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Table S4. Regression analyses to determine the effects of new UA-PD on cPRA increases (0-1.000) after failed transplant and relisting, augmented to evaluate the interaction between the effects of HLA-DR and DQ. Results are stratified by receipt of an initial (A) deceased donor kidney or (B) living donor kidney and by pre-transplantation cPRA (0%, 1-50%, 51-100%). The interaction term “DR & DQ Interaction” estimates the change in cPRA given an additional HLA-DR UA-PD in the presence of an HLA-DQ UA-PD. These results are presented graphically as recipient scenarios in Figures S2-S3.

Figure S1. Scenarios applying regression analyses from Table S3 to demonstrate interactions between the effects of HLA-DR and HLA-DQ mismatches (MM) on the probabilities of being relisted with new HLA-DR and HLA-DQ UA-PD (0-100.0%). Scenarios are presented for example A) deceased donor recipients and B) living donor recipients. Rightmost columns depict expected changes in probabilities of new HLA-DR and HLA-DQ UA-PD given the presence or absence of HLA-DR and/or HLA-DQ mismatches, as compared a recipient with no HLA-DR or DQ mismatches.

Figure S2. Scenarios applying regression analyses from Table S4 to demonstrate interactions between the effects of HLA-DR and HLA-DQ UA-PD on cPRA increases (0-100.0%) in prior deceased donor recipients with pre-transplant cPRA of 0% (A) or 1-50% (B). The rightmost column depicts expected increases in cPRA after graft failure and relisting with new HLA-DR and/or HLA-DQ UA-PD as compared to a recipient relisted with no HLA-DR or DQ UA-PD.

Figure S3. Scenarios applying regression analyses from Table S4 to demonstrate interactions between the effects of HLA-DR and HLA-DQ UA-PD on cPRA increases (0-100.0%) in prior living donor recipients with pre-transplant cPRA of 0% (A) or 1-50% (B). The rightmost column depicts expected increases in cPRA after graft failure and relisting with new HLA-DR and/or HLA-DQ UA-PD as compared to a recipient relisted with no HLA-DR or DQ UA-PD.

Characteristics	Failed Deceased Donor Kidney			Failed Living Donor Kidney		
	African American Recipient	White Recipient	Hispanic Recipient	African American Recipient	White Recipient	Hispanic Recipient
Median age, yr (IQR)	50 [40,59]*	54.5 [39,64]*	44 [29,56]*	43 [33,53]*	45 [32,56]*	35 [26,46]*
Male, n (%)	951, 60.57%	647, 57.87%	290, 57.88%	165, 56.31%	512, 60.52%	117, 53.92%
Median BMI, kg/m ² (IQR)	28, [24, 33]*	28, [24, 32]*	27, [24, 31]*	28, [24, 33]*	27, [23, 31]*	26.5, [22,31]*
Cause of ESRD, n (%)						
GN	424, 27.01%	313, 28.00%	157, 31.34%	118, 40.27%	353, 41.73%	88, 40.55%
Diabetes	304, 19.36%*	183, 16.37%*	115, 22.95%*	48, 16.38%*	86, 10.17%*	33, 15.21%*
Hypertension	557, 35.48%*	154, 13.77%*	81, 16.17%*	83, 28.33%*	86, 10.17%*	37, 17.05%*
PKD	65, 4.14%*	151, 13.51%*	27, 5.39%*	12, 4.10%*	107, 12.65%*	11, 5.07%*
Other	220, 14.01%*	317, 28.35%*	121, 24.15%*	32, 10.92%*	214, 25.30%*	48, 22.12%*
Education level, n (%)						
No college	678, 43.18%*	438, 39.18%*	326, 65.07%*	103, 35.15%*	263, 31.09%*	91, 41.94%*
Some college	468, 29.81%*	303, 27.10%*	106, 21.16%*	104, 35.49%	249, 29.43%	67, 30.88%
College graduate	265, 16.88%*	214, 19.14%*	42, 8.38%*	61, 20.82%*	222, 26.24%*	40, 18.43%*
Graduate degree	96, 6.11%*	92, 8.23%*	13, 2.59%*	17, 5.80%*	75, 8.87%*	7, 3.23%*
Insurance status						
Private	312, 19.87%*	345, 30.86%*	81, 16.17%*	119, 40.61%*	491, 58.04%*	83, 38.25%*
Medicare	1,100, 70.06%*	687, 61.45%*	322, 64.27%*	151, 51.54%*	314, 37.12%*	101, 46.54%*
Medicaid	117, 7.45%*	58, 5.19%*	81, 16.17%*	18, 6.14%*	27, 3.19%*	25, 11.52%*
Other/Missing	41, 2.61%	28, 2.50%	17, 3.39%	5, 1.71%	14, 1.65%	8, 3.69%
Median time on dialysis pre-transplant, days (IQR)	1,687.5, *	1,162 *	1,533.5*	661.5*	452*	418.5*
Median time from initial transplant to return to dialysis, days (IQR)	[1,026, 2,472]	[641.5, 1,769]	[880, 2,469]	[388, 1,301.5]	[268, 846]	[270.5, 736]
Median time between graft failure/relisting, days (IQR)	745*	579.5*	613*	1,062	955.5	1,096
Median time from initial transplant to return to dialysis, days (IQR)	[218, 1,239]	[168, 1,265]	[192, 1,174]	[593, 1,465]	[412, 1,439]	[569, 1,464]
Median time between graft failure/relisting, days (IQR)	1,104*	648.5*	891*	1,440	1,376	1,411
Pre-transplant cPRA	[258, 1,911]	[110, 1,628]	[168, 1,802]	[749, 2,107]	[432, 2,194]	[530, 2,200]
Pre-transplant cPRA						
0%	961, 61.21%	734, 65.65%	323, 64.47%	198, 67.58%*	628, 74.23%*	165, 76.04%*
0.1-50%	318, 20.25%	221, 19.77%	105, 20.96%	65, 22.18%	160, 18.91%	35, 16.13%
50.1-80%	132, 8.41%*	57, 5.10%*	30, 5.99%*	13, 4.44%	32, 3.78%	11, 5.07%
80.1-98.0%	119, 7.58%	88, 7.87%	31, 6.19%	11, 3.75%	21, 2.48%	5, 2.30%
>98.1%	40, 2.55%	18, 1.61%	12, 2.40%	6, 2.05%	5, 0.59%	1, 0.46%
Peak post-graft loss cPRA						
0%	290, 18.47%*	289, 25.85%*	98, 19.56%*	51, 17.41%*	242, 28.61%*	55, 25.35%*
0.1-50%	127, 8.09%*	133, 11.90%*	51, 10.18%*	25, 8.53%*	121, 14.30%*	22, 10.14%*
50.1-80%	145, 9.24%	120, 10.73%	55, 10.98%	33, 11.26%	105, 12.41%	30, 13.82%
80.1-98.0%	276, 17.58%	210, 18.78%	78, 15.57%	60, 20.48%	169, 19.98%	40, 18.43%
>98.1%	732, 46.62%*	366, 32.74%*	219, 43.71%*	124, 42.32%*	209, 24.70%*	70, 32.26%*
HLA-A mismatch, n (%)						
0	93, 5.92%*	145, 12.97%*	59, 11.78%*	40, 13.65%	152, 17.97%	44, 20.28%
1	563, 35.86%	435, 38.91%	186, 37.13%	146, 49.83%	460, 54.37%	110, 50.69%
2	914, 58.22%*	538, 48.12%*	256, 51.10%*	107, 36.52%*	234, 27.66%*	63, 29.03%*
HLA-B mismatch, n (%)						
0	47, 2.99%*	96, 8.59%*	30, 5.99%*	28, 9.56%	89, 10.52%	28, 12.90%
1	349, 22.23%*	313, 28.00%*	100, 19.96%*	124, 42.32%*	410, 48.46%*	116, 53.46%*
2	1,174, 74.78%*	709, 63.42%*	371, 74.05%*	141, 48.12%*	347, 41.02%*	73, 33.64%*
HLA-C mismatch, n (%)						
0	110, 7.01%*	123, 11.00%*	44, 8.78%*	56, 19.11%	167, 19.74%	47, 21.66%
1	645, 41.08%	472, 42.22%	191, 38.12%	138, 47.10%*	423, 50.00%*	128, 58.99%*
2	815, 51.91%*	523, 46.78%*	266, 53.09%	99, 33.79%*	256, 30.26%*	42, 19.35%*
HLA-DR mismatch, n (%)						

0	126, 8.03%*	180, 16.10%*	58, 11.58%*	47, 16.04%	129, 15.25%	41, 18.89%
1	738, 47.01%	536, 47.94%	246, 49.10%	147, 50.17%	437, 51.65%	104, 47.93%
2	706, 44.97%*	402, 35.96%*	197, 39.32%*	99, 33.79%	280, 33.10%	72, 33.18%
HLA-DQ mismatch, n (%)						
0	257, 16.37%*	227, 20.30%*	80, 15.97%*	72, 24.57%	188, 22.22%	42, 23.96%
1	863, 54.97%	599, 53.58%	267, 53.29%	172, 58.70%	487, 57.57%	124, 57.14%
2	450, 28.66%	292, 26.12%	154, 30.75%	49, 16.72%	171, 20.21%	41, 18.89%

Table S1. Demographics and relevant characteristics stratified by deceased vs. living donor category of the initial failed graft and recipient race/ethnicity. Asterisks (*) denote statistically significant differences between the three race/ethnicity groups ($p < 0.05$).

A) Deceased	Difference Between Initial and Maximum cPRA After Failed Transplant and Re-Listing			
	All Data	Initial cPRA was 0	(0,.5]	(.5,1]
DQ UA	0.235*** (0.009)	0.279*** (0.011)	0.198*** (0.018)	0.047*** (0.009)
DR UA	0.124*** (0.010)	0.145*** (0.012)	0.097*** (0.020)	0.038*** (0.010)
A UA	0.231*** (0.011)	0.283*** (0.013)	0.195*** (0.022)	0.060*** (0.010)
B UA	0.205*** (0.011)	0.225*** (0.013)	0.232*** (0.023)	0.057*** (0.010)
C UA	0.113*** (0.011)	0.137*** (0.013)	0.088*** (0.022)	0.023** (0.011)
A Mismatch	-0.026*** (0.006)	-0.030*** (0.008)	-0.013 (0.013)	-0.005 (0.006)
B Mismatch	-0.022*** (0.008)	-0.018* (0.010)	0.004 (0.016)	0.002 (0.007)
C Mismatch	-0.012* (0.007)	-0.007 (0.008)	-0.011 (0.013)	-0.010 (0.006)
DQ Mismatch	-0.020*** (0.007)	-0.013 (0.008)	-0.024 (0.015)	-0.001 (0.007)
DR Mismatch	-0.010 (0.007)	-0.004 (0.009)	-0.004 (0.015)	-0.007 (0.007)
Time between failure and relisting	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000 (0.000)
Time between relisting and final follow up	0.000*** (0.000)	0.000*** (0.000)	0.000 (0.000)	0.000 (0.000)
PRA Original	-0.600*** (0.013)		-0.663*** (0.052)	-0.558*** (0.024)
Constant	0.308*** (0.016)	0.195*** (0.021)	0.316*** (0.032)	0.499*** (0.023)
Observations	3,443	2,173	711	559
R-squared	0.737	0.771	0.698	0.642

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

B) Living	Difference Between Initial and Maximum cPRA After Failed Transplant and Re-Listing			
	All Data	Initial cPRA was 0	(0,.5]	(.5,1]
DQ UA	0.290*** (0.015)	0.332*** (0.018)	0.266*** (0.033)	0.055*** (0.020)
DR UA	0.187*** (0.016)	0.192*** (0.019)	0.190*** (0.036)	0.063*** (0.020)
A UA	0.218*** (0.018)	0.248*** (0.021)	0.159*** (0.037)	-0.001 (0.024)
B UA	0.168*** (0.018)	0.177*** (0.021)	0.183*** (0.037)	0.076*** (0.022)
C UA	0.130*** (0.019)	0.144*** (0.023)	0.107*** (0.038)	-0.004 (0.028)
A Mismatch	-0.044*** (0.012)	-0.037*** (0.014)	-0.051* (0.027)	0.020 (0.015)
B Mismatch	0.008 (0.014)	0.007 (0.017)	0.033 (0.032)	0.017 (0.016)
C Mismatch	0.003 (0.012)	0.004 (0.014)	-0.016 (0.028)	0.001 (0.015)
DQ Mismatch	-0.028** (0.013)	-0.035** (0.016)	-0.027 (0.029)	-0.009 (0.017)
DR Mismatch	0.036*** (0.013)	0.041*** (0.015)	0.009 (0.029)	-0.015 (0.017)
Time between failure and relisting	0.000*** (0.000)	0.000*** (0.000)	0.000 (0.000)	-0.000 (0.000)
Time between relisting and final follow up	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000* (0.000)
PRA Original	-0.609*** (0.028)		-0.569*** (0.097)	-0.526*** (0.058)
Constant	0.180*** (0.020)	0.142*** (0.023)	0.235*** (0.045)	0.421*** (0.052)
Observations	1,424	1,036	273	115
R-squared	0.696	0.714	0.678	0.656

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table S2. Regression analysis to determine the relationship between UA-PD at each HLA locus and changes in cPRA after relisting (Figure 4), stratified by failed (A) deceased and (B) living donor kidney and by pre-transplantation cPRA (0%, 1-50%, 51-100%). The relationship between new UA-PD and cPRA was largely independent of potential contributors to sensitization—overall HLA mismatches, time between graft failure and relisting, time between relisting and final follow up and pre-transplantation cPRA.

A) Deceased	A UA	B UA	C UA	DR UA	DQ UA
DR & DQ Interaction	-0.041** (0.018)	-0.046** (0.018)	-0.017 (0.015)	-0.075*** (0.018)	-0.113*** (0.017)
A Mismatch	0.204*** (0.013)	0.034** (0.013)	0.004 (0.011)	0.009 (0.013)	0.009 (0.013)
B Mismatch	0.014 (0.017)	0.145*** (0.017)	0.021 (0.014)	-0.016 (0.016)	-0.007 (0.016)
C Mismatch	0.001 (0.014)	0.027* (0.014)	0.095*** (0.011)	0.008 (0.014)	-0.030** (0.013)
DR Mismatch	0.074*** (0.023)	0.083*** (0.023)	0.014 (0.019)	0.270*** (0.022)	0.126*** (0.022)
DQ Mismatch	0.040 (0.028)	0.046 (0.028)	0.007 (0.023)	0.095*** (0.027)	0.402*** (0.027)
Constant	0.087*** (0.032)	0.060* (0.033)	0.024 (0.027)	0.034 (0.031)	0.039 (0.031)
Observations	3,443	3,443	3,443	3,443	3,443
R-squared	0.085	0.054	0.030	0.079	0.138
Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1					
B) Living	A UA	B UA	C UA	DR UA	DQ UA
DR & DQ Interaction	-0.038 (0.026)	-0.049* (0.027)	-0.037* (0.020)	-0.105*** (0.026)	-0.133*** (0.026)
A Mismatch	0.262*** (0.021)	0.012 (0.021)	0.000 (0.016)	0.006 (0.021)	-0.007 (0.021)
B Mismatch	-0.014 (0.027)	0.160*** (0.028)	0.001 (0.020)	-0.014 (0.026)	-0.029 (0.026)
C Mismatch	0.003 (0.023)	0.036 (0.024)	0.126*** (0.018)	0.022 (0.023)	0.005 (0.023)
DR Mismatch	0.025 (0.033)	0.046 (0.034)	0.007 (0.025)	0.307*** (0.032)	0.136*** (0.033)
DQ Mismatch	0.035 (0.041)	0.055 (0.042)	0.037 (0.032)	0.077* (0.041)	0.457*** (0.041)
Constant	0.085** (0.035)	0.078** (0.036)	0.020 (0.027)	0.028 (0.035)	0.042 (0.035)
Observations	1,424	1,424	1,424	1,424	1,424
R-squared	0.127	0.072	0.055	0.094	0.171
Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1					

Table S3. Regression analyses to determine the effects of HLA mismatches [0-2] on the probabilities of UA-PD (0-1.000), augmented to evaluate the interactions between the effects of HLA-DR and HLA-DQ. Results are stratified by receipt of an initial (A) deceased donor kidney or (B) living donor kidney. The interaction term “DR & DQ Interaction” estimates the change in probability of an UA-PD with each additional HLA-DR mismatch in the presence of an HLA-DQ mismatch, or with each additional HLA-DQ mismatch in the presence of an HLA-DR mismatch. These results are presented graphically as recipient scenarios in Figure S1.

A) Deceased	Difference Between Initial and Maximum cPRA After Failed Transplant and Re-Listing			
	All Data	Original is 0	Original is (0,0.5]	Original > 0.5
DR & DQ Interaction	-0.289*** (0.016)	-0.366*** (0.019)	-0.257*** (0.032)	-0.075*** (0.016)
DQ UA	0.352*** (0.011)	0.424*** (0.013)	0.307*** (0.022)	0.077*** (0.011)
DR UA	0.284*** (0.013)	0.359*** (0.016)	0.230*** (0.025)	0.075*** (0.012)
A UA	0.217*** (0.011)	0.255*** (0.013)	0.191*** (0.022)	0.058*** (0.010)
B UA	0.195*** (0.011)	0.217*** (0.013)	0.217*** (0.022)	0.055*** (0.010)
C UA	0.105*** (0.010)	0.120*** (0.012)	0.094*** (0.021)	0.022*** (0.010)
A Mismatch	-0.024*** (0.006)	-0.028*** (0.007)	-0.008 (0.013)	-0.004 (0.006)
B Mismatch	-0.026*** (0.008)	-0.022** (0.009)	-0.000 (0.015)	0.000 (0.007)
C Mismatch	-0.010 (0.006)	-0.004 (0.007)	-0.012 (0.012)	-0.009 (0.006)
DQ Mismatch	-0.014** (0.007)	-0.006 (0.008)	-0.020 (0.014)	0.001 (0.007)
DR Mismatch	-0.015** (0.007)	-0.007 (0.008)	-0.012 (0.014)	-0.009 (0.007)
Time between failure and relisting	0.000*** (0.000)	0.000*** (0.000)	0.000** (0.000)	-0.000 (0.000)
Time between relisting and final follow up	0.000*** (0.000)	0.000*** (0.000)	0.000 (0.000)	0.000 (0.000)
PRA Original	-0.601*** (0.012)		-0.661*** (0.049)	-0.558*** (0.023)
Constant	0.290*** (0.015)	0.167*** (0.019)	0.301*** (0.031)	0.495*** (0.023)
Observations	3,443	2,173	711	559
R-squared	0.759	0.803	0.724	0.656

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

B) Living	Difference Between Initial and Maximum cPRA After Failed Transplant and Re-Listing			
	All Data	Original is 0	Original is (0,0.5]	Original > 0.5
DR & DQ Interaction	-0.359*** (0.027)	-0.409*** (0.031)	-0.340*** (0.057)	-0.008 (0.040)
DQ UA	0.417*** (0.017)	0.481*** (0.020)	0.379*** (0.037)	0.057** (0.023)
DR UA	0.392*** (0.022)	0.417*** (0.025)	0.397*** (0.048)	0.068** (0.034)
A UA	0.199*** (0.017)	0.220*** (0.020)	0.154*** (0.035)	-0.002 (0.024)
B UA	0.164*** (0.017)	0.174*** (0.020)	0.181*** (0.035)	0.075*** (0.022)
C UA	0.115*** (0.018)	0.126*** (0.021)	0.086** (0.036)	-0.004 (0.029)
A Mismatch	-0.043*** (0.011)	-0.034*** (0.013)	-0.044* (0.025)	0.020 (0.015)
B Mismatch	0.010 (0.013)	0.005 (0.015)	0.041 (0.030)	0.017 (0.016)
C Mismatch	-0.002 (0.011)	0.002 (0.013)	-0.030 (0.026)	0.001 (0.016)
DQ Mismatch	-0.017 (0.012)	-0.021 (0.014)	-0.021 (0.027)	-0.008 (0.017)
DR Mismatch	0.024** (0.012)	0.030** (0.014)	-0.007 (0.027)	-0.016 (0.017)
Time between failure and relisting	0.000*** (0.000)	0.000*** (0.000)	0.000 (0.000)	-0.000 (0.000)
Time between relisting and final follow up	0.000*** (0.000)	0.000*** (0.000)	0.000** (0.000)	0.000* (0.000)
PRA Original	-0.609*** (0.026)		-0.569*** (0.091)	-0.525*** (0.059)
Constant	0.153*** (0.019)	0.103*** (0.022)	0.219*** (0.042)	0.420*** (0.053)
Observations	1,424	1,036	273	115
R-squared	0.731	0.756	0.716	0.656

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table S4. Regression analyses to determine the effects of new UA-PD on cPRA increases (0-1.000) after failed transplant and relisting, augmented to evaluate the interaction between the effects of HLA-DR and DQ. Results are stratified by receipt of an initial (A) deceased donor kidney or (B) living donor kidney and by pre-transplantation cPRA (0%, 1-50%, 51-100%). The interaction term “DR & DQ Interaction” estimates the change in cPRA given an additional HLA-DR UA-PD in the presence of an HLA-DQ UA-PD. These results are presented graphically as recipient scenarios in Figures S2-S3.

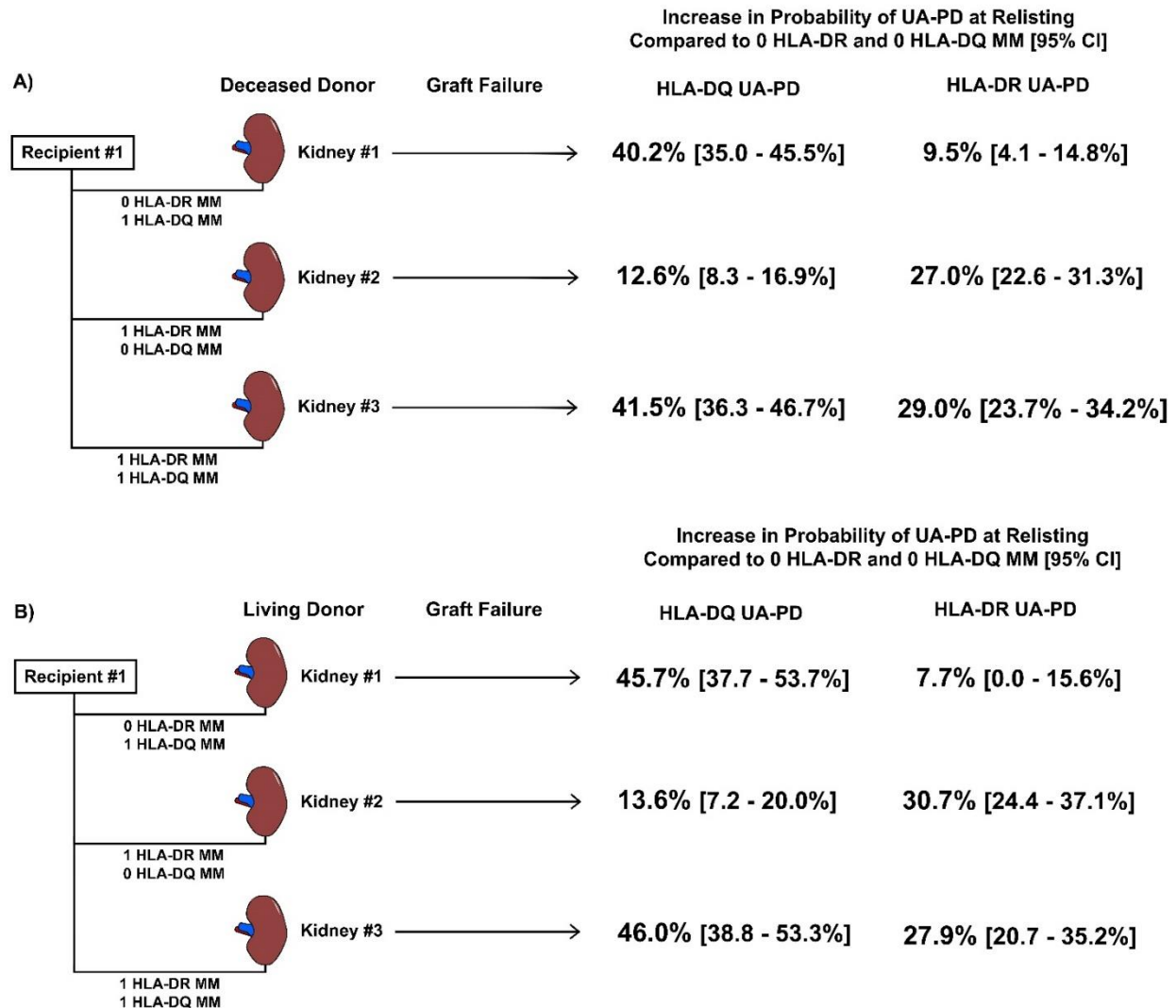


Figure S1. Scenarios applying regression analyses from Table S3 to demonstrate interactions between the effects of HLA-DR and HLA-DQ mismatches (MM) on the probabilities of being relisted with new HLA-DR and HLA-DQ UA-PD (0-100.0%). Scenarios are presented for example A) deceased donor recipients and B) living donor recipients. Rightmost columns depict expected changes in probabilities of new HLA-DR and HLA-DQ UA-PD given the presence or absence of HLA-DR and/or HLA-DQ mismatches, as compared a recipient with no HLA-DR or DQ mismatches.

Deceased Donor Recipients

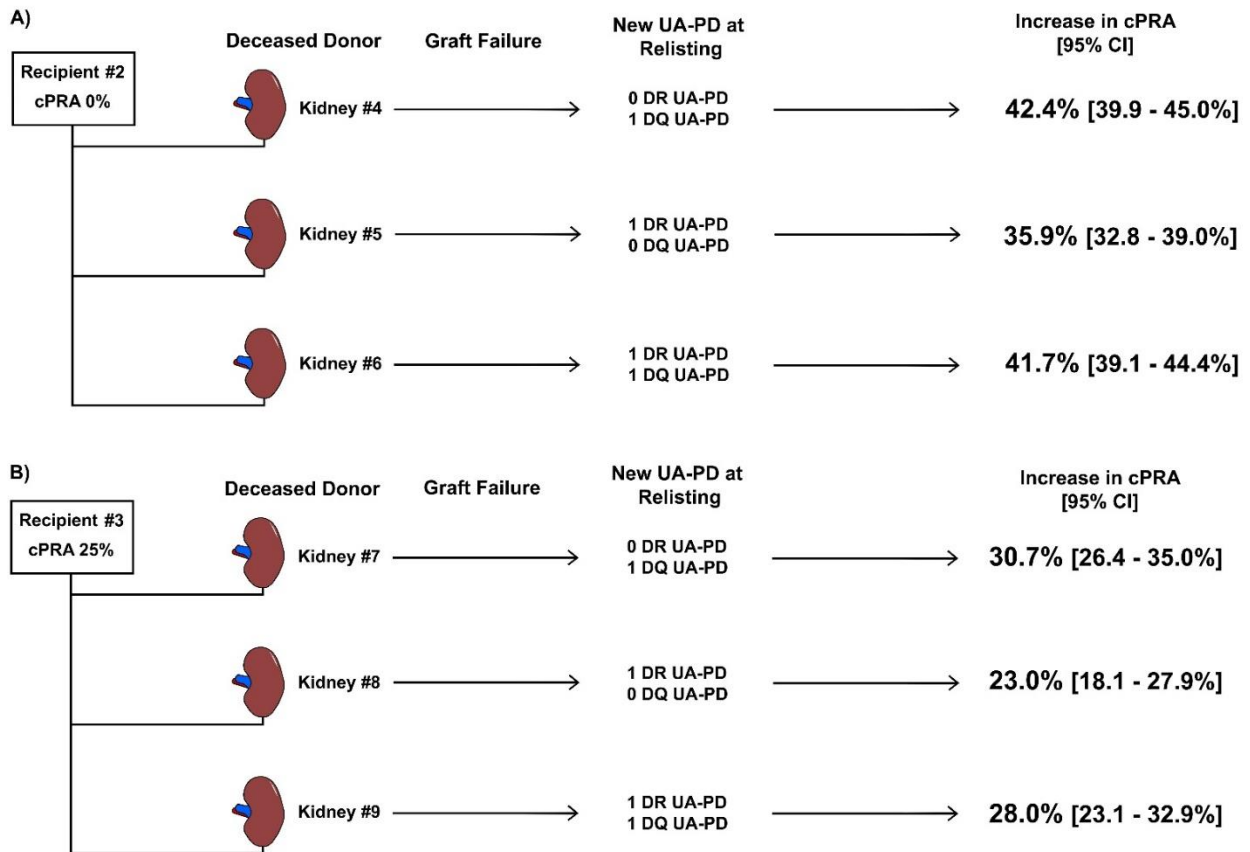


Figure S2. Scenarios applying regression analyses from Table S4 to demonstrate interactions between the effects of HLA-DR and HLA-DQ UA-PD on cPRA increases (0-100.0%) in prior deceased donor recipients with pre-transplant cPRA of 0% (A) or 1-50% (B). The rightmost column depicts expected increases in cPRA after graft failure and relisting with new HLA-DR and/or HLA-DQ UA-PD as compared to a recipient relisted with no HLA-DR or DQ UA-PD.

Living Donors

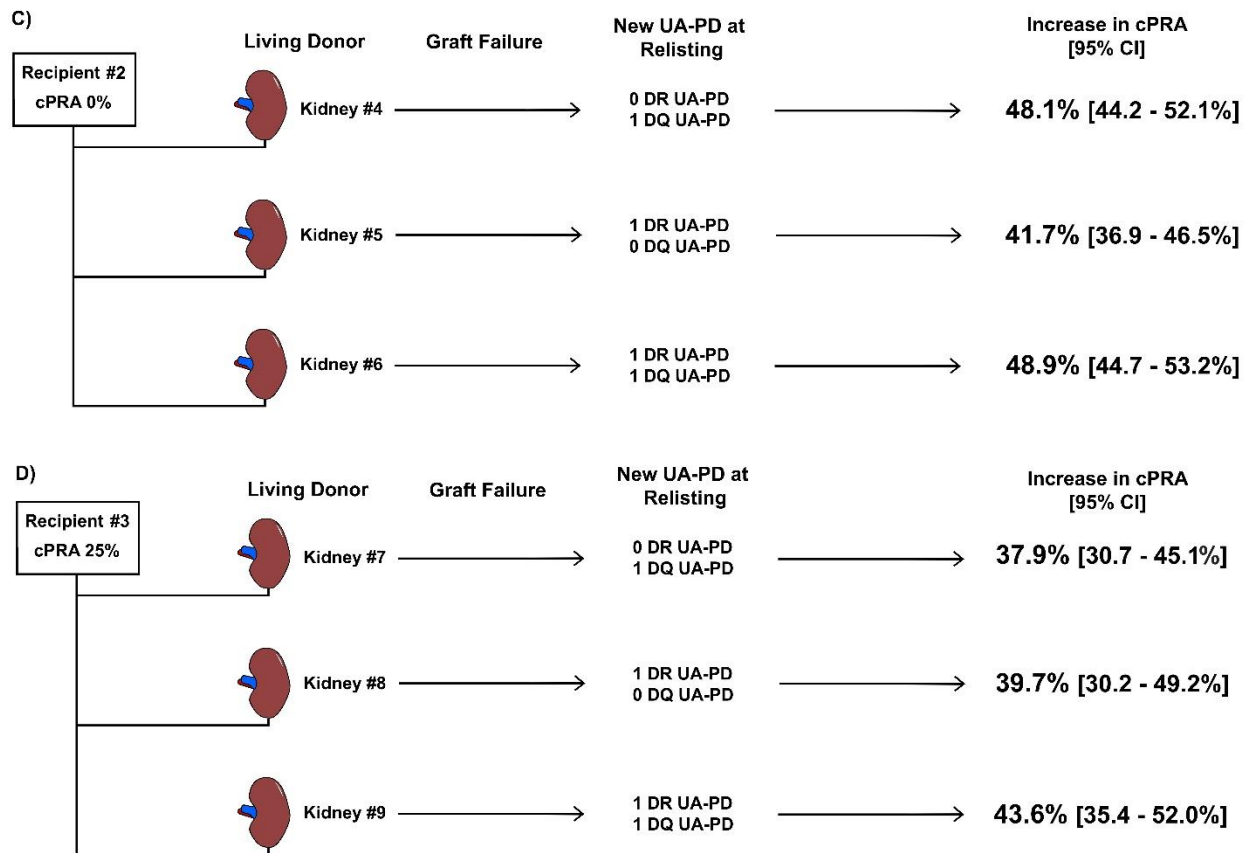


Figure S3. Scenarios applying regression analyses from Table S4 to demonstrate interactions between the effects of HLA-DR and HLA-DQ UA-PD on cPRA increases (0-100.0%) in prior living donor recipients with pre-transplant cPRA of 0% (A) or 1-50% (B). The rightmost column depicts expected increases in cPRA after graft failure and relisting with new HLA-DR and/or HLA-DQ UA-PD as compared to a recipient relisted with no HLA-DR or DQ UA-PD.