Addressing Geographic Disparities in Organ Availability

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

I do not intend to reference unlabeled/unapproved uses of drugs or products in my presentation.

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Measuring Geographic Disparity

- Summative metrics do not measure disparity
  - Averages or totals across the U.S.
  - On average, 40% of patients with MELD 38-39 die within 90 days
  - # of Waitlist deaths + waitlist removal for too sick
  - Total # deaths pre and post transplant

- Disparity Metrics
  - Range or variation across the country
  - At some OPOs, 18% of patients with MELD 38-39 die within 90 days; at some, 82% die
  - *OPO-wise variance* in death rate
  - *OPO-wise variance* in transplant rate
  - *OPO-wise variance* in MELD at transplant

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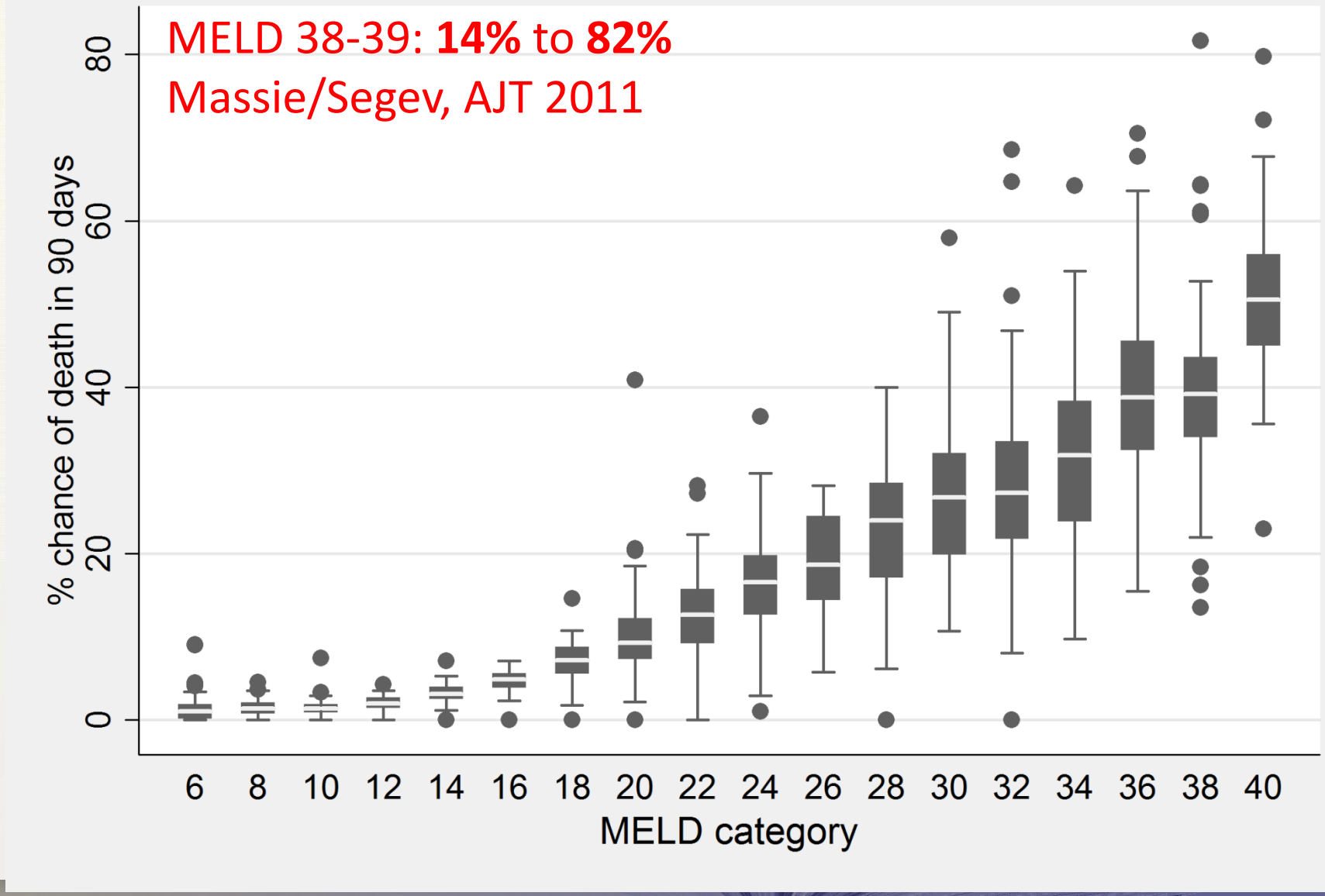
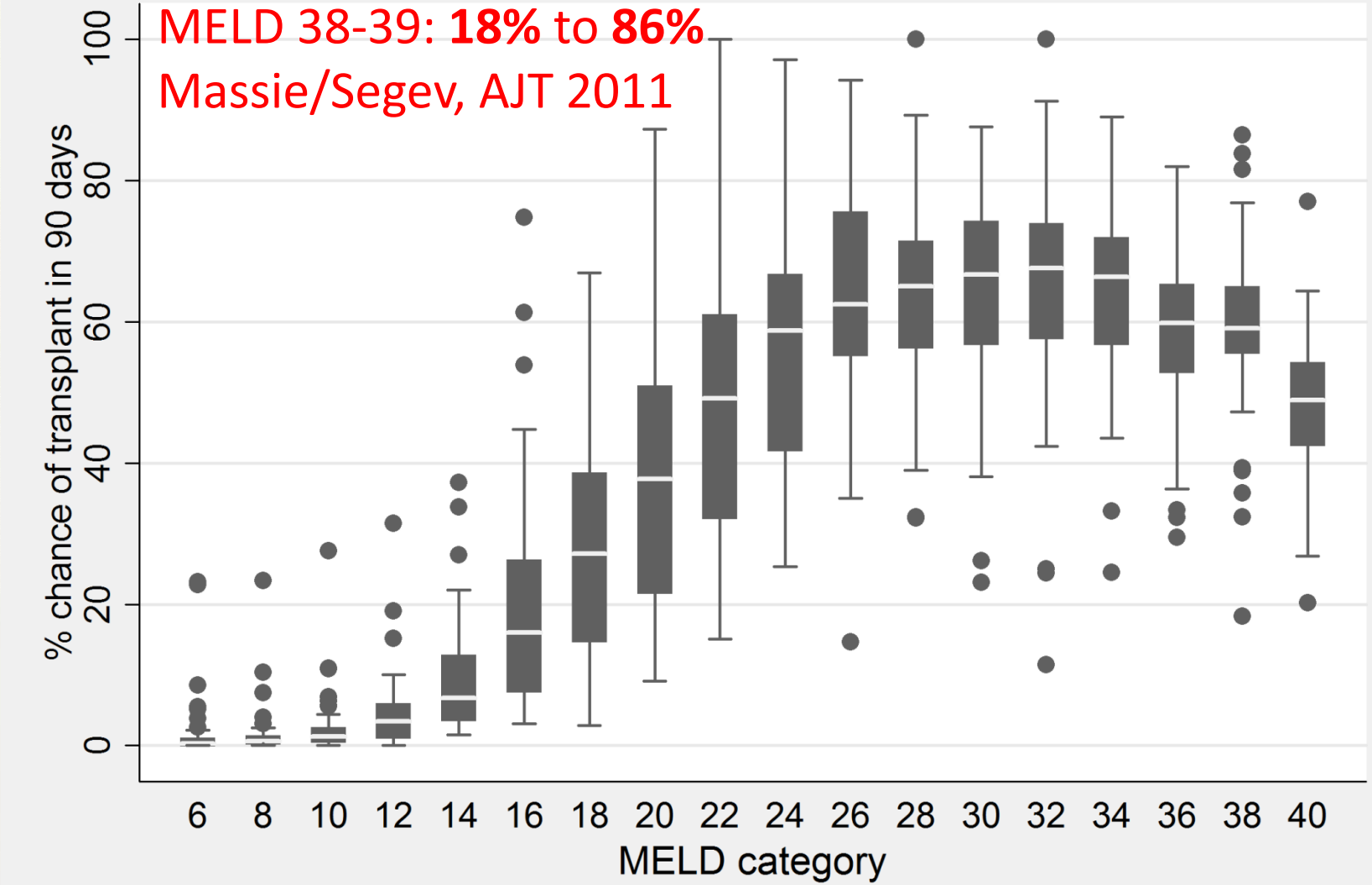
Liver Waitlist Death Rate Distribution, by OPO



Liver Transplant Rate Distribution, by OPO



Geographic disparity in kidney transplant rates

- By state, rates of deceased donor kidney transplant vary from 66.7% in UT to 21.3% in DC, 24.7% in CA.
- Some DSAs have a transplant rate that is twice the national average, and some have transplant rate that is half the average; interquartile range is 0.75 to 1.29.

(Ashby, Kalbfleisch, Wolfe, Lin, Port, and Leichtman, AJT 2007)

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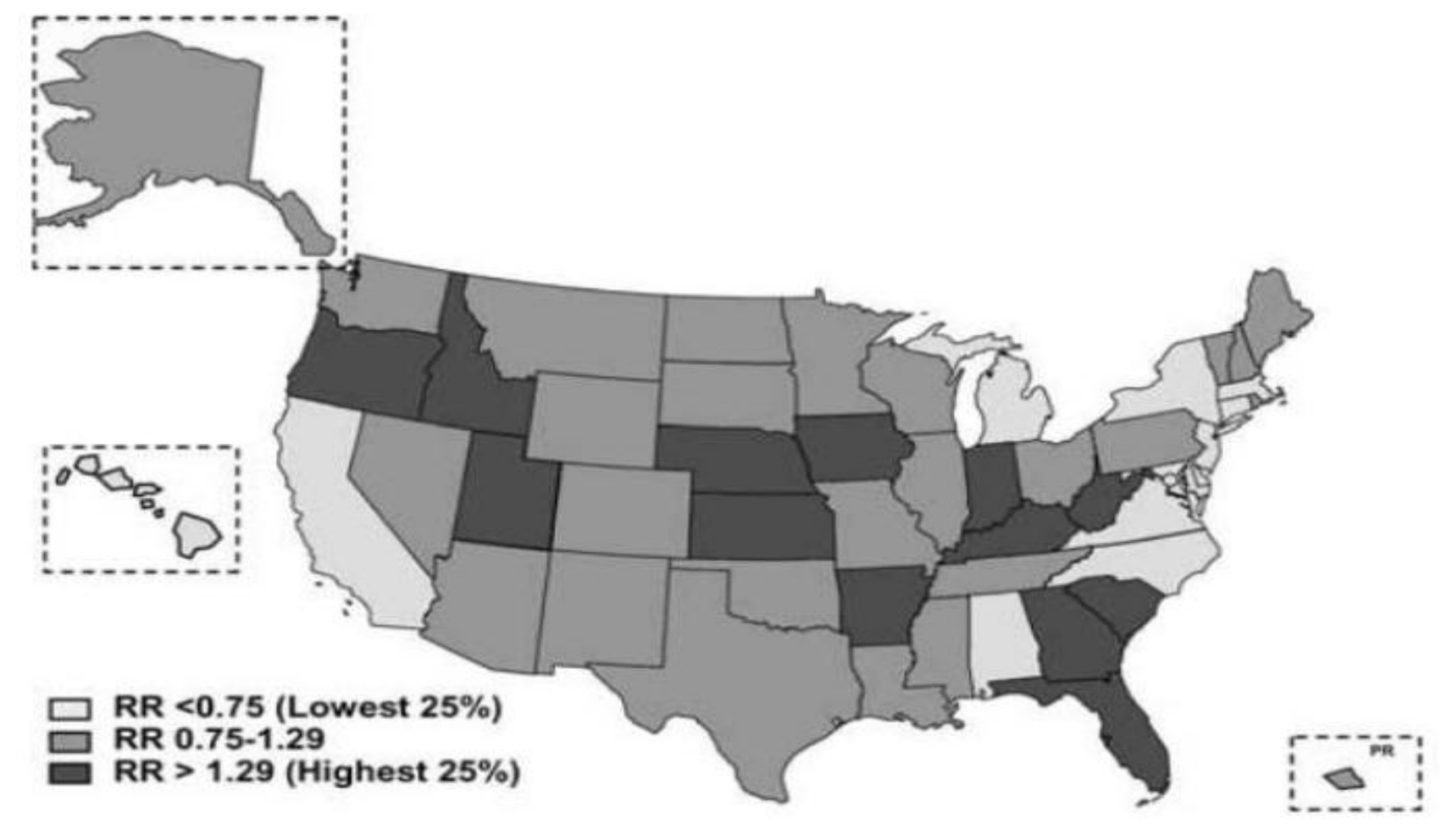
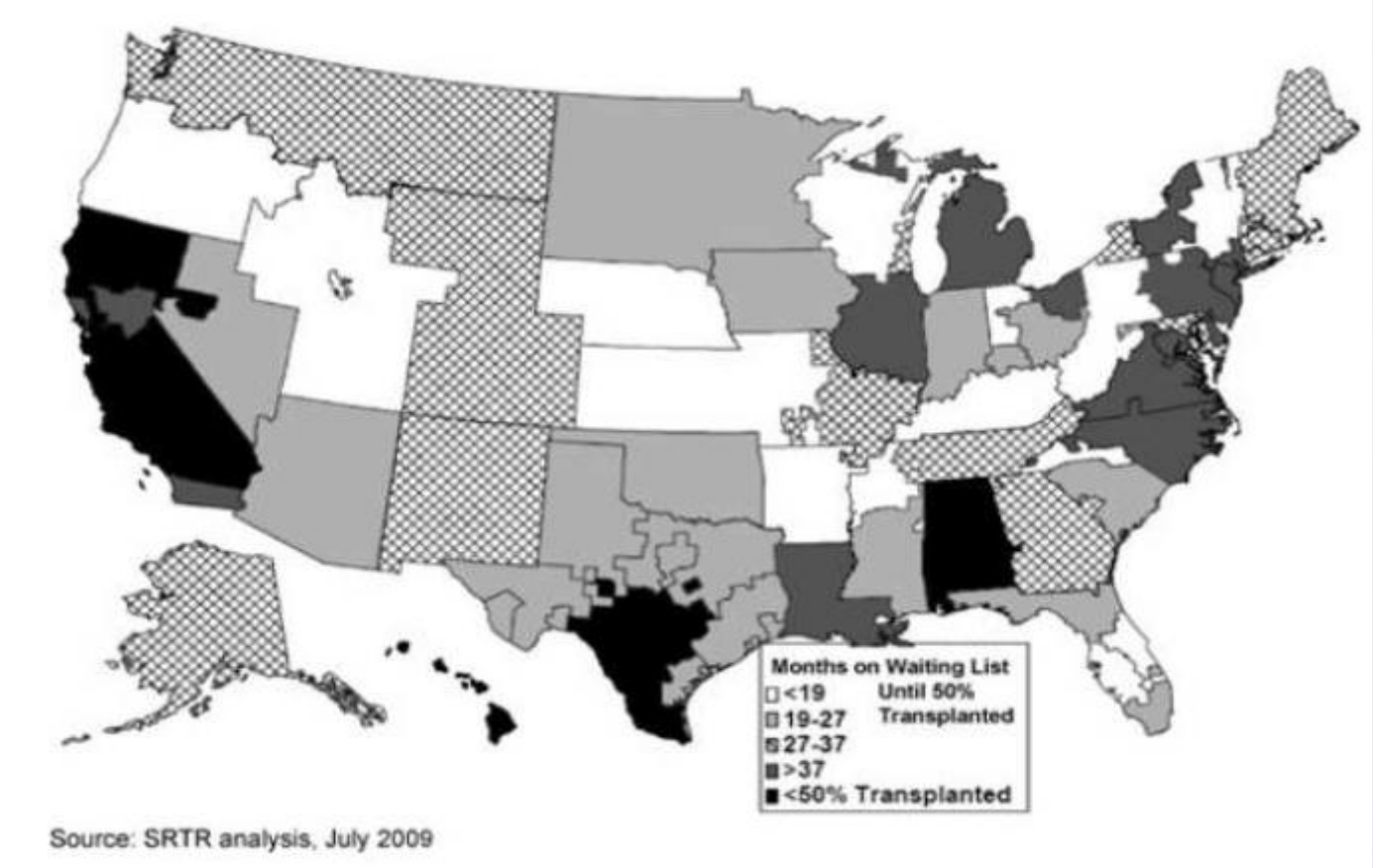
Relative rates of deceased donor transplant for kidney waitlist candidates



(Ashby, Kalbfleisch, Wolfe, Lin, Port, and Leichtman, AJT 2007)

Unadjusted median time to kidney transplant by OPO, 2002-07



(Axelrod, McCullogh, Brewer, Becker, Segev, Rao, AJT 2010)

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Alternative kidney disparity metric

Variance of ratio of number of transplants performed to number of new registrants, by OPO

- Advantages:
  - Captures the difference in rate of waitlist accumulation, while not being influenced by accumulated disparities
- Disadvantages:
  - Influenced by listing and acceptance practices
  - Neglects quality differences between kidneys

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Final Rule

… in order of decreasing medical urgency status, with waiting time in status used to break ties within status groups.

Neither place of residence nor place of listing shall be a major determinant of access to a transplant.

For each status category, ***inter-transplant program variance in the performance indicator waiting time in status shall be as small as can reasonably be achieved…***

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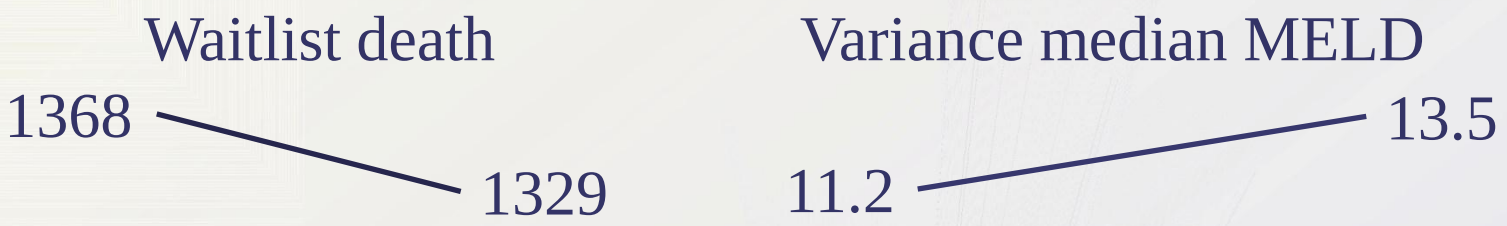
Beyond broader sharing of livers

- Fully regional sharing of livers using the current region map would decrease waitlist deaths but would paradoxically worsen geographic disparities



[LSAM 2010 results]

- We hypothesized that broader sharing can be effective if region boundaries are redrawn to minimize geographic disparity in allocation

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Approaches to resolving geographic disparity

- Broader sharing
- Redistricting
  - Reorganize current DSAs into optimal organ sharing districts ("regions"), with sharing by MELD at district level
- Concentric Circles
  - By distance or time or population, requires national exceptions
- Overlapping amoebas
  - Redistricting with districts that overlap, requires national exceptions
- Dynamic allocation with no boundaries
  - Adjust offer priority in real time in response to existing disparity, using a score that balances MELD against transport time

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Redistricting optimization model

- Calculate the **proportional allocation** number of organs for each DSA
  - p_k, the number of first organ offers that DSA *k* would receive if every organ went to highest MELD candidate anywhere in the country
- Calculate the **volume-weighted transport time** between DSAs if in the same region
  - δ_{ki}, estimated average transport time between DSA *k* and DSA *i* based on drive times, flight times, and volumes from each donor hospital and to each transplant center
- Goal: find best tradeoff

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How Optimization Works

- Minimize *total disparity*
  - Disparity = difference between number of donors a region *should* have (in a proportionally allocated system) and number of donors the district does have
  - Minimize sum of disparities:

$$\text{Minimize } \sum_{k \in \text{districts}} |p_k - dk|$$

- Subject to constraints that limit organ transport time and describe feasible district plans

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Inputs to Redistricting Optimization

- Number of districts
- Whether districts must be contiguous
- Maximum average travel time between DSAs placed in the same district
- Other characteristics required for acceptable district boundaries

Liver Committee 3/13/13:

- 4-8 contiguous districts
- Maximum average travel time between DSAs placed in the same district ≤4 hours
- ≥6 centers in each district

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Variables and parameters defined

w_{ki} = 1 if DSA k is in the region i

d_k = donors available in 2010 in DSA k

p_k = number of donors that should go to DSA k in 2010

Y_{ki} = 1 if DSA k is selected as the locus of district i, and 0 if not

δ_{ij} = volume-weighted transport time between DSA i and DSA j

$$\alpha_{ijk} = \{1 \text{ if } \delta_{ik} > \delta_{ij}, 0 \text{ if not}\}$$

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Minimize $\sum_{i \in DCT} |D_i - P_i|$

Subject to: $\sum_{i \in DCT} w_{ki} = 1, i \in DSA$

$$\sum_{i \in DCT} Y_i = 11$$

$$\sum_{k \in DSA} d_k w_{ki} = D_i, \text{ for all } i \in DCT$$

$$\sum_{k \in DSA} p_k w_{ki} = P_i, \text{ for all } i \in DCT$$

$$\sum_{k \in DSA} \alpha_{ijk} w_{ki} \leq 1 - Y_i, \text{ for all } j \in DSA, i \in DCT$$

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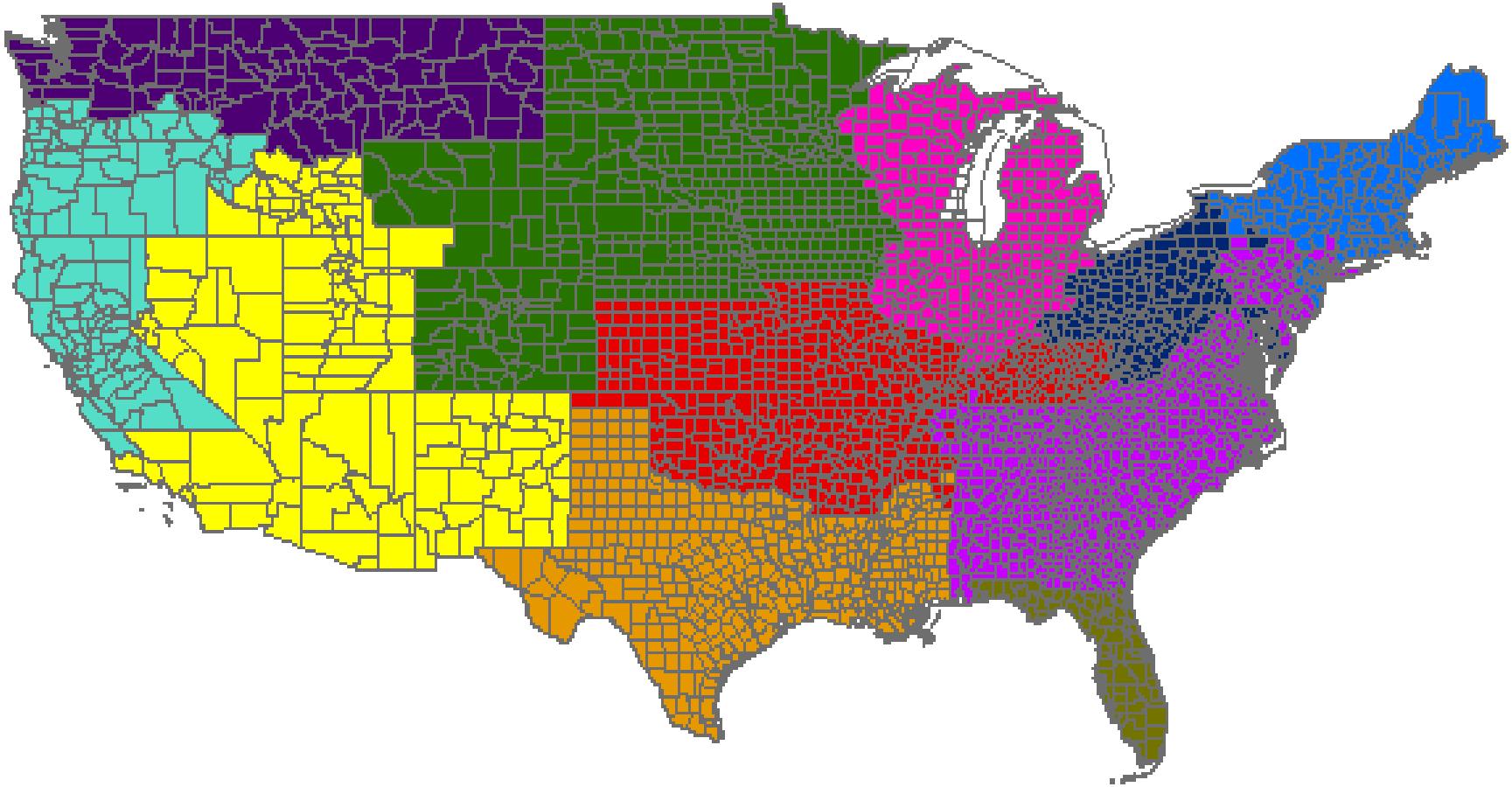
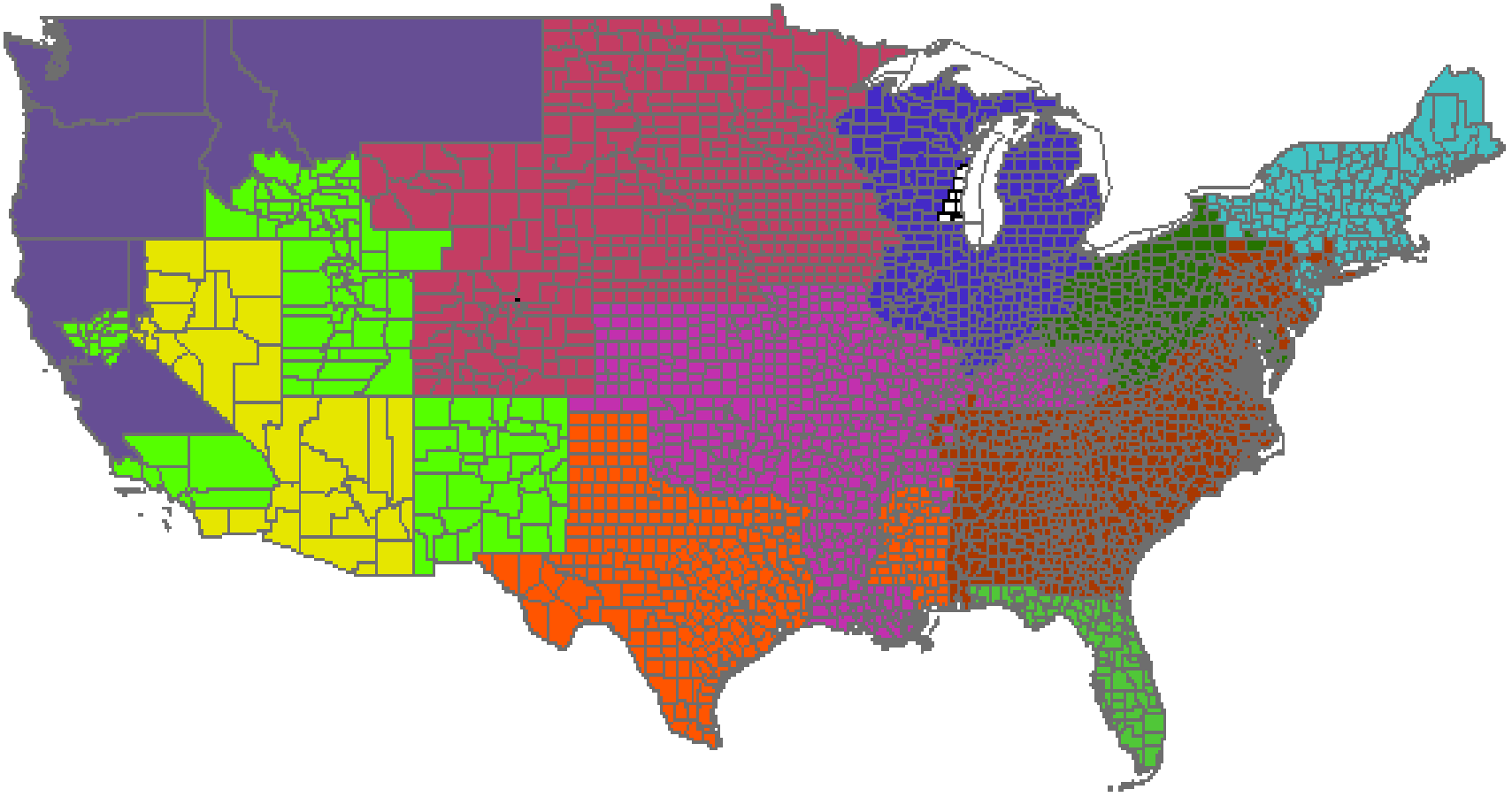
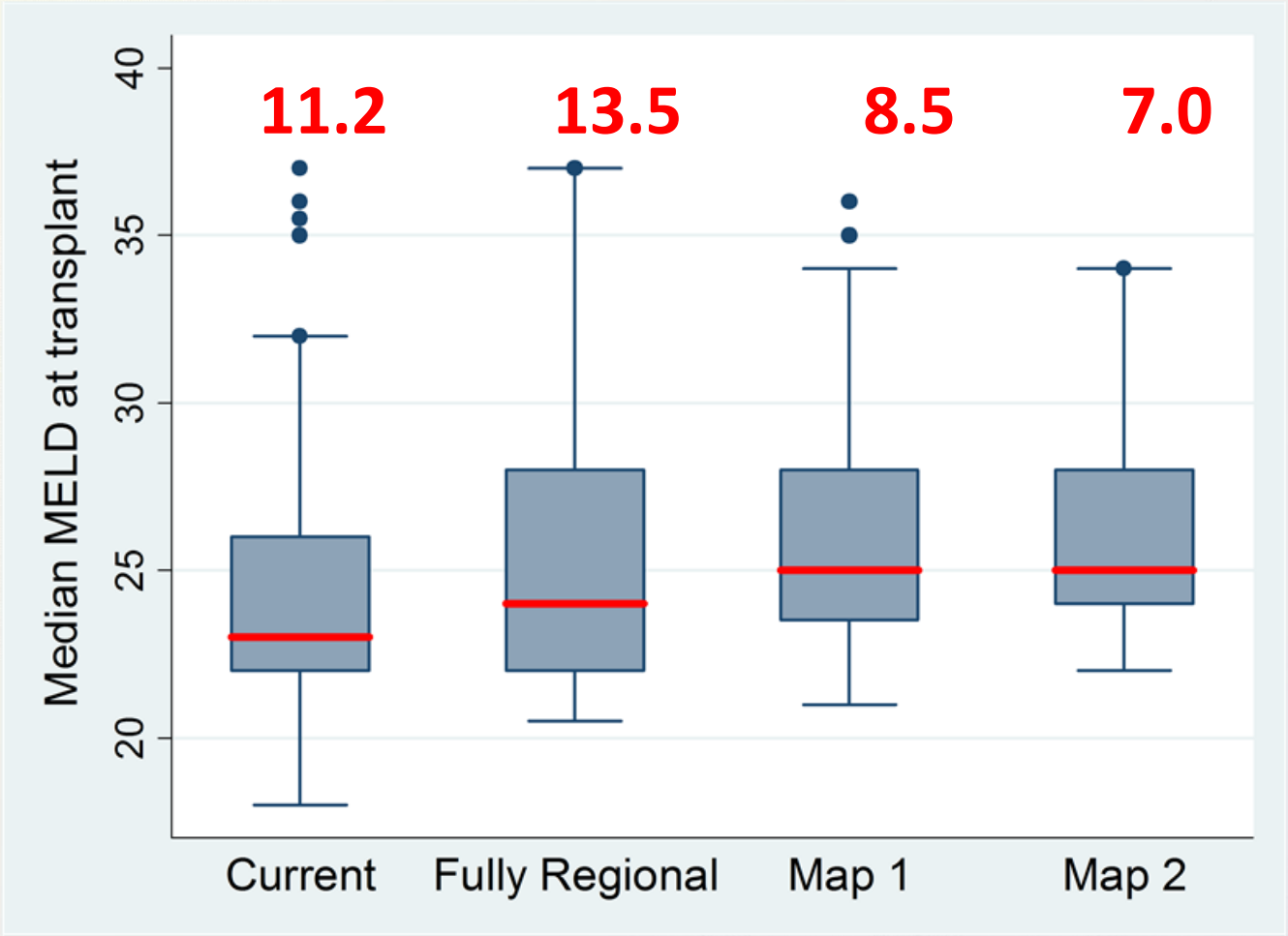
Optimized Map 1: contiguous



Optimized Map 2: noncontiguous



Variance in MELD transplant



Gentry / Segev, American Journal of Transplantation, 2013

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Compare to concentric circles

- Concentric circles – first allocate within 500 miles, then everywhere else
- Radius of concentric circles is analagous to the number of regions decision – limits travel time
- Advantages: simplicity and transparency
- Disadvantages: requires a national exception review board and is not superior to using optimal maps

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Concentric circles

- Variance of median MELD is 9.61, higher than in our optimized 11-region maps
- Travel time (1.7 hrs) and flying (63%) are almost identical to 11-region maps
- Waitlist deaths (2046) are similar to the higher rates among optimized 10 and 11-region maps
- Overall, these comparable size concentric circles are not superior to optimized maps on any metric

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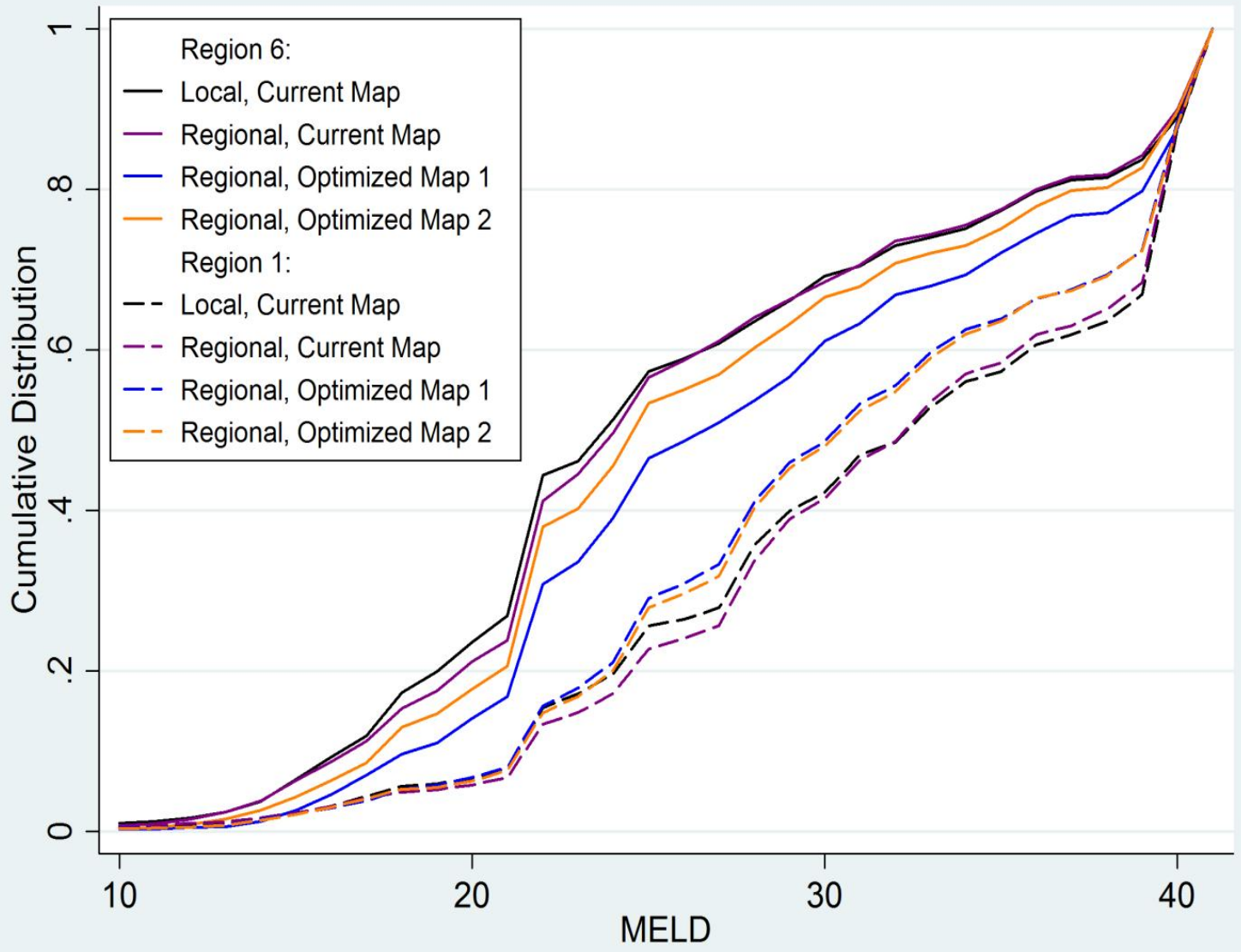
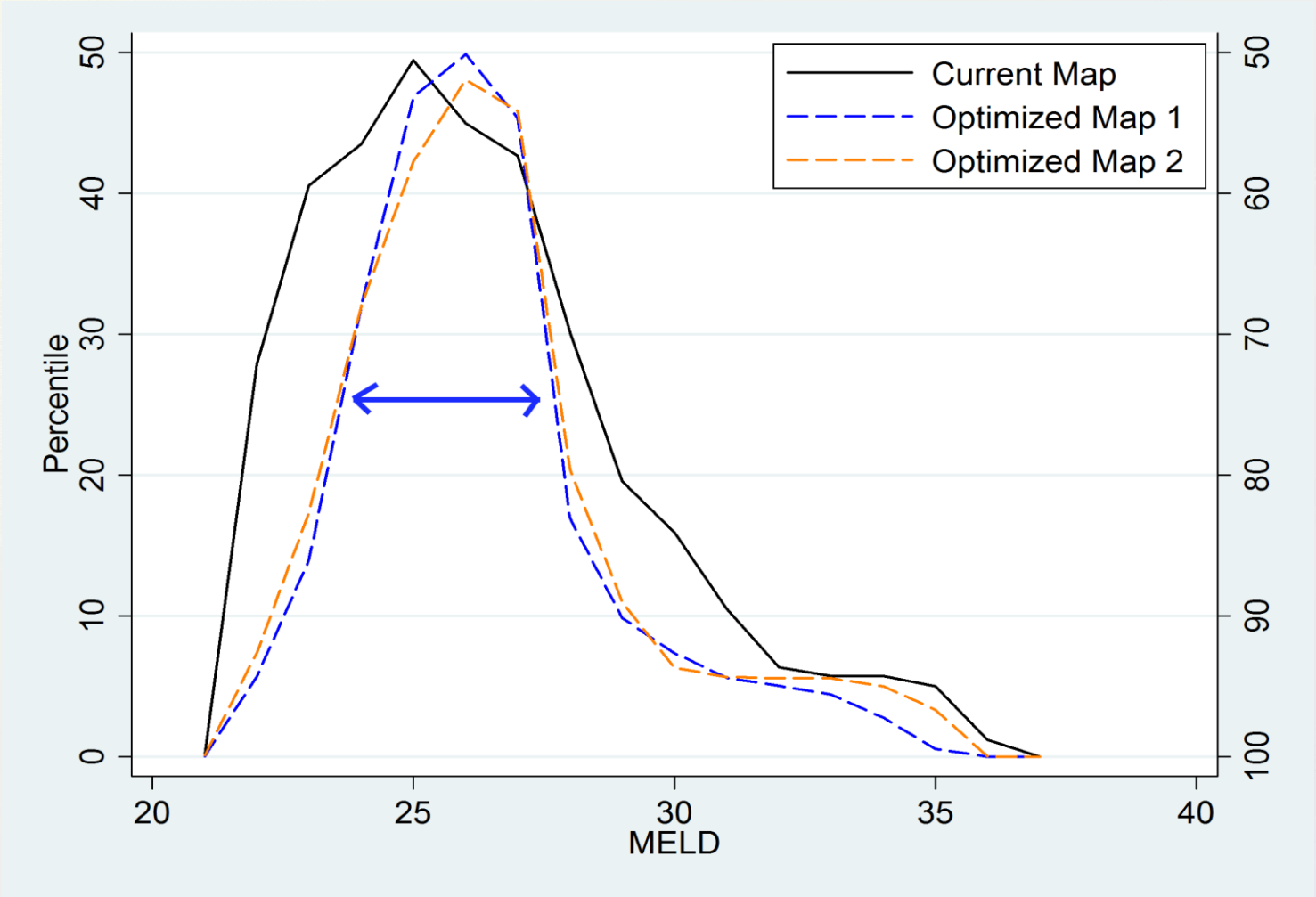

Region 6:
Local, Current Map
Regional, Current Map
Regional, Optimized Map 1
Regional, Optimized Map 2
Region 1:
Local, Current Map
Regional, Current Map
Regional, Optimized Map 1
Regional, Optimized Map 2
Cumulative Distribution
0
.2
.4
.6
.8
1
10
20
30
40
MELD

Mountain plot (folded cumulative distribution)



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Limitations of LSAM

- Only one year runs
  - Existing disparities have already accumulated
  - Will take longer than a year to "clear the deck"
  - LSAM likely *underestimates* the improvement in disparity metrics that will come from any new map
  - Harder to reach outcome of waitlist death
- Behavior affects outputs but is not modeled
  - Same center organ acceptance regardless of map
  - Same OPO performance regardless of map

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Conclusions

- Fully regional sharing using an optimized map would both alleviate geographic disparities and reduce waitlist deaths.

[LSAM 2010 results]

- Objective criteria guide the optimal map design, yielding the regions that best achieve the goal of reducing geographic disparities
- Optimized maps improve geographic equity compared with either local-first allocation or regional sharing with the existing regions.
- Maps with fewer districts require a higher cost in terms of transport, but might do more to reduce waitlist death.

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Nov 2012 OPTN board resolution

** **RESOLVED:**

- The existing geographic disparity in allocation of organs for transplant is unacceptably high.
- The Board directs the organ-specific committees to define the measurement of fairness and any constraints for each organ system by June 30, 2013. The measurement of fairness may vary by organ type but must consider fairness based upon criteria that best represent patient outcome.
- The Board requests that optimized systems utilizing overlapping versus non-overlapping geographic boundaries be compared, including using or disregarding current DSA boundaries in allocation.

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