O Unit, Where Art Thou?

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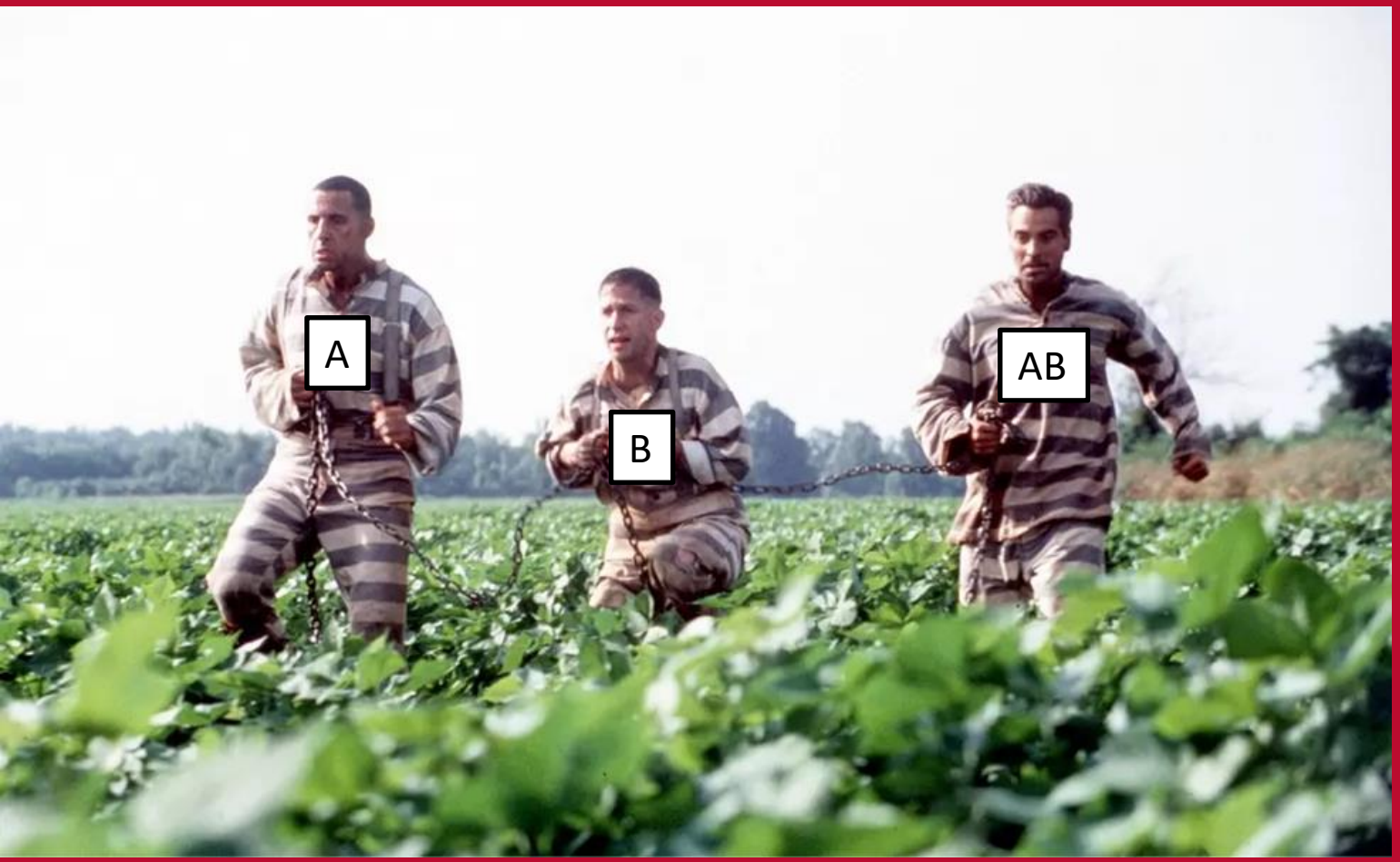
Washington University in St. Louis

WashU Medicine



O Unit, Where Art Thou?

O Brother, Where Art Thou? Coen, Joel, et al. Touchstone Home Video, 2001.

Disclosures

- Recognize the circumstances unique to pediatrics that necessitate increased use of O negative packed red blood cells
- Describe the process of providing type specific packed red blood cells to neonates
- Identify methods to reduce O negative packed red blood cells use while matching for C/E/K antigens in sickle cell disease patients
- Discuss an ongoing project to further reduce O negative packed red blood cell use in neonates

Learning Objectives

Recognize the circumstances unique to pediatrics that necessitate increased use of O negative packed red blood cells

The Little Adult Fallacy

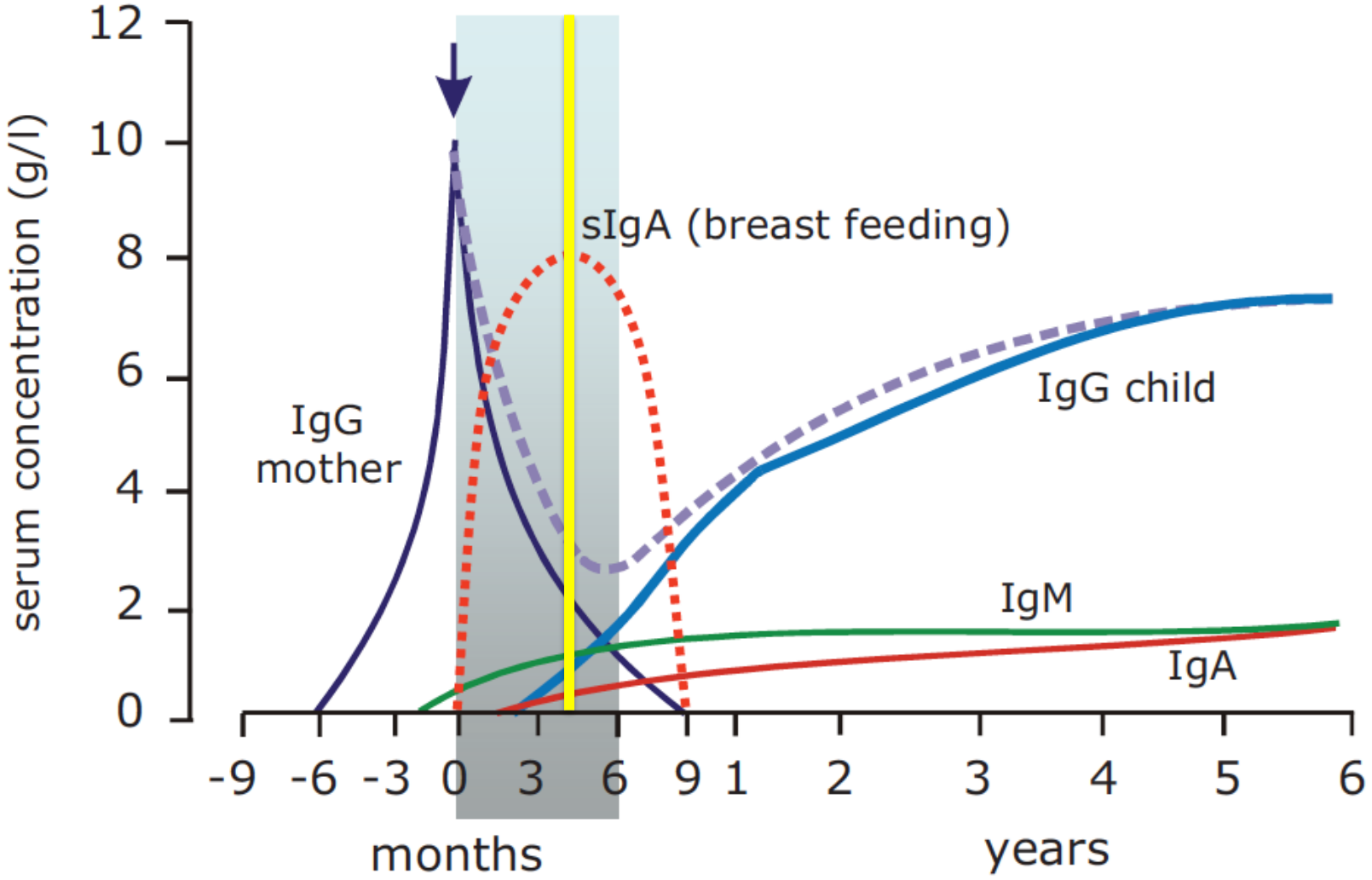
Photo illustration by Zachary Scott for The New York Times

Standard Compatibility Testing

BB&TS §5.14.1				BB&TS §5.14.2	BB&TS §5.14.3
Forward Typing		Reverse Typing		RhD Typing	Screen
Anti-A	Anti-B	A1 Cells	B Cells	Anti-D	2-3 Cells
✓	✓	✓	✓	✓	✓

Galel S, ed. Standards for blood banks and transfusion services. 34th ed. Bethesda, MD: AABB, 2024.

Unique Neonatal Considerations



Niers L et al. Nutritional support for the infant's immune system. Nutr Rev. 2007 Aug;65(8 Pt

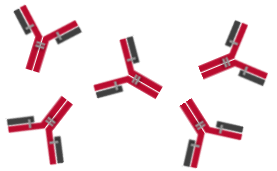
Neonatal Compatibility Testing

~~BB&TS §5.14.1~~ BB&TS §5.14.2 BB&TS §5.14.3

Forward Typing		Reverse Typing		RhD Typing	Screen
Anti-A	Anti-B	A1 Cells	B Cells	Anti-D	2-3 Cells
✓	✓	✗	✗	✓	✓

BB&TS §5.17.1 BB&TS §5.30.2 BB&TS §5.17.1

At this level, you can only give O type units to the neonate.



AHG

RhIg

Maternal Plasma

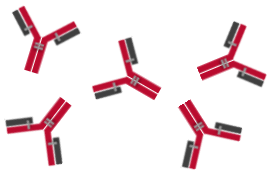
Galel S, ed. Standards for blood banks and transfusion services. 34th ed. Bethesda, MD: AABB, 2024.

Neonatal Compatibility Testing

~~BB&TS §5.14.1~~ BB&TS §5.14.2 BB&TS §5.14.3

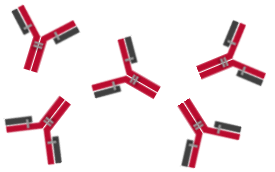
Forward Typing		Reverse Typing		RhD Typing	Screen
Anti-A	Anti-B	A1 Cells	B Cells	Anti-D	2-3 Cells
✓	✓	✓	✓	✓	✓

BB&TS §5.17.1 BB&TS §5.17.2 BB&TS §5.30.2 BB&TS §5.17.1



AHG

Type Specific



AHG

RhIg

Maternal Plasma

Galel S, ed. Standards for blood banks and transfusion services. 34th ed. Bethesda, MD: AABB, 2024.

Maternal Isohemagglutinins

Week of life	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Babies with Antibodies	77	4	3	2	0	0	0	0	0	0	0	0	0	0	0	0
Total babies tested	771	107	75	69	58	56	48	45	37	17	27	21	7	4	5	2

Week of life	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Babies with Anti-A	57	3	3	1	0	0	0	0	0	0	0	0	0	0	0	0
Total babies tested for Anti-A	600	83	57	49	38	40	35	32	29	13	19	16	4	3	5	1

Week of life	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Babies with Anti-B	23	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Total babies tested for Anti-B	239	36	19	21	25	16	15	15	10	5	9	6	4	3	0	1

Shaikh S, Sloan SR. Transfusion. 2011 May;51(5):938-42.

Maternal Isohemagglutinins

Week of life	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Babies with Antibodies	77	4	3	2	0	0	0	0	0	0	0	0	0	0	0	0
Total babies tested	771	107	75	69	58	56	48	45	37	17	27	21	7	4	5	2

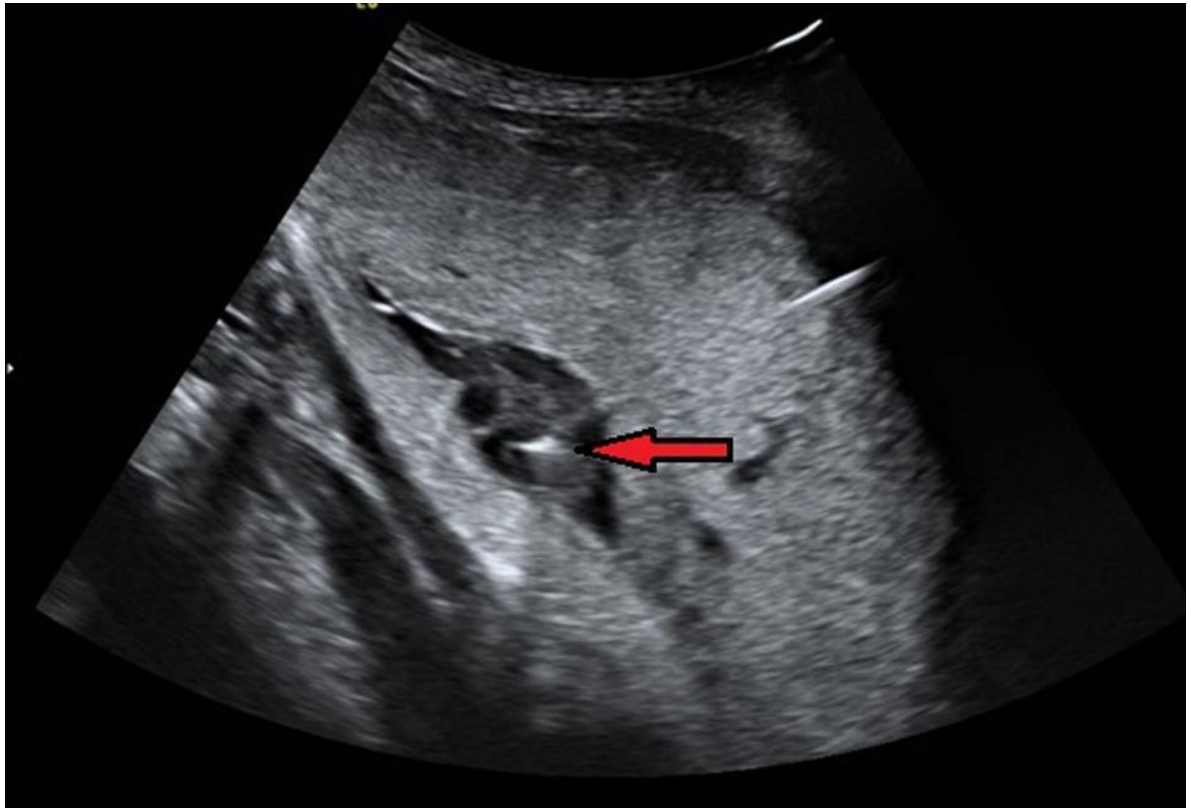
Week of life	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Babies with Anti-A	57	3	3	1	0	0	0	0	0	0	0	0	0	0	0	0
Total babies tested for Anti-A	600	83	57	49	38	40	35	32	29	13	19	16	4	3	5	1

Week of life	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Babies with Anti-B	23	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Total babies tested for Anti-B	239	36	19	21	25	16	15	15	10	5	9	6	4	3	0	1

Shaikh S, Sloan SR. Transfusion. 2011 May;51(5):938-42.

Intrauterine Transfusion

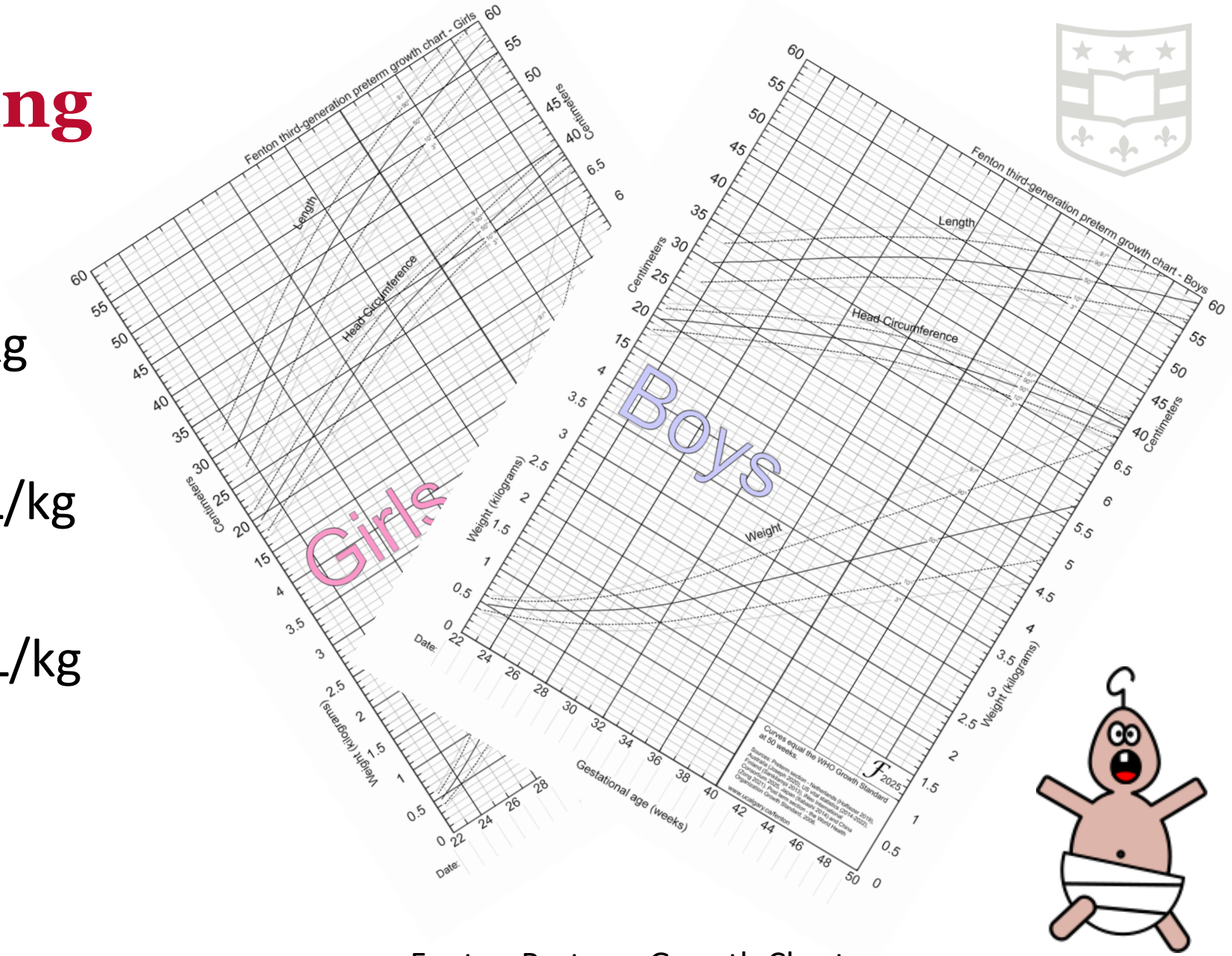
- Group O, Rh(D)-negative RBCs
- Crossmatch compatible with maternal plasma
- Irradiated
- Saline Washed
- CMV Safe (Leukoreduced)
- Hemoglobin S Negative
- Collected within 5-7 days of IUT



Bigelow CA et al. Eur J Obstet Gynecol Reprod Biol. 2016

Pediatric Dosing

- pRBCs – 5 to 15 mL/kg
- Plasma – 10 to 15 mL/kg
- Platelets – 5 to 10 mL/kg
- Cryo – 2 to 3 mL/kg



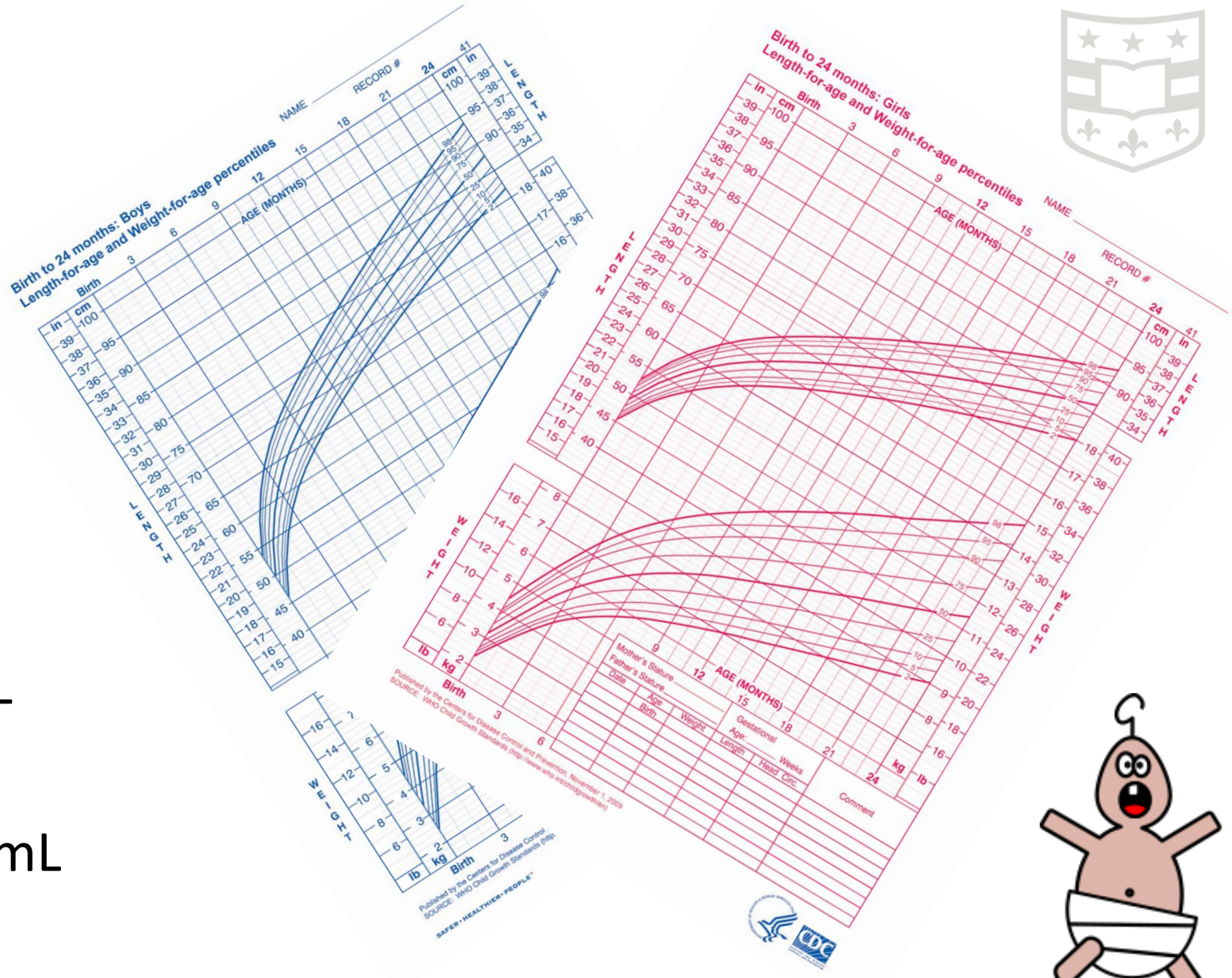
Fenton Preterm Growth Charts

https://live-ucalgary.ucalgary.ca/resource/preterm-growth-chart/preterm-growth-chart

Mo YD, Roseff SD, Wong ECC, ed. Pediatric Hemotherapy Data Card. Bethesda, MD: AABB, 2021.

Neonatal Doses

- 2m F – 5kg – 50mL
- 3m M – 6.3 kg – 63mL
- 36w GA M – 3kg – 30mL
- 28w GA F – 1.2 kg – 12 mL

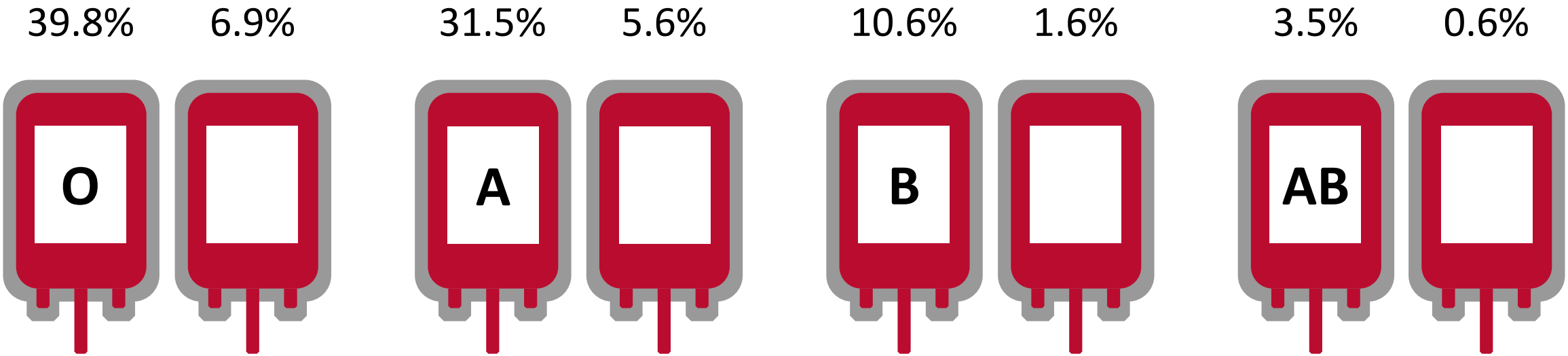


WHO Child Growth Standard Charts

https://www.cdc.gov/growthcharts/who-charts.html

Mo YD, Roseff SD, Wong ECC, ed. Pediatric Hemotherapy Data Card. Bethesda, MD: AABB,

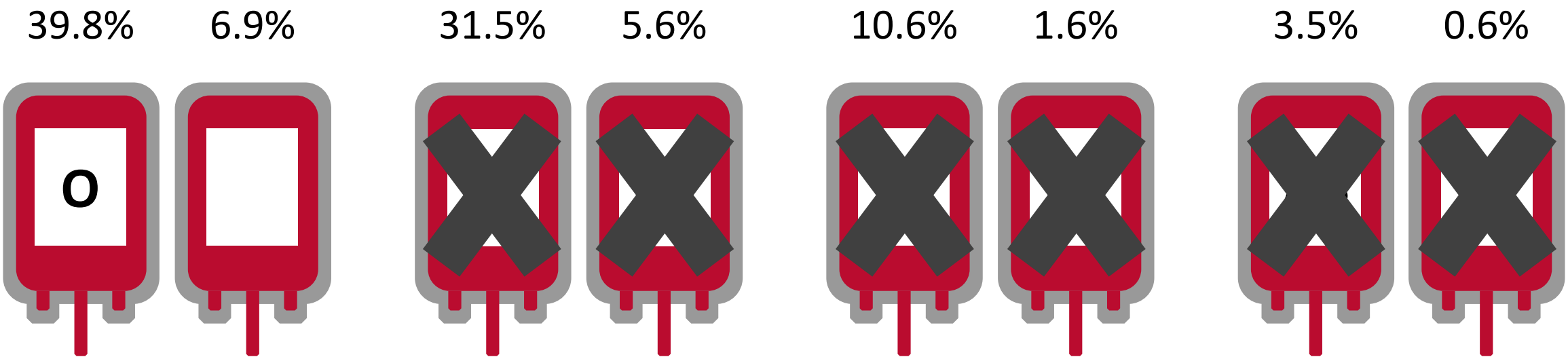
Neonatal Transfusion Logistics



Taking the extreme percentile weights from both growth charts (Fenton, WHO) leads to neonatal doses (10mL/kg) range from 3.5 mL (24w GA F) to 88 mL (4m M)

Garratty G et al. Transfusion. 2004 May;44(5):703-6.
https://www.cdc.gov/growthcharts/who-charts.html
https://live-ucalgary.ucalgary.ca/resource/preterm-growth-chart/preterm-growth-chart
Mo YD, Roseff SD, Wong ECC, ed. Pediatric Hemotherapy Data Card. Bethesda, MD: AABB, 2021.

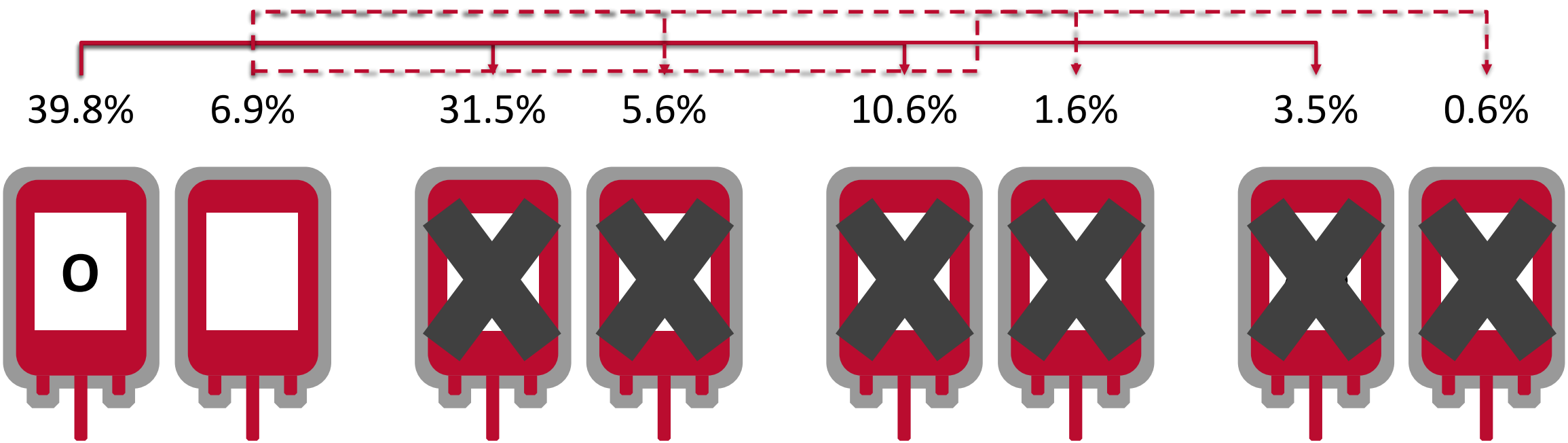
Neonatal Transfusion Logistics



To prevent waste, pediatric blood banks may only keep leukoreduced, irradiated O positive and O negative pRBCs on hand for neonatal transfusion

Garratty G et al. Transfusion. 2004 May;44(5):703-6.

Neonatal Transfusion Logistics



Unfortunately, this causes 39.8% (O+) of the population to support 85.4% (O/A/B/AB+) of the population and 6.9% (O-) of the population to support the other 14.7% (O/A/B/AB-)

Garratty G et al. Transfusion. 2004 May;44(5):703-6.

Describe the process of providing type specific packed red blood cells to neonates

BB & TM Standards

- §5.17.2
  - If a non-group-O neonate is to receive non-group-O Red Blood Cells that are not compatible with the maternal ABO group, the neonate's serum or plasma shall be tested for anti-A or anti-B.
- 5.17.2.1
  - Test methods shall include an antiglobulin phase using either donor or reagent A1 or B red cells. Standard 5.14.6 applies.
- 5.17.2.2
  - If anti-A or anti-B is detected, Red Blood Cells lacking the corresponding ABO antigen shall be transfused.

Galel S, ed. Standards for blood banks and transfusion services. 34th ed. Bethesda, MD: AABB, 2024.

Neonatal and Maternal Compatibility

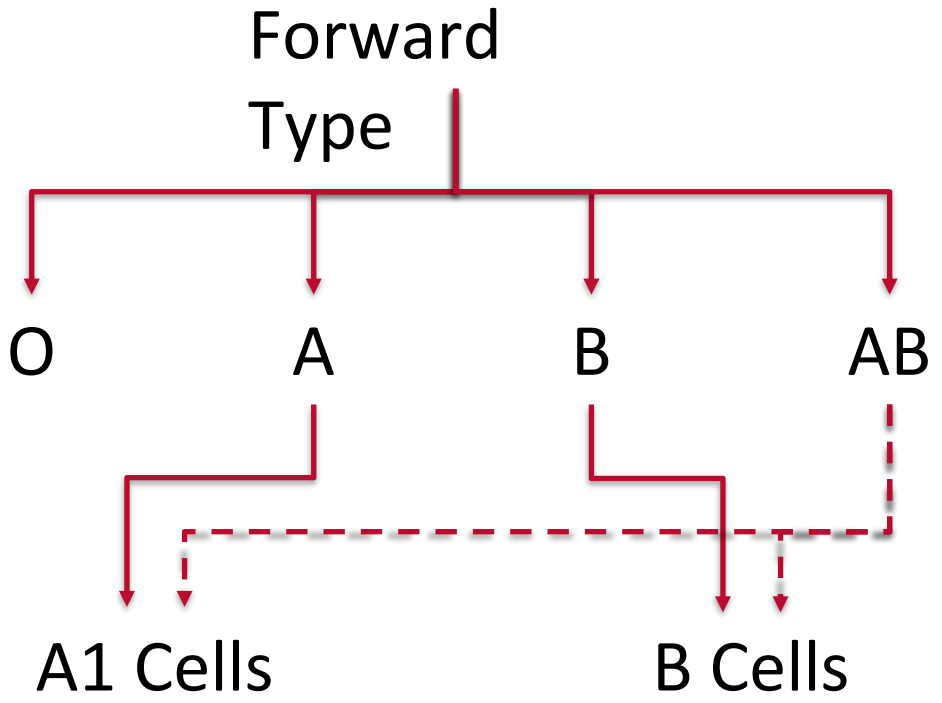
Neonate	Mother	Maternal/Passive Isoagglutinin	Compatibility
O	O, A, B, AB	N/A	O
A	A	Anti-B	A, O
A	AB	None	A, O
A	B	Anti-A	O
B	B	Anti-A	B, O
B	AB	None	B, O
B	A	Anti-B	O
AB	AB	None	AB, A, B, O
AB	A	Anti-B	A, O
AB	B	Anti-A	B, O
A, B, AB	O	Anti-A, Anti-B, and Anti-A,B	O

Neonatal and Maternal Compatibility

Neonate	Mother	Maternal/Passive Isoagglutinin	Compatibility
O	O, A, B, AB	N/A	O
A	A	Anti-B	A, O
A	AB	None	A, O
A	B	Anti-A	O
B	B	Anti-A	B, O
B	AB	None	B, O
B	A	Anti-B	O
AB	AB	None	AB, A, B, O
AB	A	Anti-B	A, O
AB	B	Anti-A	B, O
A, B, AB	O	Anti-A, Anti-B, and Anti-A,B	O

Isoagglutinin Gel Method

- Reagents:
  - Anti-IgG Gel Card
  - A1 Cells
  - B Cells
  - Patient Serum/Plasma
- Steps:
  - Combine
  - Incubate
  - Centrifuge
  - Interpret



"Modified Reverse Type"

Indirect Antiglobulin Test

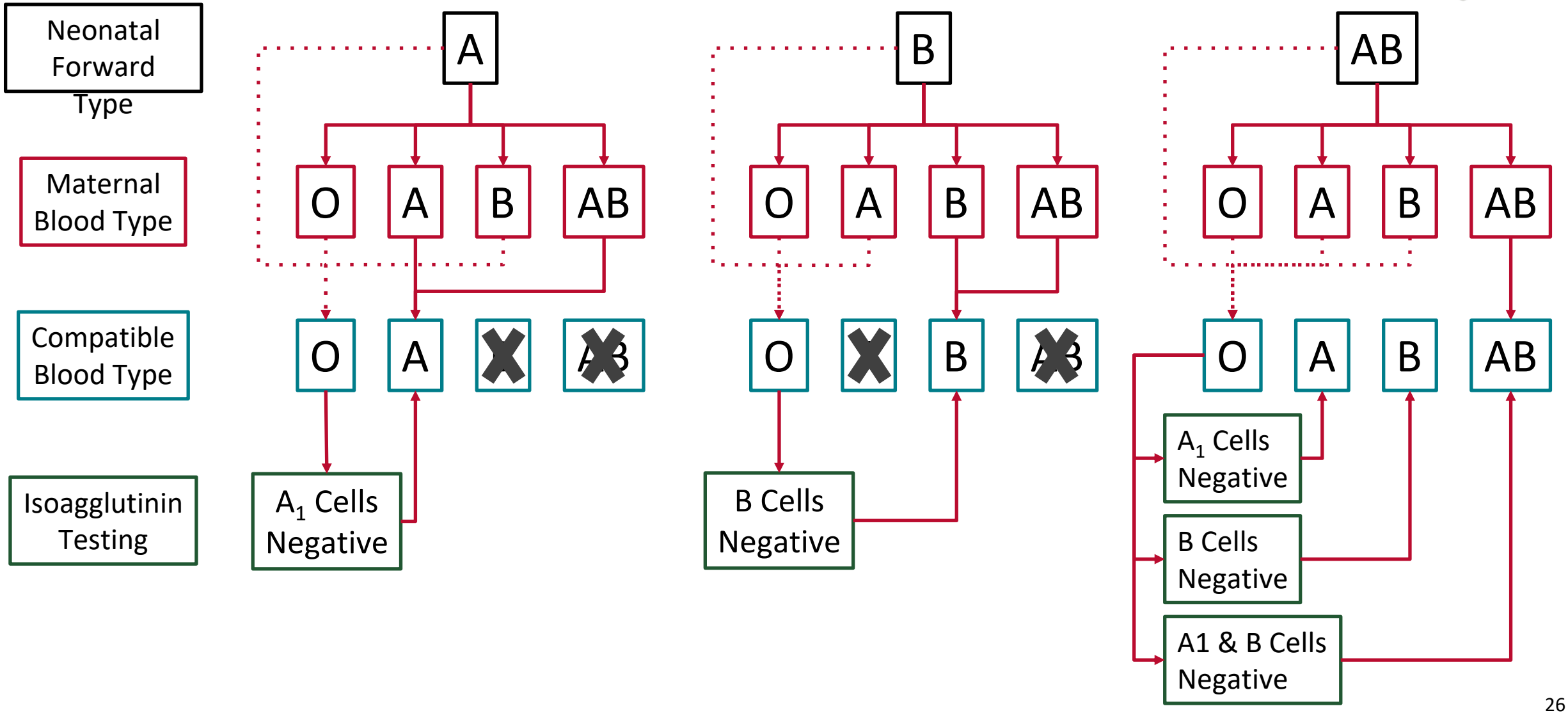
Isoagglutinin Result Interpretation

Blood Type	A Cell	B Cell	Interpretation	Compatibility
O	NT	NT	N/A	O
A	0	NT	Negative	A, O
A	+	NT	Maternal anti-A	O
B	NT	0	Negative	B, O
B	NT	+	Maternal anti-B	O
AB	0	0	Negative	AB, A, B, O
AB	+	0	Maternal anti-A	B, O
AB	0	+	Maternal anti-B	A, O
AB	+	+	Maternal anti-A & anti-B OR maternal anti-A,B	O

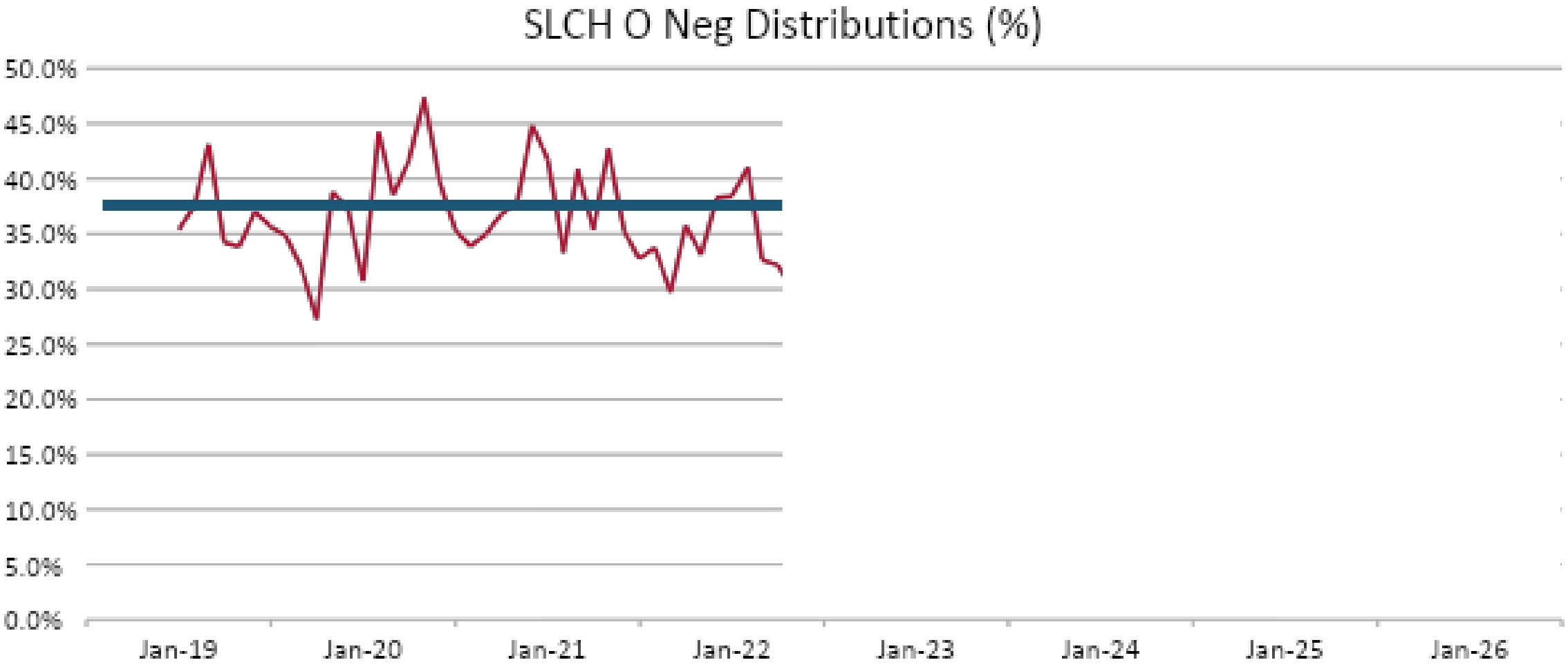
Isoagglutinin Result Interpretation

Blood Type	A Cell	B Cell	Interpretation	Compatibility
O	NT	NT	N/A	O
A	0	NT	Negative	A, O
A	+	NT	Maternal anti-A	O
B	NT	0	Negative	B, O
B	NT	+	Maternal anti-B	O
AB	0	0	Negative	AB, A, B, O
AB	+	0	Maternal anti-A	B, O
AB	0	+	Maternal anti-B	A, O
AB	+	+	Maternal anti-A & anti-B OR maternal anti-A,B	O

Neonatal Transfusion Algorithm



SLCH O Negative Distributions



Identify methods to reduce O negative packed red blood cells use while matching for C/E/K antigens in sickle cell disease patients

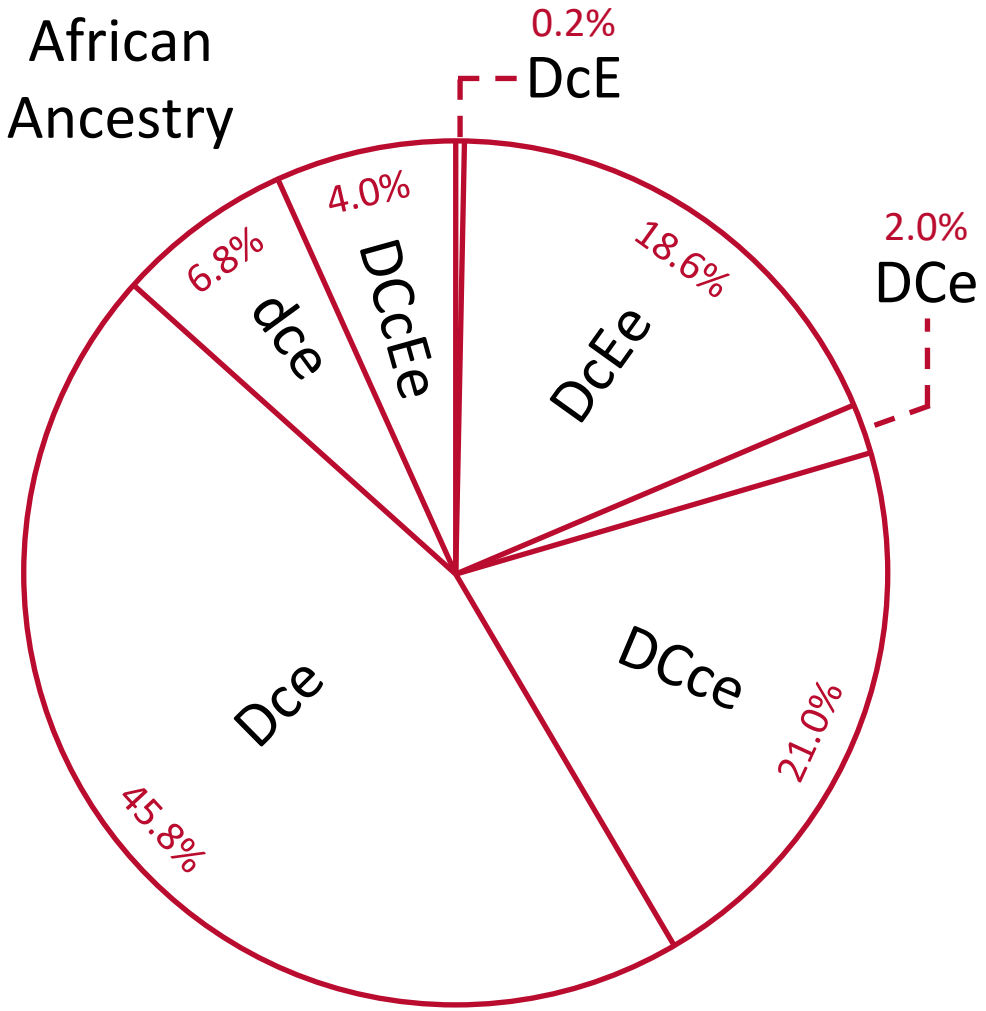
American Society of Hematology Guidelines

- … *recommends* prophylactic red cell antigen matching for Rh (C, E or C/c, E/e) and K antigens over only ABO/RhD matching for patients with sickle cell disease (all genotypes) receiving transfusions
  - Strong recommendation based on moderate certainty in the evidence about the effects

- C and E Matching vs. C/c and E/e Matching
  - 2.0% of African Americans are at risk for developing an anti-c (DCe phenotype)
  - 0.2% of African Americans are at risk for developing an anti-e (DcE phenotype)

Reid ME, Lomas-Francis C, Olsson ML. The Blood Antigen FactsBook. 3rd ed. Elsevier; 2012.
Chou ST et al. American Society of Hematology 2020 guidelines for sickle cell disease: transfusion support. Blood Adv. 2020 Jan 28;4(2):327-355.

RhD and RhCE Phenotypes in African A.

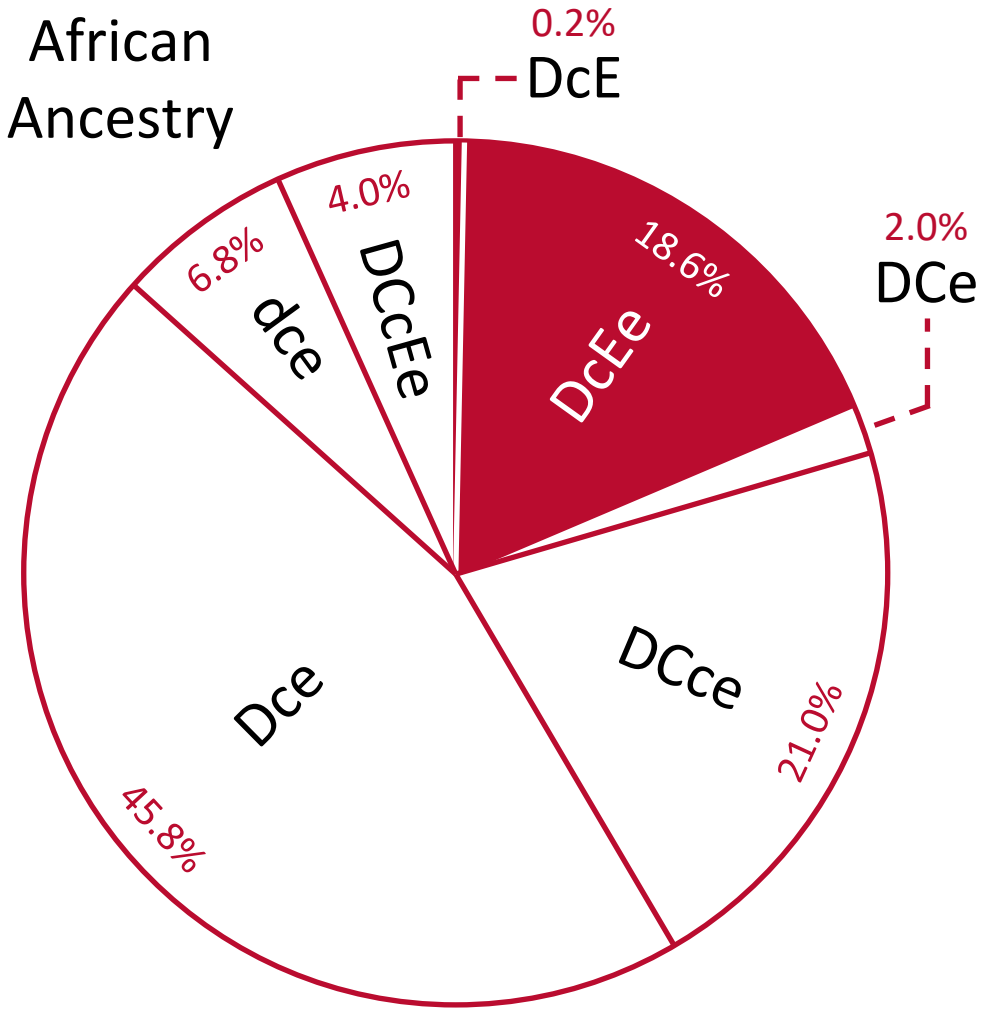


RhD Positive	
Phenotype	Prevalence (%)
DCe	2.0
DcE	0.2
DCcE	21.0
DcEe	18.6
Dce	45.8
DCE	~ 0
DCEe	~ 0
DCcE	~ 0
DCcEe	4.0

RhD Negative	
Phenotype	Prevalence (%)
dCe	~ 0
dcE	~ 0
dCcE	~ 0
dcEe	~ 0
dce	6.8
dCE	~ 0
dCEe	~ 0
dCcE	~ 0
dCcEe	~ 0

Reid ME, Lomas-Francis C, Olsson ML. The Blood Antigen FactsBook. 3rd ed. Elsevier; 2012.

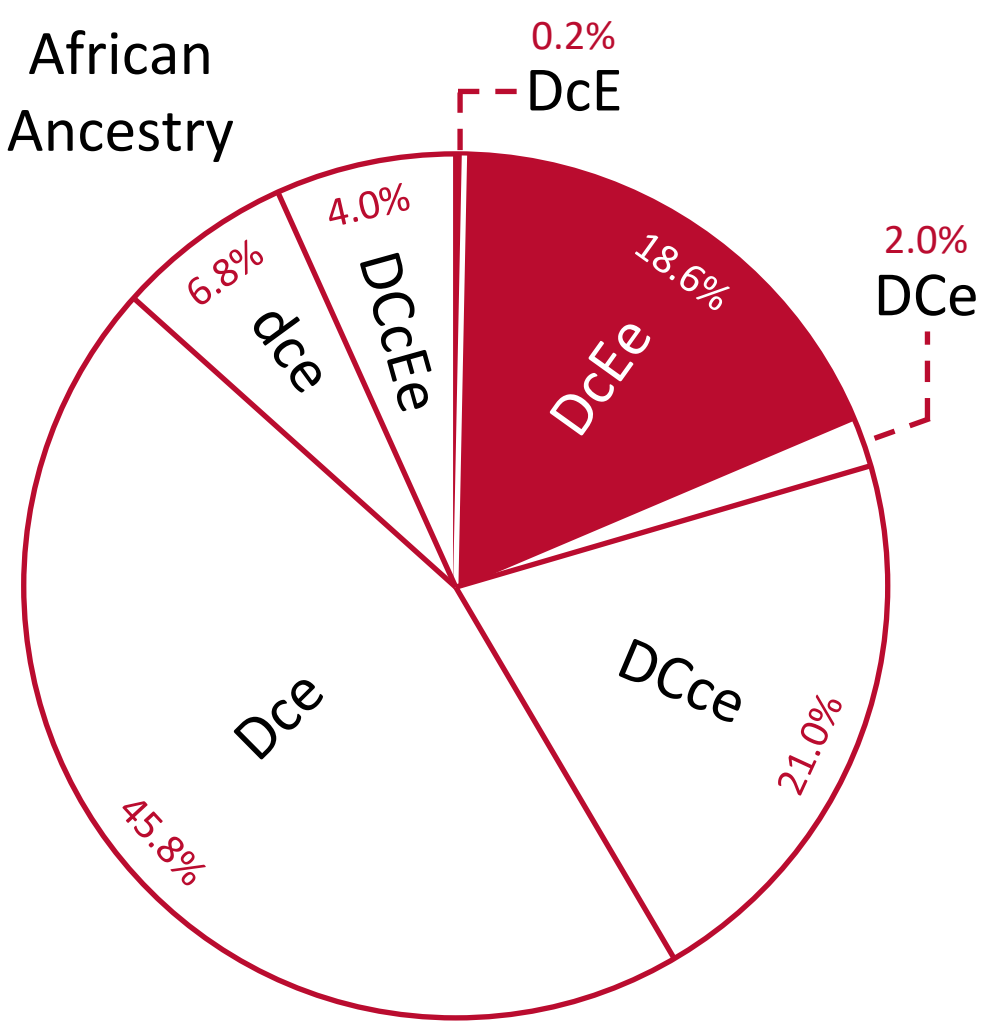
At risk for only an alloanti-C

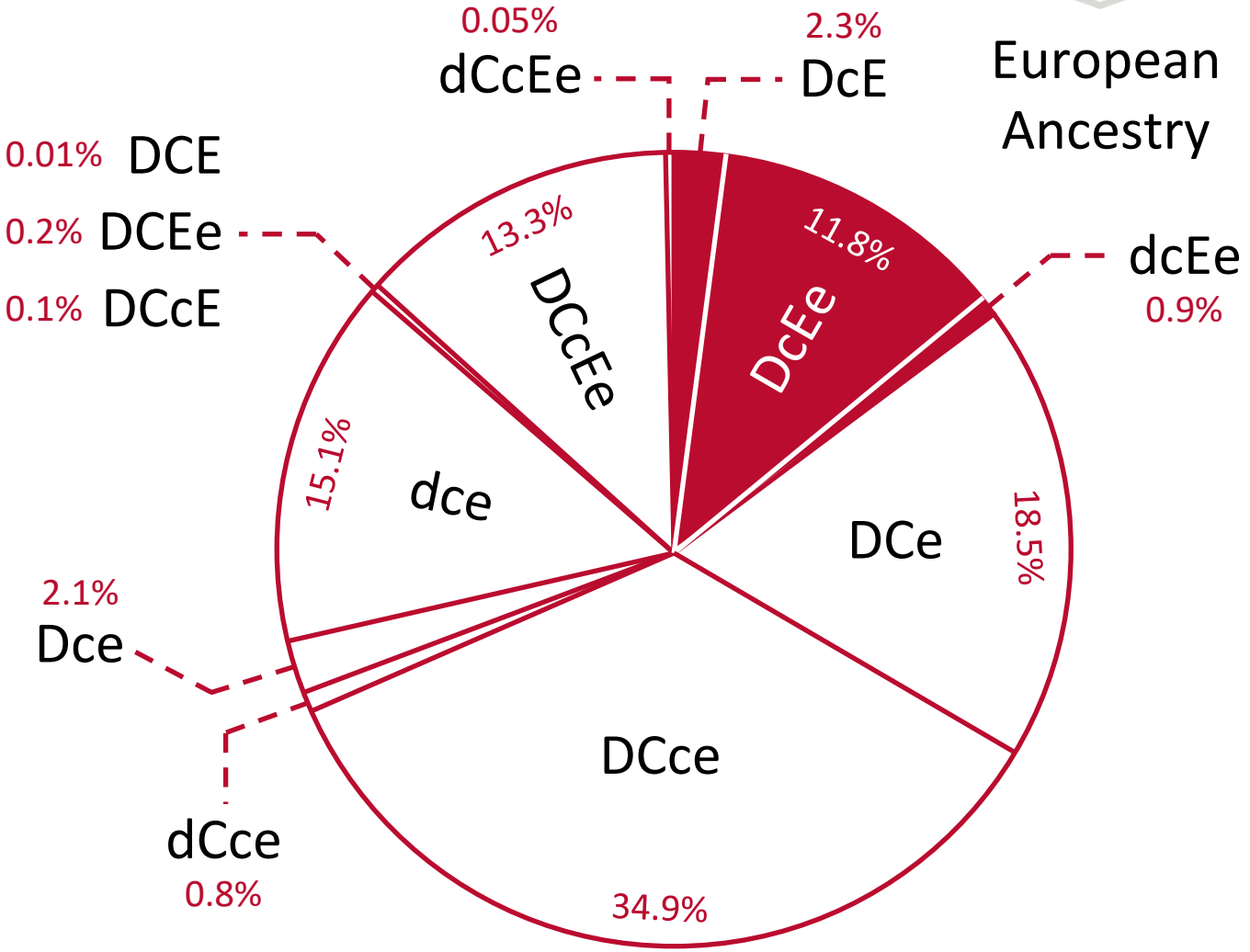


18.8% of African Americans are at risk for developing only an anti-C (DcE and DcEe phenotypes) alloantibody

Reid ME, Lomas-Francis C, Olsson ML. The Blood Antigen FactsBook. 3rd ed. Elsevier; 2012.

At risk for only an alloanti-C

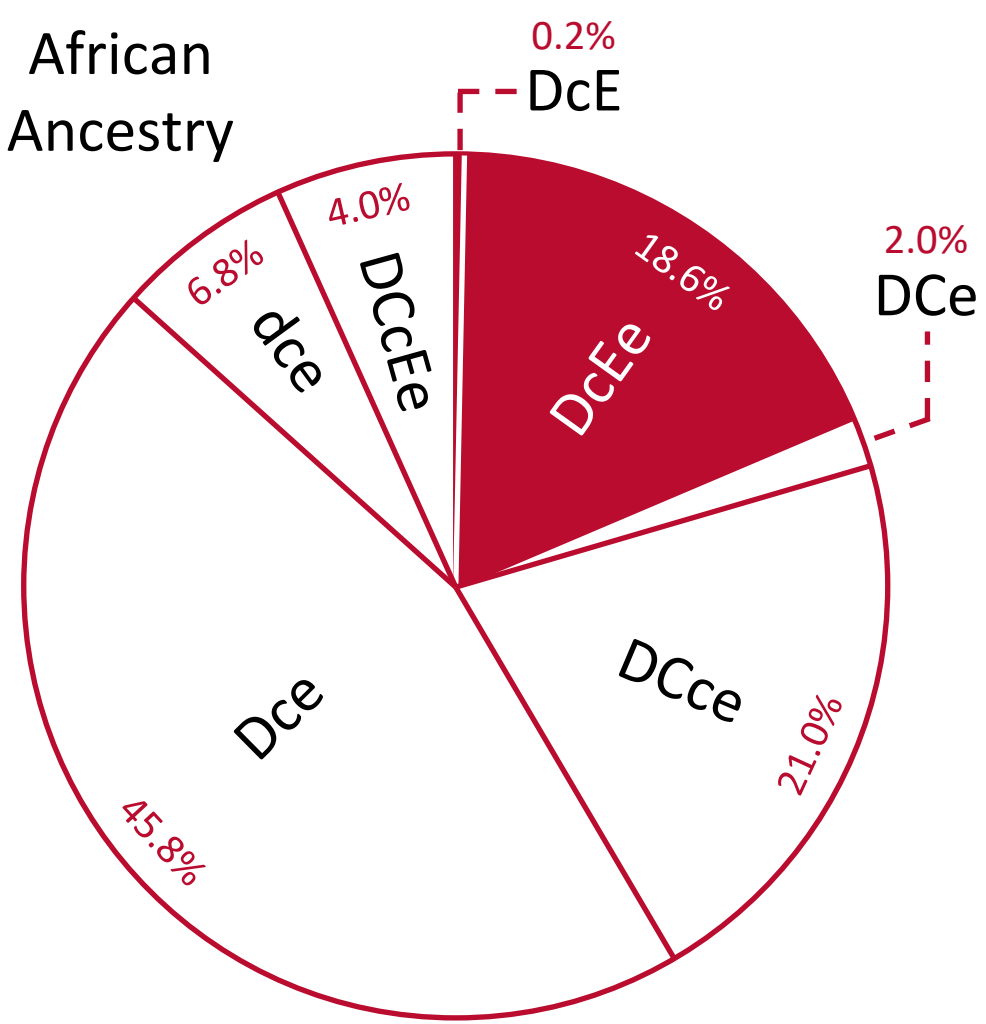


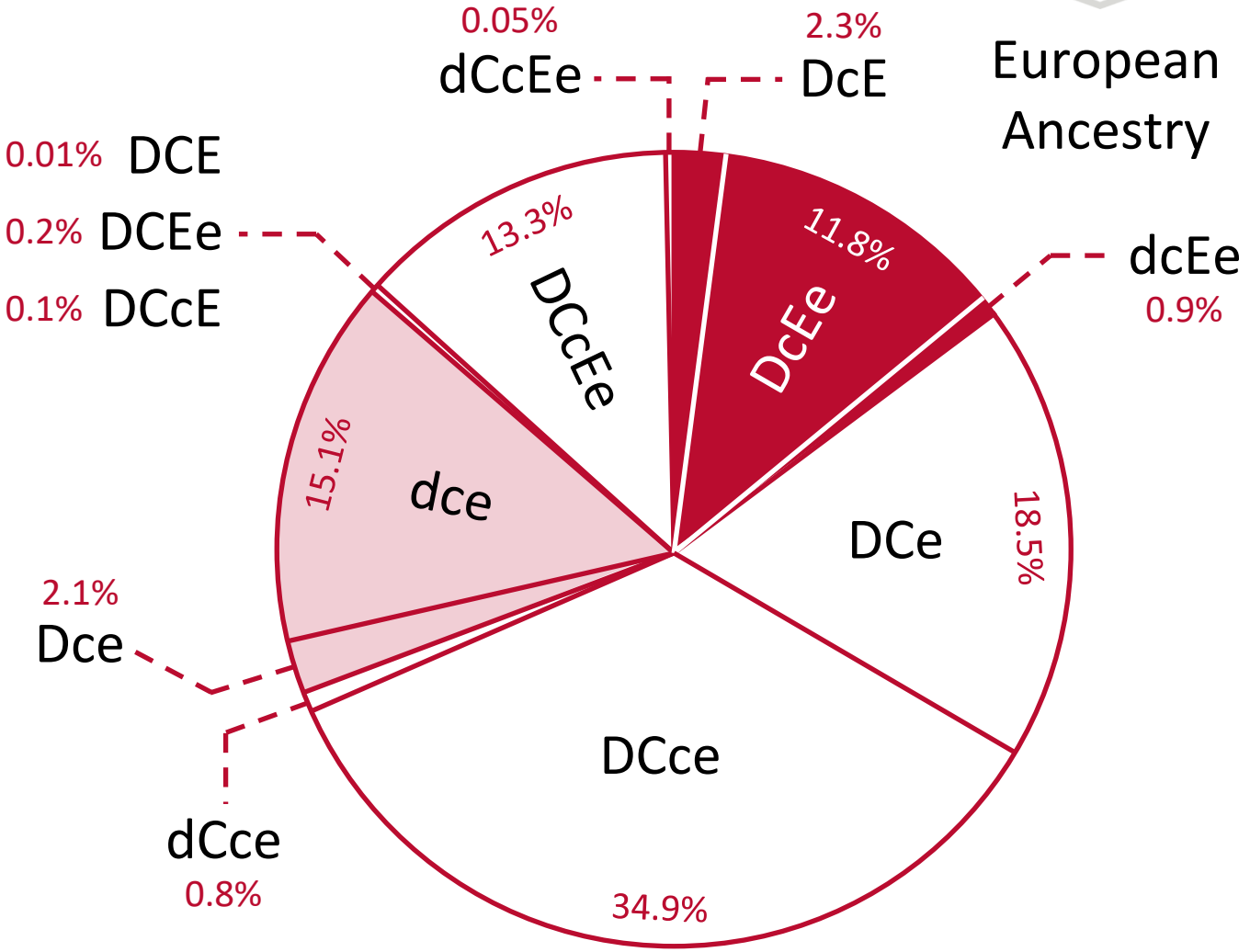


18.8% vs. 15.0%

Reid ME, Lomas-Francis C, Olsson ML. The Blood Antigen FactsBook. 3rd ed. Elsevier; 2012.

At risk for only an alloanti-C

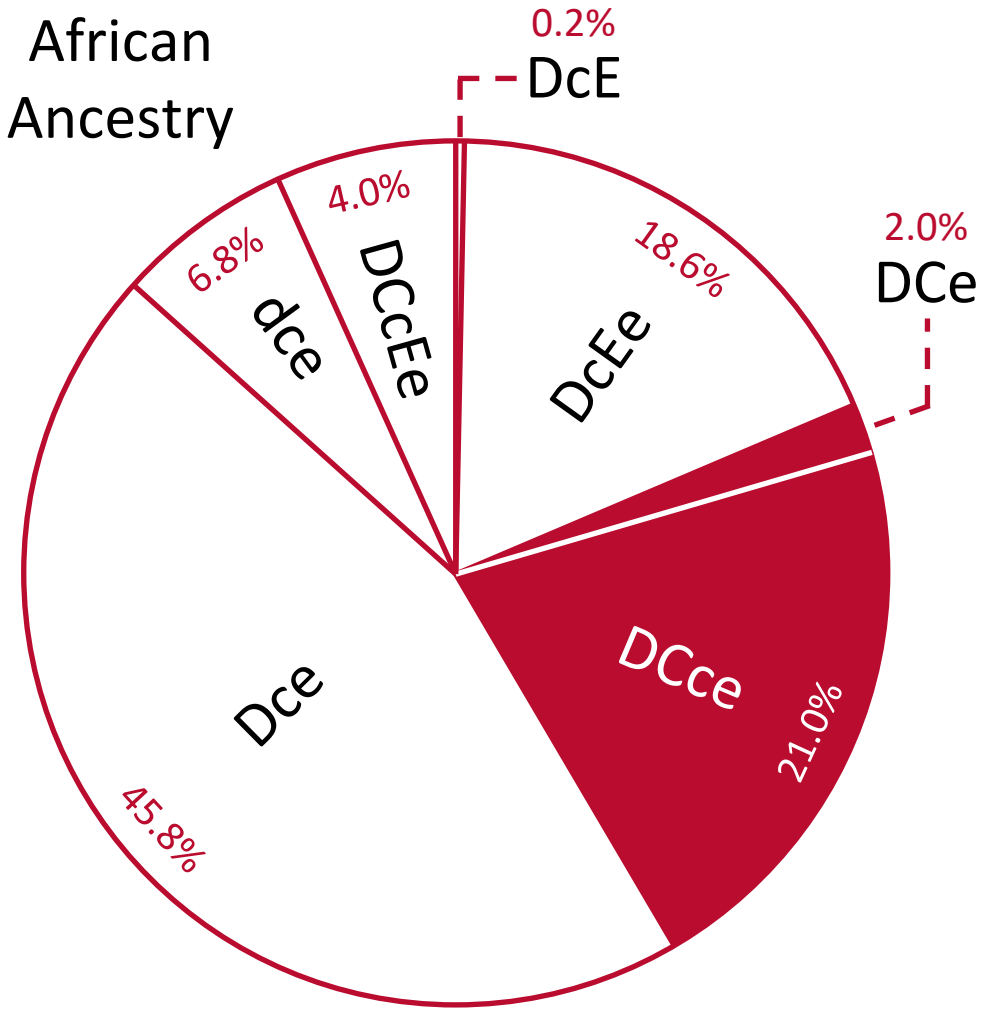




18.6% vs. 32.2%

Reid ME, Lomas-Francis C, Olsson ML. The Blood Antigen FactsBook. 3rd ed. Elsevier; 2012.

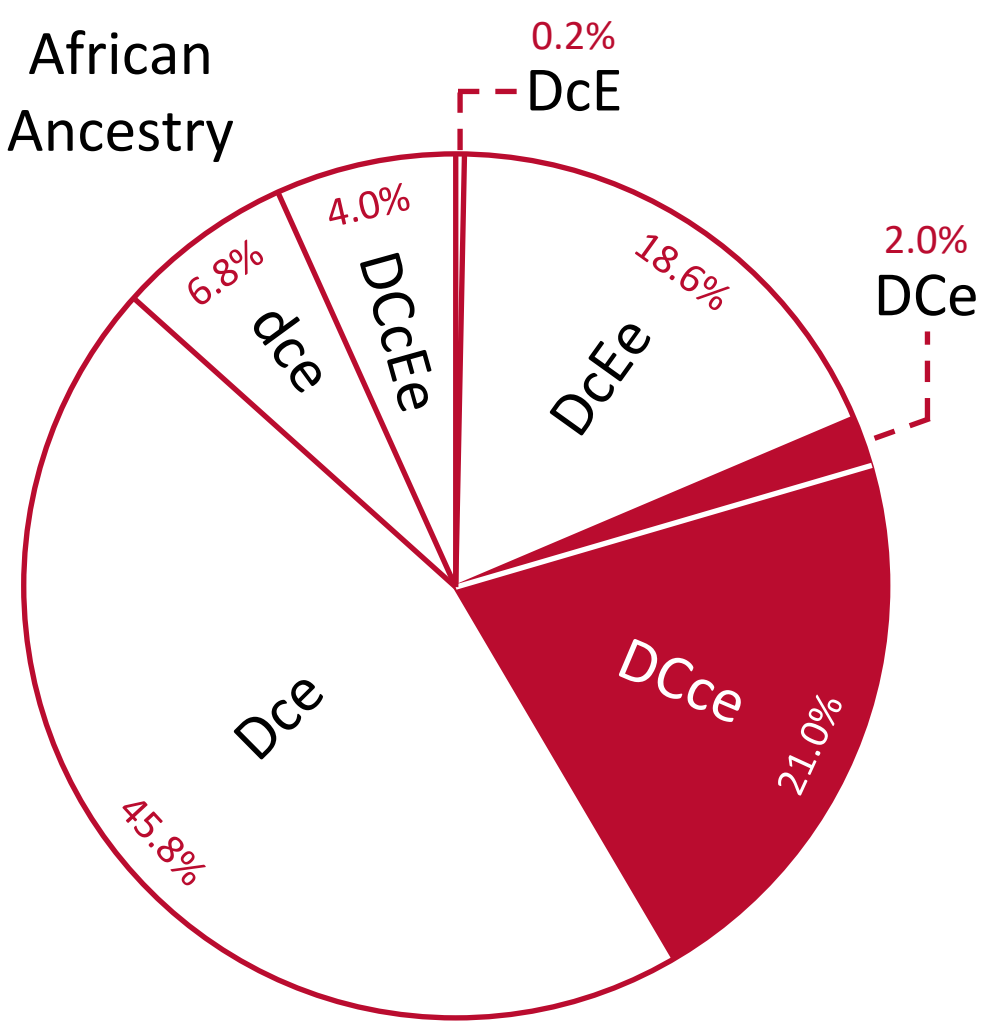
At risk for only an alloanti-E

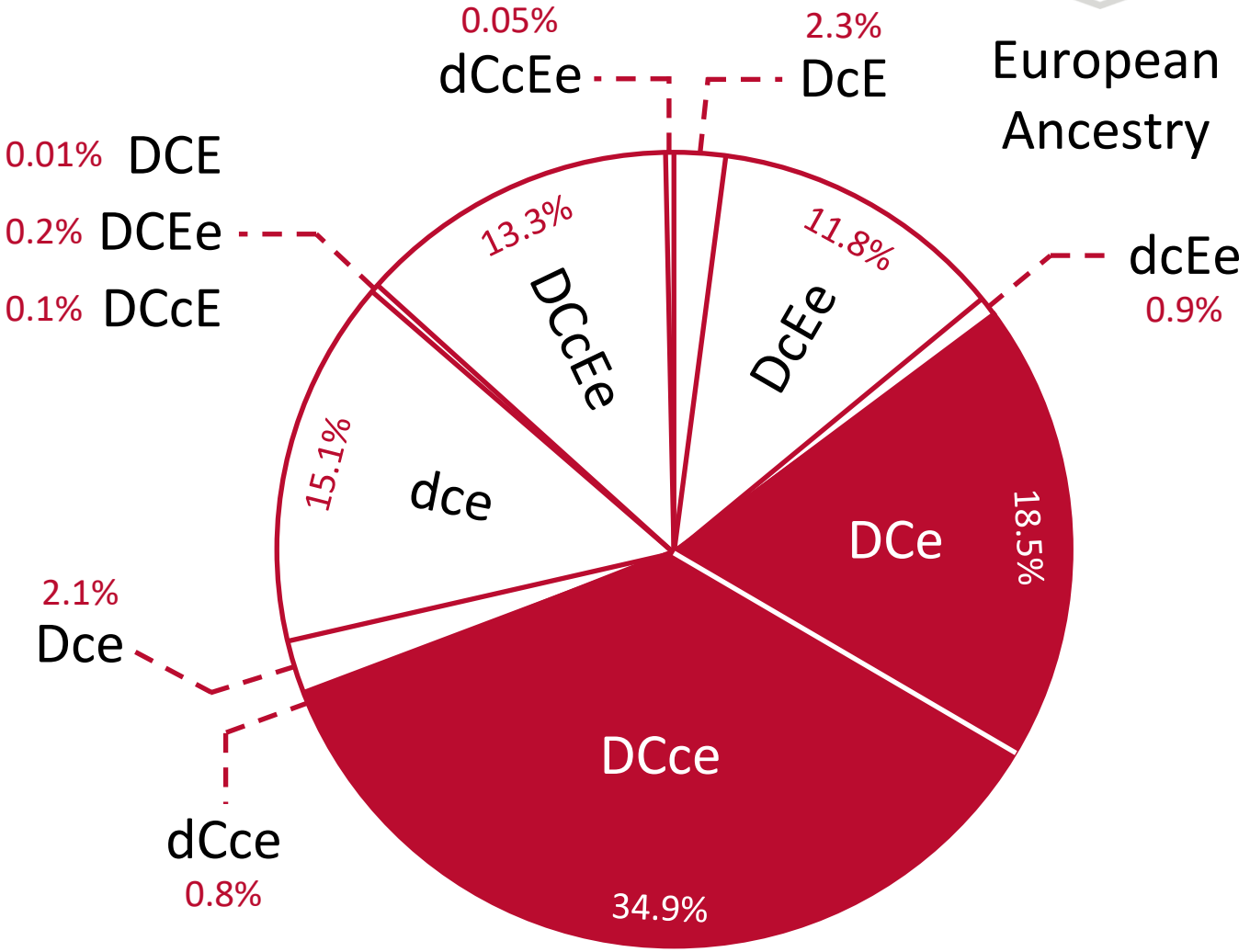


23.0% of African Americans are at risk for developing only an anti-E (DCe and DCce phenotypes) alloantibody

Reid ME, Lomas-Francis C, Olsson ML. The Blood Antigen FactsBook. 3rd ed. Elsevier; 2012.

At risk for only an alloanti-E

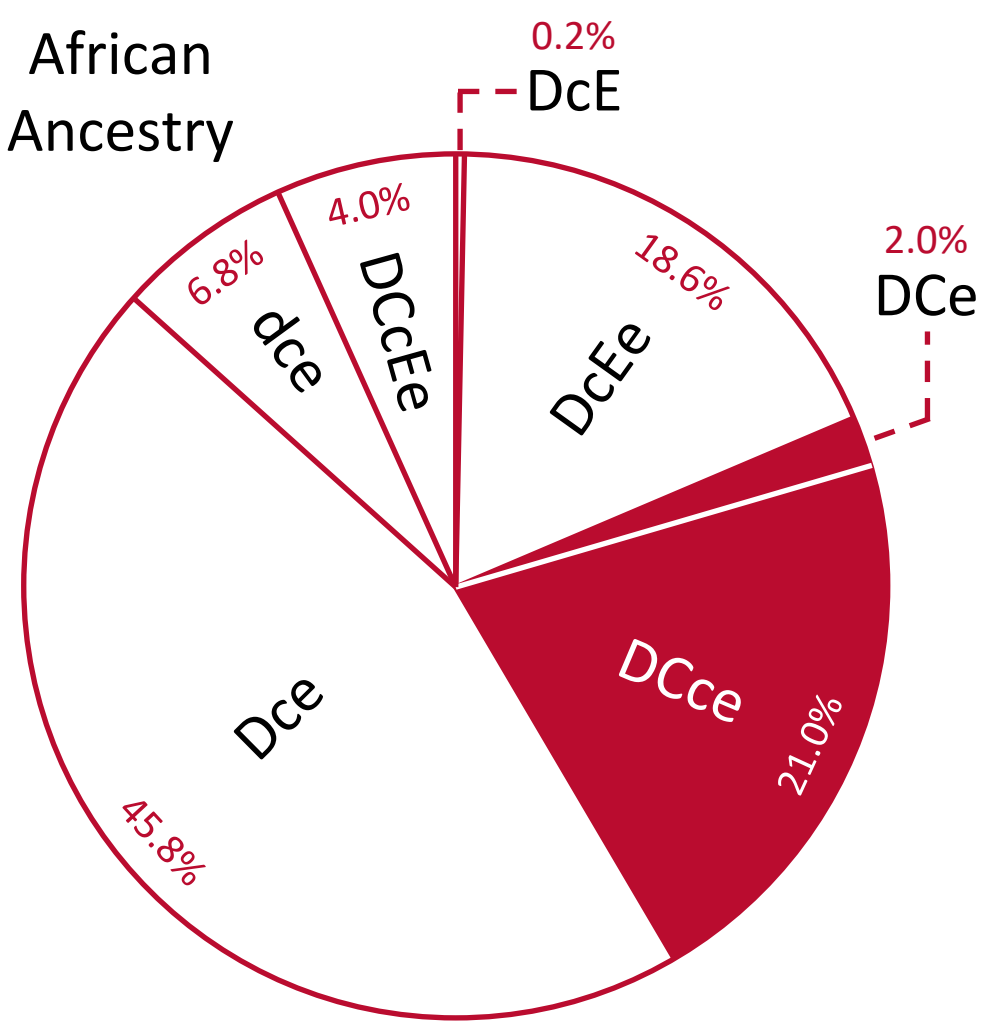


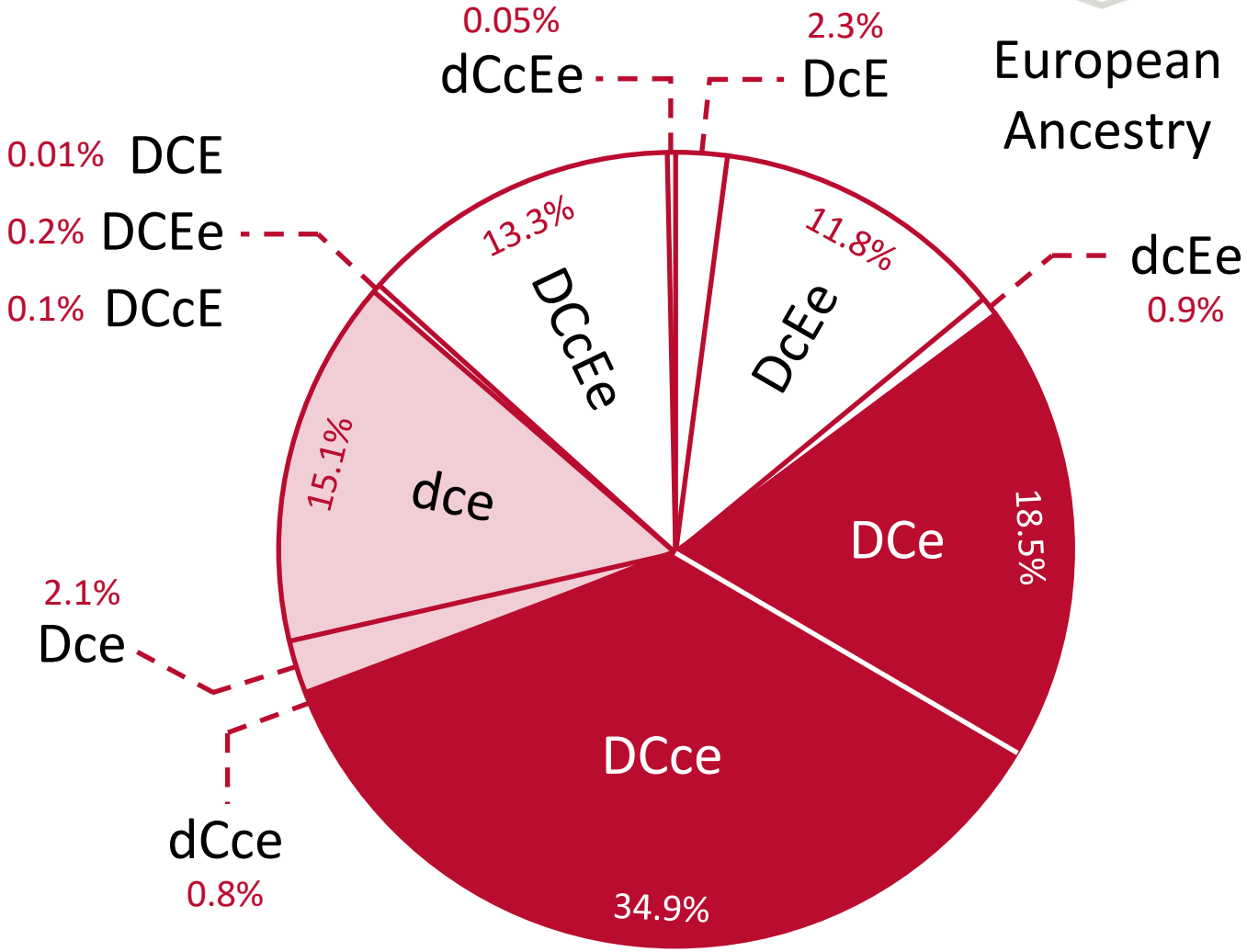


23.0% vs. 54.2%

Reid ME, Lomas-Francis C, Olsson ML. The Blood Antigen FactsBook. 3rd ed. Elsevier; 2012.

At risk for only an alloanti-E

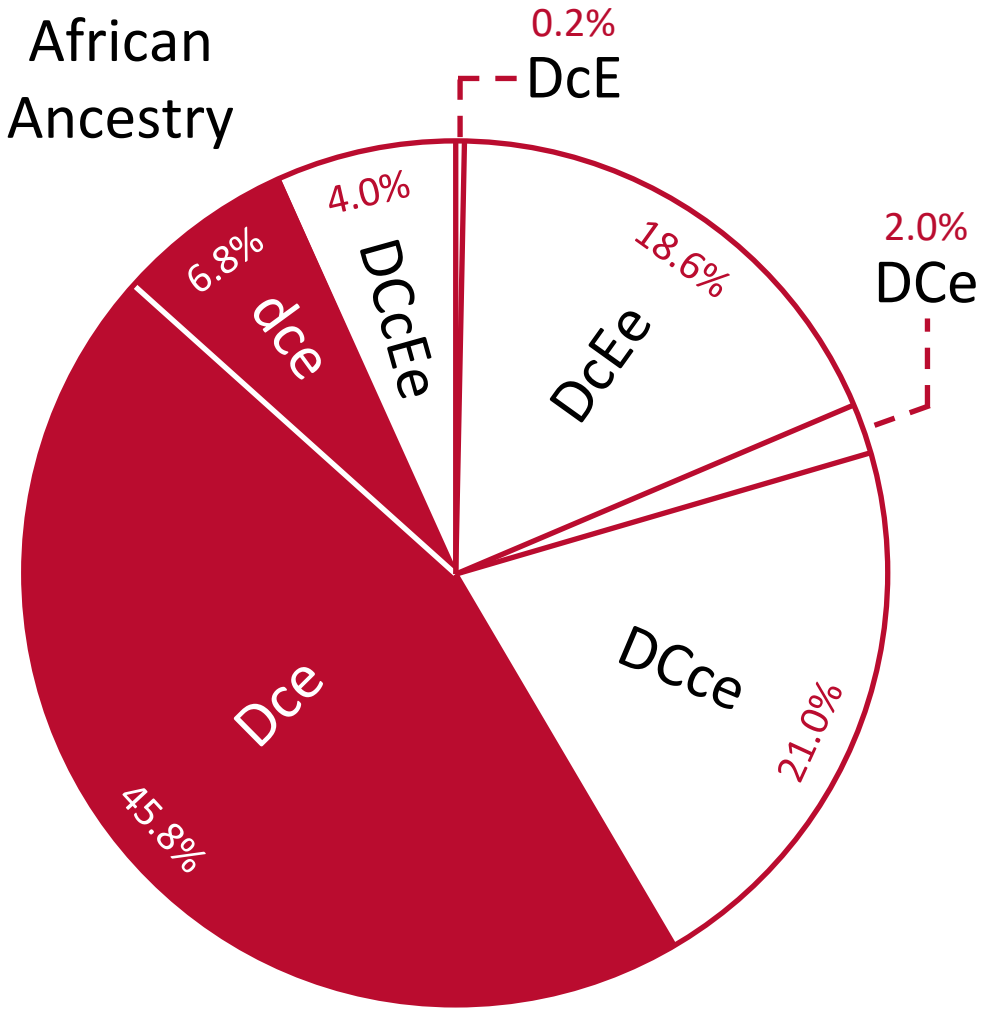




23.0% vs. 71.4%

Reid ME, Lomas-Francis C, Olsson ML. The Blood Antigen FactsBook. 3rd ed. Elsevier; 2012.

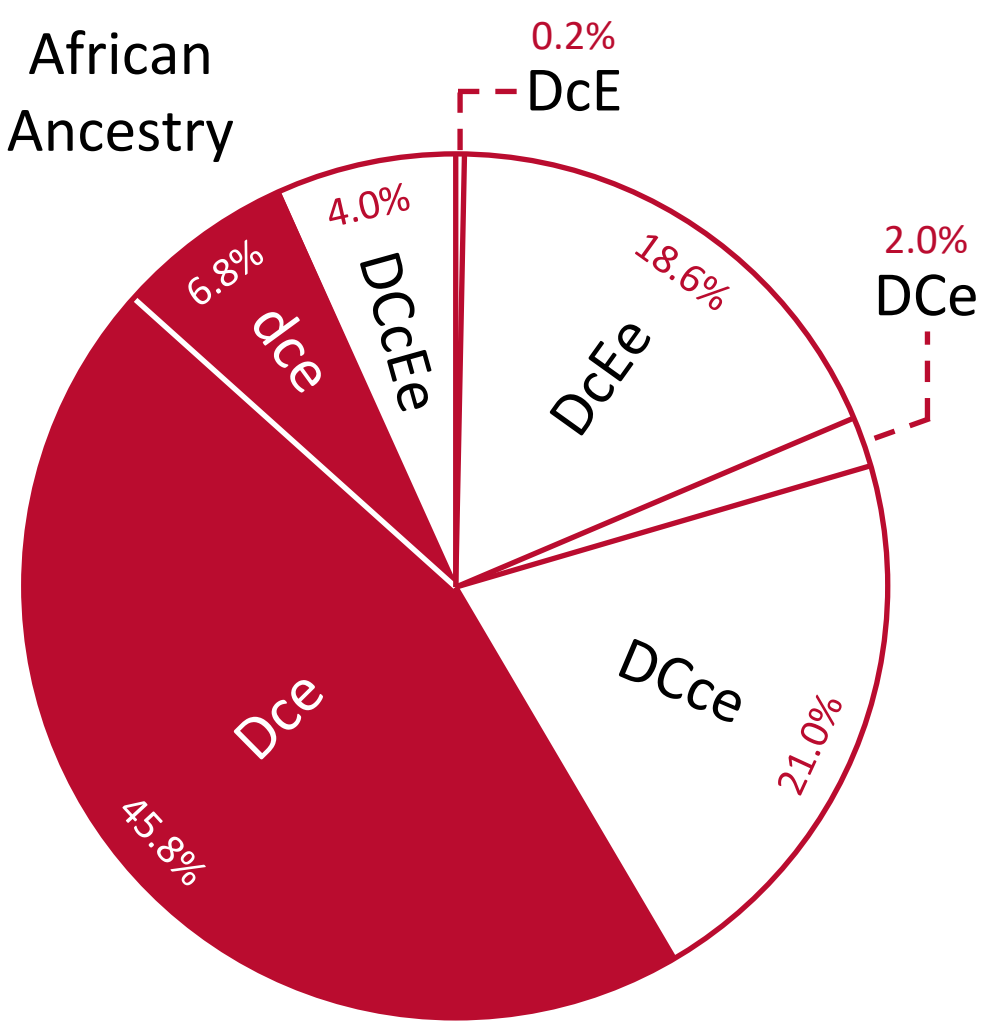
At risk for both alloanti-C and alloanti-E

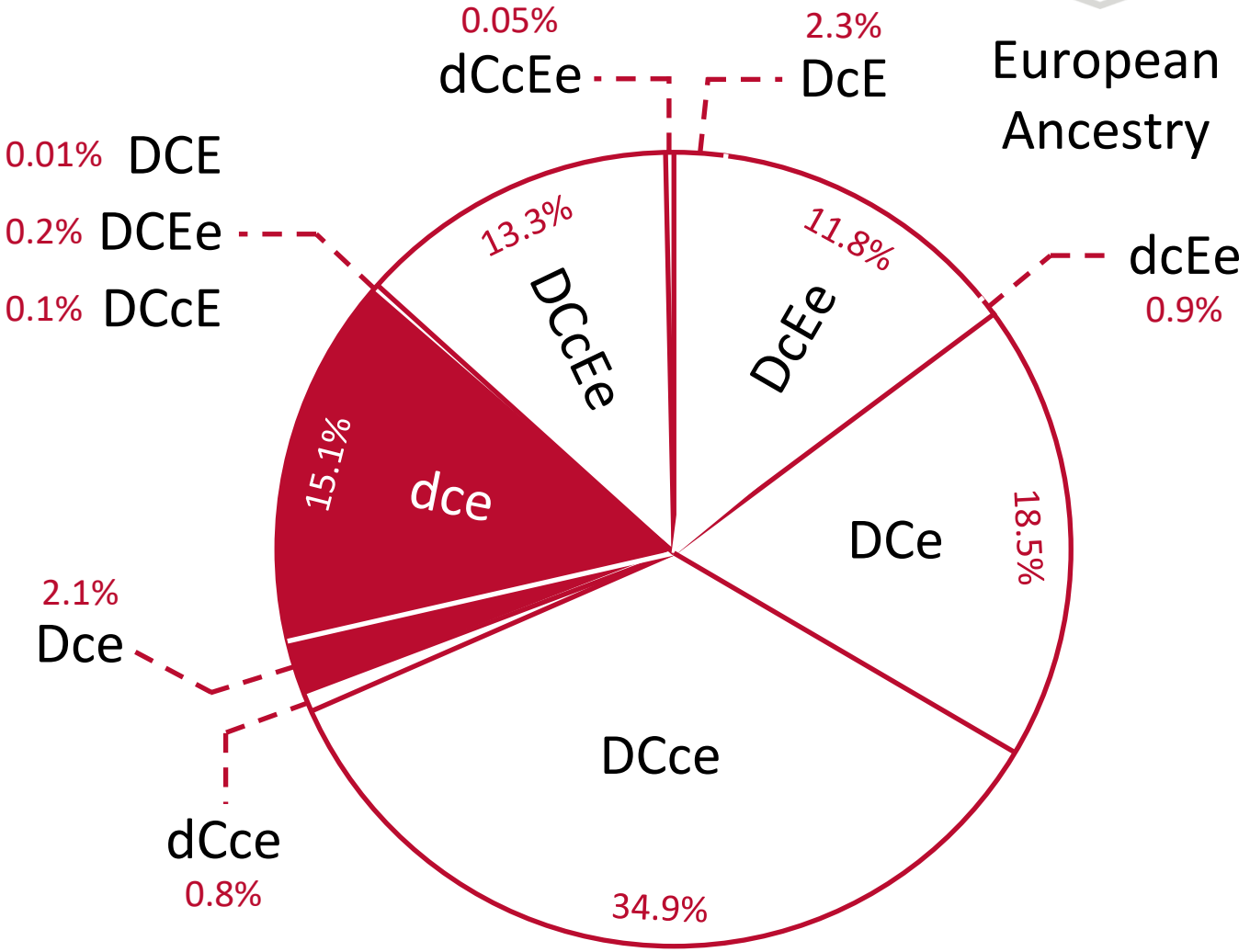


52.6% of African Americans are at risk for developing both an anti-C and an anti-E (Dce and dce phenotypes) alloantibodies

Reid ME, Lomas-Francis C, Olsson ML. The Blood Antigen FactsBook. 3rd ed. Elsevier; 2012.

At risk for both alloanti-C and alloanti-E

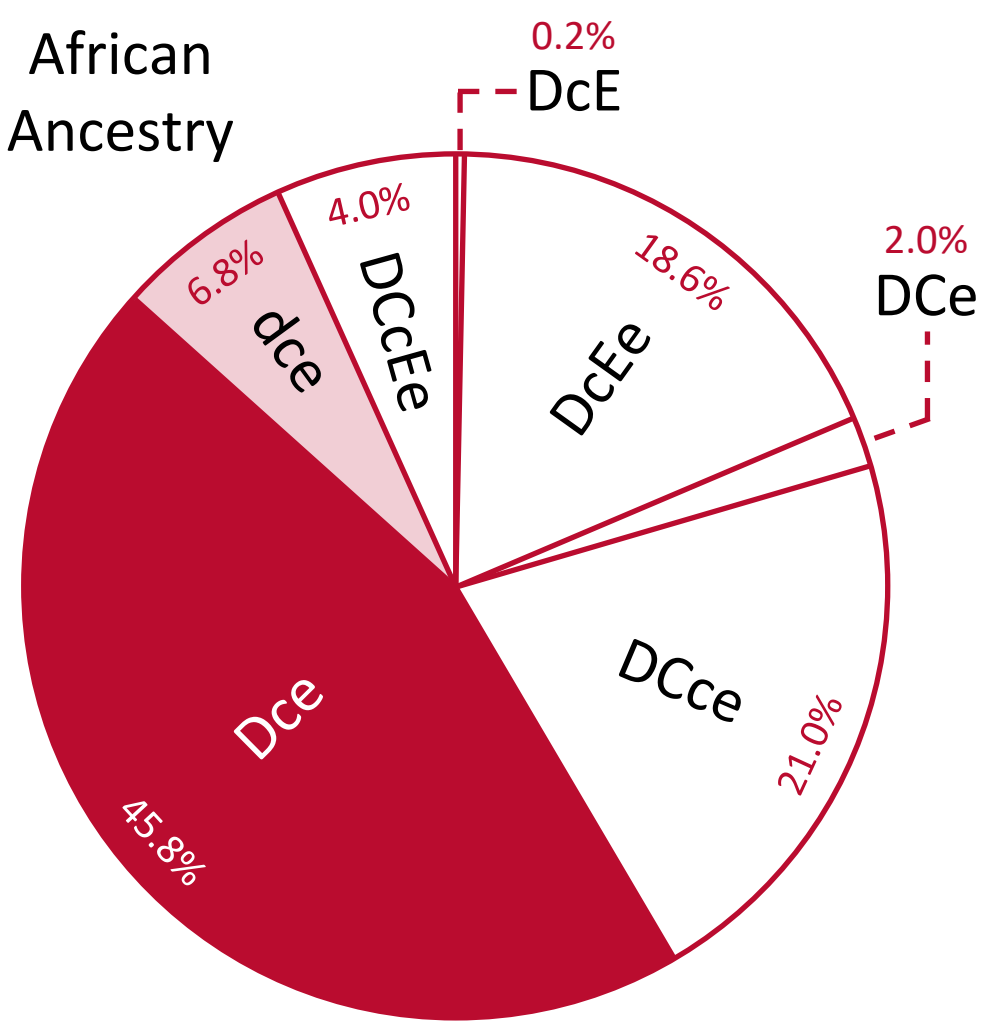


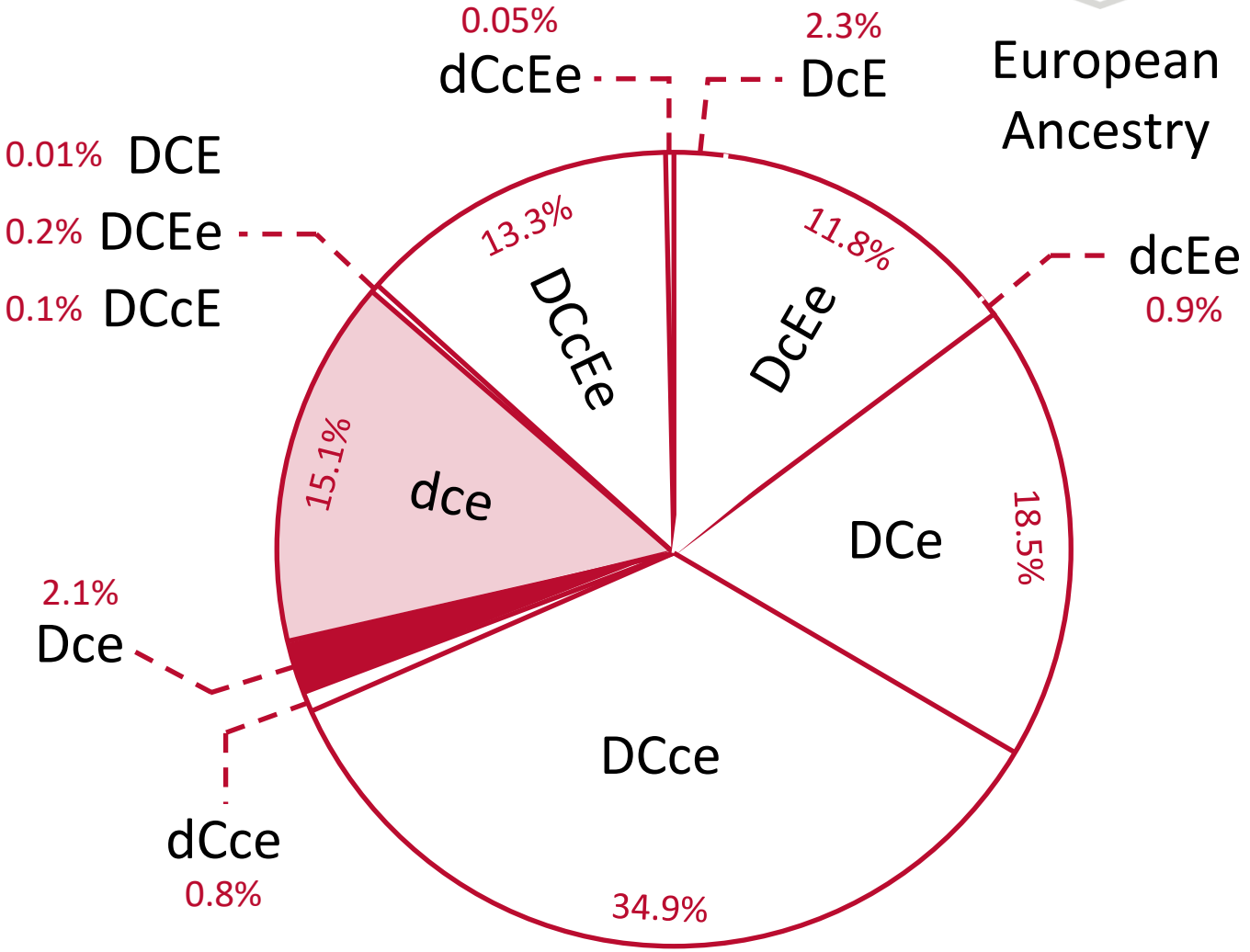


52.6% vs. 17.1%

Reid ME, Lomas-Francis C, Olsson ML. The Blood Antigen FactsBook. 3rd ed. Elsevier; 2012.

At risk for both alloanti-C and alloanti-E

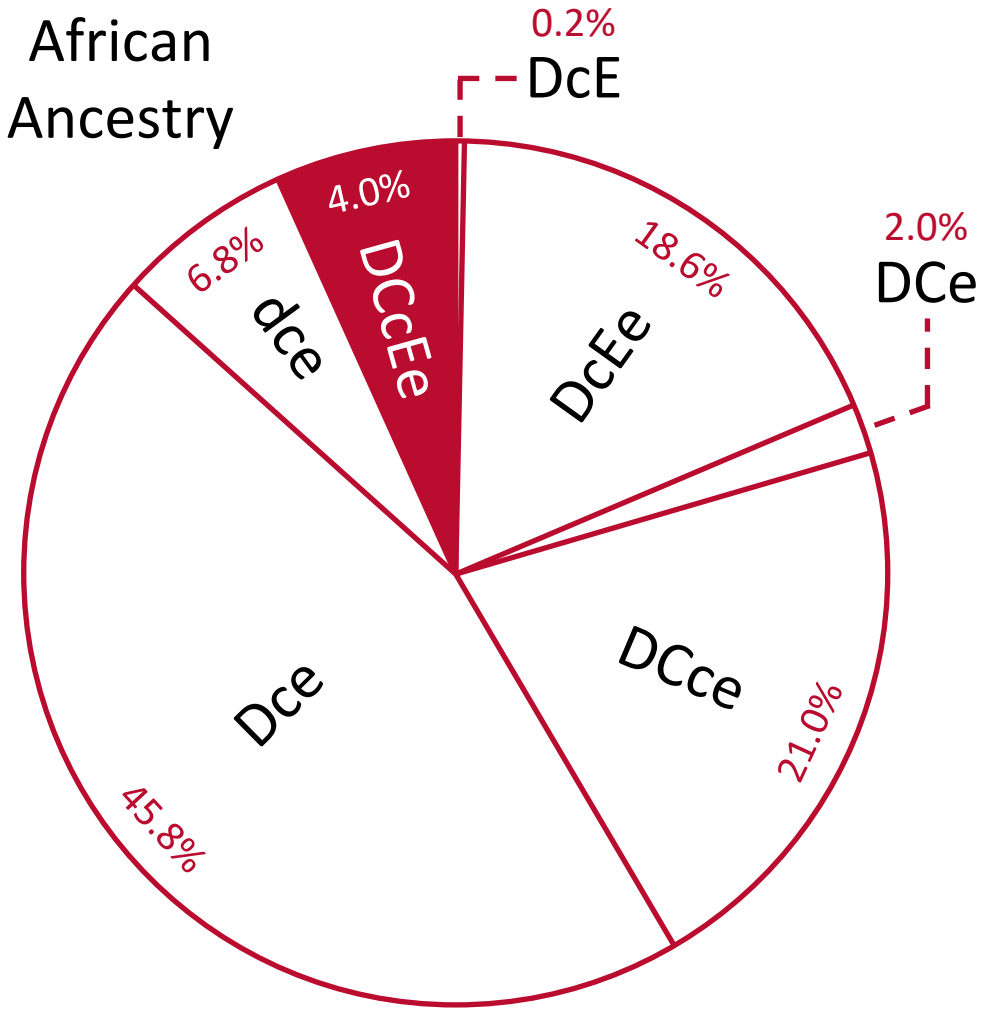




45.8% vs. 2.1%

Reid ME, Lomas-Francis C, Olsson ML. The Blood Antigen FactsBook. 3rd ed. Elsevier; 2012.

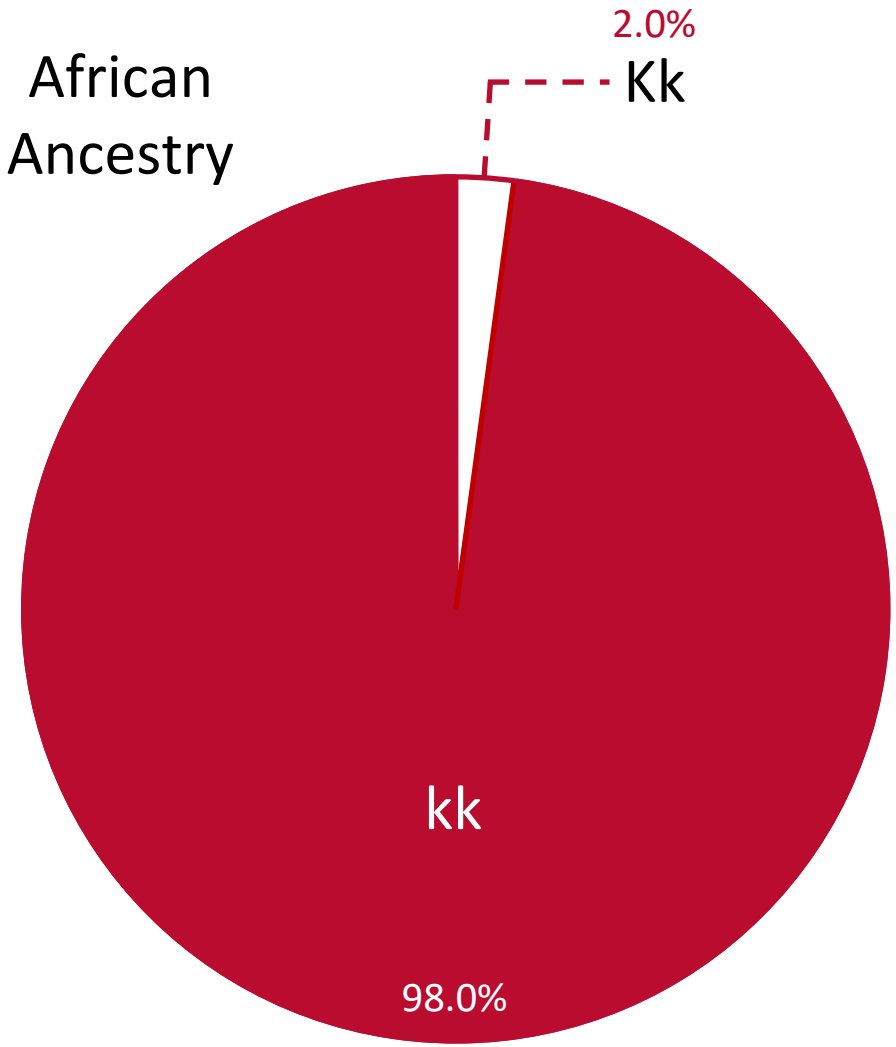
No risk for both alloanti-C or alloanti-E



4.0% of African Americans have no risk for developing either an anti-C or an anti-E (DCcEe phenotype) alloantibodies

Reid ME, Lomas-Francis C, Olsson ML. The Blood Antigen FactsBook. 3rd ed. Elsevier; 2012.

At risk for alloanti-K

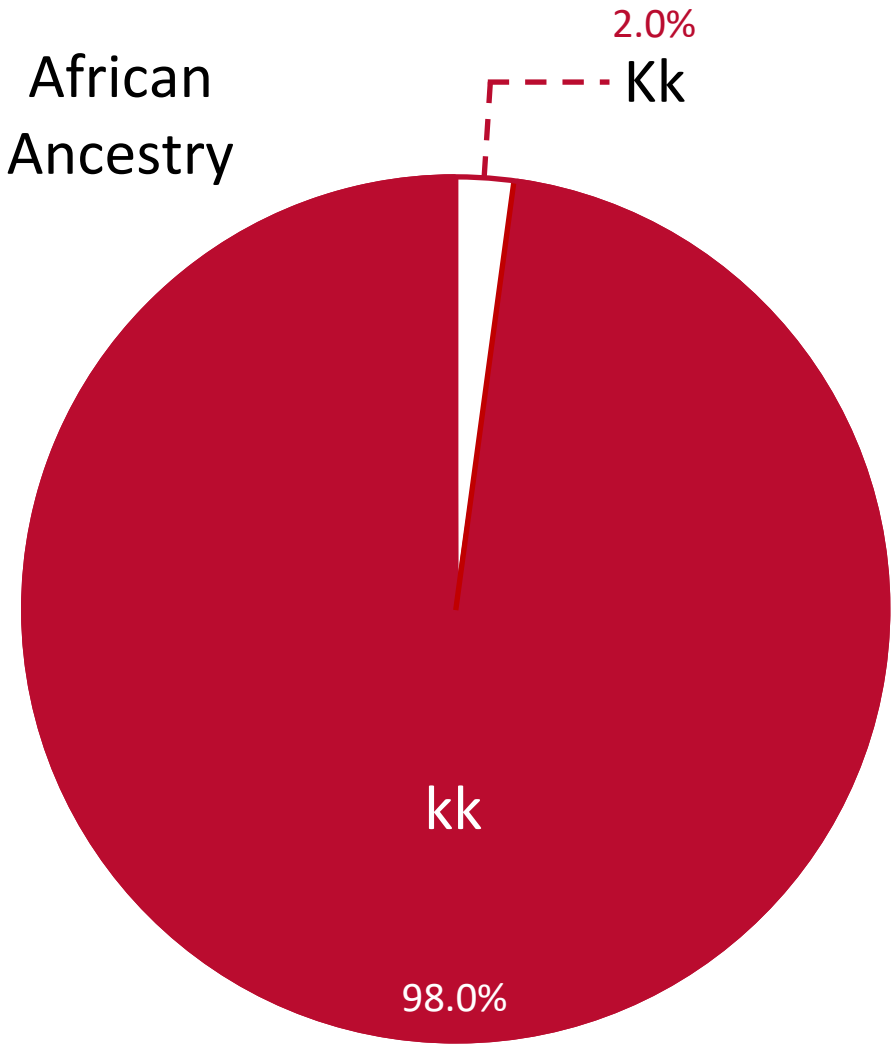


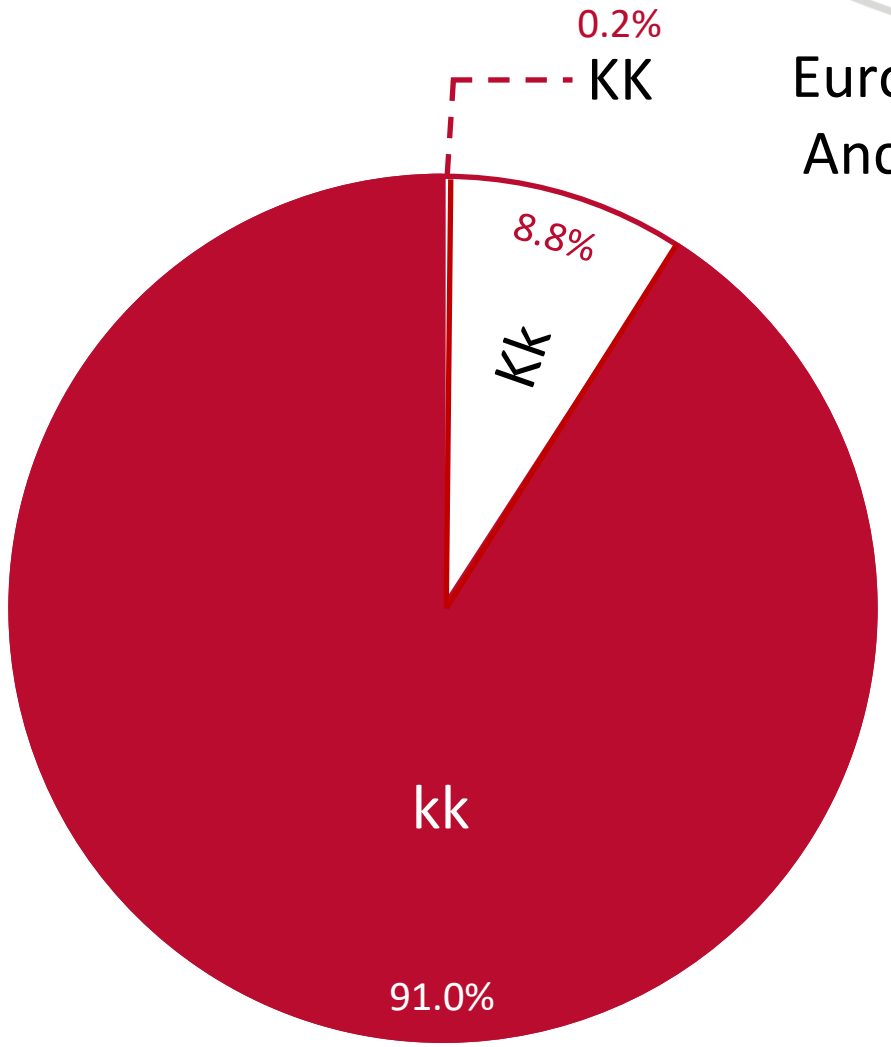
Kell Antigen (K/k)	
Phenotype	Prevalence (%)
KK	~ 0
Kk	2.0
kk	98

98.0% of African Americans are at risk for developing an anti-K (kk phenotypes) alloantibody

Reid ME, Lomas-Francis C, Olsson ML. The Blood Antigen FactsBook. 3rd ed. Elsevier; 2012.

At risk for alloanti-K





98.0% vs. 91.0%

Reid ME, Lomas-Francis C, Olsson ML. The Blood Antigen FactsBook. 3rd ed. Elsevier; 2012.

C/E/K Risk Summary

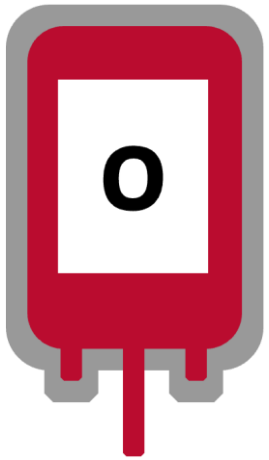
- 18.8% of African Americans are at risk for developing only an anti-C (DcE and DcEe phenotypes) alloantibody
- 23.0% of African Americans are at risk for developing only an anti-E (DCe and DCce phenotypes) alloantibody
- 52.6% of African Americans are at risk for developing both an anti-C and an anti-E (Dce and dce phenotypes) alloantibodies

- 98% of African Americans are at risk for developing an anti-K alloantibody with basically 0% risk of developing an anti-k alloantibody

Reid ME, Lomas-Francis C, Olsson ML. The Blood Antigen FactsBook. 3rd ed. Elsevier; 2012.

The Conundrum – The Ask

Need C & E Negative
O Positive Unit



The Conundrum – RhD Positive

Phenotype	European Ancestry	African Ancestry	Asian Ancestry
DCe	18.5	2.0	51.8
DcE	2.3	0.2	4.4
DCce	34.9	21.0	8.5
DcEe	11.8	18.6	2.5
Dce	2.1	45.8	0.3
DCE	0.01	Rare	Rare
DCEe	0.2	Rare	1.4
DCcE	0.1	Rare	0.4
DCcEe	13.3	4.0	30.0

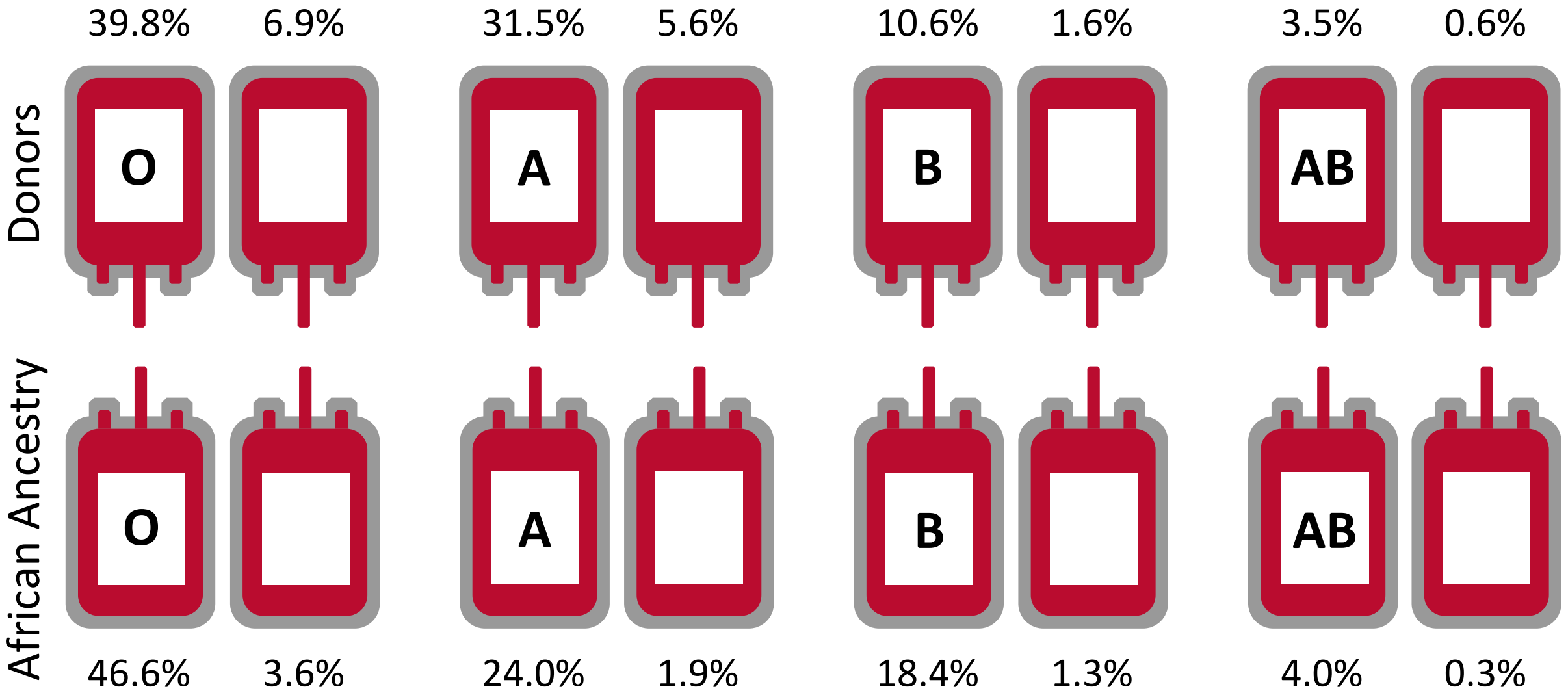
Reid ME, Lomas-Francis C, Olsson ML. The Blood Antigen FactsBook. 3rd ed. Elsevier; 2012.

The Conundrum – RhD Negative

Phenotype	European Ancestry	African Ancestry	Asian Ancestry
dCce	0.8	Rare	0.1
dCe	Rare	Rare	0.1
dcEe	0.9	Rare	Rare
dcE	Rare	Rare	Rare
dce	15.1	6.8	0.1
dCcEe	0.05	Rare	Rare
dCEe/dCcE/dCE	Rare	Rare	Rare
dC^{s}cee	0	1-2	0

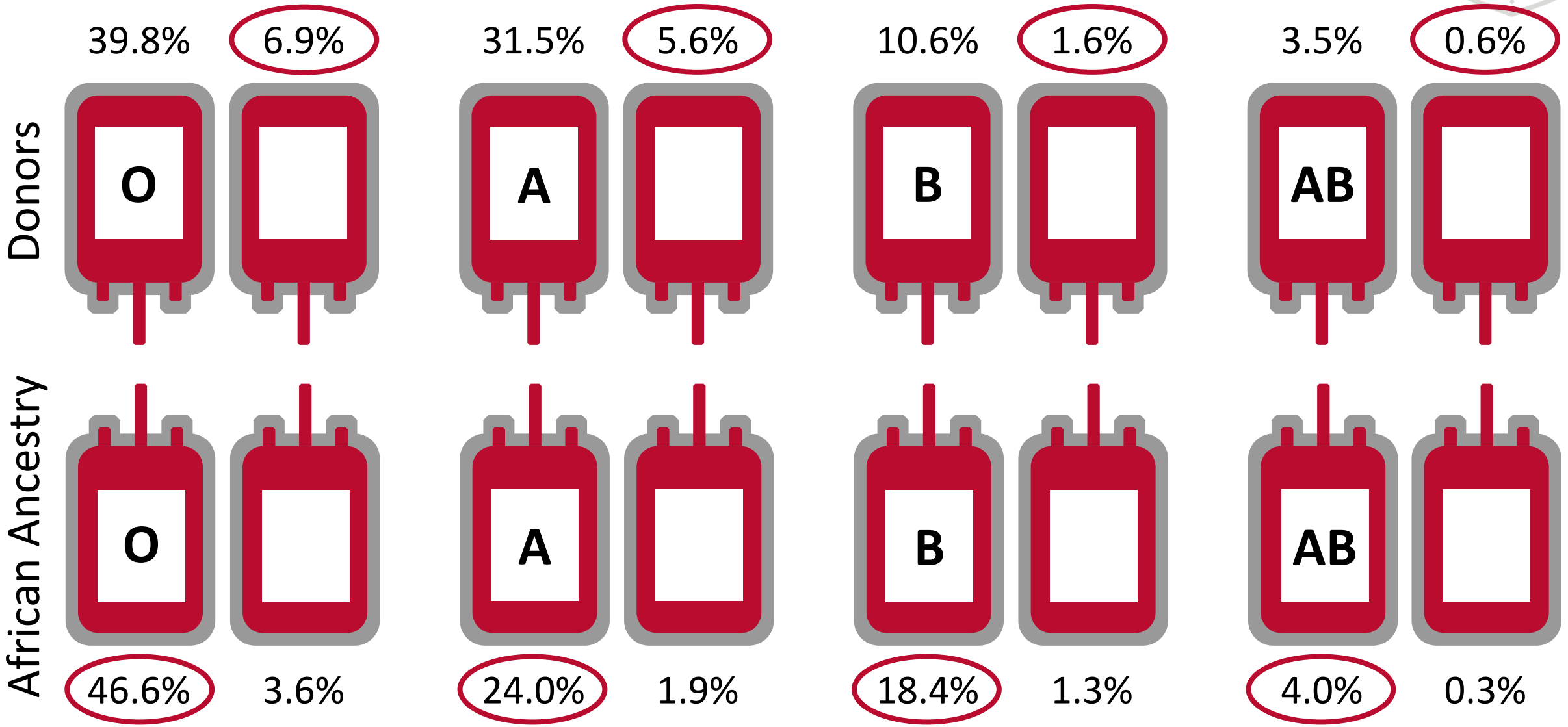
Reid ME, Lomas-Francis C, Olsson ML. The Blood Antigen FactsBook. 3rd ed. Elsevier; 2012.

The Conundrum – The Donors



Garratty G et al. Transfusion. 2004 May;44(5):703-6.

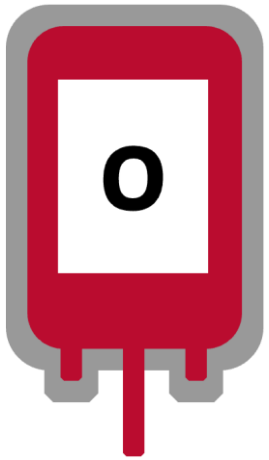
The Conundrum – The Donors



Garratty G et al. Transfusion. 2004 May;44(5):703-6.

The Conundrum – The Solution

Need C & E Negative
O Positive Unit



~2.1% of all Rh phenotypes (positive & negative)

Reid ME, Lomas-Francis C, Olsson ML. The Blood Antigen FactsBook. 3rd ed. Elsevier; 2012.

The Conundrum – The Solution

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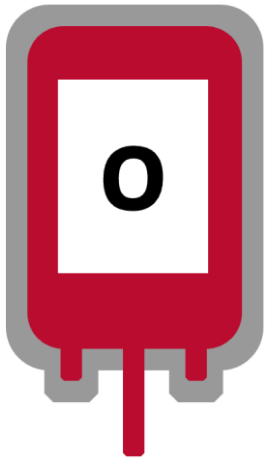
O Positive Unit



~2.5%

Reid ME, Lomas-Francis C, Olsson ML. The Blood Antigen FactsBook. 3rd ed. Elsevier; 2012.

The Conundrum – The Solution

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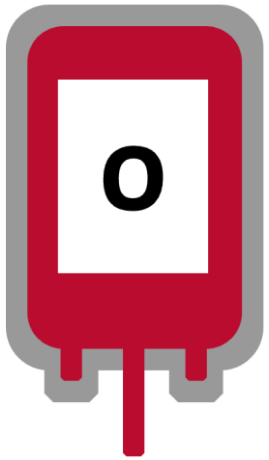
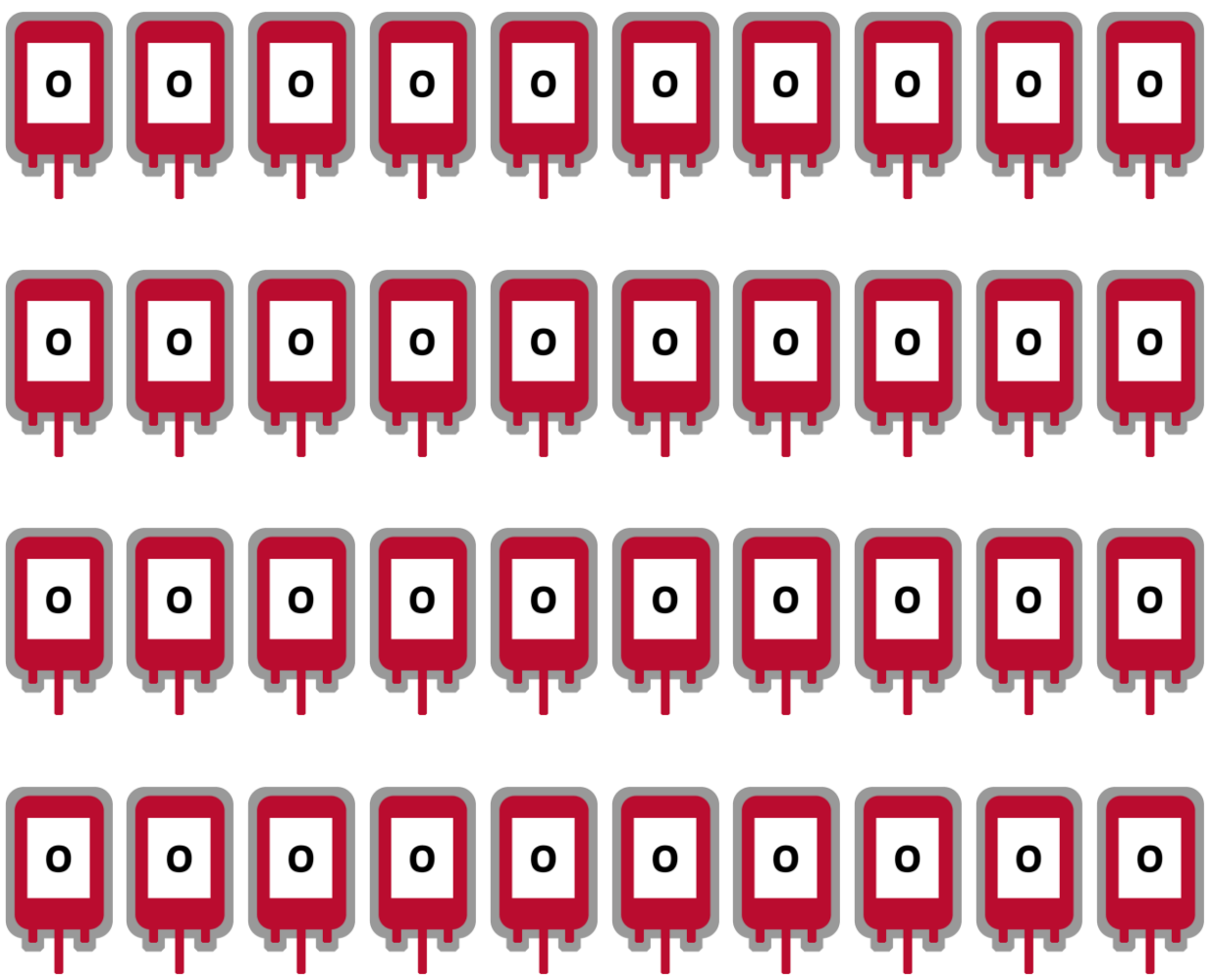
O Positive Unit



~2.5%



Reid ME, Lomas-Francis C, Olsson ML. The Blood Antigen FactsBook. 3rd ed. Elsevier; 2012.

The Conundrum – The Solution

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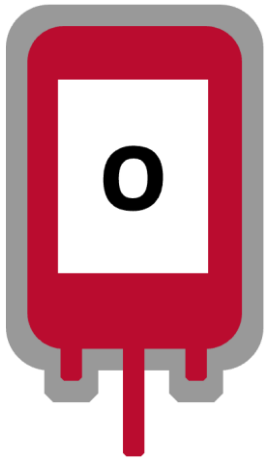
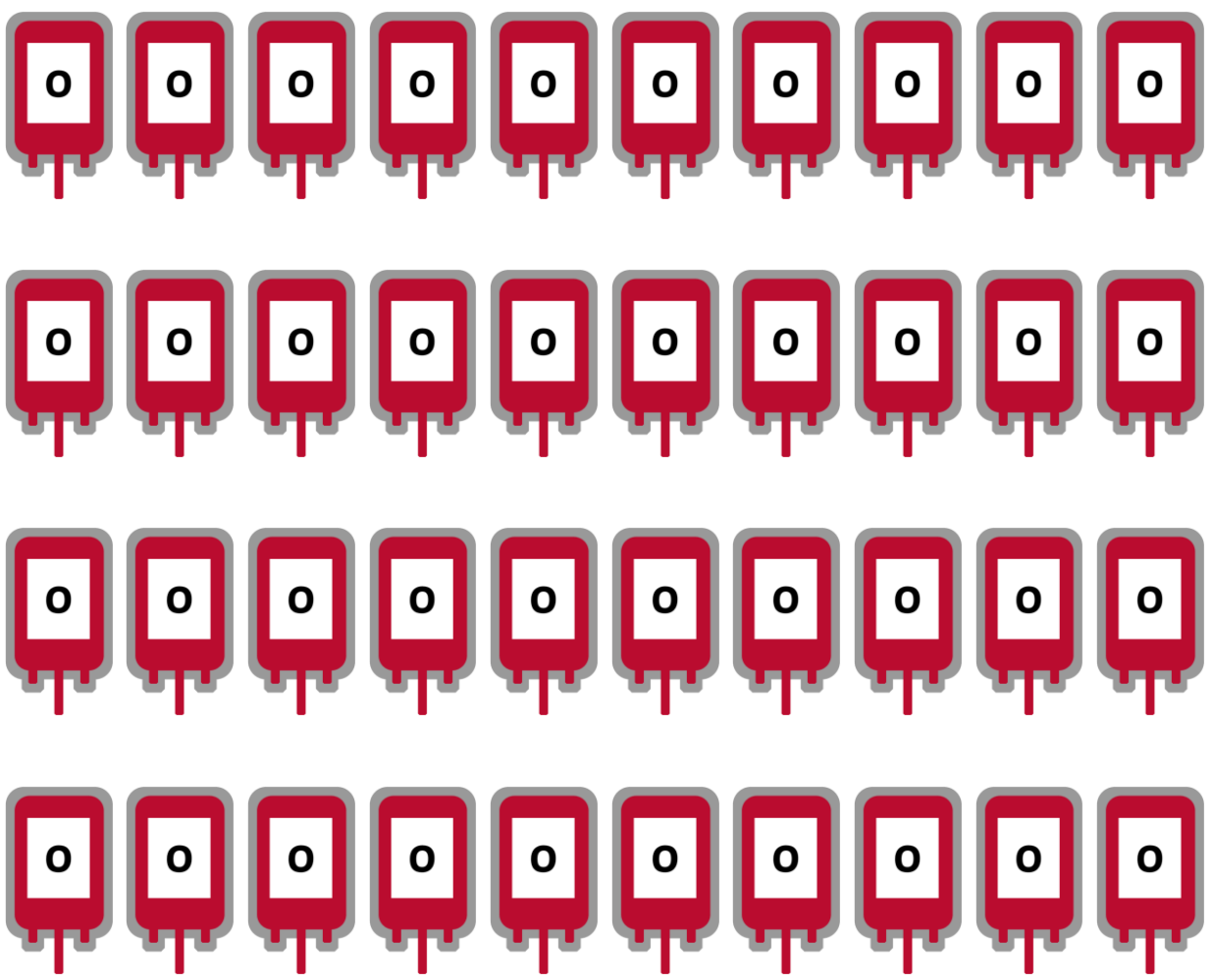


~2.5%



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The Conundrum – The Solution

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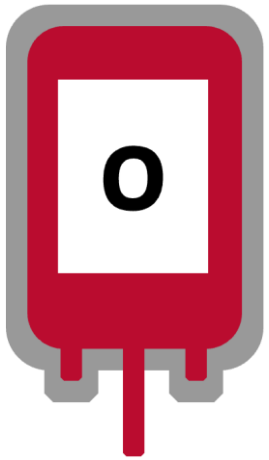

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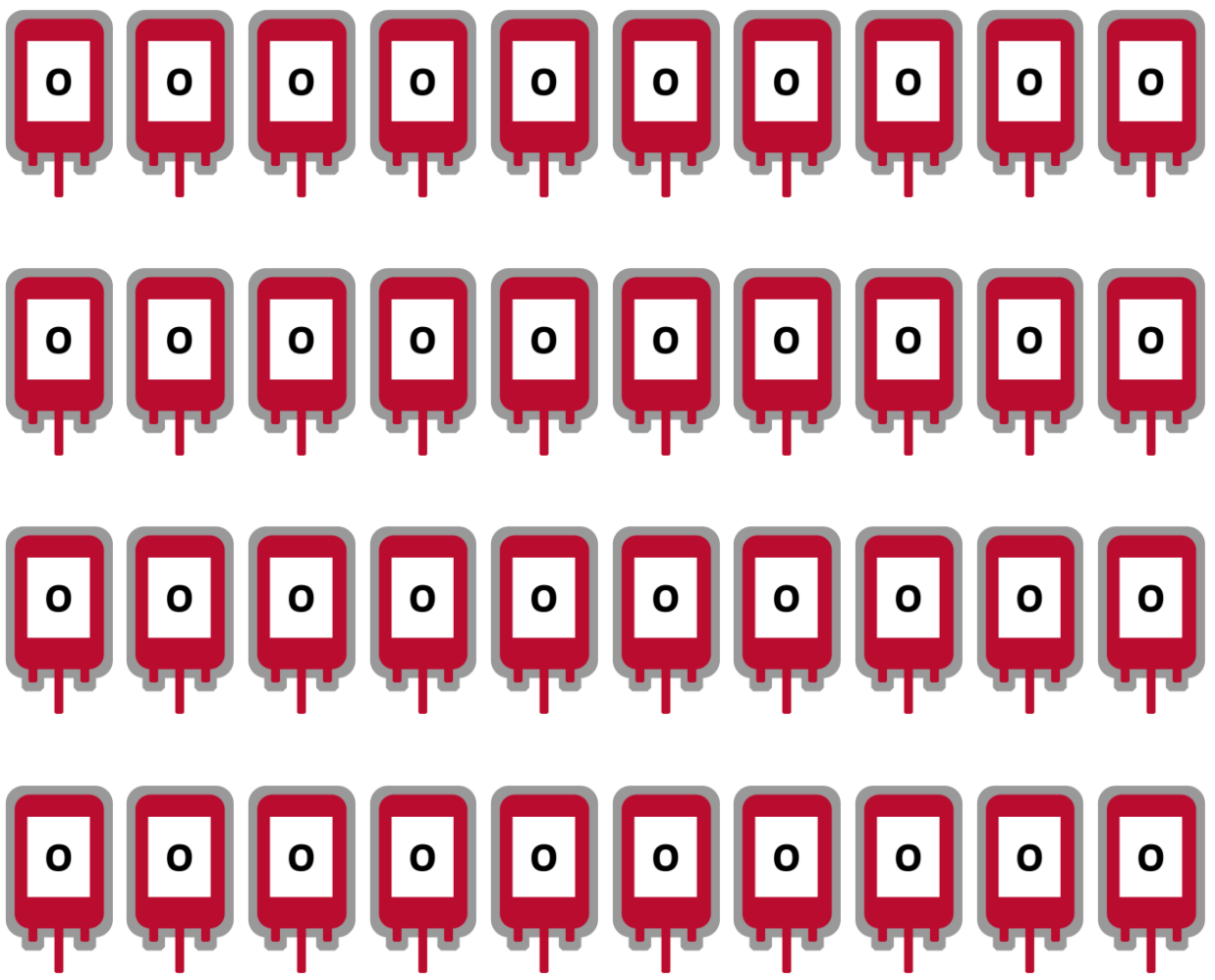
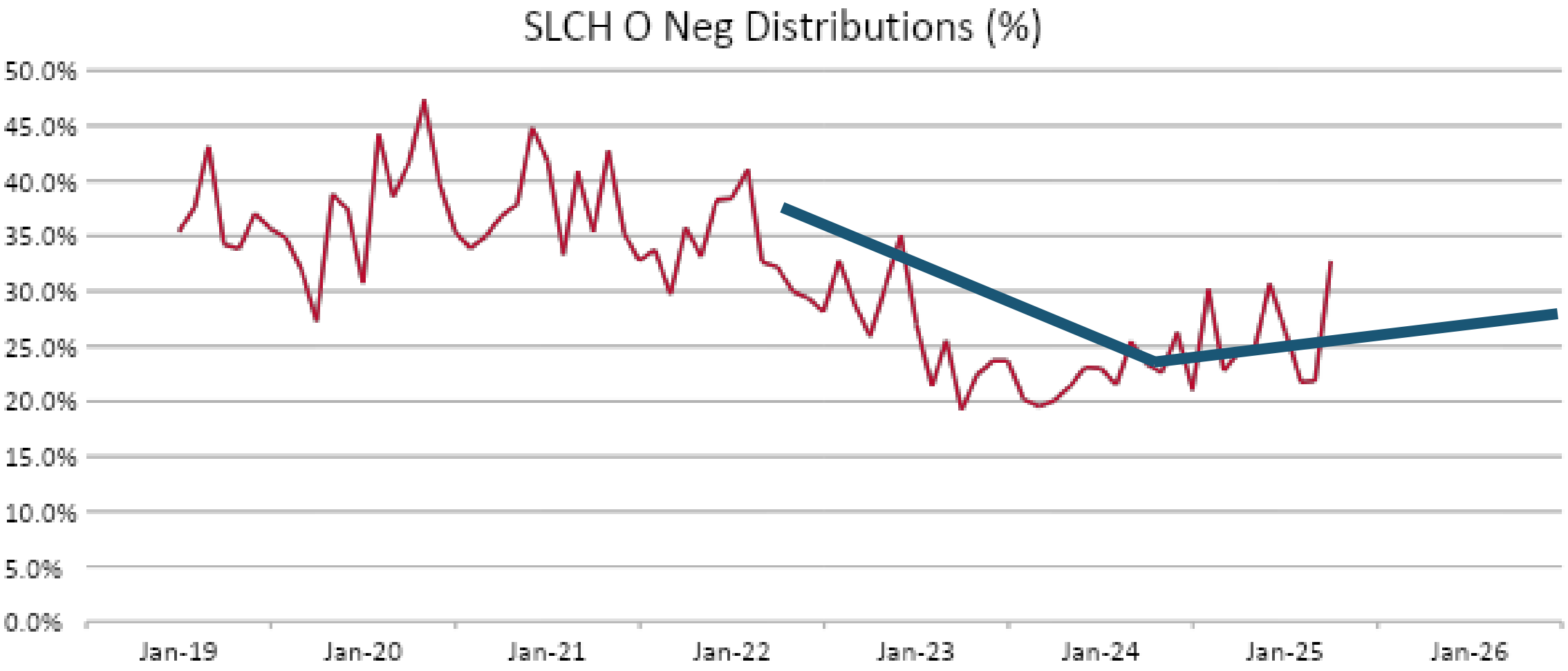


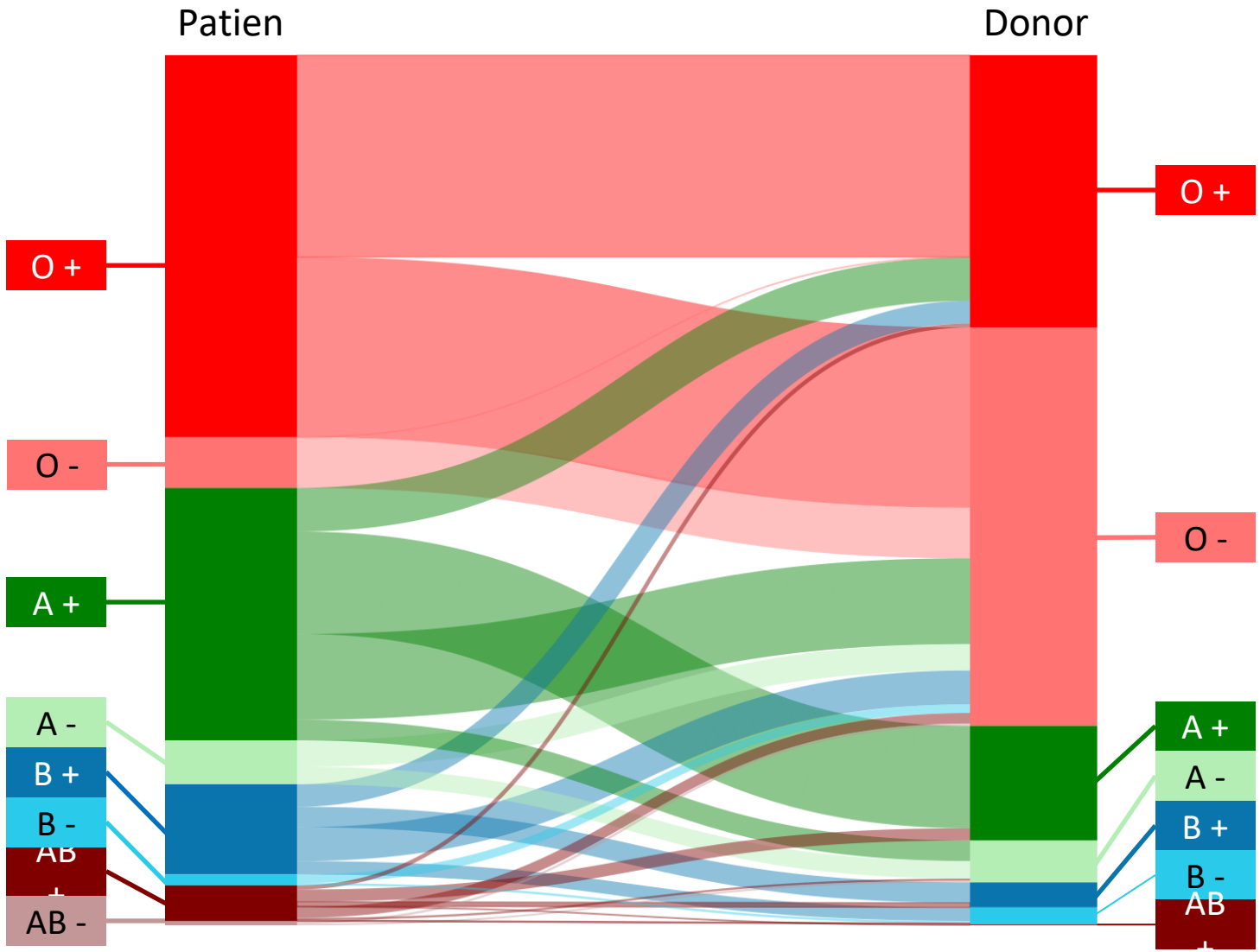
Reid ME, Lomas-Francis C, Olsson ML. The Blood Antigen FactsBook. 3rd ed. Elsevier; 2012.

SLCH O Negative Distributions



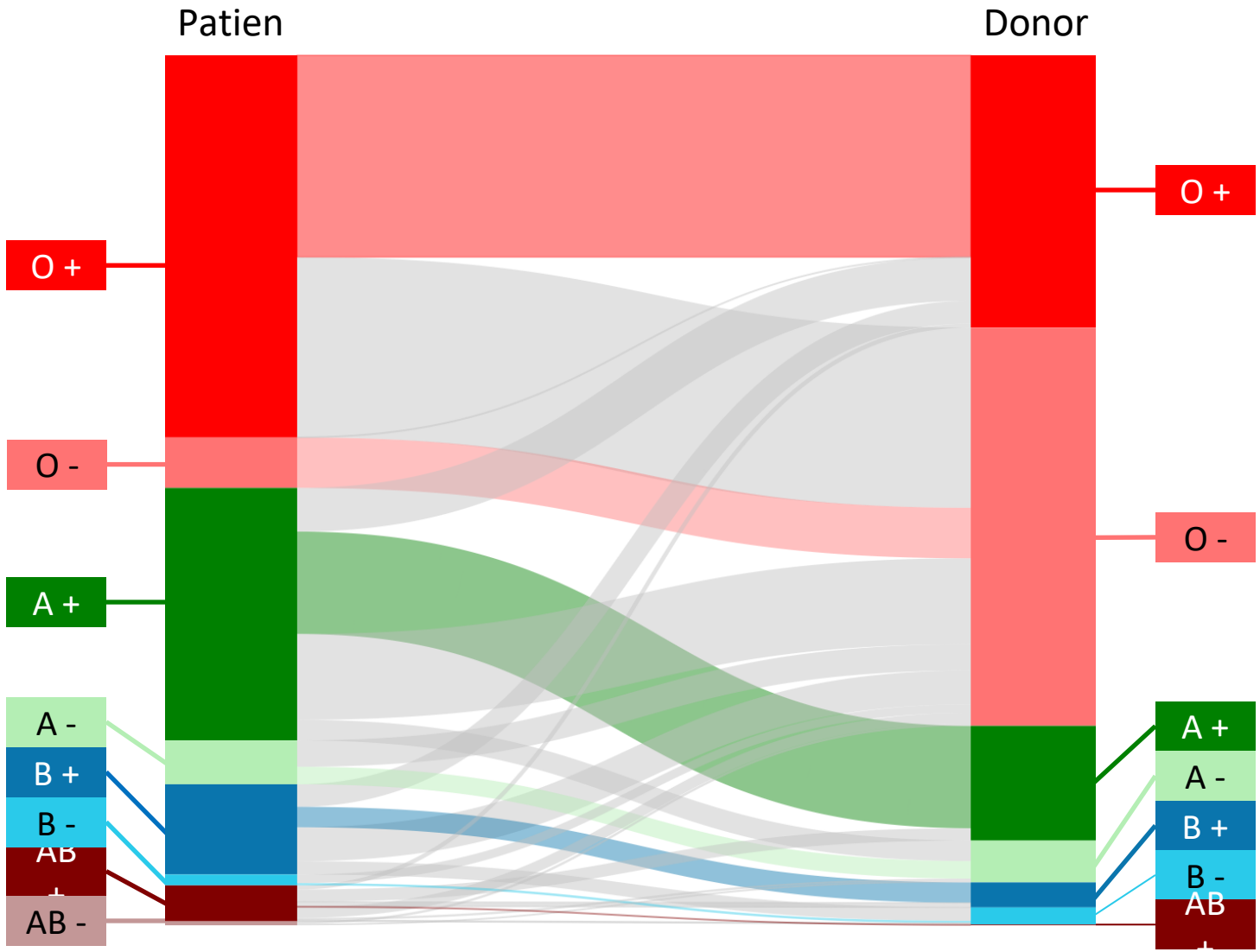
Discuss an ongoing project to further reduce O negative packed red blood cell use in neonates

Neonatal Unit Allocation 11/16 – 2/22



Type	Patient	Donor
O Pos	9910 / 43.9%	7062 / 31.3%
O Neg	1312 / 5.8%	10327 / 45.8%
A Pos	6546 / 29.0%	2974 / 13.2%
A Neg	1138 / 5.0%	1086 / 4.8%
B Pos	2340 / 10.4%	650 / 2.9%
B Neg	282 / 1.2%	443 / 2.0%
AB Pos	932 / 4.13%	20 / 0.09%
AB Neg	102 / 0.5%	0 / 0.0%

Neonatal Unit Allocation 11/16 – 2/22



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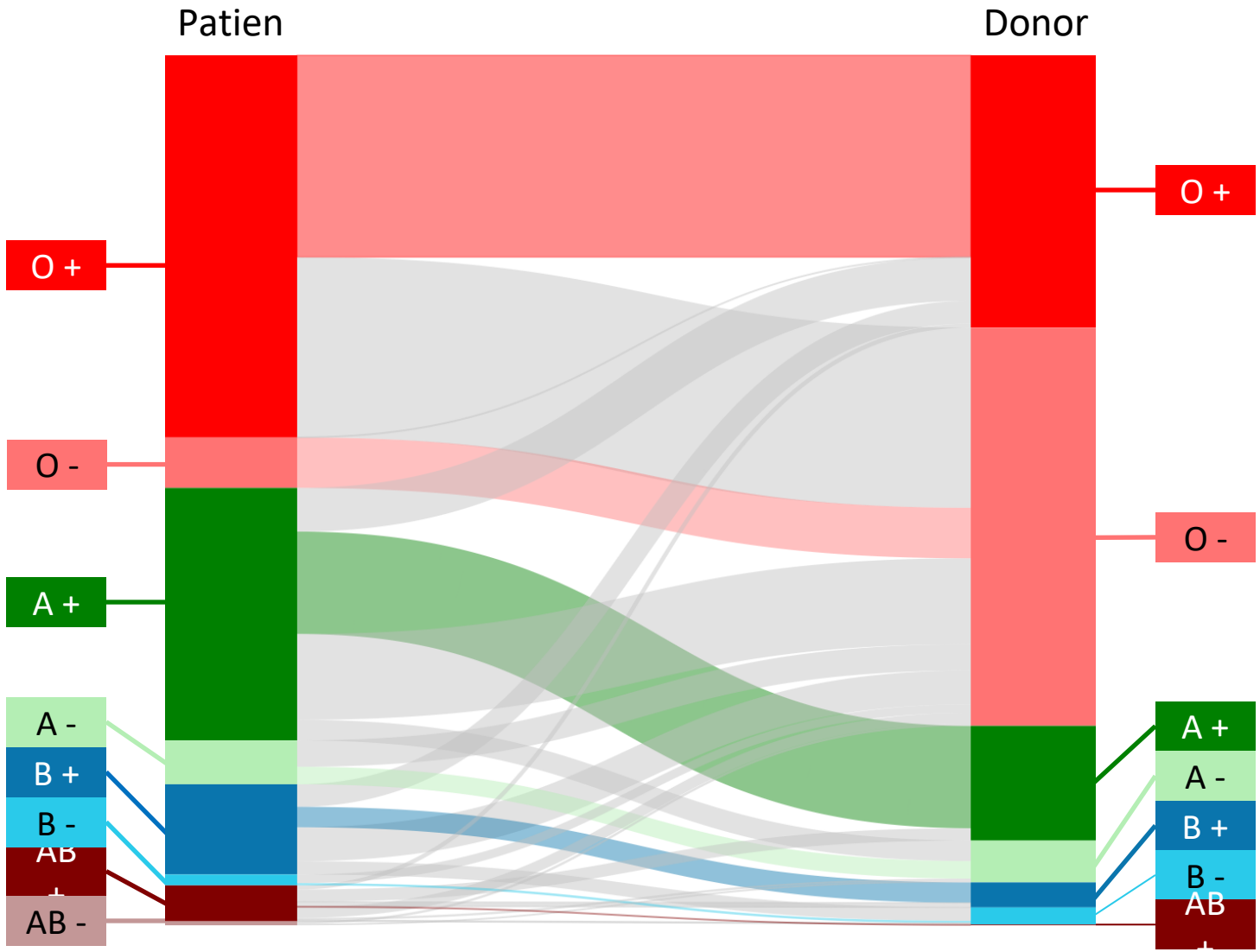
Neonatal Unit Allocation 11/16 – 2/22



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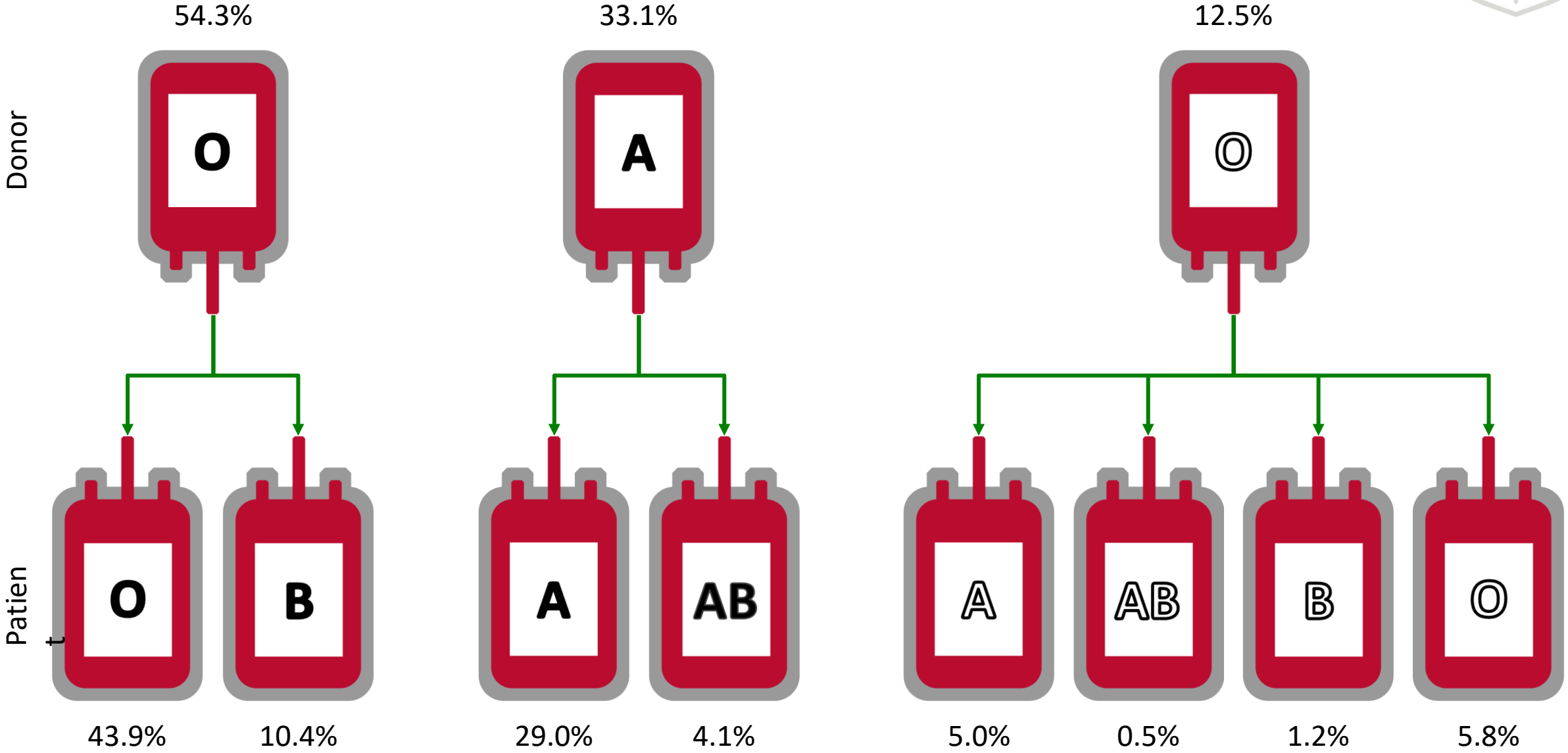
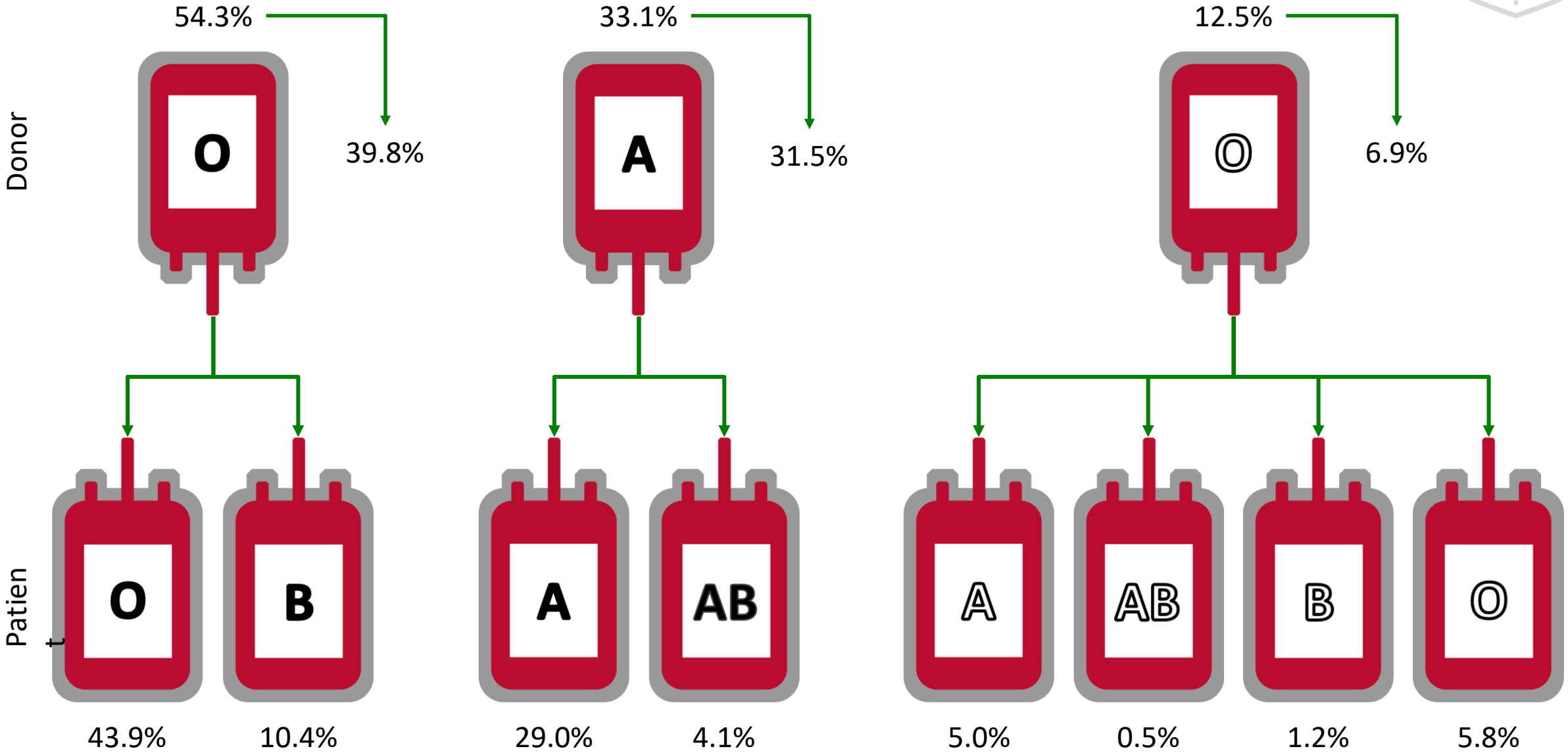
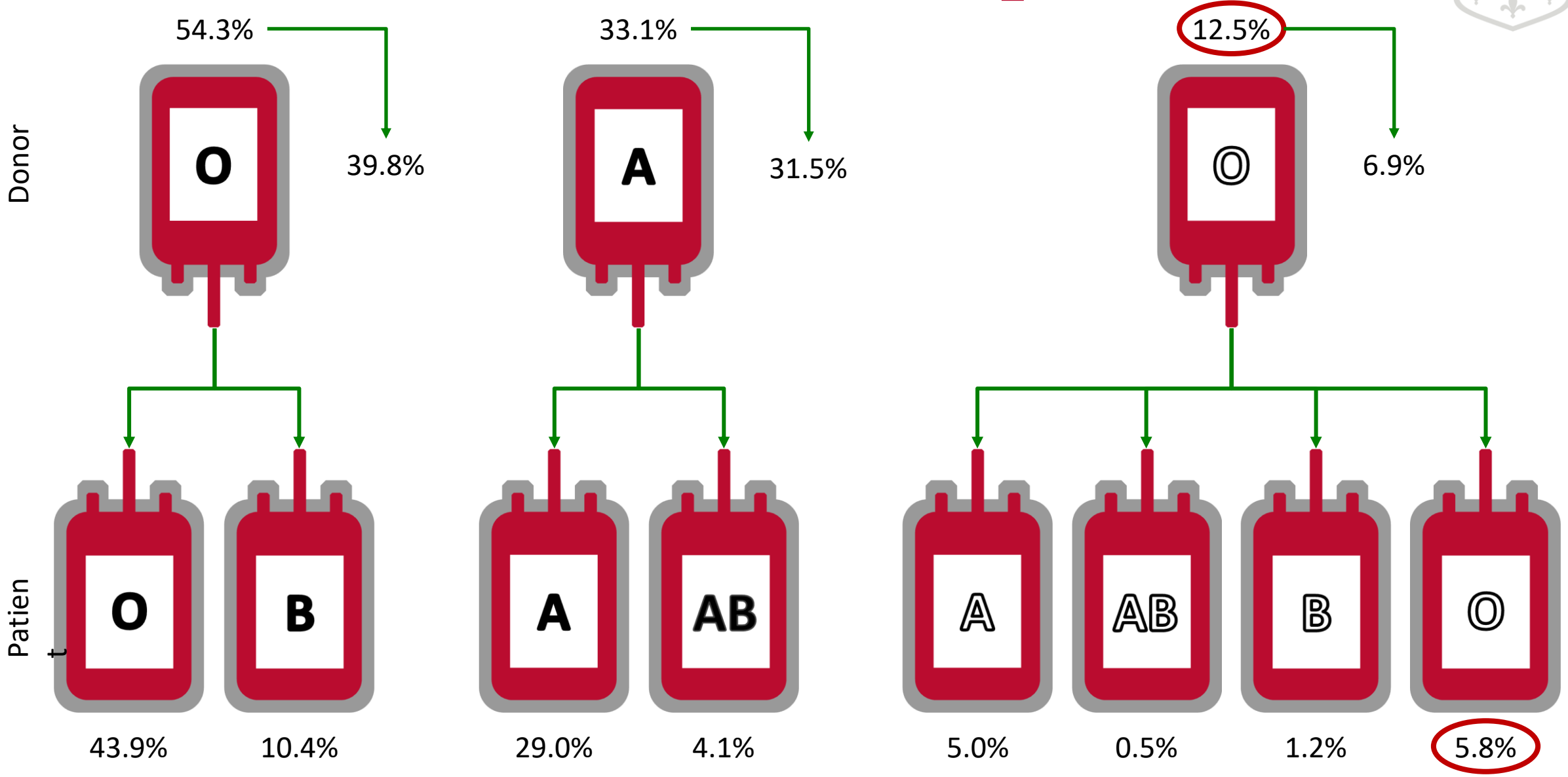
Neonatal Unit Allocation Proposal



Neonatal Unit Allocation Proposal



Neonatal Unit Allocation Proposal



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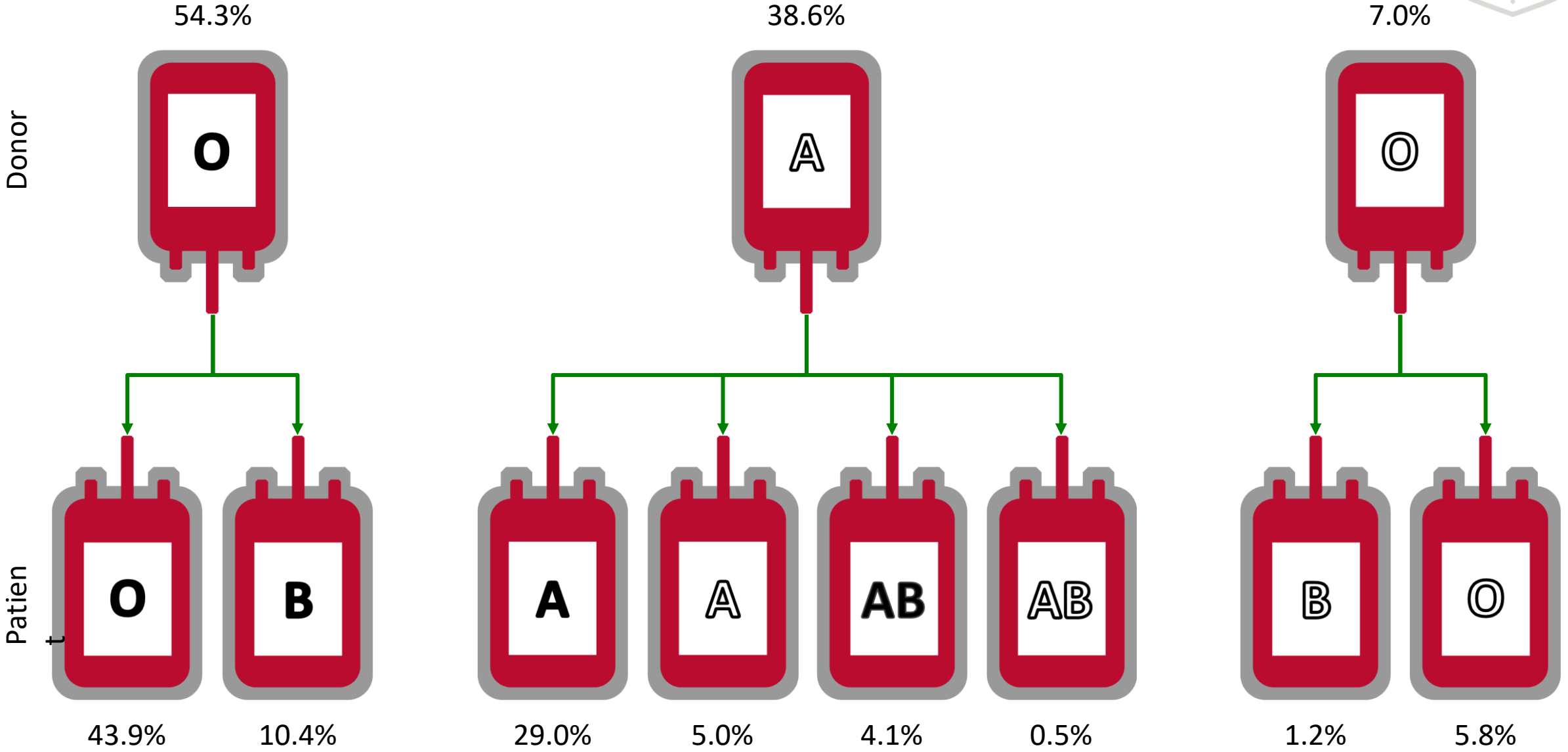

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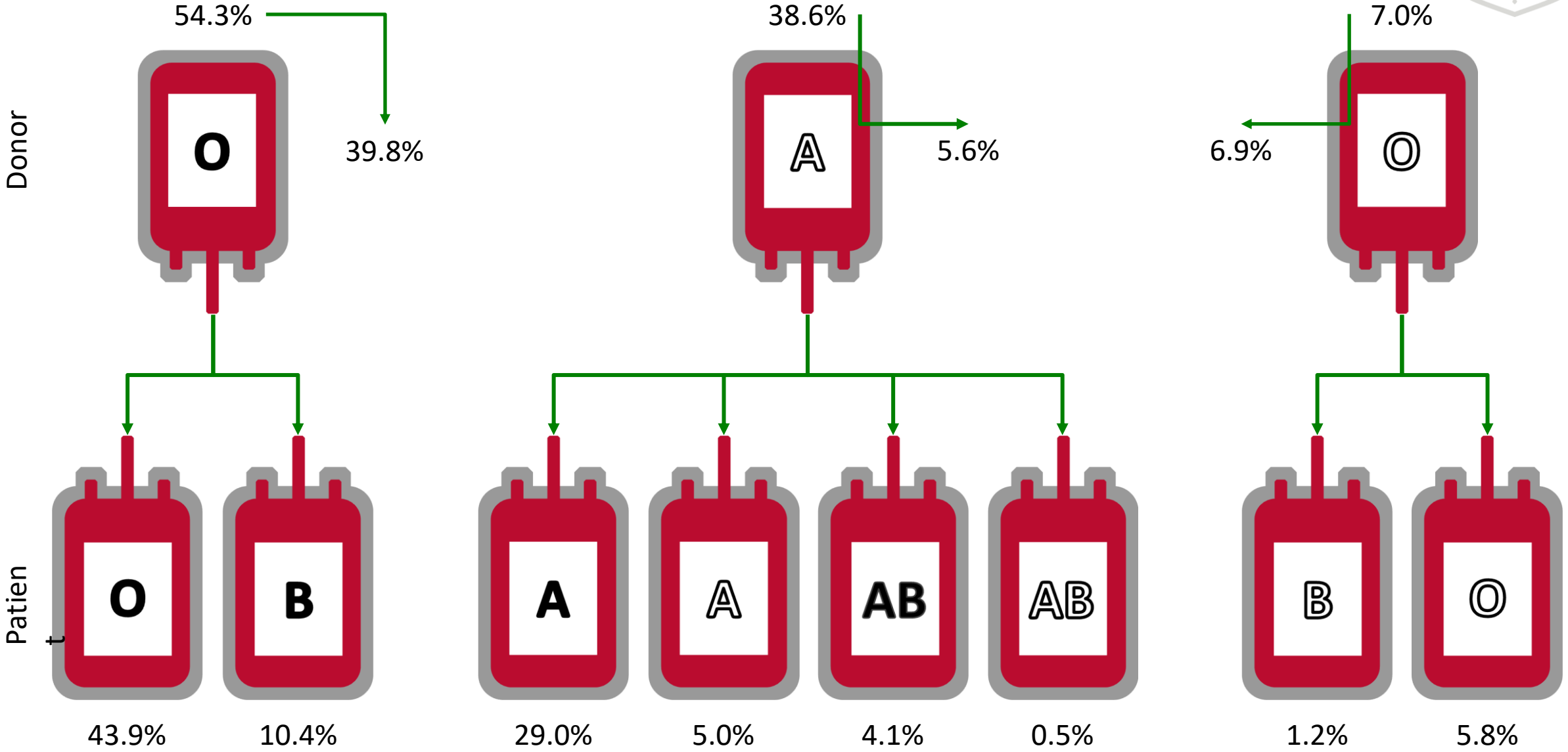

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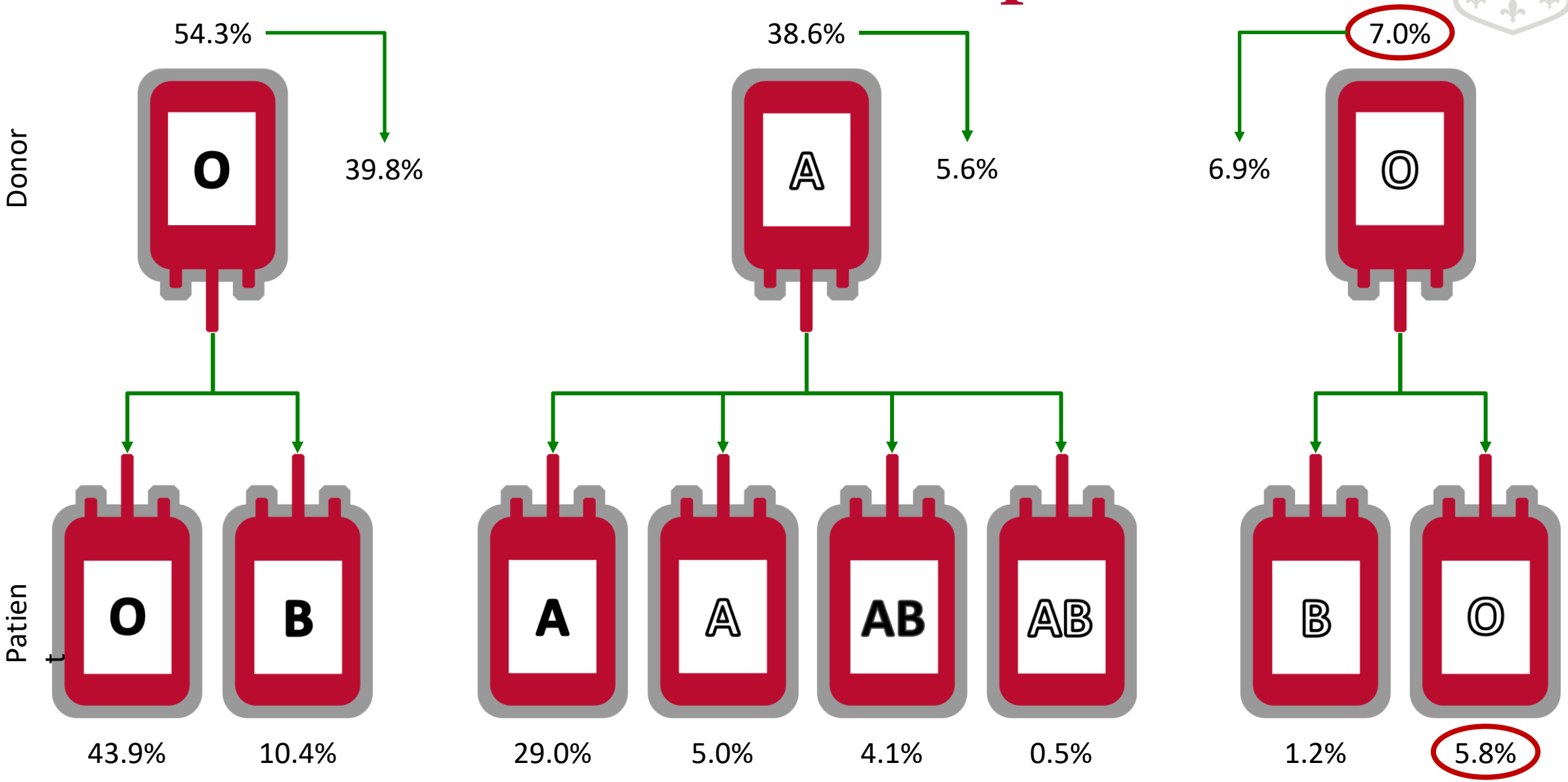

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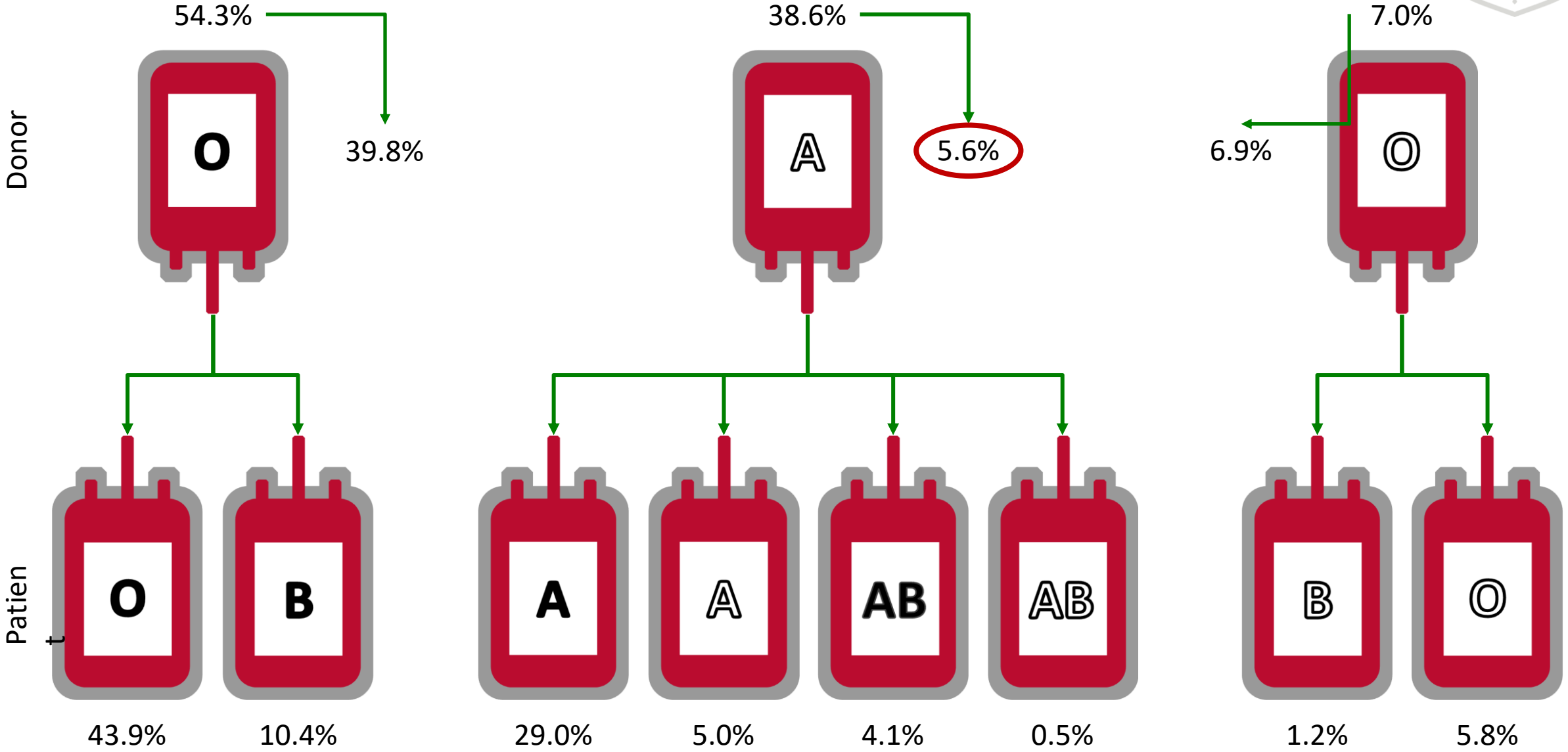
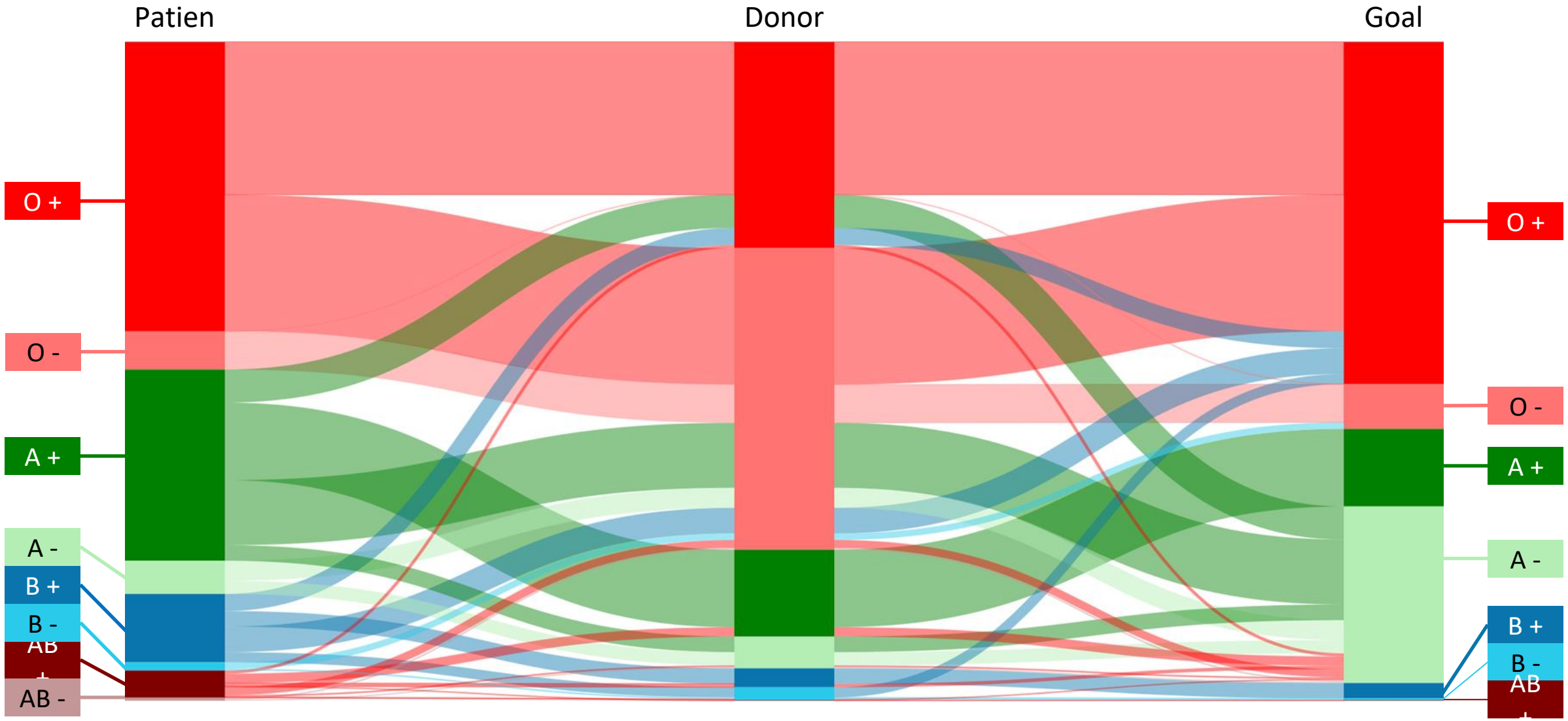


Proposed Neonatal Units O+, O-, & A-



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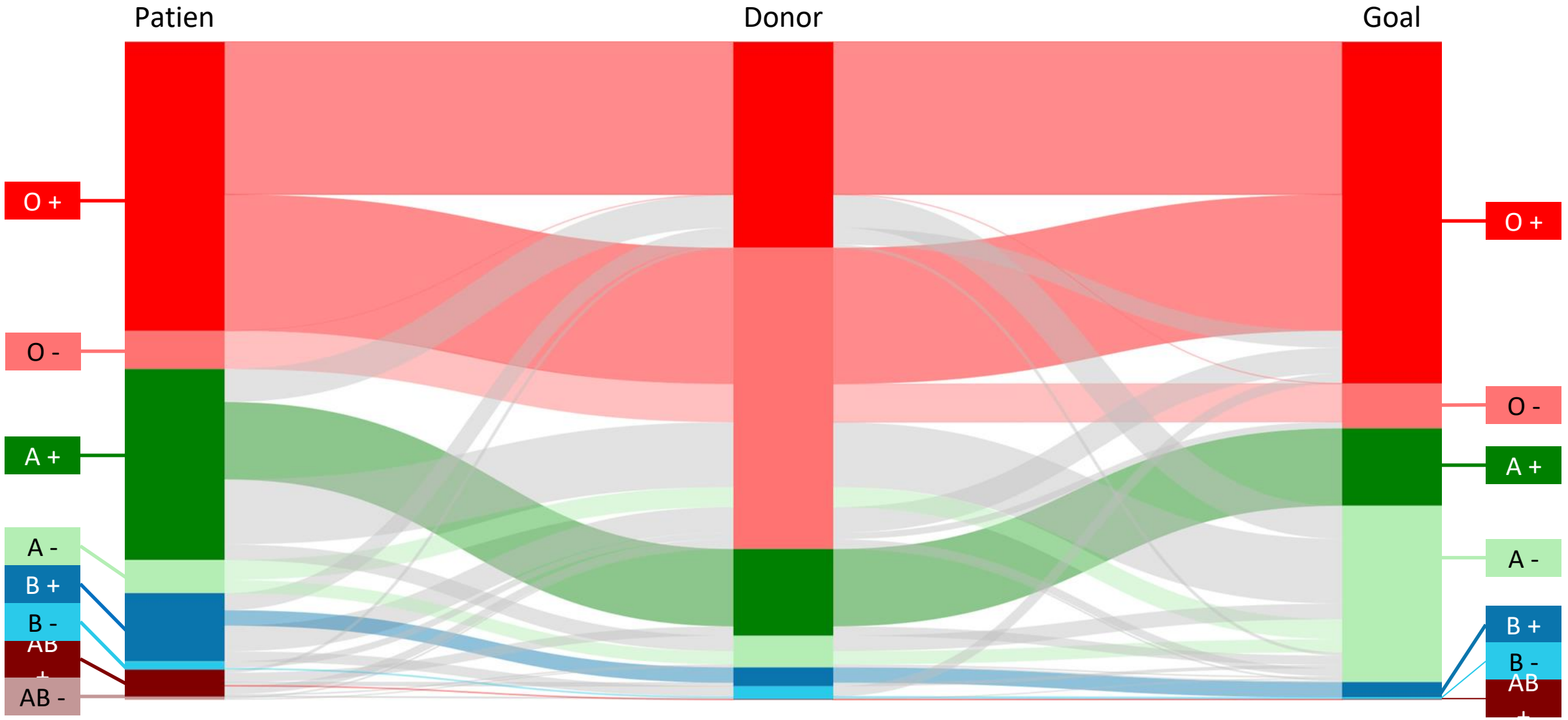

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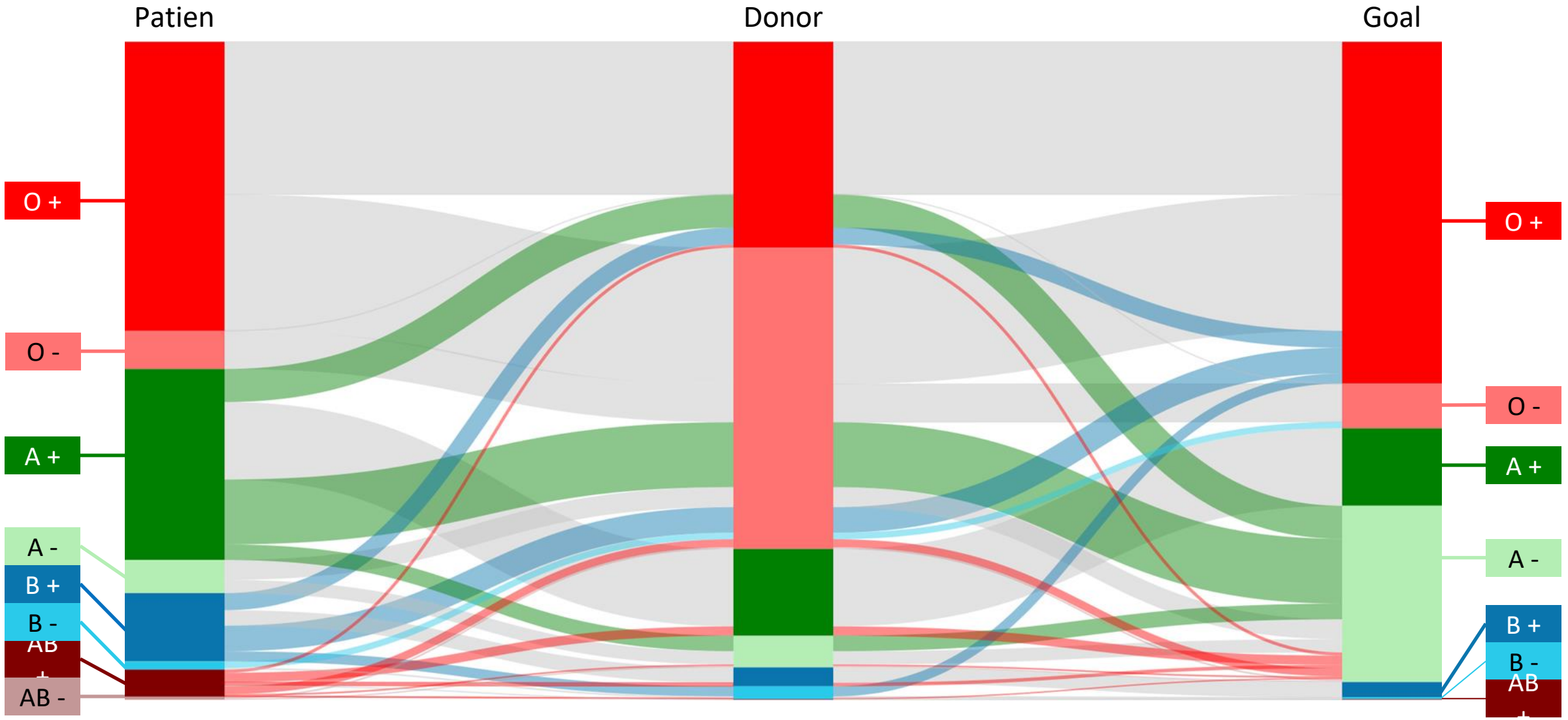

Proposed Neonatal Units O+, O-, & A-

Proposed Neonatal Units O+, O-, & A-

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WashU Medicine