

**NHS BLOOD AND TRANSPLANT
ORGAN DONATION AND TRANSPLANTATION DIRECTORATE**

KIDNEY ADVISORY GROUP

UPDATE FROM NEW KIDNEY OFFERING SCHEME MEETING HELD ON
18th MAY 2017

BACKGROUND

- 1 The Kidney Offering Scheme working group met on 18th May 2017. Members of the group are shown in **Appendix II**. The attached working document “Developing a new National Kidney Offering Scheme” was presented detailing a number of simulations that had been developed following recommendations at previous meetings. This paper presents a summary of the simulations and discussions at the meeting.

SUMMARY

- 2 A number of caveats were discussed at the start of the meeting which need to be taken in to account when reviewing the simulations. Mainly that; only kidneys that result in a transplant are used in the simulations, decline rates are not built in, positive cross match results are not accounted for, unacceptable antigens at DP and DQ are not accounted for, and DCD kidneys are allocated on a fully shared scheme for all ages.
- 3 Five simulations were presented at the meeting:
 - S1 Current scheme
 - S2 As S1 with No Tiers
 - S3 As S1 with priority for difficult to match patients
 - S4 As S1 allowing HLA Level 4 for difficult to match patients
 - S5 As S1 prioritising D1/D2 for R1/R2 and D3/D4 for R3/R4

Simulation 1 (S1)

- 4 Simulation 1 is the baseline simulation. When comparing this to current practice there were a few differences and these are mainly due to the caveats mentioned above. All further simulations performed should be compared back to this simulation to see how things might change.

Simulation 2 (S2)

- 5 The reason for running a simulation with no tiers is that there are many 000 mismatched transplants performed in older patients under the current system that could be better utilised in other patient groups. By removing the tiers the simulations showed that fewer 000 mismatched transplants would occur overall especially in older patients where HLA matching is not as important, however paediatric patients (<18) would suffer from increased waiting time to transplant for a poorer matched graft so additional points would have to be allocated to account for this. It was felt that removing tiers overall was a good thing and that a more exponential priority by age should be given instead of the current cut-off at 18 years.

Simulation 3 (S3)

- 6 One of the recommendations from the HLA working group was to identify patients that would wait more than 7 years to transplant and give them priority earlier. In this simulation all patients that are difficult to match are given varying levels of priority based on their matchability points. By adding these points we see more difficult to match patients receiving transplants, an increase from 20% of transplants to 27% in difficult to match patients which leads to more highly sensitised patients receiving a transplant. This doesn't seem to have a large impact on other factors in the simulation, but it does increase the median waiting time of easy and moderate to match patients that remain on the waiting list. The group felt that this was a good thing to do, but that the points could be tweaked for those with a matchability score of 8 or 9 so as not to give them as much priority.

Simulation 4 (S4)

- 7 A further recommendation from the HLA working group was that HLA Level 4 ([1DR and 2B] or [2DR]) transplants should be allowed for difficult to match patients. This is particularly beneficial to patients with antibodies at HLA-A and HLA-B but none at HLA-DR. In this simulation only patients that are classed as difficult to match are given access to HLA level 4 mismatched grafts. This results in 14% of all transplants having a HLA Level 4 mismatch and a small increase in the numbers of transplants performed in difficult to match and highly sensitised patients. The group felt that this was a sensible thing to introduce but that perhaps a more clever HLA system in allocation might be appropriate and as such a small group was set up to look into this.

Simulation 5 (S5)

- 8 The final simulation was based on discussions around matching donor quality with recipient quality. Data have shown that patients classified as having a recipient risk index in the higher 50% are more likely to die with a functioning graft no matter what quality the donor is and so it may be better to utilise donors in the upper half of the donor risk index for this group and transplant them sooner. The simulation shows an extreme example of this. The simulation results in extra older recipients receiving a transplant and more transplants performed with a smaller donor-recipient age difference. Median waiting time of patients remaining on the list does reduce for older patients but the group felt that this could be reduced further. Further simulations to explore this aspect will be taken forward.

ACTION

- 9 Further work is planned to look at the order of which certain aspects should be prioritised in the scheme and then further simulations will be carried out. A meeting is planned for July to review this work and then a wider group will be convened.

NHS BLOOD AND TRANSPLANT

KIDNEY OFFERING SCHEME WORKING GROUP

DEVELOPING A NEW NATIONAL KIDNEY OFFERING SCHEME

WORKING DOCUMENT

Introduction

- 1 The Kidney Offering Scheme Working Group (KOSWG) were convened to make recommendations about how a new national scheme for offering of deceased donor kidneys should operate.

Simulating a New National Kidney Offering Scheme

- 2 A series of computer simulations can be used to investigate a number of different offering scheme algorithms. Developing a series of simulations will allow the KOSWG to explore a number of different options that will ultimately seek to provide, where possible, an equitable and transparent offering scheme. The offering scheme should also consider 'best use' of kidneys.

Data and Methods

- 3 The simulations were developed using SAS software (Version 9.3). Standard pools of real kidney donors and listed patients were used in each of the simulations to model the effects of various options.

- 4 Data Pools

Donor Pool

Data were retrieved from the UK Transplant Registry on all UK deceased kidney donors that resulted in a transplant between 1 January 2013 and 31 December 2016. The final pool randomly selected 2400 DBD and 1700 DCD of these donors.

Transplant List Pool

Data were retrieved from the UK Transplant Registry on all patients listed in the UK for a kidney only transplant as at 1 January 2012. The final pool randomly selected 5300 of these patients.

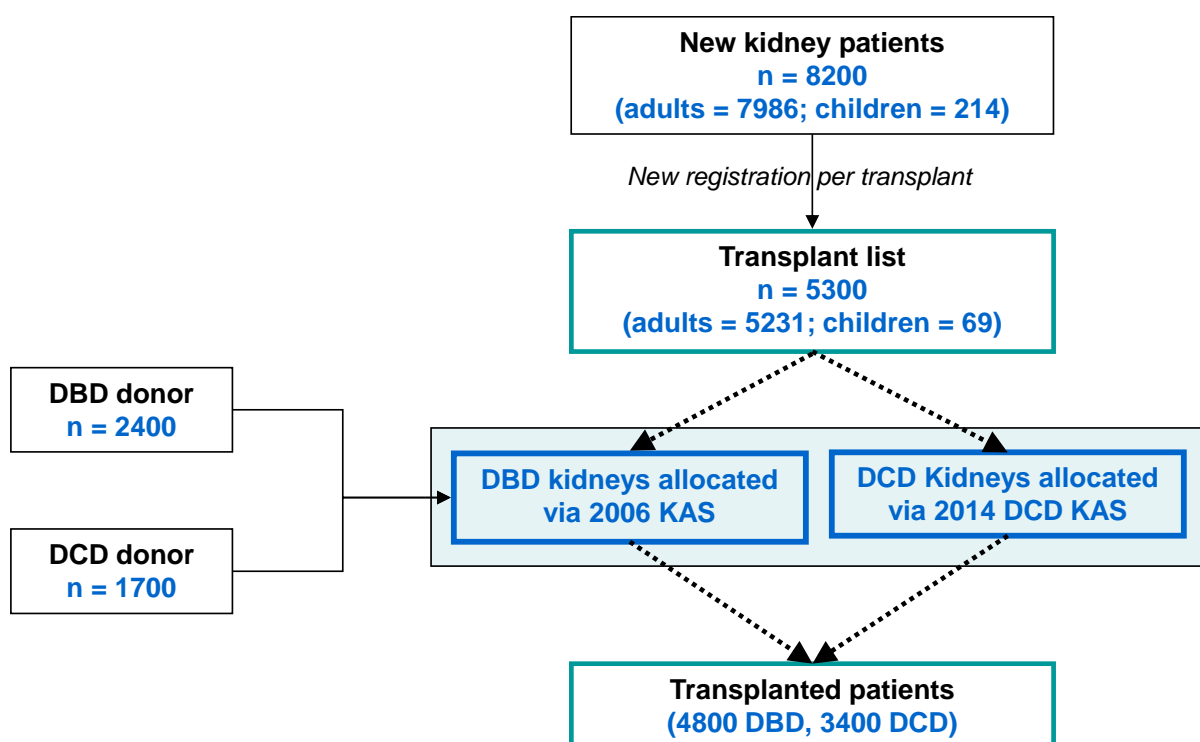
New Patients Pool

Data were retrieved from the UK Transplant Registry on all UK patients newly actively listed for a kidney only transplant between 1 January 2012 and 31 December 2016. The final pool randomly selected 8200 of these patients.

Simulation design

- 5 Simulations (S) each represent four years of kidney transplant activity. Each simulation assumes activity will remain constant over the four year period. A complete simulation 'iteration' represents a kidney donation that successfully resulted in either one or two kidney only transplants. Dual or double kidney transplants are not accounted for or considered in the simulation design. Each simulation invokes sufficient iterations such that 1200 DBD kidney and 850 DCD kidney only transplants are performed during each simulated year. The number of resulting kidney transplants from a given donor reflects the number that truly resulted in a transplant in practice. When a listed patient is transplanted they are removed from the transplant list and a new patient is added. The waiting list size therefore remains constant at 5300 patients. A summary of the simulation design is shown in Figure 1.

Figure 1 Simulation Structure



- 6 Both DBD and DCD donors were entered in to the simulation model. For the purpose of these simulations, both kidneys from a DCD donor are allocated regionally to reflect a fully shared scheme for all ages.

Table 1**Summary of the data pools used in the simulations**

Data pools for the simulations closely reflect current practice and are based on actual donor and patient registration data

		Initial transplant list		New registrations		Donors			
		N	%	N	%	DBD		DCD	
Number		5300	100	8200	100	2400	100	1700	100
Age	0-5	12	0	44	1	15	1	20	1
	6-11	20	0	59	1	24	1	14	1
	12-17	37	1	111	1	73	3	24	1
	18-29	274	5	588	7	277	12	148	9
	30-39	508	10	936	11	312	13	151	9
	40-49	1122	21	1711	21	451	19	273	16
	50-59	1418	27	2173	27	582	24	429	25
	60-69	1423	27	1969	24	455	19	414	24
	>=70	486	9	609	7	211	9	227	13
Blood group	O	2693	51	3707	45	1109	46	803	47
	A	1660	31	2935	36	965	40	680	40
	B	803	15	1186	14	245	10	165	10
	AB	144	3	372	5	81	3	52	3
Ethnicity	White	3715	70	5752	70	2243	93	1636	96
	Non-white	1585	30	2448	30	157	7	64	4
Homozygosity	HLA-A	986	19	1463	18	419	17	272	16
	HLA-B	602	11	903	11	249	10	159	9
	HLA-DR	886	17	1333	16	350	15	238	14
Risk Index	1	1652	31	3543	43	659	27	363	21
	2	1389	26	1984	24	617	26	410	24
	3	1085	20	1453	18	552	23	468	28
	4	1174	22	1220	15	572	24	459	27
Diabetic	Yes	507	10	1019	12	-	-	-	-
cRF	0-9	3567	67	5515	67	-	-	-	-
	10-39	341	6	596	7	-	-	-	-
	40-59	298	6	492	6	-	-	-	-
	60-84	469	9	599	7	-	-	-	-
	85-94	248	5	335	4	-	-	-	-
	95-99	255	5	425	5	-	-	-	-
	100	122	2	238	3	-	-	-	-
Matchability	Easy	1138	21	2191	27	-	-	-	-
	Moderate	2736	52	4336	53	-	-	-	-
	Difficult	1426	27	1673	20	-	-	-	-
Waiting time	<1 yr	1497	28	-	-	-	-	-	-
	1-3 yrs	2147	41	-	-	-	-	-	-
	3-5 yrs	1173	22	-	-	-	-	-	-
	5-7 yrs	403	8	-	-	-	-	-	-
	>=7 yrs	80	2	-	-	-	-	-	-

Table 1a **Summary of the data pools used in the simulations**

Data pools for the simulations closely reflect current practice and are based on actual donor and patient registration data

	Initial transplant list		New registrations		Donors			
	N	%	N	%	DBD		DCD	
	N	%	N	%	N	%	N	%
Local Transplant Centre								
Belfast	116	2	167	2	102	4	54	3
Birmingham	513	10	523	6	171	7	100	6
Bristol	276	5	351	4	95	4	90	5
Cambridge	191	4	386	5	120	5	132	8
Cardiff	169	3	253	3	83	3	52	3
Coventry	75	1	148	2	33	1	28	2
Edinburgh	172	3	228	3	87	4	89	5
Glasgow	246	5	438	5	102	4	50	3
GOSH	9	0	28	0	-	-	-	-
Guy's	332	6	528	6	-	-	-	-
Leeds	276	5	560	7	106	4	101	6
Leicester	277	5	302	4	60	3	37	2
Liverpool	175	3	292	4	140	6	77	5
Manchester	445	8	734	9	145	6	113	7
Newcastle	170	3	352	4	163	7	111	7
Nottingham	160	3	228	3	52	2	78	5
Oxford	193	4	329	4	90	4	64	4
Plymouth	87	2	159	2	94	4	67	4
Portsmouth	165	3	286	3	96	4	63	4
Royal Free	222	4	402	5	-	-	-	-
Royal London	190	4	415	5	-	-	-	-
Sheffield	172	3	233	3	68	3	29	2
St George's	260	5	418	5	-	-	-	-
WLRTC	409	8	440	5	-	-	-	-
DCD Regions								
North	1484	28	2604	32	743	31	541	32
Midlands	1504	28	1987	24	606	25	458	27
South West	890	17	1378	17	458	19	336	20
London	1422	27	2231	27	593	25	365	21

The Simulations

Simulations (S) each represents four years of kidney only transplant activity. Each simulation assumes activity will remain constant over the next four years.

S1 Current scheme

As per Appendix I

S2 As S1 with No Tiers

Remove Tiers A-C from current scheme

S3 As S1 with priority for difficult to match patients

Matchability = 8, equivalent to 1.5 years waiting time

Matchability = 9, equivalent to 2 years waiting time

Matchability = 10, equivalent to 5 years waiting time

S4 As S1 allowing HLA Level 4 for difficult to match patients

[1 DR and 2 B] or [2 DR] will be allowed for recipients with match points 8-10

S5 As S1 prioritising D1/D2 for R1/R2 and D3/D4 for R3/R4

2000 points given for a D1/D2 to R1/R2 or D3/D4 to R3/R4

Key Principles

Whilst reviewing the simulations the following key principles will be helpful

- 1) More effective 'quality' matching of donor and recipient
- 2) More tailored HLA matching by age
- 3) Geographical equity of access
- 4) Avoid prolonged waiting times that are predictable
- 5) Unify DBD and DCD offering

The Results

Table 1 shows the demographic characteristics of total transplants performed in each simulated four year period. As a comparison, data on deceased donor transplants performed in 2016 are presented. It is worth noting that DCD donor transplants performed in 2016 are not fully allocated for all donor ages and as such the results displayed will not be fully reflective.

Table 2 shows demographic characteristics of patients simulated as still waiting at the end of the four year period. As a comparison, a snapshot of the waiting list as at 31 December 2016 is presented.

Table 3 shows median waiting time of patients still active at the end of the simulated four year period by demographics. As a comparison, a snapshot of the waiting list as at 31 December 2016 is presented.

Figure 1 shows recipient age group by HLA mismatch level for each simulation. As a comparison, data from 2016 is also presented.

Figure 2 shows donor risk index by recipient risk index for each simulation. As a comparison, data from 2016 is also presented.

Table 1 All patients - deceased donor kidney only transplant activity by factors

Factor	Level	Actual	Simulated transplants (Total for 4 years)				
		transplants 2016	S1	S2	S3	S4	S5
Number of transplants		2103	8196	8195	8195	8198	8192
		%	%	%	%	%	%
Donor type	DBD	57	59	59	59	59	59
	DCD	43	41	41	41	41	41
HLA mm	1	11	16	8	16	16	16
	2	36	49	55	44	48	40
	3	48	35	37	40	22	44
	4	6				14	
Waiting time	<1 yr	29	17	14	18	17	17
	1-3 yrs	41	36	39	36	36	38
	3-5 yrs	20	34	35	32	34	33
	5-7 yrs	5	11	10	12	11	11
	>=7 yrs	5	2	2	2	2	2
Matchability	Easy	40	27	26	25	26	28
	Moderate	42	53	54	48	51	53
	Difficult	18	20	20	27	22	20
Age (years)	0-5	1	1	1	1	1	1
	6-11	1	1	1	1	1	1
	12-17	1	2	1	2	2	2
	18-29	6	8	8	8	8	7
	30-39	12	13	13	13	13	11
	40-49	20	23	24	24	23	21
	50-59	27	26	26	26	25	26
	60-69	24	21	20	20	21	23
	>=70	7	7	6	7	7	8
Blood group	O	43	44	45	44	44	44
	A	41	39	39	39	39	39
	B	12	12	11	13	12	12
	AB	5	5	5	5	5	5
cRF	0-9	65	69	69	66	68	70
	10-39	9	7	7	7	7	7
	40-59	6	6	6	6	6	6
	60-84	8	8	8	9	8	8
	85-94	5	4	4	5	4	4
	95-99	6	4	4	5	5	4
	100	2	1	1	3	2	1
Homozygosity	HLA-A	17	17	18	18	18	17
	HLA-B	11	11	11	11	11	11
	HLA-DR	17	17	17	18	18	17
Diabetic	Yes	9	10	9	9	9	12
Donor-recipient age difference	<15 yrs	69	64	66	63	65	70
	15-25 yrs	21	24	24	24	24	21
	>25 yrs	10	12	10	13	11	9
Ethnicity	White	71	73	72	72	72	73
	Non-white	29	27	28	28	28	27
Tier	LW	5	2	2	2	2	2
	A	0	0	0	0	0	0
	B	0	0	0	0	0	0
	C	3	5	5	5	5	5
	D	9	13	13	13	13	13
	E	83	80	80	80	80	80

Table 2 All patients – demographic summary of waiting list

Factor	Level	Actual waiting	Simulated waiting list (end of year 4)				
		list 31 Dec 2016	S1	S2	S3	S4	S5
Number on waiting list		4937 %	5304 %	5305 %	5305 %	5302 %	5308 %
Waiting time	<1 yr	44	34	32	31	31	31
	1-3 yrs	37	47	49	47	48	47
	3-5 yrs	11	16	17	19	18	18
	5-7 yrs	3	2	2	2	2	3
	>=7 yrs	4	1	1	1	1	1
Matchability	Easy	19	21	23	23	22	20
	Moderate	49	52	51	59	54	52
	Difficult	32	27	27	17	24	28
Age (years)	0-5	0	0	0	0	0	0
	6-11	0	0	0	0	0	0
	12-17	1	0	0	0	0	0
	18-29	6	4	4	4	4	6
	30-39	12	8	7	8	7	10
	40-49	20	17	16	17	17	21
	50-59	28	28	28	28	28	27
	60-69	25	32	33	32	32	28
>=70	8	10	11	11	10	8	
Blood group	O	53	53	51	53	53	53
	A	27	27	27	27	26	27
	B	17	18	20	18	18	18
	AB	2	2	2	2	2	2
cRF	0-9	51	65	64	69	66	63
	10-39	8	6	6	7	6	7
	40-59	6	6	6	6	6	6
	60-84	8	8	7	7	8	8
	85-94	6	4	5	4	4	5
	95-99	9	6	7	5	6	6
	100	12	5	5	3	4	5
Homozygosity	HLA-A	19	19	18	18	19	19
	HLA-B	12	12	11	11	11	12
	HLA-DR	19	16	16	14	14	16
Diabetic	Yes	11	14	14	15	14	11
Ethnicity	White	65	66	68	68	67	66
	Non-white	35	34	32	32	33	34

Table 3 All patients – Median waiting time of patients on the waiting list at year end

Factor	Level	Actual waiting	Simulated waiting list (end of year 4)				
		list 31 Dec 2016 Median	S1 Median	S2 Median	S3 Median	S4 Median	S5 Median
All patients		437	576	591	615	606	609
Matchability	Easy	290	498	551	595	559	502
	Moderate	363	537	550	641	590	577
	Difficult	823	702	717	548	677	756
Age (years)	0-5	242	293	415	329	208	208
	6-11	202	231	303	264	264	267
	12-17	183	545	423	605	459	584
	18-29	395	371	372	343	372	437
	30-39	410	447	422	450	446	551
	40-49	444	464	465	492	488	579
	50-59	445	597	600	634	634	645
	60-69	426	676	703	736	712	690
	>=70	619	666	719	759	709	573
Blood group	O	480	640	646	686	674	661
	A	332	431	458	474	457	479
	B	523	680	723	709	720	699
	AB	327	343	349	347	394	289
cRF	0-9	305	548	564	618	588	570
	10-39	404	537	547	594	574	599
	40-59	425	558	569	582	609	584
	60-84	419	613	627	595	626	667
	85-94	531	583	594	576	576	625
	95-99	909	699	772	628	697	771
	100	1770	933	900	764	883	1001
Homozygosity	HLA-A	501	595	595	612	611	638
	HLA-B	460	613	604	652	613	636
	HLA-DR	446	529	533	486	485	579
Diabetic	Yes	405	598	617	649	634	551
Ethnicity	White	411	562	582	615	592	595
	Non-white	508	602	609	618	633	639

Figure 1 Age group by mismatch of transplants

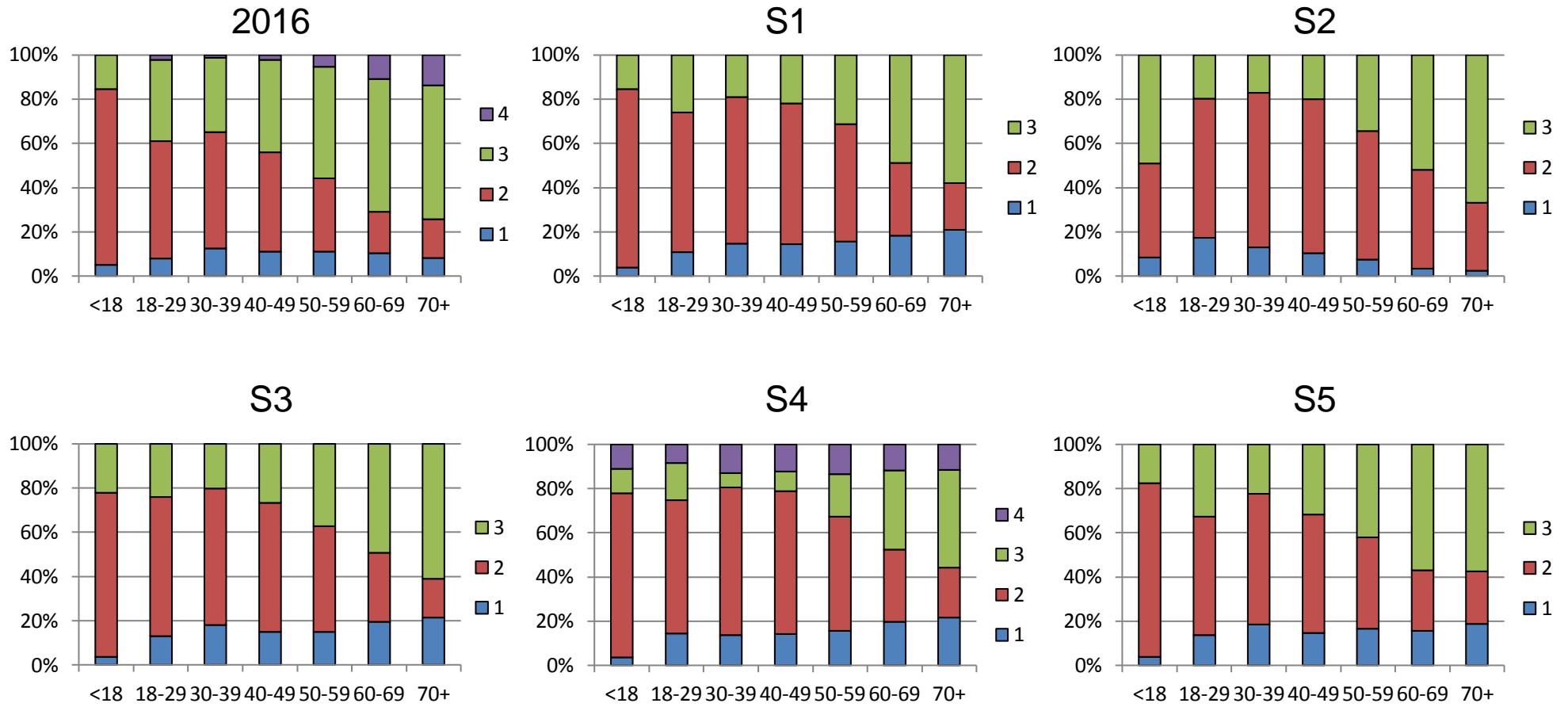
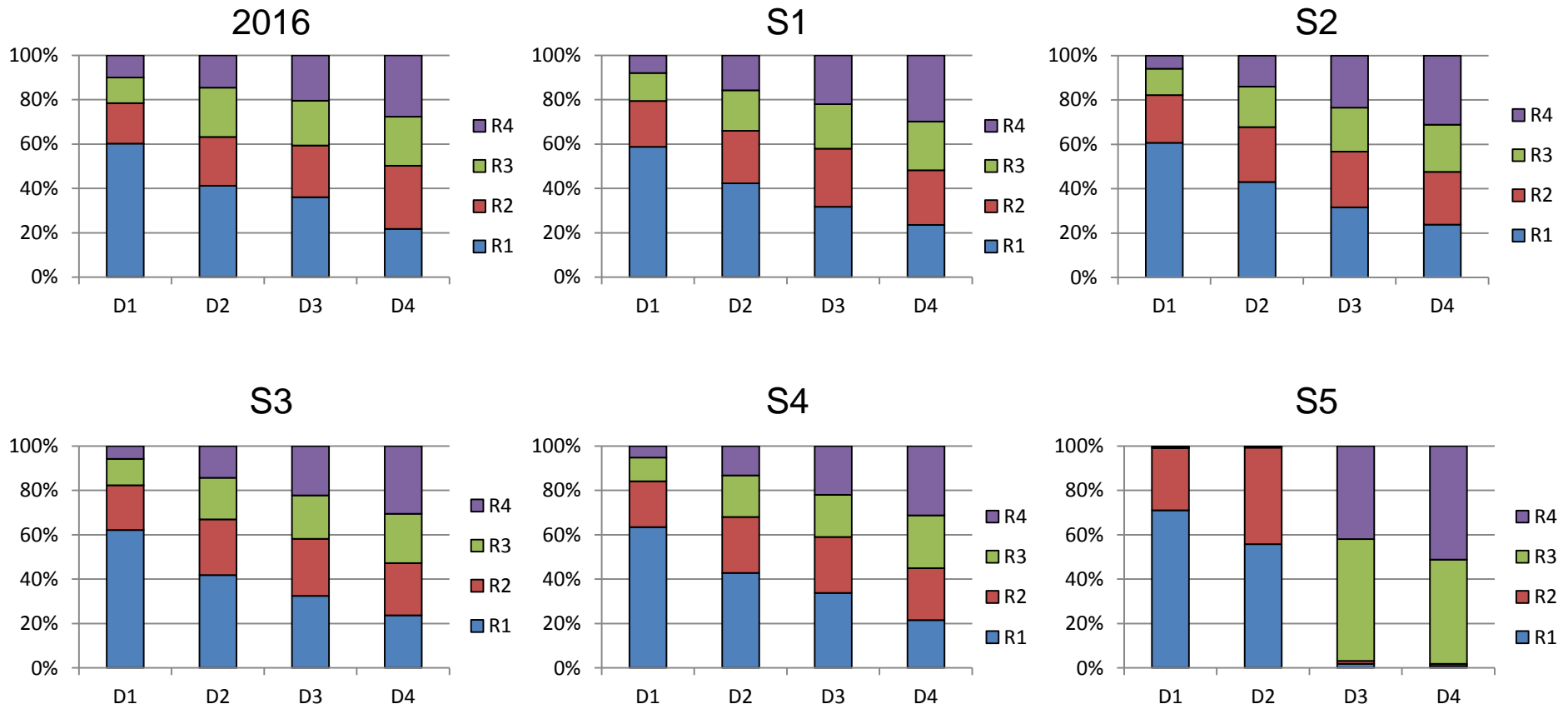


Figure 2 Donor Risk Index by Recipient Risk Index



APPENDIX I – 2006 Kidney Allocation Scheme Principles

All kidneys from deceased donors are allocated via an evidence-based computer algorithm. This is based on five ranked Tiers of recipients who are eligible (as defined below) to receive a particular donor's organs:

Tier A	000 mismatched paediatric patients - highly sensitised* or HLA-DR homozygous
Tier B	000 mismatched paediatric patients - others
Tier C	000 mismatched adult patients - highly sensitised* or HLA-DR homozygous
Tier D	000 mismatched adult patients – others & favourably matched paediatric patients (100, 010, 110 mismatches)
Tier E	All other eligible patients

* $\geq 85\%$ calculated reaction frequency (based on comparison with pool of 10,000 donor HLA types on national database)

DCD donors will be restricted to recipients at centres within the sharing region for the donor. The sharing regions are:

North	Midlands	South West	London
Edinburgh	Birmingham	Bristol	GOSH
Glasgow	Cambridge	Cardiff	Guy's
Leeds	Coventry	Oxford	The Royal Free
Liverpool	Leicester	Plymouth	The Royal London
Manchester	Nottingham	Portsmouth	St George's
Newcastle	Sheffield		WLRTC
	Belfast		

Paediatric patients in Tiers A and B are prioritised according to waiting time. In the remaining Tiers, patients are prioritised according to a points-based system based on 7 elements, these include:

- Waiting time **(1)**
- HLA match & age combined **(2)**
- Donor-recipient age difference **(3)**
- Location of patient relative to donor **(4)**
- HLA-DR homozygosity **(5)**
- HLA-B homozygosity **(6)**
- Blood group match **(7)**

Points scores are calculated as shown:

(1) Waiting time points = number of days of waiting time accrued (see definitions)

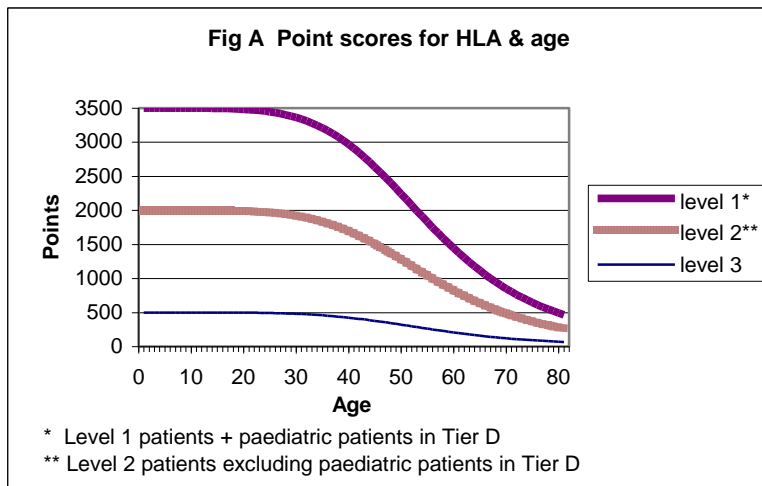
(2) HLA match & age points combined are defined as:

$3500/(1+(\text{age}/55)^5)$ for level 1 mismatch patients and paediatric patients in Tier D

$2000/(1+(\text{age}/55)^5)$ for level 2 mismatch patients excluding paediatric patients in Tier D

$500/(1+(\text{age}/55)^5)$ if level 3 mismatch

Points scores are illustrated in Figure A and mismatch levels are shown in Table C below



(3) Age difference points = $-\frac{1}{2} (\text{donor-recipient age difference})^2$

(4) Location points =

- 900 for patients at the same centre as the donor
- 750 for patients at another centre within the local area as defined below:
 - Area A - Bristol, Cardiff, London (Guy's, Royal Free, Royal London, St George's and the West London Renal Transplant Centre), Oxford, Plymouth and Portsmouth
 - Area B - Belfast, Birmingham, Coventry, Cambridge, Leicester, Nottingham and Sheffield
 - Area C - Edinburgh, Glasgow, Leeds, Liverpool, Manchester and Newcastle

For DCD donors, no points are awarded for location

(5) HLA-DR homozygous points = 500 for all HLA-DR homozygous patients (where HLA level > 1)

(6) HLA-B homozygous points = 100 for all HLA-B homozygous patients (where HLA level > 1)

(7) Blood group points =

-1000 for blood group B patients when the donor is group O (Tiers D and E only)

+1500 points for blood group B patients when the donor is group A2 provided that they have been registered as suitable for such a transplant and their waiting time exceeds 730 days (this is currently a pilot limited to three London centres)

Definitions

All deceased donor kidneys are allocated according to

- Restricted blood group compatible matches (see Table A)
- Defaulting of rare HLA specificities to more common equivalents (see Table B)
- HLA mismatch levels (see Table C).

Table A Donor - recipient blood group matching policy

Donor	Recipient			
	O	A	B	AB
O	✓	✓ *	✓	✓ *
A	-	✓	✓ #	✓
B	-	-	✓	✓ *
AB	-	-	-	✓

* 000 mismatched highly sensitised or 000 HLA-DR homozygous adult patients & 000 mismatched paediatric patients only

- blood group incompatible

Kidneys from donors of subtype A2 can be allocated to patients of blood group B as part of a pilot scheme in 3 London transplant centres where patients are regularly tested to ensure ongoing suitability for this programme

Table B Defaulting of rare HLA specificities

Rare Specificity	Common Equivalent
A36	A1
A80	A1
A43	A10
B53	B5
B41	B40
B42	B7
B46	B15
B47	B27
B48	B40
B59	B8
B67	B22
B70	B35
B73	B7
B78	B35
B81	B7
B82	B12
B83	B12
DR103	DR1
DR10	DR1
DR9	DR4
DR11, DR12	DR5

The rare specificities indicated will be 'defaulted' to their more common equivalents so that patients with rare tissue types match with more donors. The defaults will be applied (as appropriate) at NHS Blood and Transplant as part of the allocation algorithm. This will enable

patients with rare specificities also to be considered a match should a donor with the same rare specificity become available.

Table C HLA mismatch levels

Level	HLA mismatch summary	HLA mismatch combinations included
1	000	000
2	[0 DR and 0/1 B]	100, 010, 110, 200, 210
3	[0 DR and 2 B] or [1 DR and 0/1 B]	020, 120, 220, 001, 101, 201, 011, 111, 211
4	[1 DR and 2 B] or [2 DR]	021, 121, 221, 002, 102, 202, 012, 112, 212, 022, 122, 222

APPENDIX II

Initial group membership

Chair	Chris Watson
Working Group Chairs	Susan Fuggle, David Turner, Lorna Marson, Rachel Hilton
Clinicians	Chris Callaghan, Chris Dudley, Keith Rigg, Phil Mason, Peter Friend
Associate Medical Director	John Forsythe
Statisticians	Lisa Mumford, Rachel Johnson