Developing a Kidney Waiting List Calculator

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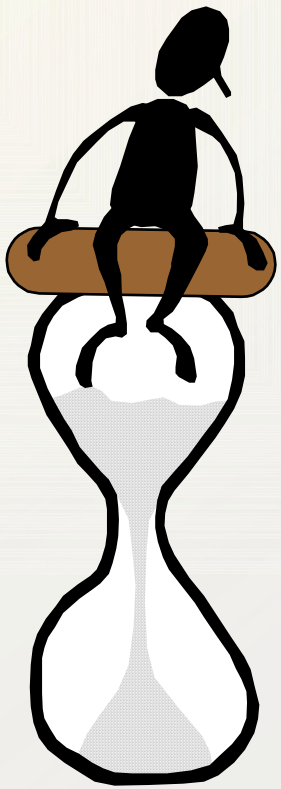
I have no financial relationships to disclose within the past 12 months relevant to my presentation

My presentation does not include discussion of off-label or investigational use.

Motivation



- A basic question: How long will I need to wait to receive a kidney transplant???
- Some national data are available:

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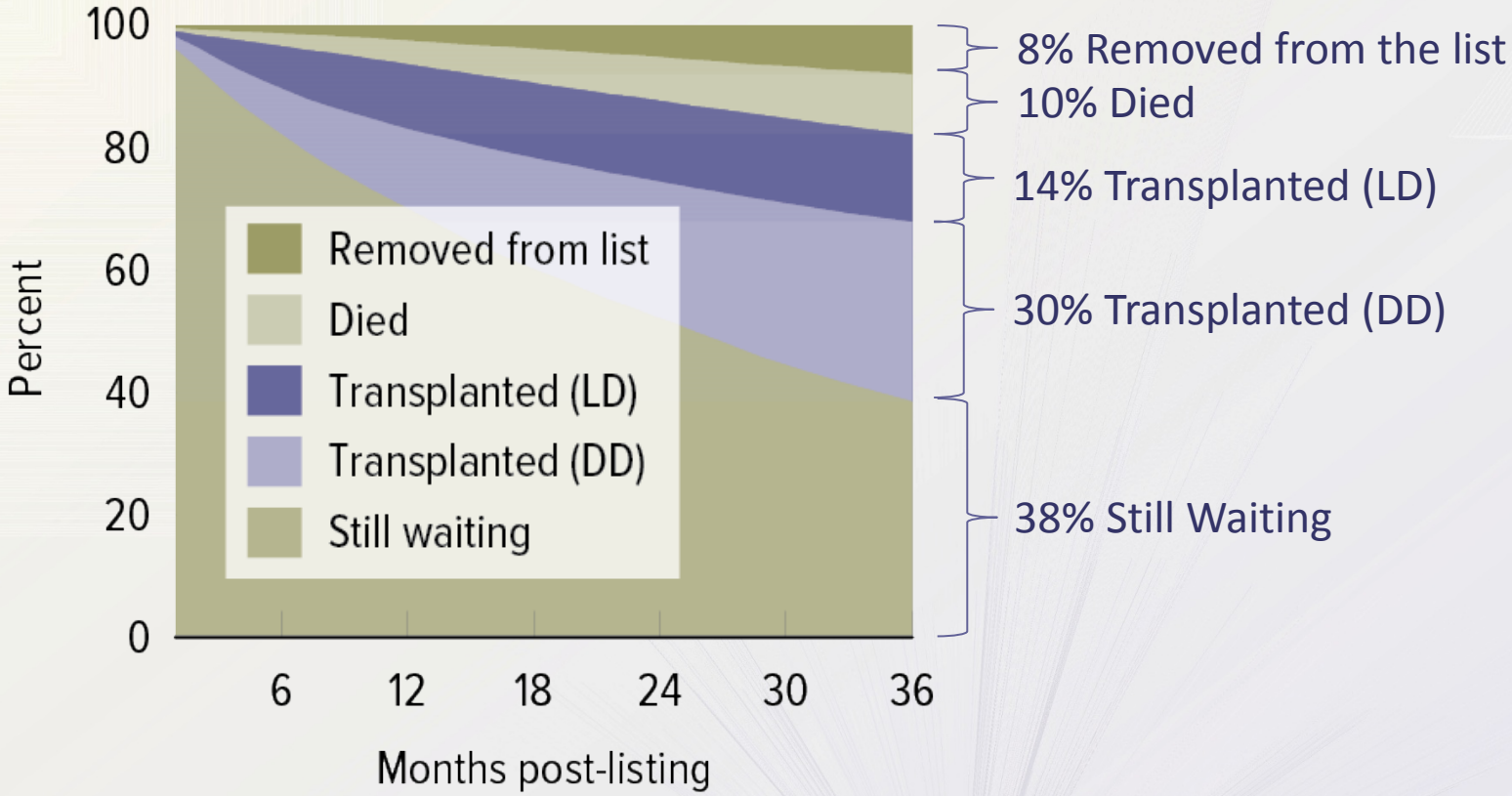
OPTN/SRTR 2010 Annual Data Report, Figure KI 1.7

Kidney transplant waiting list status by month post-listing among new adult listings in 2006



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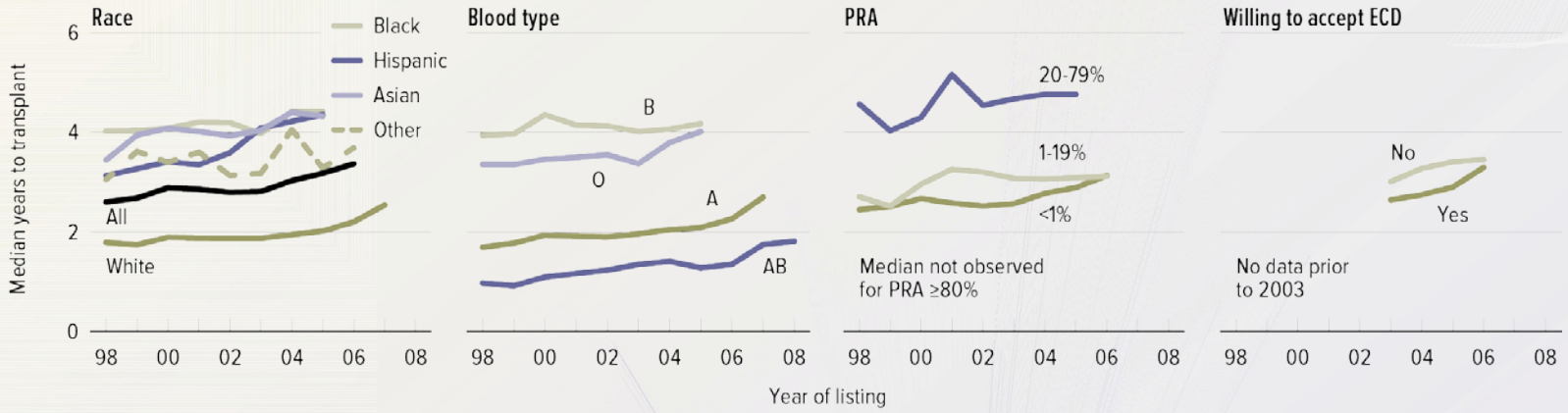
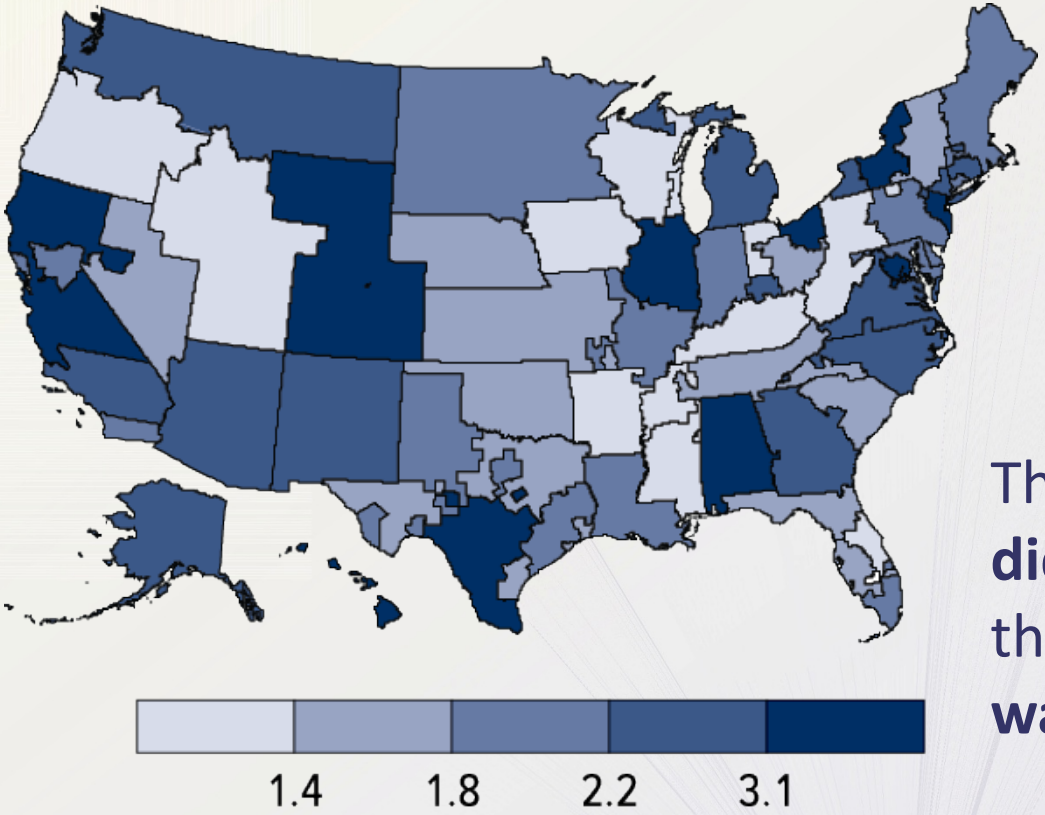
OPTN/SRTR 2010 Annual Data Report, KI 1.10

Median years to kidney transplant for wait-listed adult patients



OPTN/SRTR 2010 Annual Data Report, KI 1.9

Median years to kidney transplant (deceased donor) for adult patients transplanted in 2009, by DSA



This answers **"How long did people wait?"** rather than **"How long will I wait?"**.

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SRTR OPO-Specific Reports Contain Data by DSA

Table 8
Time to Transplant for Waitlist Patients at Centers served by this OPO**
Patients Registered between 07/01/2005 and 12/31/2010
Donation Service Area served by LifeCenter Northwest (WALC)
Organ: Kidney, Liver, and Heart

Kidney

	Months to Transplant*	
Percentile	**DSA**	**U.S.**
5th	3.8	1.8
10th	6.0	3.9
25th	15.6	13.2
50th (median time to transplant)	33.6	50.0
75th	>72	>72

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What does the Kidney Calculator do?

- Based on candidate characteristics (including donor service area, blood type, CPRA, and willingness to accept an ECD kidney) the calculator will predict the following event probabilities for the first five years following listing:
  - The candidate receives a living-donor transplant
  - The candidate receives a deceased-donor transplant
  - The candidate remains on the waiting list
  - The candidate is removed from the waiting list
  - The candidate dies on the waiting list or is removed from the list for being too sick for transplant

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What else does the Kidney Calculator do?

- The kidney calculator also calculates post-transplant survival probabilities
  - If the candidate receives a living-donor transplant
  - If the candidate receives a deceased-donor transplant, adjusted for differences in graft quality (KDPI)

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Estimating Waiting Time is Difficult

- The median waiting times for some DSAs are long
  - Longer follow-up is needed, so analysis cohorts need to stretch deeper into the past
  - The experience of past candidates may be different from what candidates today will experience, due to changes in policies, medical practice, etc.
- The meaning of waiting time is unclear when there are competing risks . . .

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The Modeling Challenge: The Competing Risks Covariate Disconnect

- A candidate on the waiting list can be removed by different events, each of which needs to be modeled separately:
  - Deceased-donor transplant
  - Living-donor transplant
  - Death (or too sick for transplant)
  - Some other event (e.g., transplant no longer needed)
- When there are competing risks, a higher/lower rate may or may not be associated with increasing/decreasing event probability
  - If a covariate **increases** the rate of transplant by a small amount and increases the rate of death by a large amount, the probability of transplant may **decrease**
  - If a covariate **decreases** the rate of transplant by a small amount and decreases the rate of death by a large amount, the probability of transplant may **increase**

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Waiting Times & Competing Risks

- When there are competing risks, discussing waiting times is troublesome
  - Some candidates will experience competing events before receiving a deceased-donor transplant
  - The probability of experiencing a competing event may eventually exceed 50%, making reporting of “median waiting time” difficult.
- It is more straightforward to discuss the probability of receiving a transplant by a particular time than to summarize the waiting times

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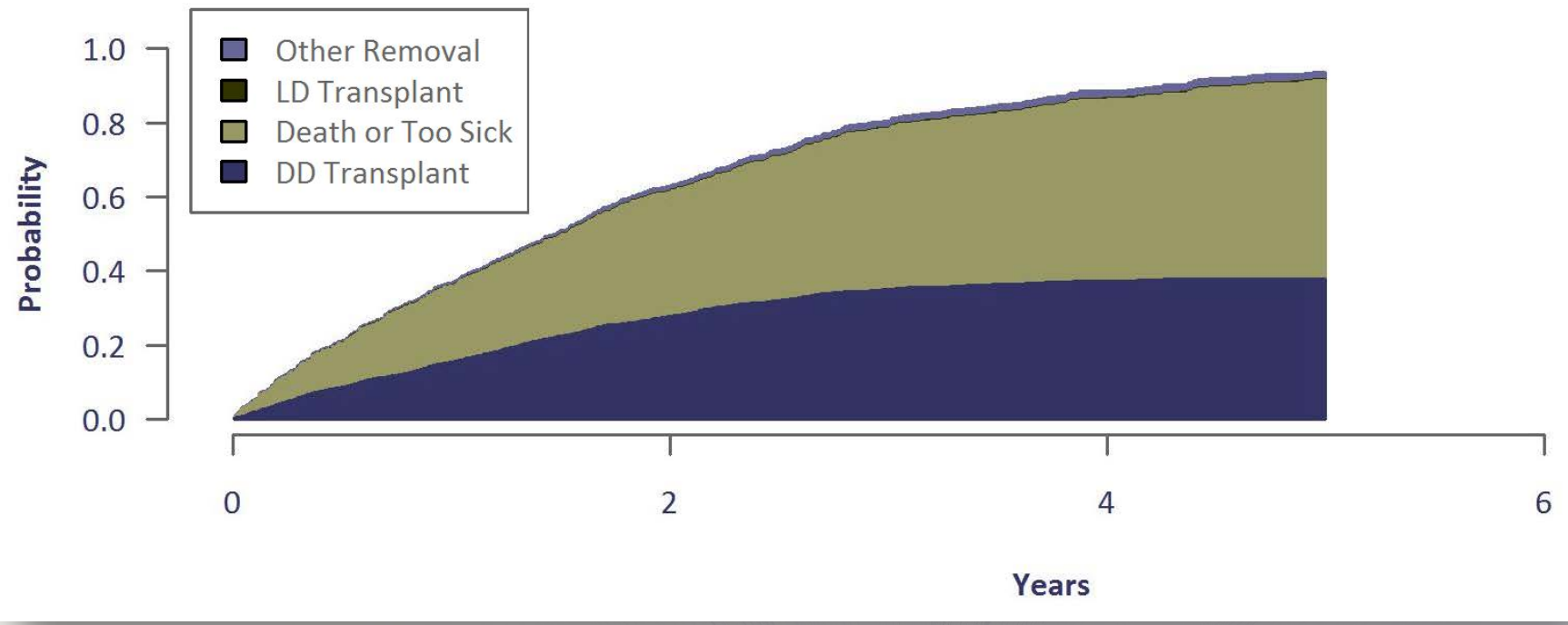
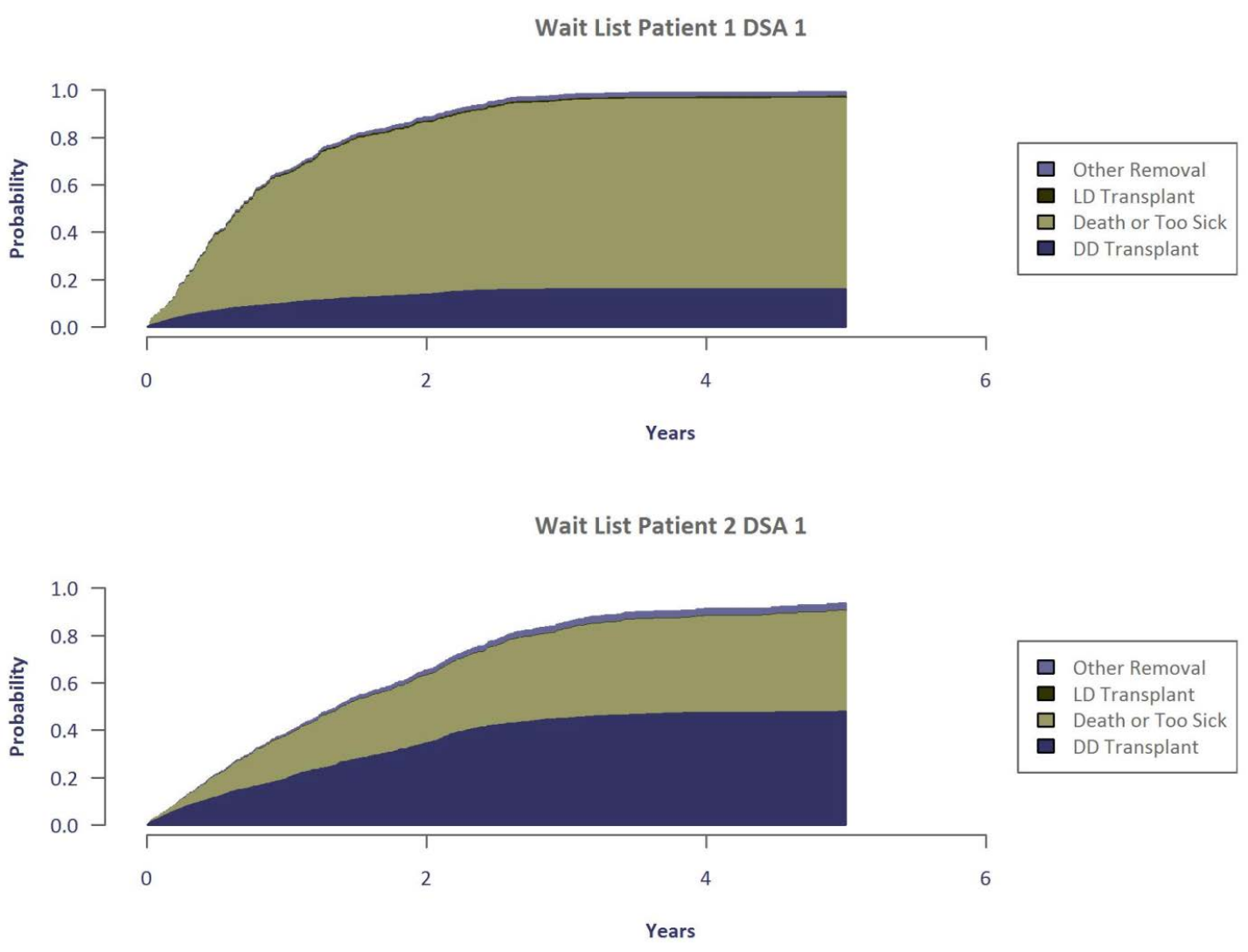
Cumulative Incidence

- Stacked Cumulative Incidence Curves:



Two Example Candidates—DSA 1



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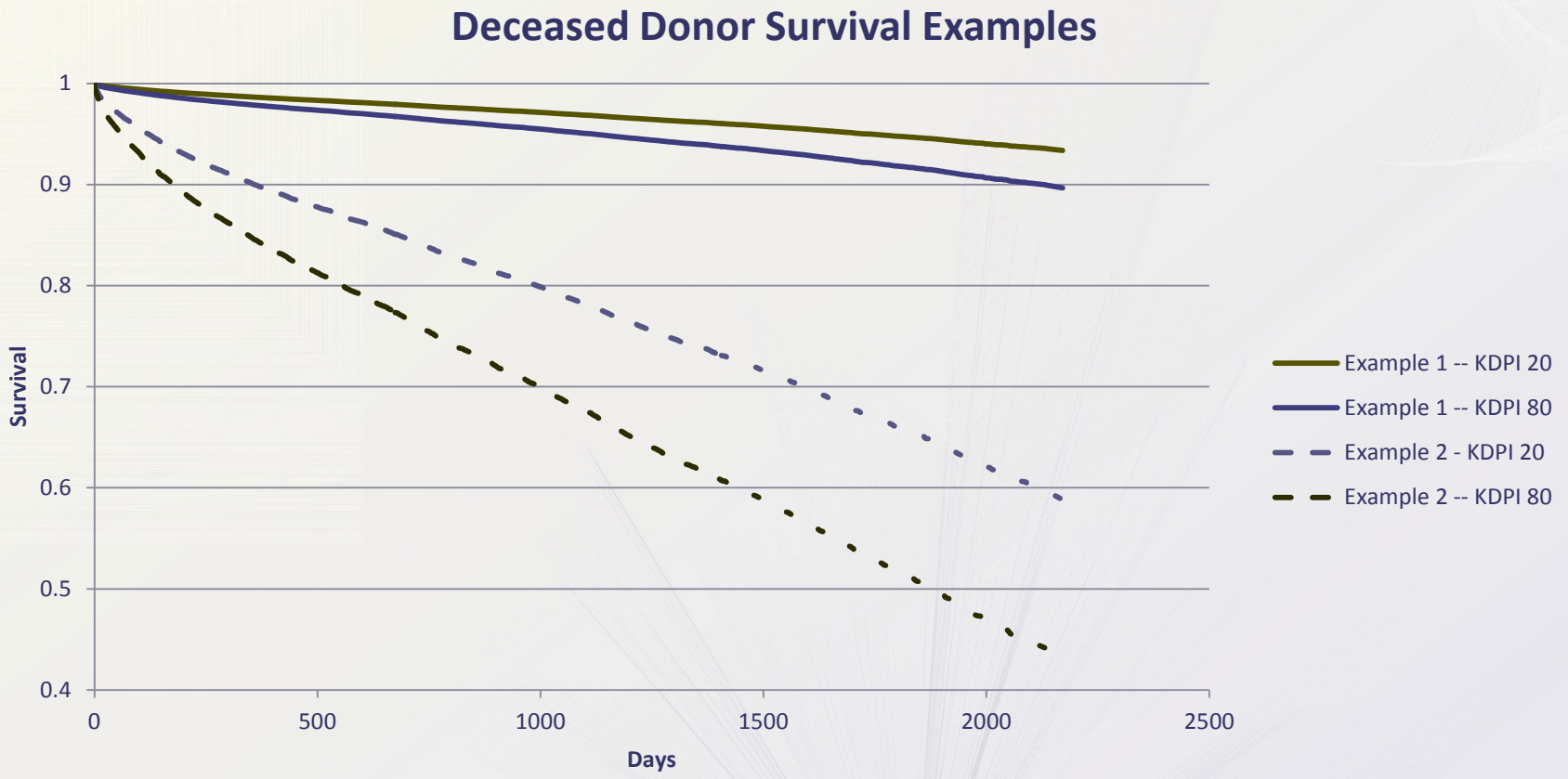
Deceased-Donor Survival Examples



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Example

Patient 1: 39-year-old Hispanic Male, CPRA< 20, blood type O, diabetes status unknown, 2.4 years on dialysis, overweight BMI, primary diagnosis: glomerulonephritis, albumin 3.6, no PAD, no COPD, no Malignancy, will not accept ECD.	
Probability of receiving a deceased donor transplant within 5-years of listing:	16.1% (DSA 1) 7.0% (DSA 2)
Probability of dying or being removed from the list due to deteriorating condition prior to receiving a deceased donor transplant within 5-years of listing:	80.3% (DSA 1) 90.5% (DSA 2)
5-year survival probability if this patient received a living donor transplant from a donor under the age of 50 today:	95.90%
5-year survival probability if this patient received a living donor transplant from a donor over the age of 50 today:	95.30%
5-year survival probability if this patient received a deceased donor transplant from a donor with a KDPI of 20% today:	94.70%
5-year survival probability if this patient received a deceased donor transplant from a donor with a KDPI of 80% today:	91.70%

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Conclusions

- Predicting waiting times is a very difficult endeavor.
- Models are still being investigated and the process refined.
- End goal is a web-based calculator that could be used to educate transplant candidates about their prospects for receiving a deceased donor kidney transplant.

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Supporting Slides

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Current Models

DD Transplant	LD Transplant	Death While Waiting	Removal From the List
• Blood Type	• DSA	• DSA	• DSA
• CPRA	• Age	• Age	• Age
• ECD Willingness	• Race	• Gender	• Gender
• DSA	• DM	• Race	• Race
	• Dialysis Time	• DM	• BMI
	• BMI	• Dialysis Time	• DGN
	• DGN	• BMI	• Albumin
	• Albumin	• DGN	• PAD
	• PAD	• Albumin	• COPD
	• COPD	• PAD	• Malignancy
	• Malignancy	• COPD	• CPRA
	• CPRA	• Malignancy	• ECD Willingness
	• ABO		
	• ECD Willingness		

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Competing Risks

- Analyses of waiting list outcomes should consider competing risks
- A candidate on the waiting list can be removed by different events:
  - Deceased-donor transplant
  - Living-donor transplant
  - Death (or too sick for transplant)
  - Some other event (e.g., transplant no longer needed)
- Experiencing one event precludes experiencing the other events. For example, if a candidate dies, then he or she will not get a transplant.

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Event-specific Rates (i.e., Hazards)

- One way to deal with competing risks is to model the rate that each event occurs. Create models for the:
  - Deceased-donor transplant rate
  - Living-donor transplant rate
  - Death (or too sick for transplant) rate
  - Other removal rate
- Each of these models can take the form of a Cox Proportional Hazards Regression Model

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Competing Event Probabilities

- The probability of experiencing one particular event depends not only on that event's rate, but also on the rates of all the competing events
  - If the rate of death is much higher than the rate of transplant, then the probability of transplant will be low **even if the rate of transplant is high**
- The event probability is a function of the event rate and the probability remaining on the waiting list (which is a function of **all** the competing event rates)

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Covariate Effects without Competing Risks

- The covariate in a Cox Proportional Hazards Regression Model explain effects on the event rate (hazard)
  - When there are no competing risks, a **higher** rate implies that the probability of the event **increases**
  - When there are no competing risks, a **lower** rate implies that the probability of the event **decreases**
- This does not hold under competing risks . . .

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The Competing Risks Covariate Disconnect

- When there are competing risks, a higher/lower rate may or may not be associated with increasing/decreasing event probability
  - If a covariate **increases** the rate of transplant by a small amount and increases the rate of death by a large amount, the probability of transplant may **decrease**
  - If a covariate **decreases** the rate of transplant by a small amount and decreases the rate of death by a large amount, the probability of transplant may **increase**

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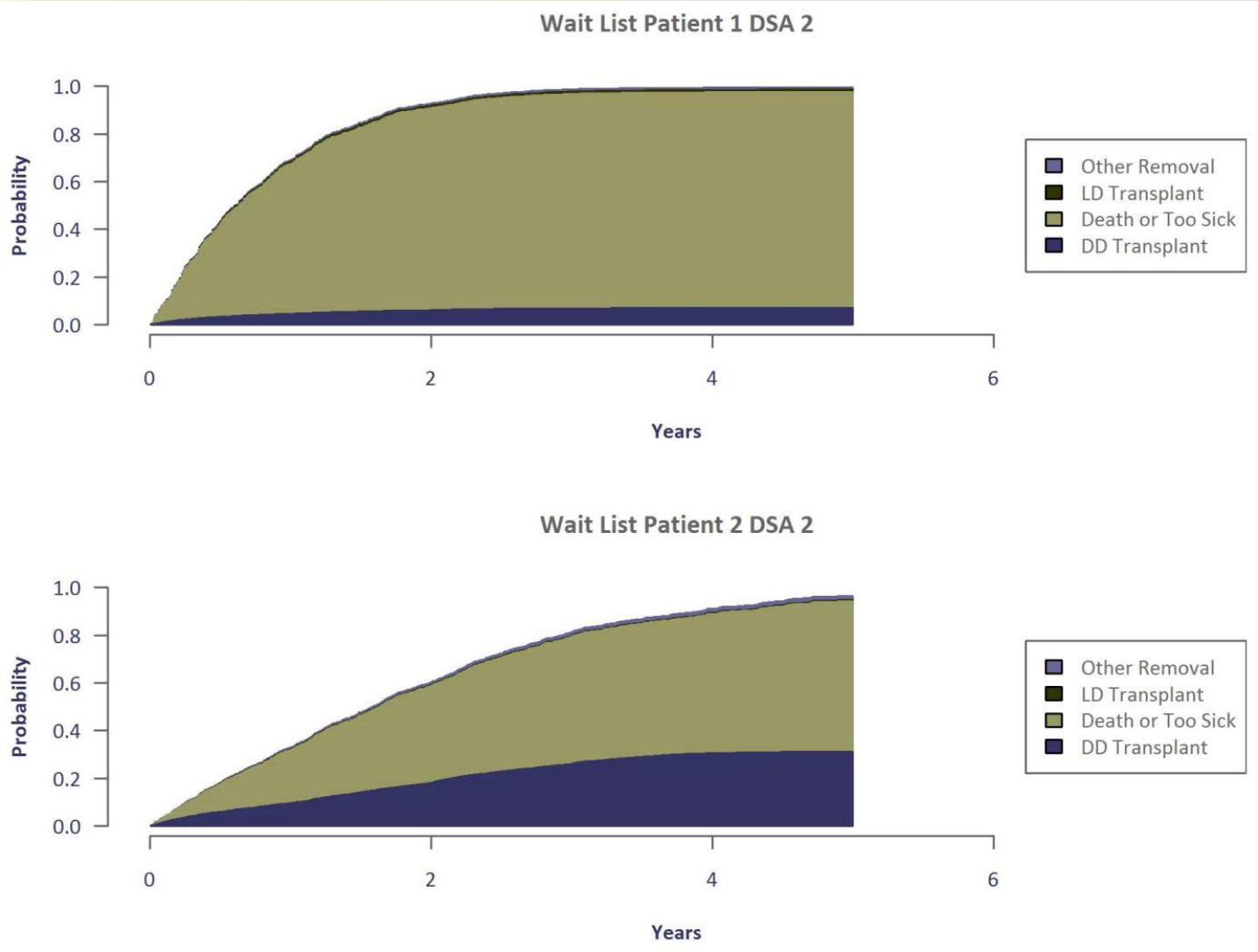
Two Example Candidates—DSA 2



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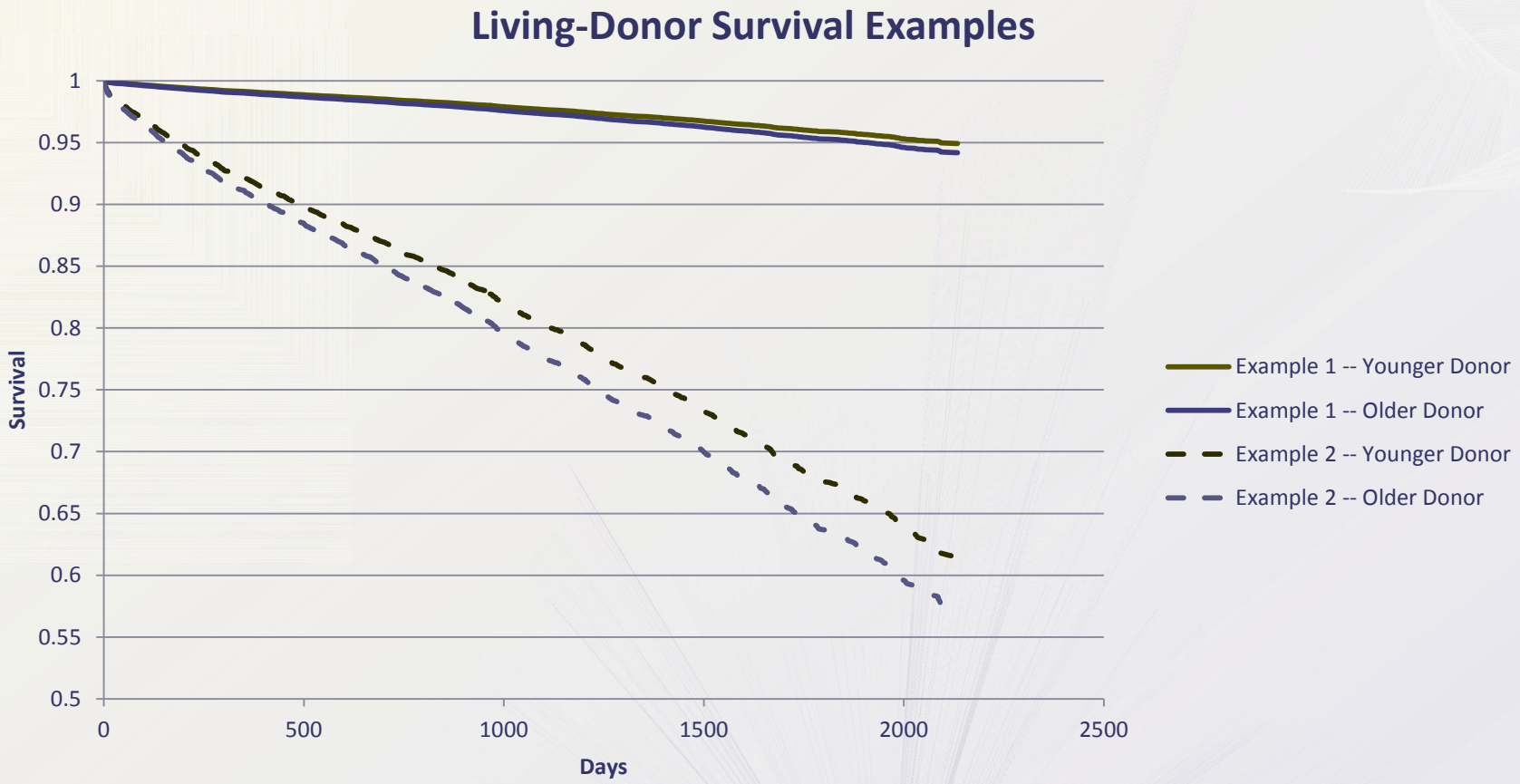
Living-Donor Survival Examples



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Example 2

Patient 2: 74-year-old African-American Female, 20 < CPRA < 79 , blood type A, No diabetes, 10 years on dialysis, overweight BMI, primary diagnosis: hypertension, 3.6 < albumin < 5.2, no PAD, no COPD, no Malignancy, will accept ECD.	
Probability of receiving a deceased donor transplant within 5-years of listing:	47.9% (DSA 1) 31.1% (DSA 2)
Probability of dying or being removed from the list due to deteriorating condition prior to receiving a deceased donor transplant within 5-years of listing:	42.3% (DSA 1) 63.0% (DSA 2)
5-year survival probability if this patient received a living donor transplant from a donor under the age of 50 today:	67.40%
5-year survival probability if this patient received a living donor transplant from a donor over the age of 50 today:	63.50%
5-year survival probability if this patient received a deceased donor transplant from a donor with a KDPI of 20% today:	65.60%
5-year survival probability if this patient received a deceased donor transplant from a donor with a KDPI of 80% today:	51.10%

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