Inequality in Life Expectancies Across Europe

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Introduction

- Literature on economic inequality across countries and over time

  Katz and Murphy (1992), Krueger et al. (2010), Piketty (2014)

- Less is known about inequality in mortality and health

- Lack of harmonized cross-country data with socio-economic information

  Mackenbach et al. (2008), Avendano et al. (2011), Maki et al. (2013), Majer et al. (2010)

- Importance
  - A major driver of welfare
  - Central for the redistributive role of public policies
  - Ageing population

Inequality in Mortality and Health

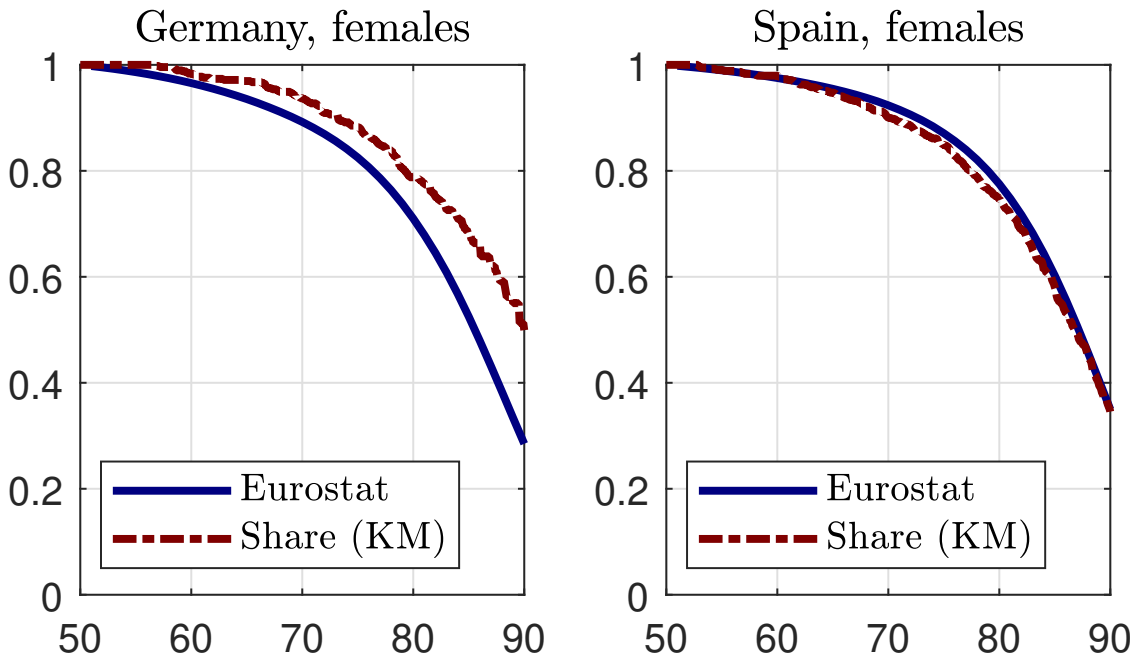
- Harmonized household panel data 2004—2015
  - SHARE (Survey of Health, Ageing, and Retirement in Europe)
  - HRS (Health and Retirement Study)
  - ELSA (English Longitudinal Study of Ageing)
- Gender
- Age 50-90
- Health: conditions limiting the activities of daily living (ADLs)
- Education: College (ISCED 1997 5-6) vs. non-college

Goals

- Estimate multi-state life tables (at age 50)
- Compute healthy (HLE), unhealthy (ULE), total life expectancy (LE)
- Interactions between gender and socio-economic status
- Education gradient in longevity (high − low education)
- Gender gap in the gradient (females − males)
- Decomposition

Data Validation

- Compare survival functions for each country and gender
- Survey data and population life tables
- Test: $\left|\mathrm{LE}_{50}^{survey} - \mathrm{LE}_{50}^{census}\right| < 2.5$ years



- Weak evidence of attrition bias

Regions and Countries

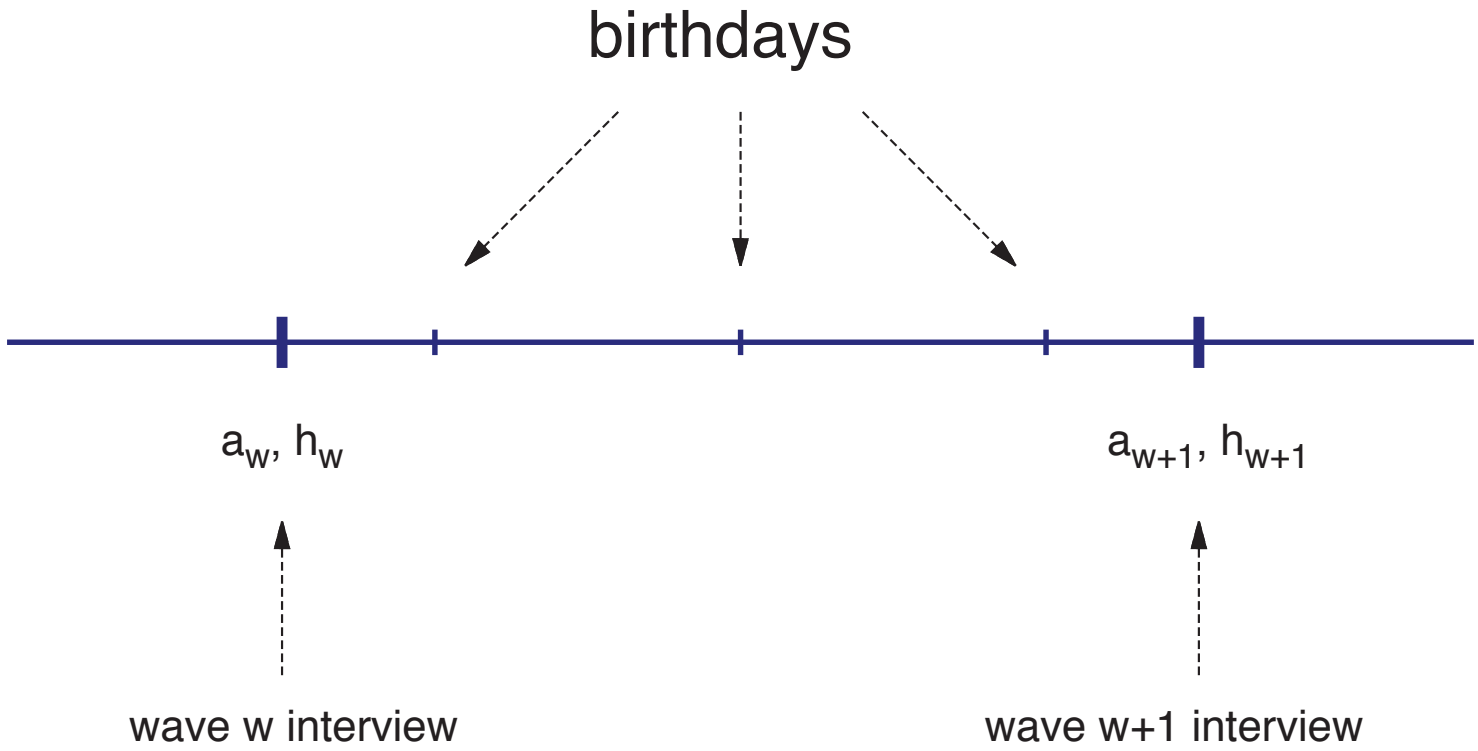
SHARE	Western Europe	Austria, France
	Eastern Europe	Czechia, Estonia, Poland, Slovenia
	Scandinavia	Denmark, Sweden
	Mediterranean	Italy, Spain
ELSA		England
HRS		United States

Statistical Model

- Measurement at survey wave w
- Respondent age a_w
- Three health states h_w: 0 (dead), 1 (unhealthy), 2 (healthy)
- Compute the probability $P(h_{w+1} | a_w, h_w, a_{w+1})$

Statistical Model: Two Key Problems

- Irregular intervals between waves
- Health status only observed at interview dates (if at all)



Statistical Model: Transitions

- Model the transitions from state $h \in \{1,2\}$ to state $h' \in \{0,1,2\}$ as independent competing risks in continuous time
- Assumptions:
  - i) The underlying hazard rates $\lambda_{h,h'}(a)$ constant between birthdays
  - ii) At most one transition between any 2 birthdays (or between an interview and the nearest birthdays)
- The likelihood function for $P(h_{w+1} | a_w, h_w, a_{w+1})$, combine
  - i) Probability factors for complete 1-year intervals between birthdays
  - ii) Probability factors for the 2 incomplete intervals between a_w and $\text{int}(a_w)+1$, and between $\text{int}(a_w+1)$ and a_{w+1}

Statistical Model: i) Complete 1-year Intervals

- Transition probabilities $p_{hh'}$ from each state $h \in \{1,2\} \rightarrow h' \in \{0,1,2\}$
- Multinomial logit

$$p_{ii}(a) = \frac{1}{1 + e^{f_{ik}(a)} + e^{f_{i0}(a)}}$$

$$p_{ik}(a) = \frac{e^{f_{ik}(a)}}{1 + e^{f_{ik}(a)} + e^{f_{i0}(a)}}$$

$$p_{i0}(a) = \frac{e^{f_{i0}(a)}}{1 + e^{f_{ik}(a)} + e^{f_{i0}(a)}}$$

  where $f_{ij}(a) = \beta_{ij}^0 + \beta_{ij}^1 a$

- 4 parameters per logit: Estimate 8 parameters per sample

Statistical Model: ii) Incomplete Intervals

- Multinomial probabilities: pdf's of duration under competing risks (probability that a transition occurs in an interval of 1 year or less)
- The underlying hazard rates $\lambda_{hh'}(a)$ can be recovered from

$$1 - p_{ik}(a) - p_{i0}(a) = e^{-(\lambda_{ik}(a)+\lambda_{i0}(a))}$$

$$p_{ik}(a) = \frac{\lambda_{ik}(a)}{\lambda_{ik}(a)+\lambda_{i0}(a)}\left[1 - e^{-(\lambda_{ik}(a)+\lambda_{i0}(a))}\right]$$

- The probabilities for a fraction d of a year are

$$\tilde{p}_{ii}(a,d) = e^{-(\lambda_{ik}(a)+\lambda_{i0}(a))d}$$

$$\tilde{p}_{ik}(a,d) = \frac{\lambda_{ik}(a)}{\lambda_{ik}(a)+\lambda_{i0}(a)}\left[1 - e^{-(\lambda_{ik}(a)+\lambda_{i0}(a))d}\right]$$

$$\tilde{p}_{ik}(a,d) = \frac{\lambda_{i0}(a)}{\lambda_{ik}(a)+\lambda_{i0}(a)}\left[1 - e^{-(\lambda_{ik}(a)+\lambda_{i0}(a))d}\right]$$

Statistical Model: Likelihood

- Compute for each individual transition the likelihood $P(h_{w+1}|a_w, h_w, a_{w+1})$ by integrating over all possible health trajectories
- In data H we observe N of such individual transitions
- Because transitions are independent, the full likelihood is

$$p(H|\beta) = \prod_{n=1}^{N} P(h^n_{w+1}|a^n_{w+1}, a^n_w, h^n_w)$$

Bayesian Estimation: Priors

- Problem: small sample size for some country-gender-education groups
- Bayesian methods: impose a set of regularity priors to reduce the uncertainty of estimated parameters
  1. Conditional on surviving, the probability of remaining in good health decreases with age
  2. Conditional on surviving, the probability of moving from bad to good health decreases with age
  3. Probability of surviving decreases with age
  4. Probability of dying is larger when in bad health than in good health
- The posterior distribution is given by $p(\beta|H) \propto p(H|\beta) \cdot p(\beta)$

Bayesian Estimation: Sampling from the Posterior

- MCMC techniques to sample from the posterior of β
- Standard Metropolis algorithm:
  1. Initialize at a given $\beta^{t=0}$
  2. Propose a candidate: $\beta^c = \beta^t + \varepsilon$, where $\varepsilon \sim N(0, \sigma_\varepsilon)$
  3. Accept β^c with probability: $\alpha(\beta^c|\beta^t) = \min\left\{1, \frac{p(\beta^c|H)}{p(\beta^t|H)}\right\}$
  4. If candidate is accepted $\beta^{t+1} = \beta^c$, otherwise $\beta^{t+1} = \beta^t$
  5. Set $t = t + 1$ and go back to 2 until convergence in the posterior distribution

Computing Life Expectancies

- Posterior distribution of the parameter estimates $\rightarrow$
  Distribution of transition parameters for each country-gender-education sample
- For each draw of β, compute LE, HLE, ULE
- Report the median and standard deviation
- Education gradients (high $-$ low education)
- Gender gaps in the gradient (females $-$ males)
- Note: LE $=$ HLE $+$ ULE

Average Education Gradients

	LE	=	HLE	+	ULE
Males	3.4 (0.4)		4.0 (0.3)		-0.6 (0.2)
Females	2.2 (0.4)		3.9 (0.4)		-1.7 (0.2)

- Education advantage in life expectancy larger for males
- Education advantage in healthy life expectancy even larger and similar
- Education advantage in disability larger for females
- Compression of morbidity across education among females
- Δyear $\rightarrow -$6m in ULE for females ($-$2m for males)

Education Gradients: Decomposition

- Estimation of multi-state life tables by education and gender
- Decompose the observed gradients into differences in:
  1. Health distribution at age 50 (D)
  2. Health transition conditional on survival (T)
  3. Survival conditional on health (S)
- Counterfactual simulations

Education Gradients: Decomposition of LE

	LE	$\simeq$	LE_D	+	LE_T	+	LE_S
Males	3.4 (0.4)		0.1 (0.0)		0.8 (0.1)		2.7 (0.4)
Females	2.3 (0.4)		0.0 (0.0)		0.8 (0.1)		1.3 (0.4)

- Distribution of health at age 50 no effect
- Education advantage due to both better survival and transitions
- Transitions same for males and females
- Interaction education and gender: Larger gradient in survival for men
- More educated individuals tend to live longer mainly because of higher survival probabilities conditional on health state

Education Gradients: Decomposition of ULE

	ULE	$\simeq$	ULE_D	+	ULE_T	+	ULE_S
Males	-0.6 (0.2)		-0.1 (0.0)		-1.1 (0.1)		0.7 (0.1)
Females	-1.7 (0.2)		-0.1 (0.0)		-1.9 (0.2)		0.3 (0.2)

Education advantage:

- Due to better health-protecting transitions despite higher survival rates
- Females: Health transitions
- Males: Survival
- Males: Worse transitions and survival

Gender Gaps in LE

	LE	=	HLE	+	ULE
No college	3.9 (0.2)		2.5 (0.2)		1.4 (0.1)
College	2.7 (0.5)		2.4 (0.5)		0.3 (0.3)

- Gender gaps in LE and ULE larger for the less educated
- Gender gaps in HLE similar
- Positive gap: Females spend longer time in ULE
- Women STAY sicker but men die quicker ONLY for the less educated
- Δyear $\rightarrow$ $+$4m in ULE for females (only for the less-educated)

Gender Gaps: Decomposition of LE

	LE	$\simeq$	LE_D	+	LE_T	+	LE_S
No college	3.9 (0.2)		0.0 (0.0)		-0.1 (0.0)		4.0 (0.2)
College	2.7 (0.5)		0.0 (0.0)		0.1 (0.1)		2.6 (0.5)

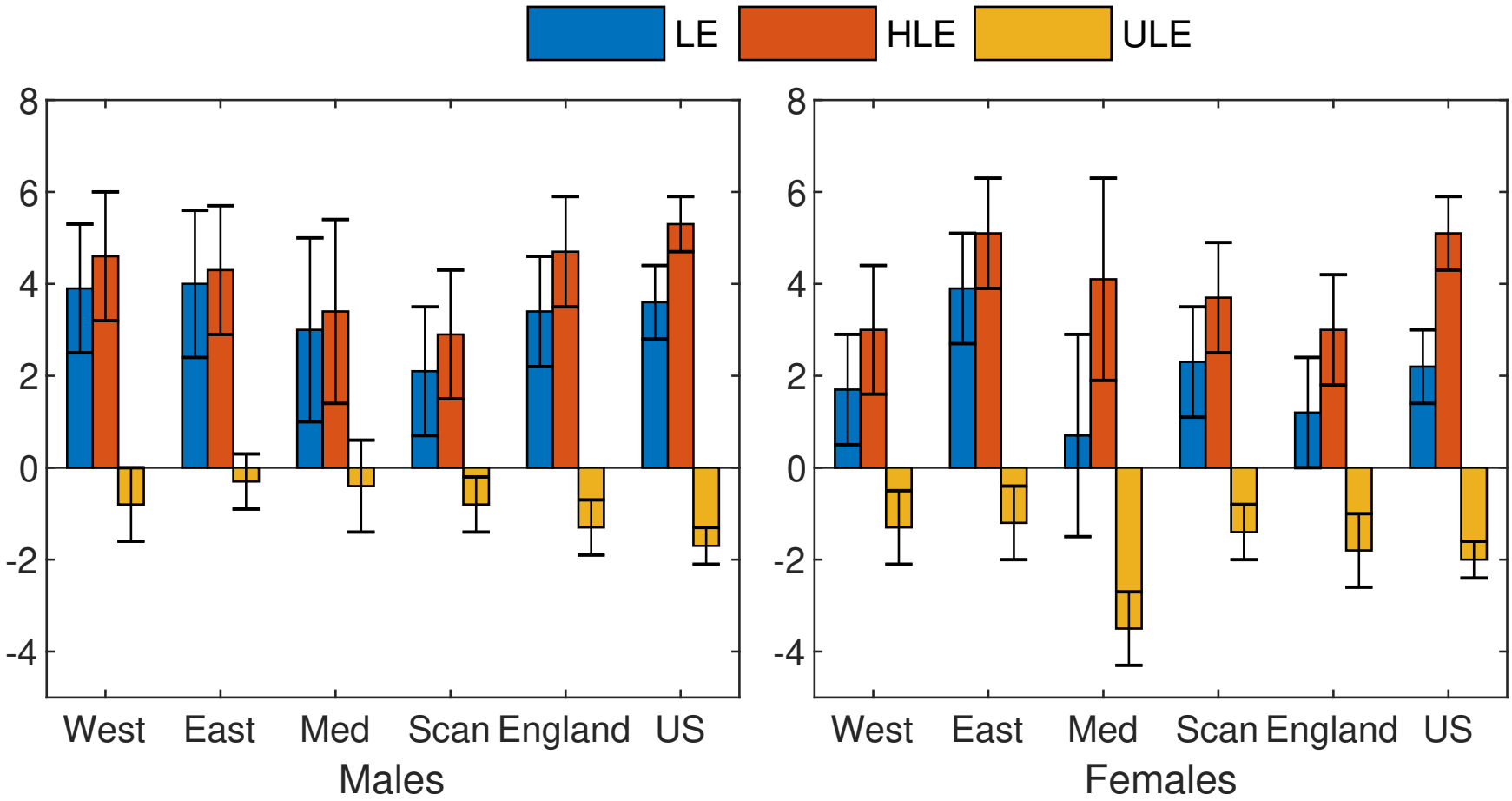
- Females live longer because of higher survival
- Mostly due to females with low education
- Education decreases gender gap in survival

Gender Gaps: Decomposition of ULE

	ULE	$\simeq$	ULE_D	+	ULE_T	+	ULE_S
No college	1.4 (0.1)		0.0 (0.0)		0.2 (0.1)		1.2 (0.1)
College	0.3 (0.3)		0.0 (0.0)		-0.3 (0.2)		0.6 (0.1)

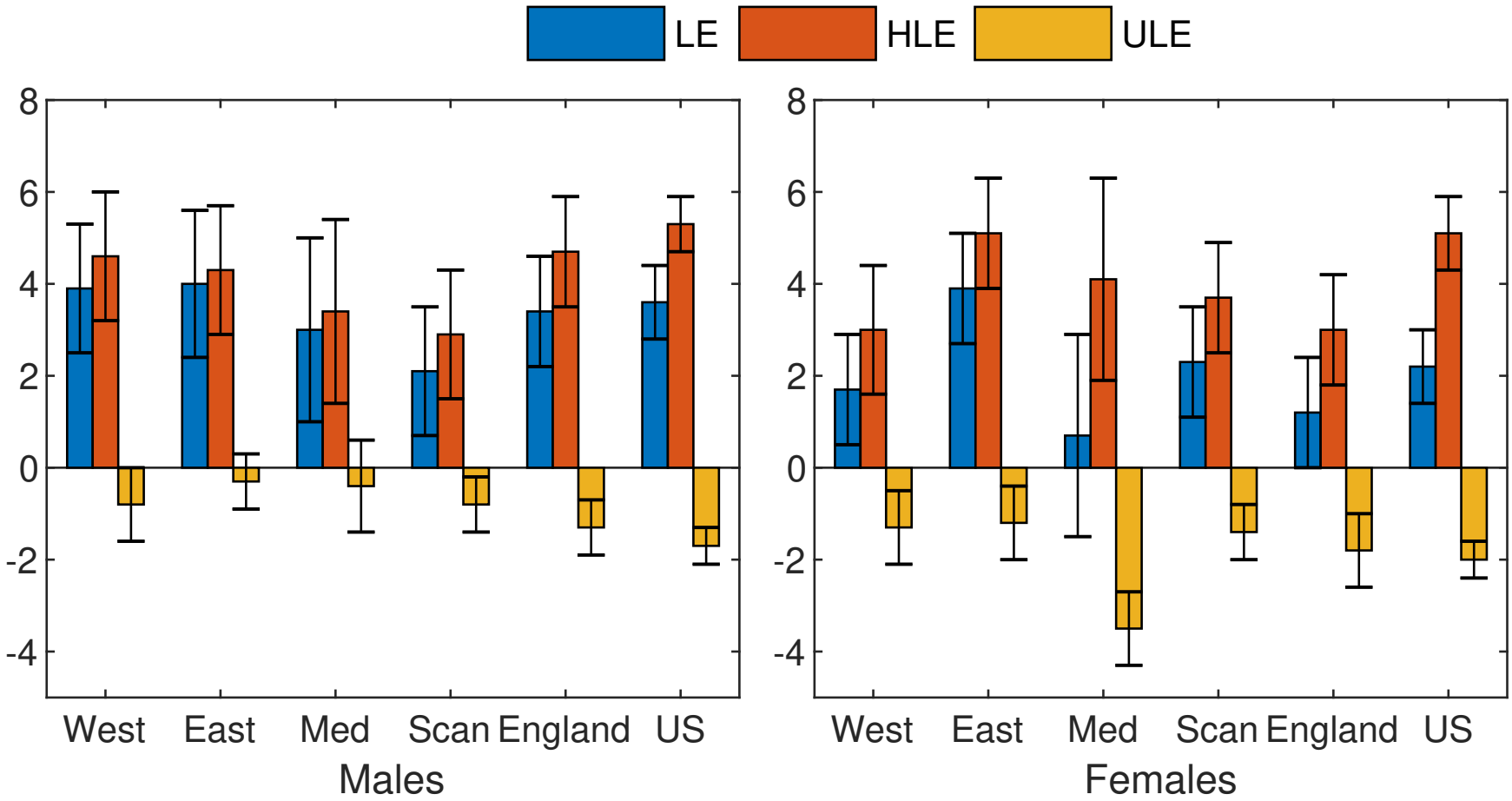
- Females experience higher survival in disability
- Women stay sicker but men die quicker
- Again more important for the low-educated
- Females with high education can transit back to good health
- Females with low education stay and stay longer in ULE

Education Gradients: Cross-Country Heterogeneity



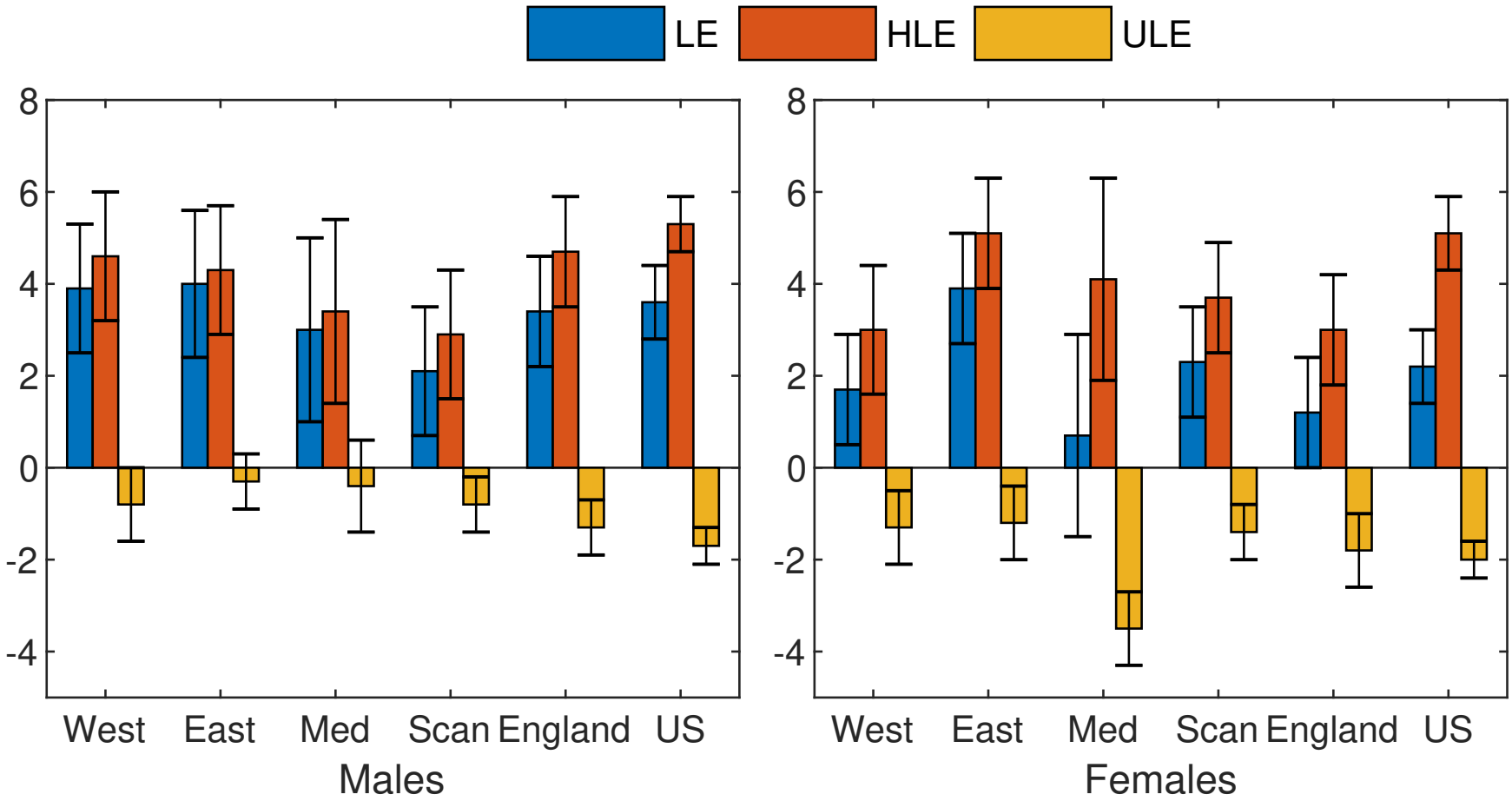
- LE: min Scan (M) and Med (F); max East (F,M)

Education Gradients: Cross-Country Heterogeneity



- HLE: min Scan (M); max US (M, F), East (F)

Education Gradients: Cross-Country Heterogeneity



- ULE: max US (M), Med (F)

Differences Across Countries: Education Gradients

	Males			Females		
	LE	HLE	ULE	LE	HLE	ULE
Western Europe	3.9 (0.7)	4.6 (0.7)	-0.8 (0.4)	1.7 (0.6)	3.0 (0.7)	-1.3 (0.4)
Eastern Europe	4.0 (0.8)	4.3 (0.7)	-0.3 (0.3)	3.9 (0.6)	5.1 (0.6)	-1.2 (0.4)
Mediterranean	3.0 (1.0)	3.4 (1.0)	-0.4 (0.5)	0.7 (1.1)	4.1 (1.1)	-3.5 (0.4)
Scandinavia	2.1 (0.7)	2.9 (0.7)	-0.8 (0.3)	2.3 (0.6)	3.7 (0.6)	-1.4 (0.3)
England	3.4 (0.6)	4.7 (0.6)	-1.3 (0.3)	1.2 (0.6)	3.0 (0.6)	-1.8 (0.4)
US	3.6 (0.4)	5.3 (0.4)	-1.7 (0.2)	3.2 (0.4)	5.1 (0.4)	-2.0 (0.2)

- LE: The largest gradients for both males and females in East

Differences Across Countries: Education Gradients

	Males			Females		
	LE	HLE	ULE	LE	HLE	ULE
Western Europe	3.9 (0.7)	4.6 (0.7)	-0.8 (0.4)	1.7 (0.6)	3.0 (0.7)	-1.3 (0.4)
Eastern Europe	4.0 (0.8)	4.3 (0.7)	-0.3 (0.3)	3.9 (0.6)	5.1 (0.6)	-1.2 (0.4)
Mediterranean	3.0 (1.0)	3.4 (1.0)	-0.4 (0.5)	0.7 (1.1)	4.1 (1.1)	-3.5 (0.4)
Scandinavia	2.1 (0.7)	2.9 (0.7)	-0.8 (0.3)	2.3 (0.6)	3.7 (0.6)	-1.4 (0.3)
England	3.4 (0.6)	4.7 (0.6)	-1.3 (0.3)	1.2 (0.6)	3.0 (0.6)	-1.8 (0.4)
US	3.6 (0.4)	5.3 (0.4)	-1.7 (0.2)	3.2 (0.4)	5.1 (0.4)	-2.0 (0.2)

- LE: The smallest gradients: Scan (males) and the Med (females)

Differences Across Countries: Education Gradients

	Males			Females		
	LE	HLE	ULE	LE	HLE	ULE
Western Europe	3.9 (0.7)	4.6 (0.7)	-0.8 (0.4)	1.7 (0.6)	3.0 (0.7)	-1.3 (0.4)
Eastern Europe	4.0 (0.8)	4.3 (0.7)	-0.3 (0.3)	3.9 (0.6)	5.1 (0.6)	-1.2 (0.4)
Mediterranean	3.0 (1.0)	3.4 (1.0)	-0.4 (0.5)	0.7 (1.1)	4.1 (1.1)	-3.5 (0.4)
Scandinavia	2.1 (0.7)	2.9 (0.7)	-0.8 (0.3)	2.3 (0.6)	3.7 (0.6)	-1.4 (0.3)
England	3.4 (0.6)	4.7 (0.6)	-1.3 (0.3)	1.2 (0.6)	3.0 (0.6)	-1.8 (0.4)
US	3.6 (0.4)	5.3 (0.4)	-1.7 (0.2)	3.2 (0.4)	5.1 (0.4)	-2.0 (0.2)

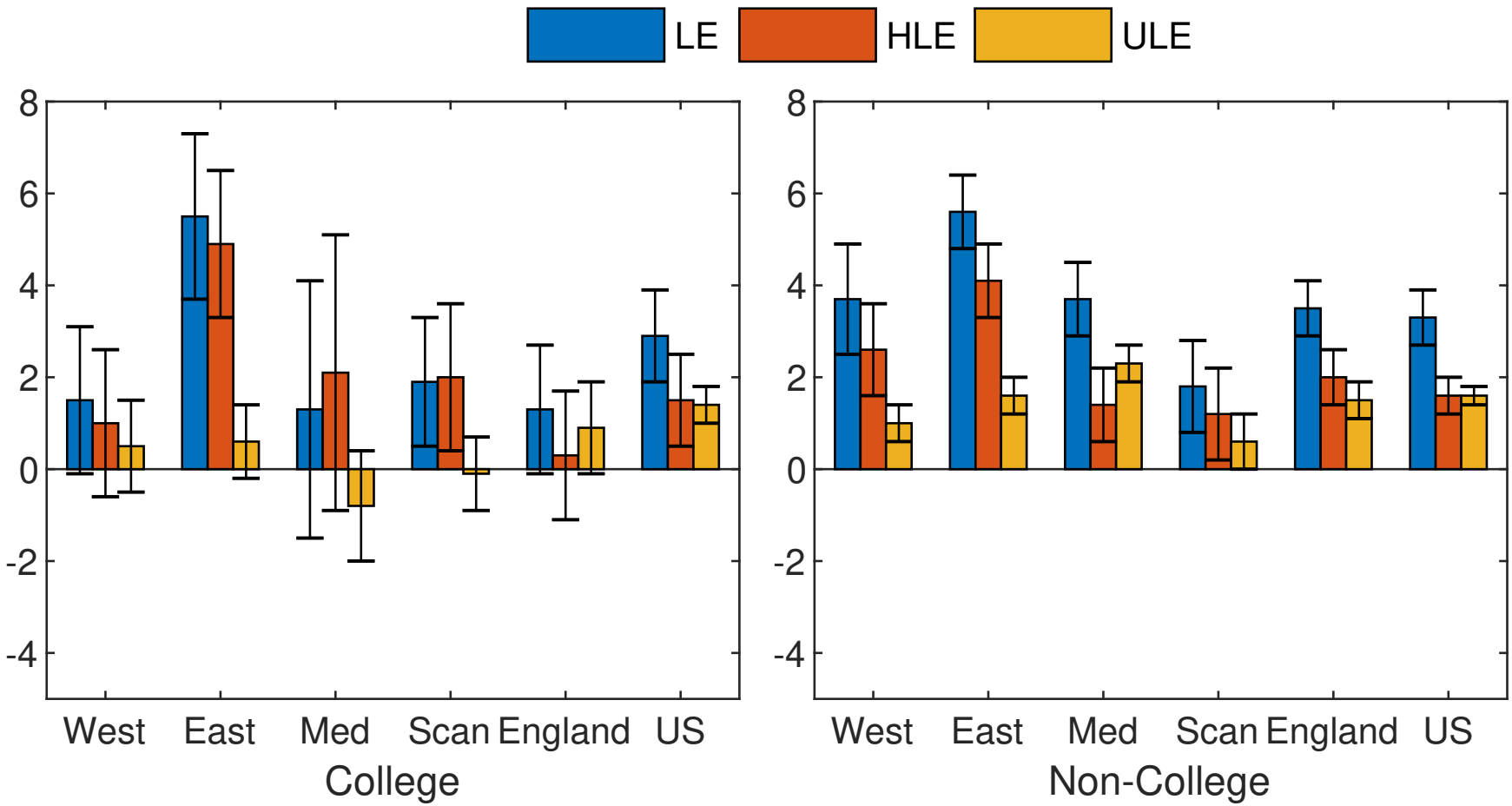
- HLE: Education advantage largest in the US (males and females)

Differences Across Countries: Education Gradients

	Males			Females		
	LE	HLE	ULE	LE	HLE	ULE
Western Europe	3.9 (0.7)	4.6 (0.7)	-0.8 (0.4)	1.7 (0.6)	3.0 (0.7)	-1.3 (0.4)
Eastern Europe	4.0 (0.8)	4.3 (0.7)	-0.3 (0.3)	3.9 (0.6)	5.1 (0.6)	-1.2 (0.4)
Mediterranean	3.0 (1.0)	3.4 (1.0)	-0.4 (0.5)	0.7 (1.1)	4.1 (1.1)	-3.5 (0.4)
Scandinavia	2.1 (0.7)	2.9 (0.7)	-0.8 (0.3)	2.3 (0.6)	3.7 (0.6)	-1.4 (0.3)
England	3.4 (0.6)	4.7 (0.6)	-1.3 (0.3)	1.2 (0.6)	3.0 (0.6)	-1.8 (0.4)
US	3.6 (0.4)	5.3 (0.4)	-1.7 (0.2)	3.2 (0.4)	5.1 (0.4)	-2.0 (0.2)

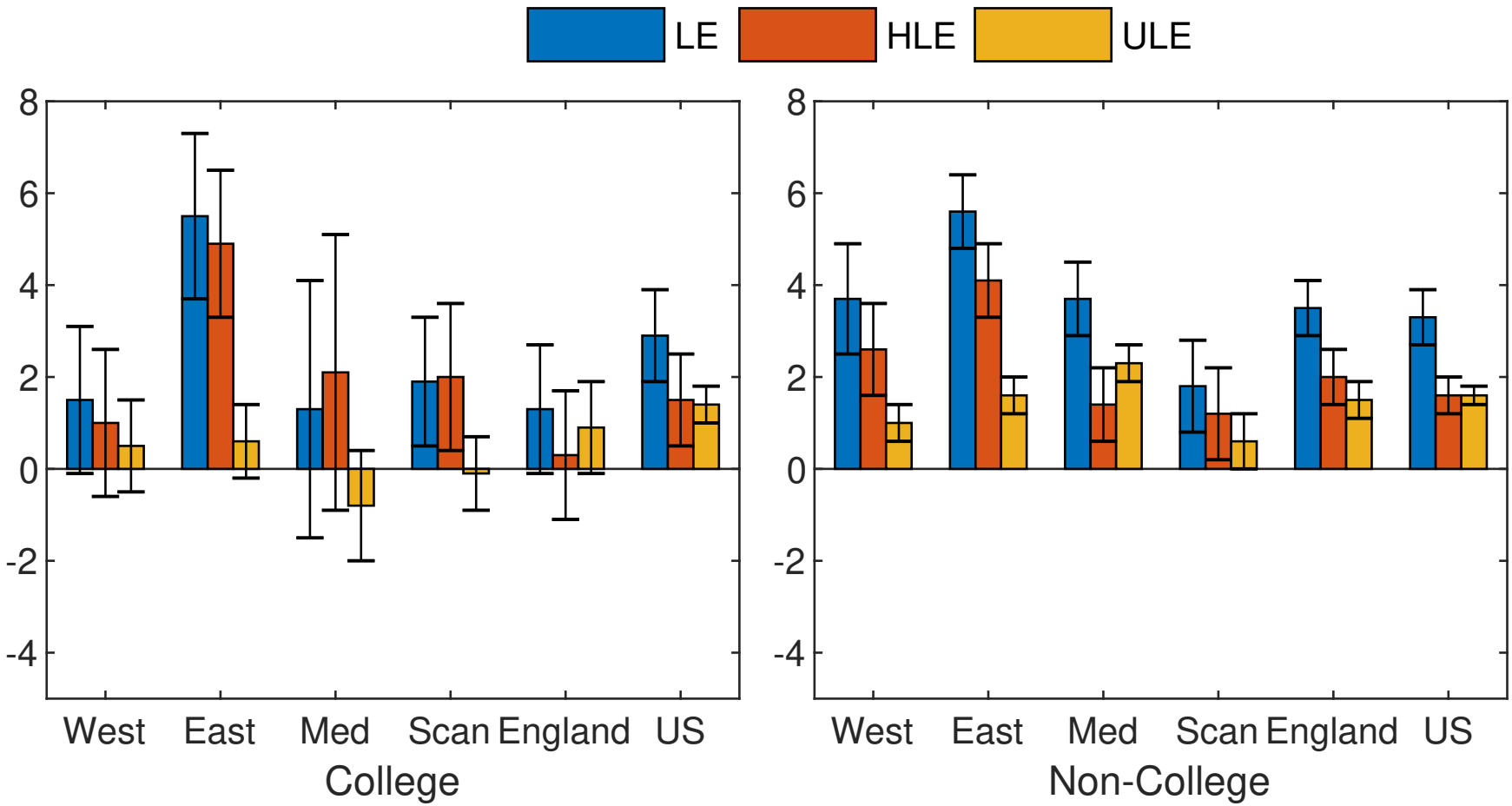
- ULE: Education advantage large among US males and Med females

Gender Gaps: Cross-Country Heterogeneity



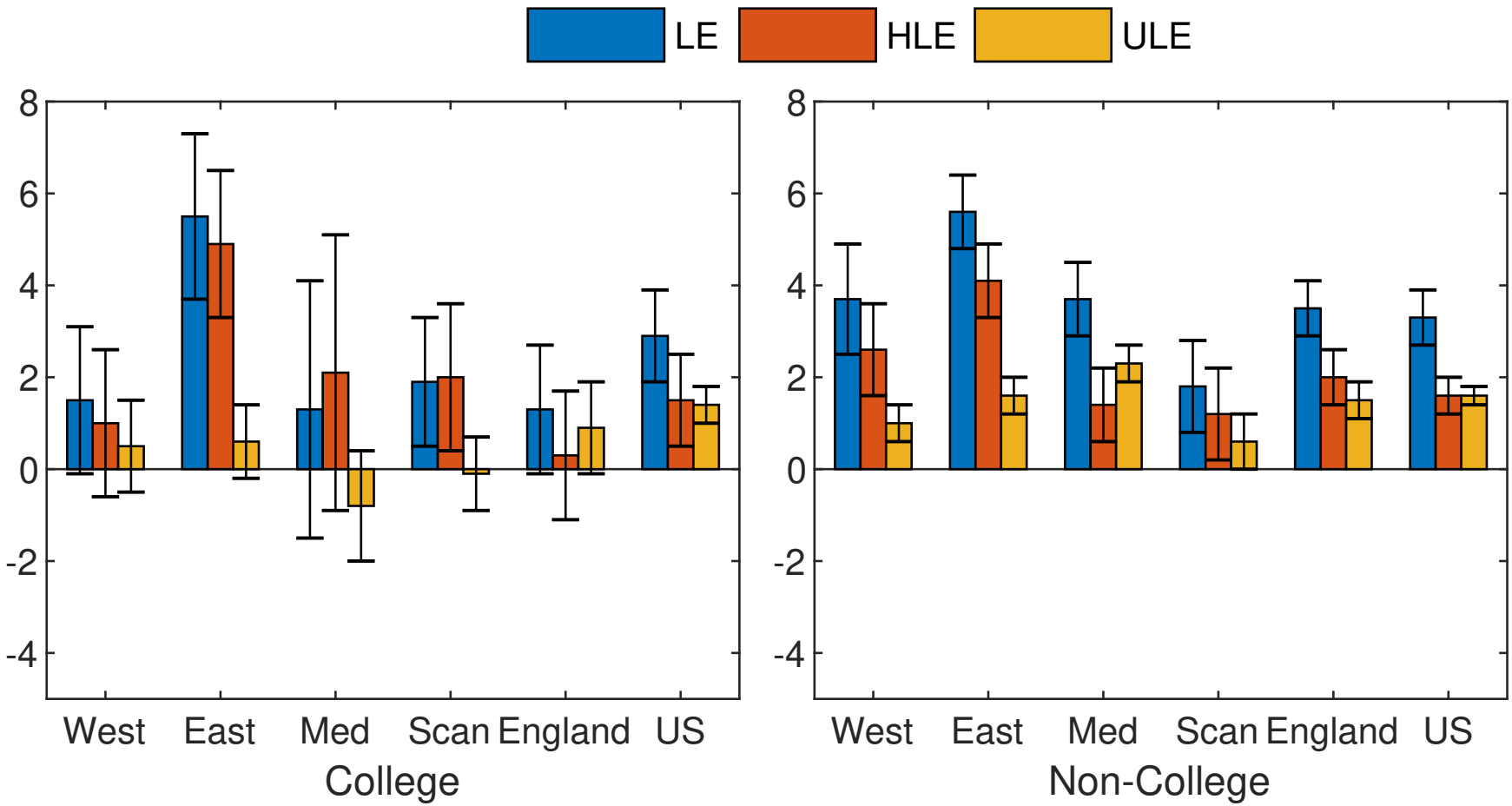
- LE: min Scan (NC); max East (C, NC)

Gender Gaps: Cross-Country Heterogeneity



- HLE: min England (C), Scan (NC); max East (C, NC)

Gender Gaps: Cross-Country Heterogeneity



- ULE: min Med (C), Scan (NC); max US(C), Med (NC)

Differences Across Countries: Gender Gaps

	College			No College		
	LE	HLE	ULE	LE	HLE	ULE
Western Europe	1.5 (0.8)	1.0 (0.8)	0.5 (0.5)	3.7 (0.6)	2.6 (0.5)	1.0 (0.2)
Eastern Europe	5.5 (0.9)	4.9 (0.8)	0.6 (0.4)	5.6 (0.4)	4.1 (0.4)	1.6 (0.2)
Mediterranean	1.3 (1.4)	2.1 (1.5)	-0.8 (0.6)	3.7 (0.4)	1.4 (0.4)	2.3 (0.2)
Scandinavia	1.9 (0.7)	2.0 (0.8)	0.1 (0.4)	1.8 (0.5)	1.2 (0.5)	0.6 (0.3)
England	1.3 (0.7)	0.3 (0.7)	0.9 (0.5)	3.5 (0.3)	2.0 (0.3)	1.5 (0.2)
US	2.9 (0.5)	1.5 (0.5)	1.4 (0.2)	3.3 (0.3)	1.6 (0.3)	1.6 (0.1)

- Larger gender gap in LE than HLE

Differences Across Countries: Gender Gaps

	College			No College		
	LE	HLE	ULE	LE	HLE	ULE
Western Europe	1.5 (0.8)	1.0 (0.8)	0.5 (0.5)	3.7 (0.6)	2.6 (0.5)	1.0 (0.2)
Eastern Europe	5.5 (0.9)	4.9 (0.8)	0.6 (0.4)	5.6 (0.4)	4.1 (0.4)	1.6 (0.2)
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US	2.9 (0.5)	1.5 (0.5)	1.4 (0.2)	3.3 (0.3)	1.6 (0.3)	1.6 (0.1)

- LE and HLE: Eastern Europe large gender gaps for both C, NC

Differences Across Countries: Gender Gaps

	College			No College		
	LE	HLE	ULE	LE	HLE	ULE
Western Europe	1.5 (0.8)	1.0 (0.8)	0.5 (0.5)	3.7 (0.6)	2.6 (0.5)	1.0 (0.2)
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US	2.9 (0.5)	1.5 (0.5)	1.4 (0.2)	3.3 (0.3)	1.6 (0.3)	1.6 (0.1)

- LE, HLE, ULE: smallest gap in Scan for the less-educated

Differences Across Countries: Gender Gaps

	College			No College		
	LE	HLE	ULE	LE	HLE	ULE
Western Europe	1.5 (0.8)	1.0 (0.8)	0.5 (0.5)	3.7 (0.6)	2.6 (0.5)	1.0 (0.2)
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US	2.9 (0.5)	1.5 (0.5)	1.4 (0.2)	3.3 (0.3)	1.6 (0.3)	1.6 (0.1)

- ULE: The female disadvantage largest for less-educated in Med

Discussion: Geo-Political Differences

Mackenbach (2017)

- Persistence/increase of socio-economic inequalities in health

Eastern disaster	Yes	Highest gradient
Nordic paradox	No	Scandinavia lowest inequality
Southern miracle	No	Gradient especially large among females

- Policies and institutions

Discussion: Fundamental Causes Theory

Phelan (1995): Fundamental causes theory

- Higher socio-economic groups benefit more from new opportunities
- Greater material and non-material resources
- Cognitive, behavioral, material capacity
- Bad shocks or new technologies
- Eastern Europe

Overall mortality can decline together with widening inequality

Discussion: Education

- Montez (2011): Gradient widening in recent years
  Declines in mortality larger for high-educated males
  Increases in mortality larger for low-educated females
- Meara (2008): LE gains among high-educated (especially males)
- Chetty et al. (2016) and Karas et al. (2011)
  Males: declines in mortality greater for the high educated
  Females: mortality risk decreased among the college-educated but increased among the rest
- College attainment
  Buckles (2016): Important for males
  Case and Deaton (2017): Cumulative advantage over life

Discussion

- Education health-protecting
- Keep track of education attainment
- College graduation vs. additional year effects

- Baker (2017): Population education transition (PET)
  Shifting education gradients
  Education: Faster to adopt and dispose of new products and techs
  Eastern Europe and Mediterranean

Conclusions

- Inequality in mortality and health outcomes
- Important interaction of gender and socio-economic status
- Compression of morbidity: Women stay sicker but men die quicker
  - Gradient larger for males: Survival
  - Gradient larger for females: Transitions
  - Compression absent among college educated
- Education gradient in HLE more important for males
- Education advantage more important for females
- Largest inequality in Eastern Europe

Conclusions

- Methodology for other applications
- Other health and socio-economic variables
- Causality (life-cycle)
- Public policy