# Causal Inference for Health Inequity Research

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# Overview

1. Misconceptions about causal inference in social epidemiology
2. A way forward: the added value of focusing on interventions/changes in social circumstances
3. An application to education and health

# What is causal inference?

"Causal inference is the leveraging of theory and **deep knowledge of institutional details** to estimate the ***impact*** of events and choices on a given outcome of interest." Scott Cunningham, *Causal Inference: The Mixtape*, Chapter 1.

"It distinguishes **true cause-and-effect relationships** from mere correlations by analyzing ***how an outcome changes*** when a treatment is applied, often utilizing counterfactuals." Hal Varian, *PNAS*.

# Three misconceptions

**Win-Win: Reconciling Social Epidemiology and Causal Inference**

Sandro Galea, Miguel A Hernán

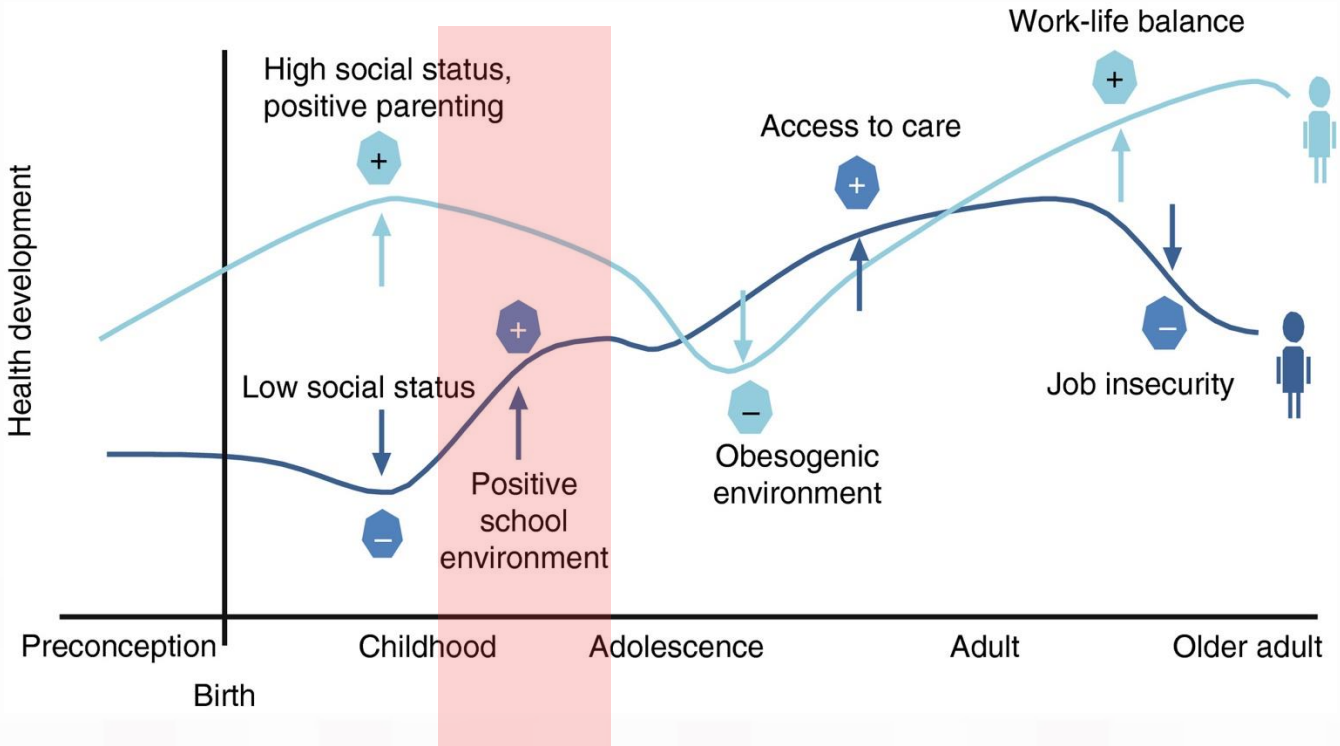
1. Social exposures are **qualitatively different** from other types of exposures
2. The goal of causal inference is to identify **'causes'**
3. Causal inference requires exposures that can be **experimentally manipulated**

# A way forward

Thinking in terms of causal inference...

1. Forces us to focus on **changes in social circumstances**
2. Forces us to carefully refine our **exposure** of interest
3. Helps to define research questions that are **policy-relevant**

# Social changes can impact health over the lifecourse




Palisano *et al*. (2017) DMCN

# Assessing the *causal* effect of social determinants

JOURNAL ARTICLE

## Producing Change to Understand the Social Determinants of Health: The Promise of Experiments for Social Epidemiology FREE

Lisa F Berkman ✉ , Mauricio Avendano , Emilie Courtin

*American Journal of Epidemiology*, Volume 192, Issue 11, November 2023, Pages 1835–1841, https://doi.org/10.1093/aje/kwac142

**Published:** 09 August 2022 **Article history** ▾

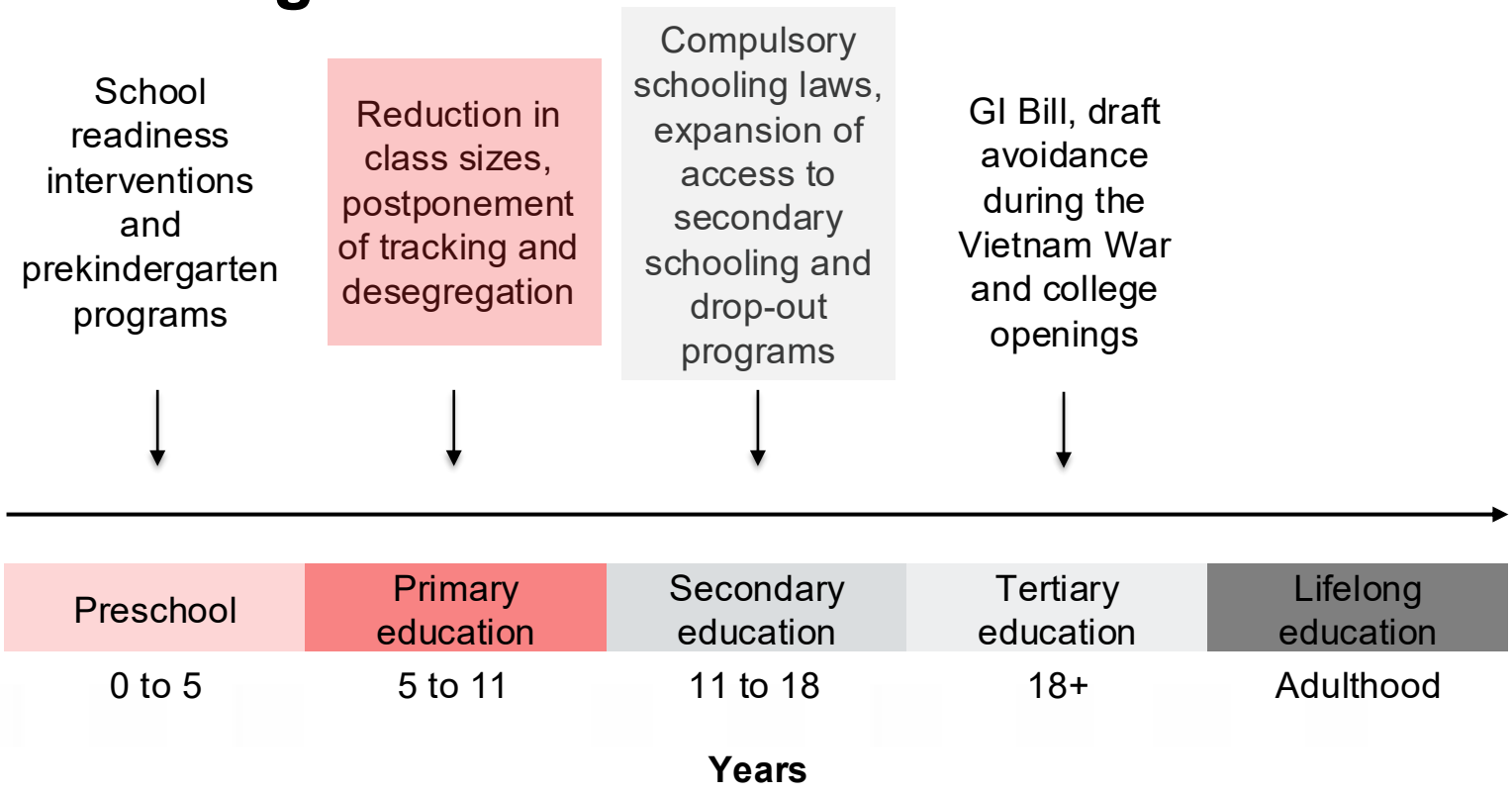
# Education and health

- Large and persistent association between education and health
  - ✓ observed in many countries and time periods,
  - ✓ for a wide variety of health measures
  - ✓ Mechanisms: occupational and income mobility, better health literacy, increased social capital

→ **Can education policies improve population health?**

Low *et al* (2005) Can education policy be health policy? Implications of research on the social determinants of health, *J health Polit Policy Law*.

# Intervening on education over the life course

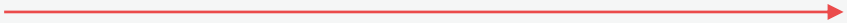


# Two examples

***Project Star: reduction in class sizes in kindergarten***

Exposure: 4-6 Premature mortality at age 28

***Berthoin reform: compulsory schooling law***



Exposure: 14-16 Health outcomes at age 55

0 Age 100

# Example 1
# Reducing class sizes

# Rationale

AJPH
A PUBLICATION OF THE AMERICAN PUBLIC HEALTH ASSOCIATION

## Health and Economic Benefits of Reducing the Number of Students per Classroom in US Primary Schools

**Peter Muennig**MD, MPH, and **Steven H. Woolf**MD, MPH

Accepted: February 08, 2007 Published Online: October 10, 2011

Abstract **Full Text** References PDF/EPUB

THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

"Although educational interventions occur outside the ambit of medicine, our analysis suggests that class-size reductions would generate more quality-adjusted life-year gains per dollar invested than the majority of medical interventions and would compare favorably with childhood vaccinations in terms of the quality of life years gained per dollar invested."

MUENNIG *ET AL.* 2007

# Project STAR

American Journal of Epidemiology

Vol. 173, No. 12
DOI: 10.1093/aje/kwr011
Advance Access publication:
May 3, 2011

**Original Contribution**

## The Effect of Small Class Sizes on Mortality Through Age 29 Years: Evidence From a Multicenter Randomized Controlled Trial

**Peter Muennig*, Gretchen Johnson, and Elizabeth Ty Wilde**

* Correspondence to Dr. Peter Muennig, Mailman School of Public Health, Columbia University, 600 West 168th Street, Sixth Floor, New York, NY 10032 (e-mail: pm124@columbia.edu).

# Overview of the trial

- Project Star Teacher Achievement Ratio
- 4-year multicentre RCT of reduced class sizes involving 11,601 students between 1985-89.
- Treatment: smaller class sizes (22-25 students) *vs* regular class sizes

**Table 2.** Number of Subjects, Number of Deaths, Hazard Ratio, and 95% Confidence Interval for Students Randomized to Small Classes (13–17 Students) Relative to Regular Size Classes (Both With and Without Aide), Project STAR, Tennessee, 1985–1989, With Follow-up Through 2007 for Mortality Data

| Characteristic | No. of Observations | No. of Deaths | Hazard Ratio | Confidence Interval |
|---|---|---|---|---|
| All subjects | 11,240 | 141 | 1.58* | 1.07, 2.32 |
| Gender | | | | |
| Male | 5,941 | 106 | 1.73* | 1.05, 2.85 |
| Female | 5,299 | 35 | 0.99 | 0.43, 2.30 |
| Race | | | | |
| White/Asian[a] | 7,082 | 89 | 1.68* | 1.04, 2.72 |
| Male | 3,751 | 69 | 1.64 | 0.90, 2.99 |
| Female | 3,331 | 20 | 1.86 | 0.62, 5.58 |
| Black[a] | 4,106 | 50 | 1.35 | 0.64, 2.83 |
| Male | 2,159 | 35 | 1.93 | 0.66, 5.63 |
| Female | 1,947 | 15 | 0.46 | 0.09, 2.35 |
| Free-lunch status | | | | |
| Free lunch | 6,799 | 91 | 1.56 | 0.95, 2.57 |
| Never free lunch | 4,441 | 50 | 2.20* | 1.06, 4.57 |
| Urbanicity | | | | |
| Urban[b] | 956 | 8 | 2.57 | 0.58, 11.4 |
| Inner city[b] | 2,660 | 34 | 1.40 | 0.60, 3.25 |
| Suburban | 2,934 | 32 | 2.02 | 0.75, 5.48 |
| Rural | 4,690 | 67 | 1.46 | 0.88, 2.42 |
| Exposure, year | | | | |
| 1 | 3,973 | 31 | 1.69 | 0.78, 3.69 |
| 2 | 2,440 | 29 | 1.12 | 0.29, 4.27 |
| 3 | 1,744 | 37 | 1.31 | 0.47, 3.67 |
| 4 | 3,083 | 44 | 1.84 | 0.95, 3.58 |
| Each added student[c] | 11,240 | 141 | 0.89 | 0.83, 0.96 |

Abbreviation: STAR, Student Teacher Achievement Ratio.

* $P < 0.05$ (significant).

[a] The white/Asian and black subgroups do not sum to 11,240 because they do not include those of other races.

[b] "Urban" and "inner city" are distinct categories.

[c] Basis of the reduced form hazard ratio for the relation between average class sizes and mortality measured by the end of 2007. Refer to the Web Appendix, which is posted on the *Journal*'s Web site (http://aje.oxfordjournals.org/), for the 2-stage least-squares estimate of the impact of each additional child on mortality.

# Effect on premature mortality (age 29)

Muennig et al, 2011, *AJPH*

# Potential explanations?

- Effect seems concentrated among White, male and non-poor students
- Benefitted less from the programme on other outcomes measured in the programme (cognitive scores, education scores, high school graduation rates)
- Non cognitive pathways and prosocial behaviours?
- Deaths mainly due to poisonings, drugs, drinking and driving, firearms
- Timing of measurement?

# Example 2
# Compulsory Schooling Laws

# Schooling policy in France

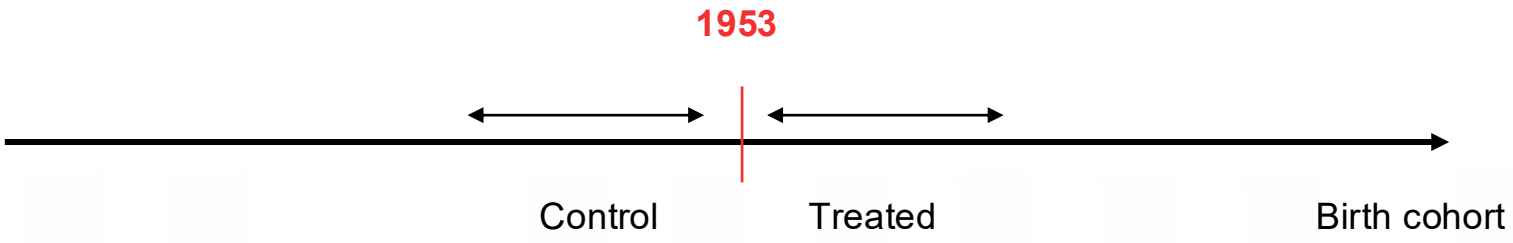
- The Berthoin reform raised the minimum school leaving age from 14 to 16 years in 1959.
- All individuals born after the 1st of January 1953 had to stay two years longer in school.
- What long-term effect on health?

Courtin E et al, 2019. Long-term impact of compulsory schooling on physical, mental and cognitive ageing: a natural experiment. *JECH*, 73:370-76.

# Research Design

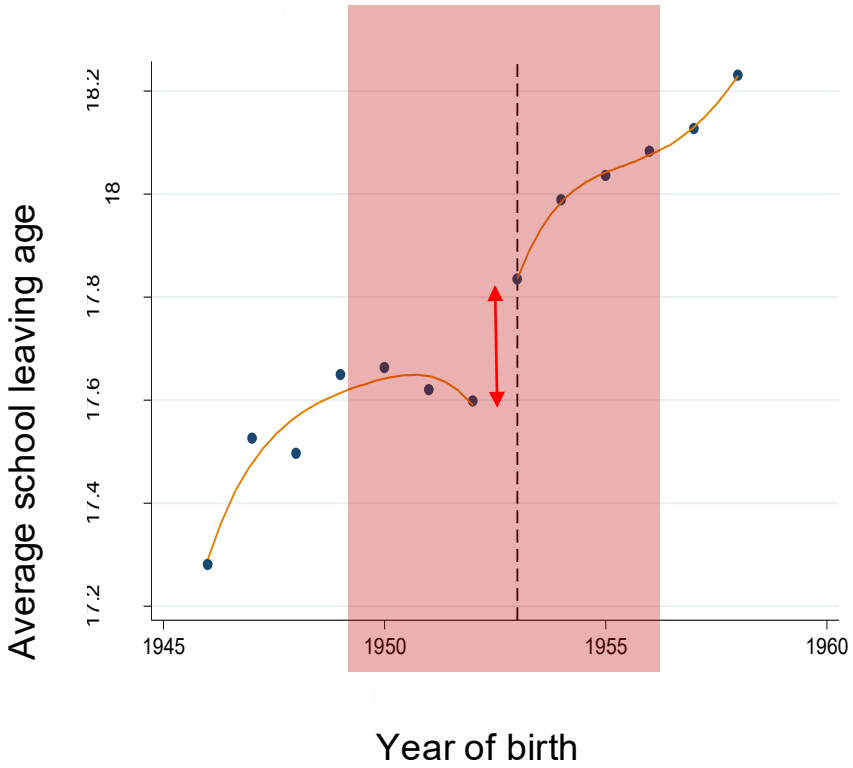
- Regression Discontinuity Design takes advantage of policy decision rules in which people are differentially assigned to an intervention if they fall below or above an arbitrary cut-off.

→ **Comparison of the health outcomes of those born just before (control) and just after (treated) the 1st of January 1953**

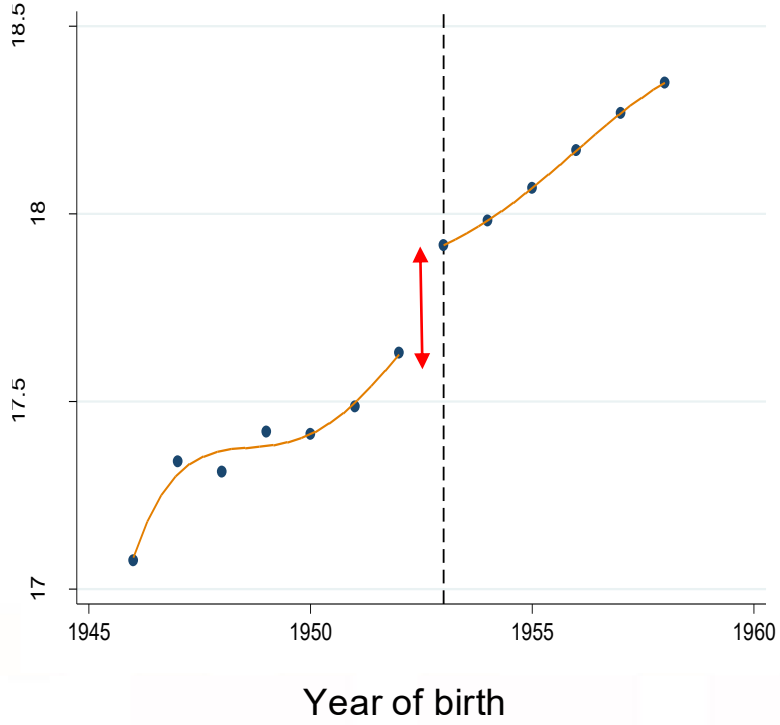


# Effect on school leaving age

**Men**



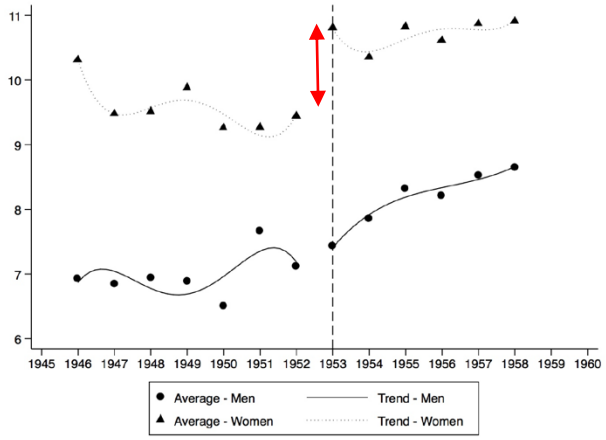

**Women**



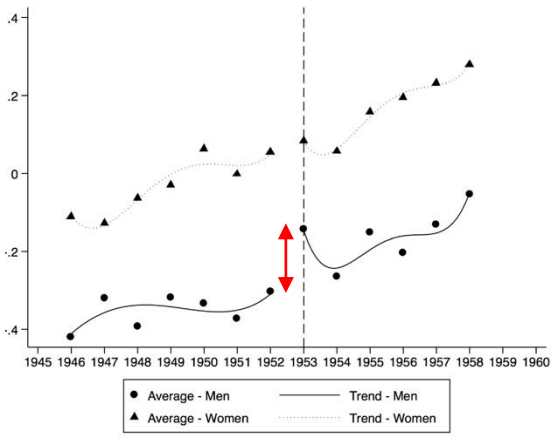

Courtin E et al, 2019. Long-term impact of compulsory schooling on physical, mental and cognitive ageing: a natural experiment. *JECH*, 73:370-76.

# Effect on health outcomes

**Depressive symptoms**




**Overall cognitive score**




**Walking speed**


Courtin E et al, 2019. Long-term impact of compulsory schooling on physical, mental and cognitive ageing: a natural experiment. *JECH*, 73:370-76.

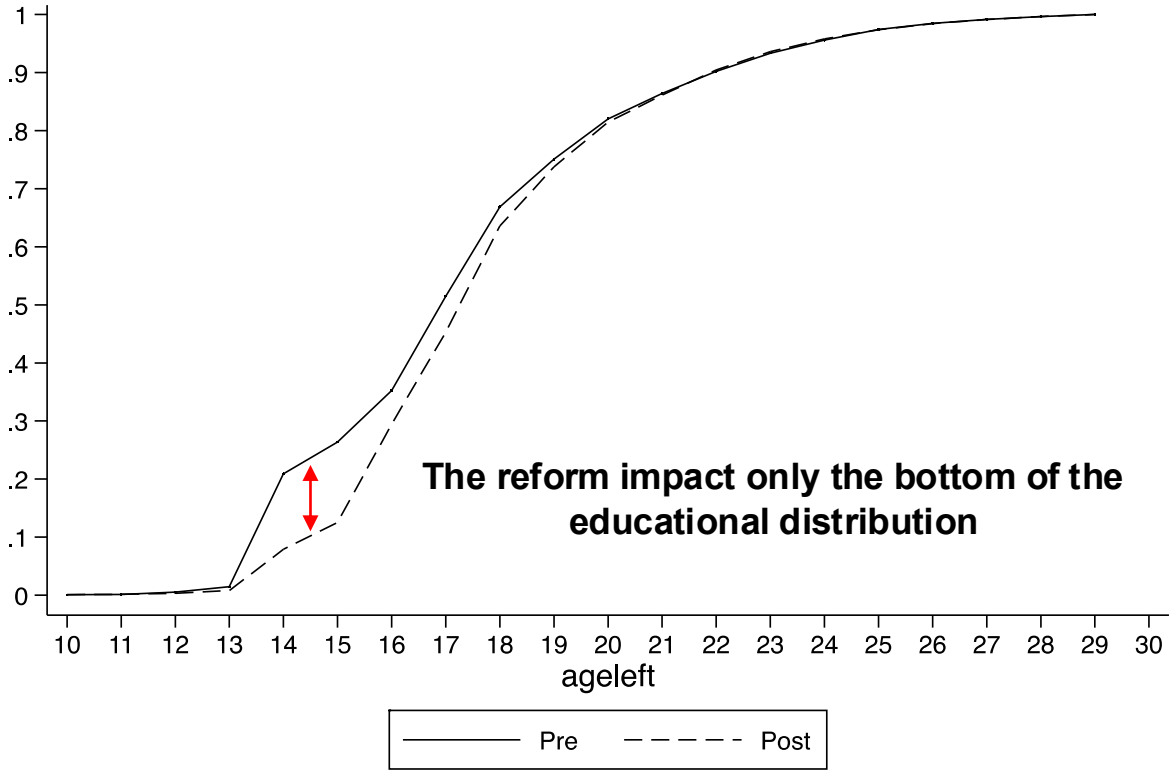
# Summary of health effects

- Positive effects on cognition among men in line with literature in the US (Glymour, *et al.* 2008) – cognitive reserve
- Too early to find effects on objective measures of health (age ≈ 61)? Or not enough power?

→ **What could explain these gender differences and in particular the negative effect on depressive symptoms among women?**

- ✓ Effect of the reform on schooling duration and education credentials
- ✓ Effect of the reform on employment and wages

# Limited effect on educational attainment




**Intervening on schooling may not necessarily be the aspect of the educational experience that matters most for health**

# Conclusions

- Intervening on social circumstances over the life course to promote health makes '*common sense*' but the reality of interventions is often more complex.
- Causal inference helps us think about very specific questions that are highly policy relevant: When should we intervene? What should be our target? For how long should we intervene?
- Experimental and quasi-experimental approaches have key role to play to understand whether and how we can intervene on social circumstances to improve population health.
- Interdisciplinary approaches are essential