# Regional Differences in the Relationship Between Type 2 Diabetes and Healthy and Total Life Expectancy in the US [1]

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# Introduction

Purposes of presentation are substantive and methodological

- Substantive:

  What are the implications of having Type 2 diabetes for subsequent health, and are there regional differences in these implications?

- Methodological:

  Can we extend multistate methods for more useful (e.g., more detailed) health analyses than the standard two state model?

# Background: Substantive

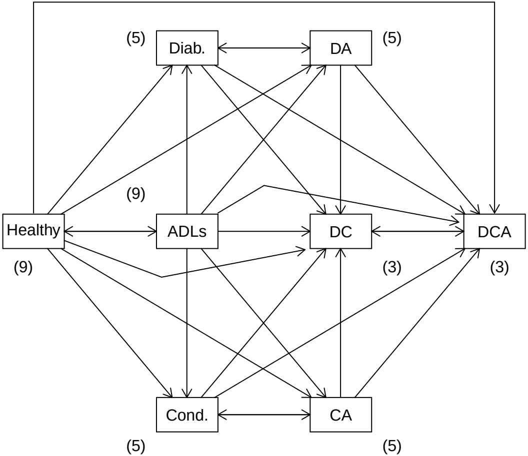
- Diabetes is an important precursor to poor health in adulthood
- Diabetes prevalence varies by region in US: more prevalent in the south than other regions
- We've found regional distinctions are more apparent when region is measured based on where the respondent was born rather than where R. lives at time of interview
- Might expect management to be poorer for those with worse habits (i.e., based on birth region) and/or those in areas with less access to health care (i.e., based on current region)
- Questions: Does the impact of diabetes on subsequent health and mortality vary by region, and is the differential impact more pronounced when region is measured at birth?

# Background: Methodological

- Multistate life tables (mslt) are useful, but we use them in a limited way: typicall only two live states
- But early mslts in family demography used multiple marital status states: why don't we use more states?
    - Marital status states are mutually exclusive, but...
    - Health states often not mutually exclusive, so we're stuck with trivial mutually exclusive states, like 1 ADL vs. 2 or more
- Overlapping state spaces commonly modeled with separate life tables for separate outcomes, but ignores relationships and sequencing between health states
- Here: Consider 3 overlapping health states
- Changing the radix, aggregating over some state expectancies, and computing various proportional expectancies enables detailed analyses health processes

# State Space of Interest

- Death not shown but allowed from all states
- Retention not shown but allowed
- 43 possible transitions
- one transition (A-DC) has small *n*; recoded to A-DCA
- Verbrugge-Jette model may suggest H-D-DC-DCA-X as a common path: is it?



# Data: Health and Retirement Study

- Panel with biennial waves from ∼1998-2012 (n=37,319)
- Only ages 50+, interviewed in 1998, and not dropped by HRS
- Only one person per household ($n = 13,607$)
- Drop persons born outside the US or out of the US in any wave or missing on all health measures ($n = 12,263$)
- Data set consists of spells $n = 66,869$ spells:

| Spell | $n$ | Deaths |
|---|---|---|
| 1 ('98-'00) | 12,263 | 911 |
| 2 ('00-'02) | 11,352 | 1023 |
| 3 ('02-'04) | 10,329 | 852 |
| 4 ('04-'06) | 9477 | 829 |
| 5 ('06-'08) | 8648 | 783 |
| 6 ('08-'10) | 7865 | 930 |
| 7 ('10-'12) | 6935 | 589 |

# Predictors

| Variable | Measure | Descriptives |
|---|---|---|
| Age | years | 68.4(10.9)[50,106] |
| Male | dummy | 44% |
| Nonwhite | dummy | 19% |
| Education | years | 12.0(3.2)[0,17] |
| Birth Region | NE | 21% |
| | MW | 30% |
| | S (reference) | 41% |
| | W | 8% |
| Current Region | NE | 16% |
| | MW | 26% |
| | S (reference) | 42% |
| | W | 16% |

# Outcomes

| Outcome | Constituent Measures | Measurement |
|---|---|---|
| Diabetes | | Dummy (absorbing) |
| Conditions | Heart Disease<br>Stroke<br>Cancer<br>Lung Disease | Dummy (1+; absorbing) |
| ADLs | Dressing<br>Bedding<br>Bathing<br>Toileting<br>Walking<br>Eating | Dummy (1+; reversible) |
| Death | | Dummy (absorbing) |

# Outcomes, continued

| State | Spell 1 (n=12,263) | Spell 7 (n=6935) |
|---|---|---|
| Healthy | 48.4% | 31.2% |
| ADLs | 6.8% | 4.8% |
| Conditions | 21.7% | 28.4% |
| Conditions + ADLs | 9.0% | 11.3% |
| Diabetes | 5.4% | 7.5% |
| Diabetes + ADLs | 1.4% | 1.7% |
| Diabetes + Conditions | 4.4% | 9.5% |
| All | 2.9% | 5.8% |
| Total Diabetic Prevalence | 14.1% | 24.4% |
| Total Condition Prevalence | 38.0% | 54.9% |
| Total ADL Prevalence | 20.1% | 23.5% |

# Observed Transitions

| | H | A | C | CA | D | DA | DC | DCA | Dead |
|---|---|---|---|---|---|---|---|---|---|
| H | 22,443 | 1495 | 1865 | 382 | 562 | 50 | 76 | 29 | 683 |
| A | 1030 | 1788 | 127 | 314 | 28 | 60 | 8* | 18 | 478 |
| C | 0 | 0 | 12,780 | 2022 | 0 | 0 | 424 | 94 | 1349 |
| CA | 0 | 0 | 1115 | 3406 | 0 | 0 | 46 | 143 | 1788 |
| D | 0 | 0 | 0 | 0 | 3239 | 356 | 372 | 96 | 163 |
| DA | 0 | 0 | 0 | 0 | 214 | 481 | 42 | 119 | 157 |
| DC | 0 | 0 | 0 | 0 | 0 | 0 | 2879 | 795 | 512 |
| DCA | 0 | 0 | 0 | 0 | 0 | 0 | 462 | 1592 | 787 |
| Dead | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ALL |

- $n = 66,869$ person-spells
- * Assigned to DCA
- Of 81 possible transitions, 43 are non-structural 0s

# Methods

1. Estimate mlogit model with 42 outcomes (all transitions)
2. Retain coefficients ($\beta_{336\times1}$) and ACOV matrix ($\Sigma_{336\times336}$)
3. Simulate 1000 sets of coefficients, $b \sim N(\beta, \Sigma)$
4. For each $b$: Generate 61 (ages 50-110) age-specific transition probability matrices, $p_{9\times9}$
    - covariates set at overall means (male=.44; nonwhite=.19; education=12) and region-specific means
    - region set to S, NE, MW, W (repeat for birth & current region), so $2 \times 8 = 16$ sets of 1000
5. For each of the 16,000 collections of 61 $p$ matrices, generate multistate life tables

# Multistate Life Tables

- Standard calculations:

| Calculation | Notes |
|---|---|
| $l_{x+1} = l_x p_{x,x+1}$ | each $l_x$ is $1 \times 9$ |
| $L_x = (l_x + l_{x+1})/2$ | linear method |
| $T_x = \sum_{i=x}^{\Omega} L_i$ | |
| $e_x = T_x / l_x$ | 9 state expectancies, including death* |

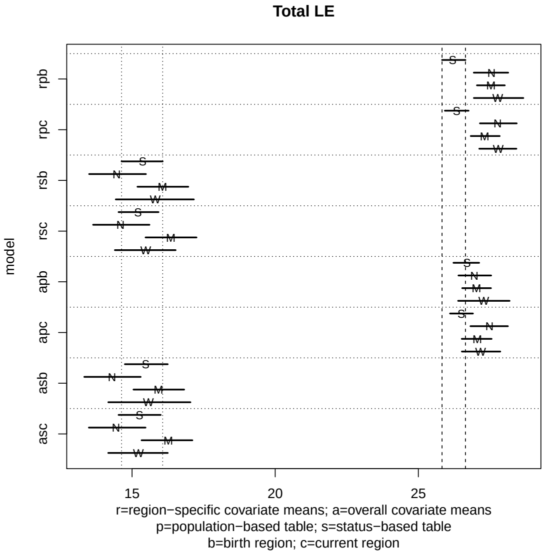
- State expectancies can be aggregated in various ways, e.g., diabetic life expectancy is $e_D + e_{DC} + e_{DA} + e_{DCA}$
- Repeat
  1. for population-based tables: radix determined by outcome proportions at $x = 50$ from model results
  2. for status-based tables: radix set so all begin with diabetes (only) at $x = 50$
- Status-based tables allow us to evaluate implications of having type 2 diabetes, because it conditions on the desired state

# Why not a Bayesian approach?

- Current multinomial probit method requires starting state as a covariate; doesn't work with living absorbing states, requiring change to outcomes-as-transitions approach
- Current method works well for two-state model but needs modification for higher dimensions
- Modifications in process; possibly important for addressing IIA assumption violation
- This approach is roughly equivalent to a Bayesian approach

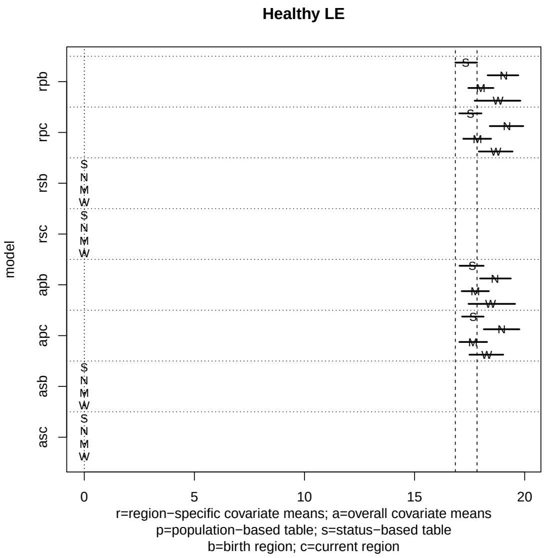
# Results 1: Total Life Expectancy ($TLE = \sum_{i=1}^{8} e^i$)

- TLE shortest for southerners...
- but not once covariates are equalized
- status based tables reveal little; TLE equivalent by region conditional on diabetes (no implications of region for life span after diabetes diagnosis)
- no birth v. current differences: patterns similar



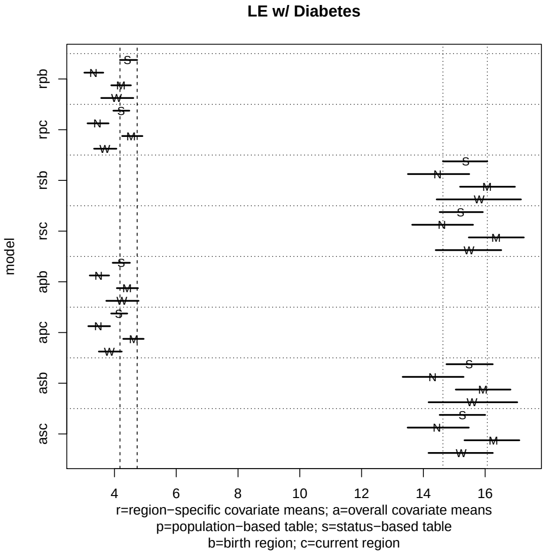
# Results 2: Healthy Life Expectancy ($HLE = e^1$)

- southerners look worse than others...
- but not different from MW once covariates are equalized



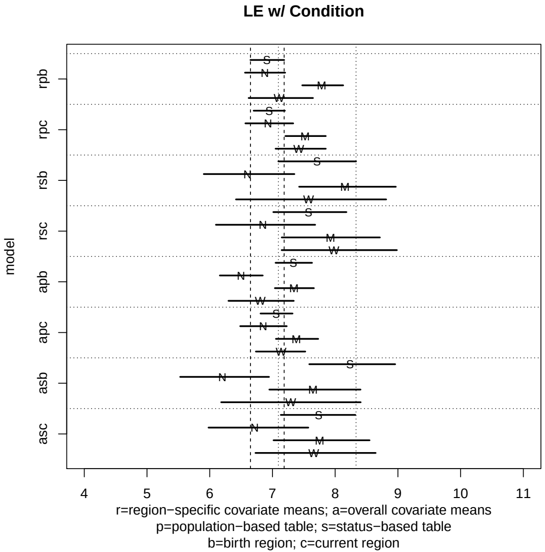
# Results 3: LE w/ Diabetes ($DLE = e^5 + e^6 + e^7 + e^8$)

- northeasterners have shortest DLE
- regional differences pronounced even after controls
- no TLE differences in status-based tables (i.e., DLE—D)



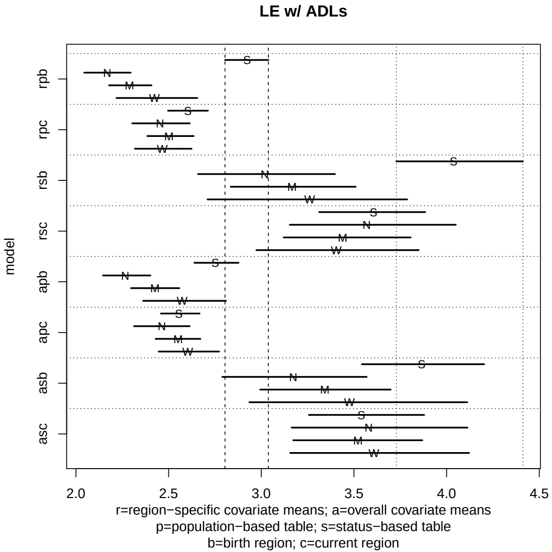
# Results 4: LE w/ Conditions ($CLE = e^3 + e^4 + e^7 + e^8$)

- midwest (birth) has longer condition time
- southerners with diabetes live longer with conditions than NE
- NE live shortest with condition
- overall regional differences slight



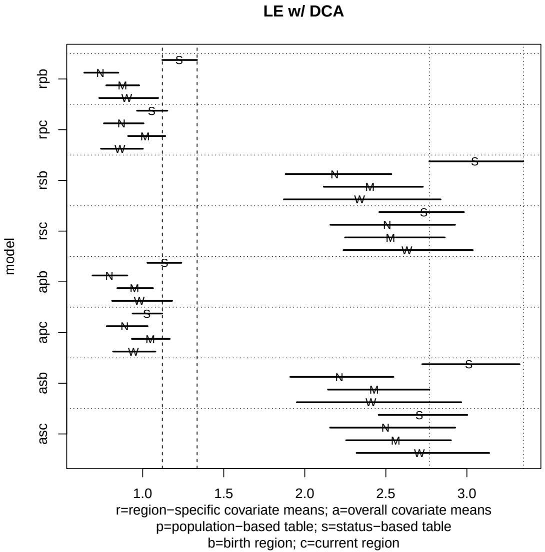
# Results 5: LE w/ ADLs ($ALE = e^2 + e^4 + e^6 + e^8$)

- Southern birth bad for LE with ADL
- difference mitigated only slightly with controls
- No current region differences
- (born) southerners with diabetes live longer with ADLs
- no current region differences



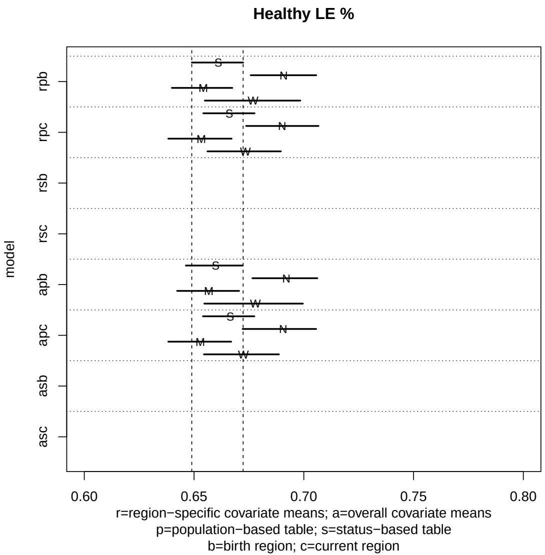
# Results 6: LE w/ All Three Health Issues ($DCALE = e^8$)

- southern birth=longest LE with DCA
- difference still exists with controls, but less pronounced
- no current region differences
- (born) southerners with diabetes live longer with all three
- but no current regional differences



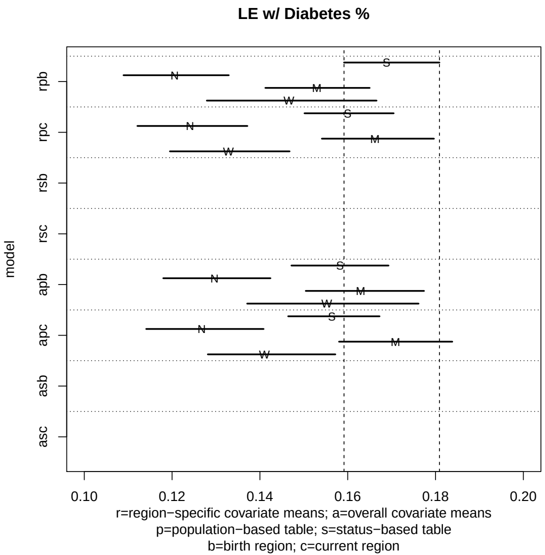
# Results 7: Proportion of Life Healthy ($HLE/TLE$)

- NE stands out with highest HLE%
- S and MW have shortest
- but, western intervals are wide



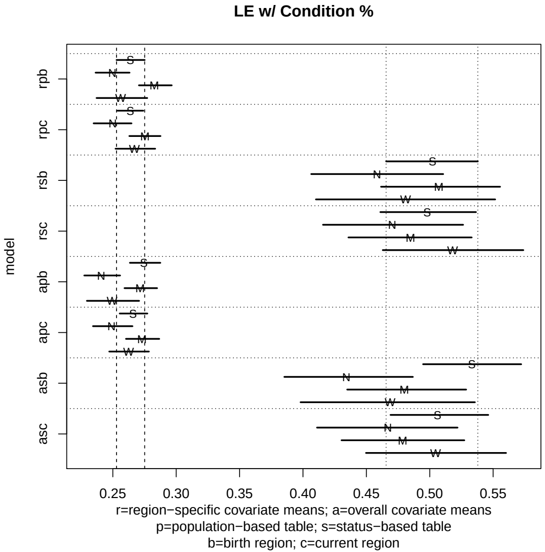
# Results 8: % of TLE to be Spent w/ Diabetes ($DLE/TLE$)

- southern birth=highest %DLE
- but MW is close
- with controls, NE appears lower than other three regions
- (note: status-based %DLE=1)



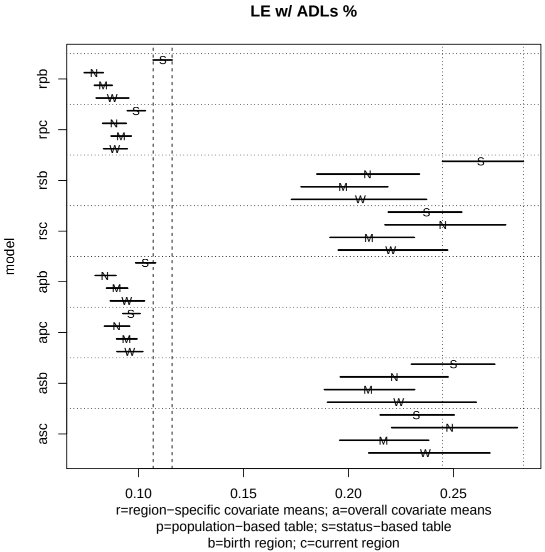
# Results 9: % of TLE Spent w/ Conditions (*CLE*/*TLE*)

- no regional differences, except...
- diabetics born in the south have higher %CLE than persons born in NE
- this is AFTER adjustment for covariates



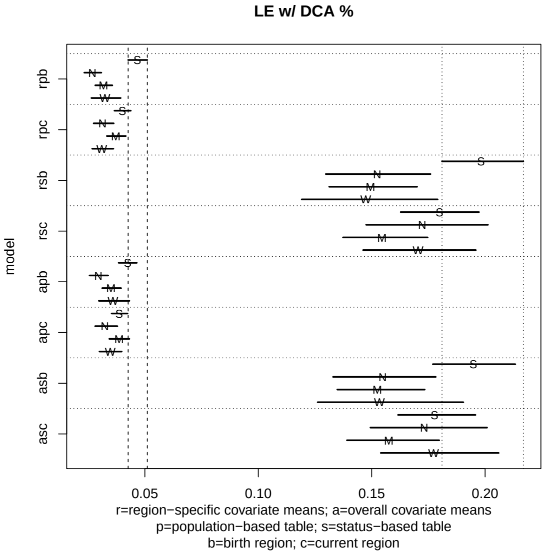
# Results 10: % of TLE Spent w/ ADLs (*ALE*/*TLE*)

- persons born in the south live longer % with ADLs
- true even after adjustment for covariates
- true in status based models: southern born have longer %ALE
- less pronounced after controls



# Results 11: % of TLE Spent w/ All 3 (*DCALE*/*TLE*)

- persons born in south have higher %DCA
- still true after controls
- true with and without controls for status based models



# (Alternative) Summary of Results: p(South is worse)

| | Population Based Results | | | | Status Based Results | | | |
|---|---|---|---|---|---|---|---|---|
| | Birth | | Current | | Birth | | Current | |
| Measure | noc | w/c | noc | w/c | noc | w/c | noc | w/c |
| TLE (<) | 100 | 77 | 99 | 91 | 53 | 44 | 57 | 49 |
| HLE (<) | 96 | 82 | 88 | 77 | - | - | - | - |
| DLE* | 86 | 59 | 69 | 61 | 46 | 54 | 42 | 48 |
| CLE | 30 | 82 | 20 | 42 | 60 | 90 | 49 | 66 |
| ALE | 100 | 95 | 82 | 57 | 99 | 91 | 65 | 45 |
| DCALE | 99 | 95 | 84 | 70 | 99 | 97 | 68 | 64 |
| %HLE (<) | 70 | 76 | 56 | 58 | - | - | - | - |
| %DLE | 97 | 66 | 75 | 65 | - | - | - | - |
| %CLE | 51 | 85 | 47 | 62 | 65 | 93 | 58 | 67 |
| %ALE | 100 | 98 | 97 | 72 | 100 | 90 | 70 | 48 |
| %DCALE | 100 | 96 | 89 | 75 | 99 | 97 | 73 | 67 |

* DLE is TLE in status based models, so this is the probability that persons from the south who have diabetes live longer after diagnosis.

# Conclusions

- Regional differences are often pronounced, but less so after controlling for regional differences in composition
- However, even after controls, the south fares poorly
- Pattern is much more pronounced when region at birth is the measure (rather than region at time of interview)
- Diabetes is worse for southern born: more years and percent of remaining life spent with ADL limitations and conditions
- This pattern is ONLY pronounced based on birth region
- Results suggest that regional differences may be due to cultural influence rather than infrastructural differences
- Methods produce considerably more detail than two-state methods.