (0.042-0.043)	ExDom: 0.84 (0.76-0.93)
OPTN	9.73 (9.72-9.74)	0.138 (0.137-0.139)	1.19 (1.09-1.29)	9.64 (9.62-9.65)	0.098 (0.098-0.099)	1.30 (1.21-1.38)	9.59 (9.58-9.61)	0.080 (0.080-0.081)	1.34 (1.25-1.41)

Wait time to deceased donor kidney transplant:* The United Network of Organ Sharing (UNOS) website lists median times to transplant, stratified by UNOS region and blood type, for patients listed in 2003-2004. We built our base model based on the median time to transplant for blood type O in all UNOS regions (**1601 days**). To enable our model to be interpreted in light of local wait list conditions, we ran our model under two additional extreme wait times: **292 days** (most favorable blood type [AB] in the speediest UNOS region) and **2891 days** (least favorable blood type [B] in the slowest UNOS region).

Table S11. "Cost"-effectiveness of each kidney allocation strategy, varying effectiveness of Safety Net (% reduction in wait time to kidney)*. LY: Life year. DDK: Deceased donor kidney. Dom: Dominated completely. DomEx: Dominated by extension. Highlighted cells indicate the dominated strategy.

	90% Reduction			75% Reduction (base model)		
Optimistic Scenario for OPTN Implementation						
Strategy	*LY (year)*	*# DDK*	*Incremental LY per DDK**	*LY (year)*	*# DDK*	*Incremental LY per DDK**
Stringent	9.56 (9.55-9.57)	0.036 (0.036-0.037)	-	9.56 (9.55-9.57)	0.036 (0.036-0.037)	-
Safety Net	9.58 (9.56-9.59)	0.044 (0.043-0.044)	2.11 (2.05-2.19)	9.57 (9.56-9.59)	0.042 (0.041-0.042)	1.85 (1.77-1.94)
OPTN	9.61 (9.59-9.62)	0.063 (0.062-0.063)	1.59 (1.52-1.66)	9.61 (9.59-9.61)	0.061 (0.060-0.061)	1.59 (1.52-1.66)
Pre-OPTN	9.59 (9.57-9.60)	0.062 (0.062-0.063)	Dom	9.59 (9.57-9.60)	0.062 (0.062-0.063)	Dom
Pessimistic Scenario for OPTN Implementation						
Strategy	*LY (year)*	*# DDK*	*Incremental LY per DDK**	*LY (year)*	*# DDK*	*Incremental LY per DDK**
Stringent	9.56 (9.55-9.57)	0.036 (0.036-0.037)	-	9.56 (9.55-9.57)	0.036 (0.036-0.037)	-
Safety Net	9.58 (9.56-9.59)	0.044 (0.043-0.044)	2.11 (2.05-2.19)	9.57 (9.56-9.59)	0.042 (0.041-0.042)	1.85 (1.77-1.94)

Pre-OPTN	9.59 (9.57-9.60)	0.062 (0.062-0.063)	ExDom: 0.67 (0.58-0.76)	9.59 (9.57-9.60)	0.062 (0.062-0.063)	ExDom: 0.89 (0.81-0.98)
OPTN	9.64 (9.63-9.65)	0.100 (0.099-0.100)	1.36 (1.28-1.44)	9.64 (9.62-9.65)	0.098 (0.098-0.099)	1.30 (1.21-1.38)

* Effectiveness of Safety Net: As the initial liver transplant may have an allosensitizing effect, wait time to a subsequent kidney transplant may be longer than otherwise predicted. Subsequently, we assumed a more modest reduction in wait time (**75%**) in the base model and tested a more effective reduction (**90%**) in the sensitivity analysis.

Table S12. "Cost"-effectiveness of each kidney allocation strategy, varying effect of Safety Net on living donation rate*. LY: Life year. DDK: Deceased donor kidney. LD: Living donations. Dom: Dominated completely. DomEx: Dominated by extension. Highlighted cells indicate the dominated strategy.

	50% Reduction			100% Reduction (base model)		
Optimistic Scenario for OPTN Implementation						
Strategy	*LY (year)*	*# DDK*	*Incremental LY per DDK**	*LY (year)*	*# DDK*	*Incremental LY per DDK**
Stringent	9.56 (9.55-9.57)	0.036 (0.036-0.037)	-	9.56 (9.55-9.57)	0.036 (0.036-0.037)	-
Safety Net	9.57 (9.56-9.59)	0.041 (0.041-0.042)	1.99 (1.90-2.09)	9.57 (9.56-9.59)	0.042 (0.041-0.042)	1.85 (1.77-1.94)
OPTN	9.61 (9.59-9.62)	0.061 (0.060-0.061)	1.58 (1.52-1.66)	9.61 (9.59-9.61)	0.061 (0.060-0.061)	1.59 (1.52-1.66)
Pre-OPTN	9.59 (9.57-9.60)	0.062 (0.062-0.063)	Dom	9.59 (9.57-9.60)	0.062 (0.062-0.063)	Dom
Pessimistic Scenario for OPTN Implementation						
Strategy	*LY (year)*	*# DDK*	*Incremental LY per DDK**	*LY (year)*	*# DDK*	*Incremental LY per DDK**
Stringent	9.56 (9.55-9.57)	0.036 (0.036-0.037)	-	9.56 (9.55-9.57)	0.036 (0.036-0.037)	-
Safety Net	9.57 (9.56-9.59)	0.042 (0.041-0.042)	1.99 (1.90-2.09)	9.57 (9.56-9.59)	0.042 (0.041-0.042)	1.85 (1.77-1.94)

Pre-OPTN	9.59 (9.57-9.60)	0.062 (0.062-0.063)	ExDom: 0.87 (0.79-0.95)	9.59 (9.57-9.60)	0.062 (0.062-0.063)	ExDom: 0.89 (0.81-0.98)
OPTN	9.64 (9.62-9.65)	0.098 (0.098-0.099)	1.31 (1.22-1.39)	9.64 (9.62-9.65)	0.098 (0.098-0.099)	1.30 (1.21-1.38)

* Effect of Safety Net on living donation rate: There exists a concern that the Safety Net provision may decrease the incentive for living donation for Safety Net-eligible patients. In our base model, we assumed the worst case scenario (**100%** reduction in living donation rate in Safety Net-eligible patients), and tested a less extreme scenario (**50%** reduction) in an alternative model.

Supplemental S2: Model Validation

Figure S3. Internal validation: Actual (red, based on derivation cohort) *versus* modelled (blue) patient survival after liver transplant (left panels) and simultaneous liver-kidney (SLK) transplant (right panels). Data are censored at 10 years.