Life Expectancy and Human Capital Investments: Evidence from Maternal Mortality Declines

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Health → Life expectancy → Education

- Longer time horizon increases the value of investments that pay out over time
- Improvements in life expectancy increase the incentive to invest in education
  - Ben-Porath (1967), Kalemli-Ozcan, Ryder, and Weil (2000), Soares (2005), Murphy and Topel (2005)
- Cross-country evidence is mixed
  - Large effect: Shastry and Weil (2003), Lorentzen, McMillan, and Wacziarg (2005)
  - No effect: Acemoglu and Johnson (2006)

Contribution

- Question:

  What is the effect of life expectancy on educational investment?

- Obtain estimates that isolate life expectancy channel
  - Use declines in maternal mortality
  - Study Sri Lanka between 1946 and 1953

- Difference-in-difference-in-differences
  - Gender
  - Time
  - District

Motivation

- Interested in apportioning the benefits of health improvements into various channels
- Cost-benefit analysis of health interventions, e.g., targeting young versus old
- Test general hypothesis that people update subjective expectations

Why maternal mortality?

- Adult mortality
  - *Future* mortality risk at time of human capital investment
  - Early in adulthood, so averted death $\longrightarrow$ large gain in life expectancy
- Does not affect school-age morbidity (Miguel and Kremer (2004), Bleakley (2007))
- Salient (easily observed) cause of death
- Males serve as comparison group

Why Sri Lanka?

- Rapid decline in maternal mortality ratio (maternal deaths per 100 live births), or MMR
  - MMR in 1946 was 1.8%
  - MMR by 1953 had fallen to 0.5%
- Represents a large mortality improvement
  - Total fertility rate (lifetime births) was $\sim$5, so lifetime mortality risk of $\sim$9%
- Geographic variation within Sri Lanka in MMR decline
- Good data

Preview of results

- MMR declines led to a 1.5 year increase in female life expectancy

- MMR declines increased female literacy by 2.5%
  - 1 percentage point (ppt) from a base of 44 ppt

- MMR declines increased female education by 4.1%
  - 1 extra year of life $\Rightarrow$ 0.12 to 0.15 more years of schooling

- Elasticity of human capital with respect to life expectancy: 0.6 to 1.0

Outline

1. Conceptual framework
2. Background on MMR declines + data
3. Empirical results: Effect of MMR on
   - Life expectancy
   - Literacy and completed education
   - (Fertility)

Conceptual framework

- Goal: how do reductions in maternal mortality risk affect investment in education?
- Household maximizes expected income and makes 2 decisions
  - Whether to have a child (C_w)
  - Schooling of child (s_g, s_b for girl, boy)
- Probability of dying during childbirth, μ (at time τ; otherwise live until T)
  - Applies to mother + applies to daughter
- Return to schooling that accrue over time (γ)
- Assume no spillover effects on boys

Maximization problem

$$\max_{s_g,\, s_b,\, C_w} \left[Y_w(C_w) + Y_h + \frac{C_w}{2}(Y_b(s_b) + Y_g(s_g)) \right]$$

where

$$Y_w = (1 - C_w \boldsymbol{\mu}) \int_{\tau}^{T_w} e^{-\delta(t-\tau)} y e^{\gamma s_w} dt$$

$$Y_g = \int_{s_g}^{\tau} e^{-\delta t} y e^{\gamma s_g} dt + (1 - C_g \boldsymbol{\mu}) \int_{\tau}^{T_g} e^{-\delta t} y e^{\gamma s_g} dt$$

$$Y_h = \int_{\tau}^{T_h} e^{-\delta(t-\tau)} y e^{\gamma s_h} dt, \quad Y_b = \int_{s_b}^{T_b} e^{-\delta t} y e^{\gamma s_b} dt$$

- High μ raises cost and lowers benefit of mother's childbearing
- High μ lowers benefit of daughter's schooling

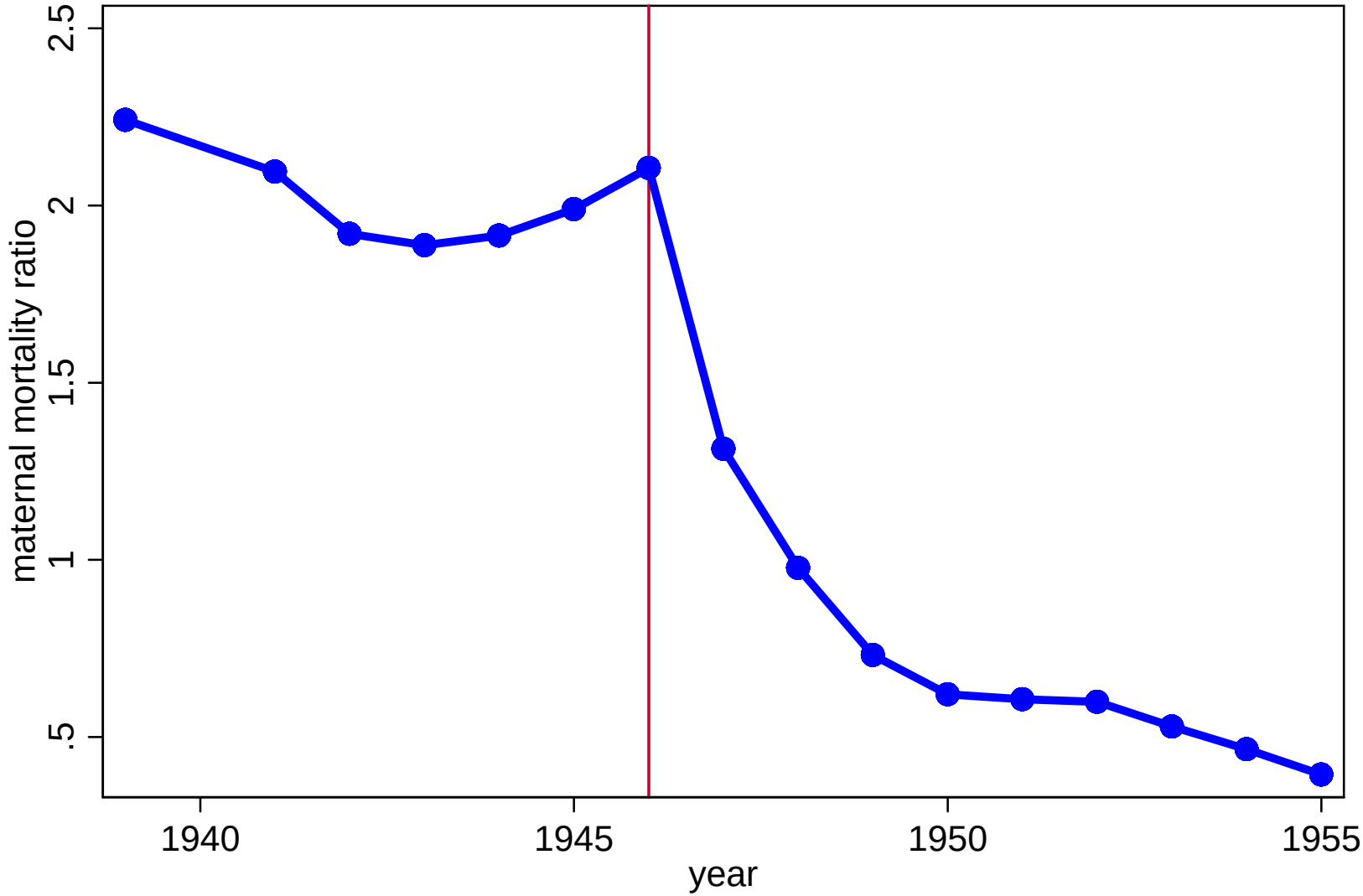
Predicted effects of maternal mortality risk

- Reduces the benefit of girls' schooling since shorter time horizon over which to earn returns
  - MMR declines $\rightarrow$ Increase in girls' education for young cohorts
- Raises cost of childbearing (chance of mother dying) and lowers benefit (daughter will have shorter life)
  - MMR declines $\rightarrow$ Increase in fertility

Background on MMR declines

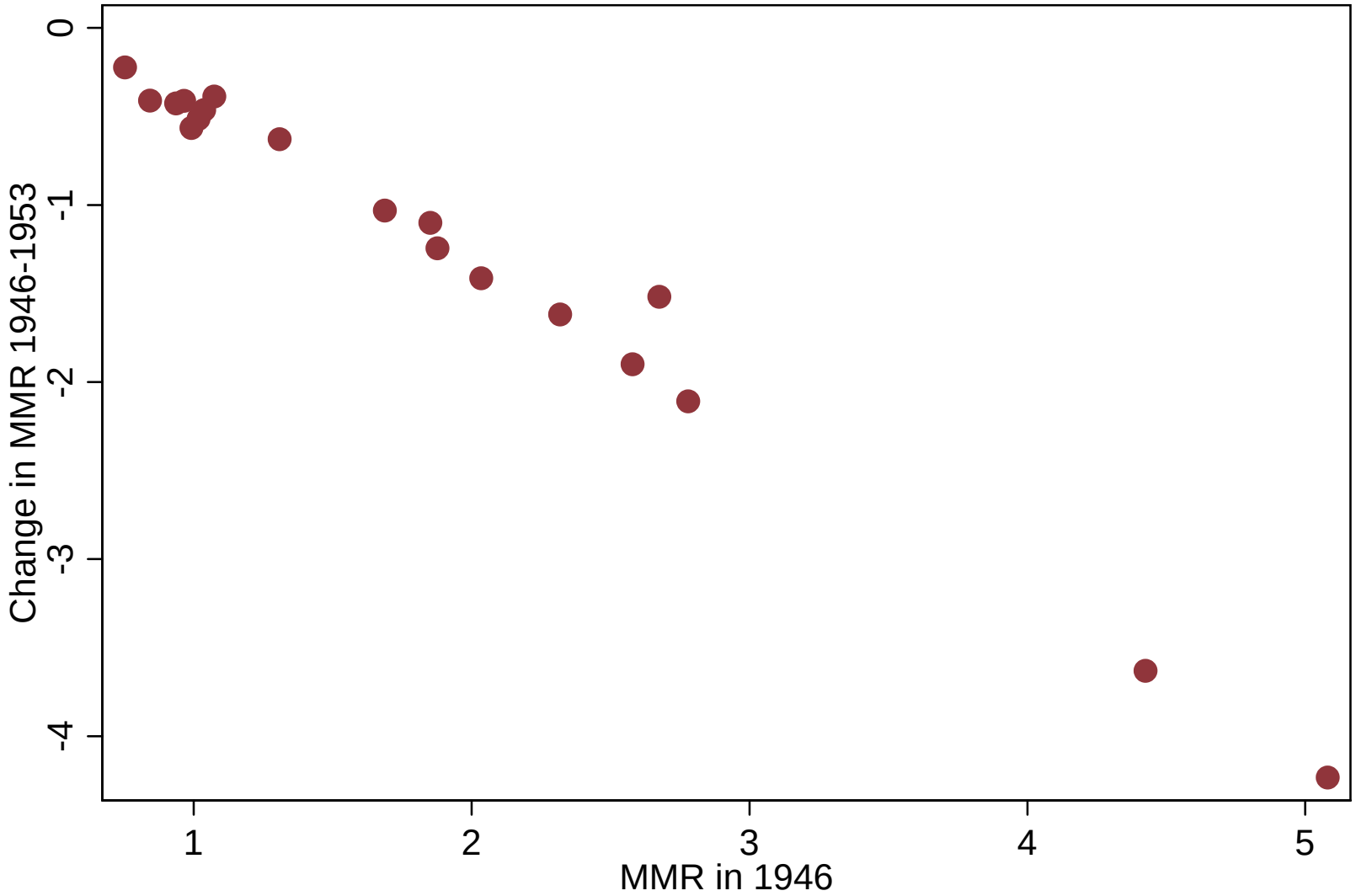
- Expansion of health care services, with focus on maternal and child health
  - Ambulances
  - Hospitals and health centers
  - Birth attendants
- New technologies (sulfa drugs, penicillin)
- Malaria eradication

Figure 3b: Maternal mortality for Sri Lanka, 1939-1955



Trend break in 1947 (with or without malaria years)

Figure 2: Declines in maternal mortality across districts



Other background information

- Returns to education for women
  - Labor mkt returns $\sim$7% (Psacharapoulos 1994)
  - Other returns: better husband, better children, control over fertility, etc.
- Other national changes occurred, e.g., independence, end of school fees
  - Identifying assumption is no gender-district-level effects correlated with MMR declines
- Malaria control and nutrition programs affect schooling
  - Affect both genders
  - Will control for these as robustness check

Data

- Vital statistics
  - Mortality by gender, 5-year age group, district, year
  - Maternal mortality ratio (not by age)
- Census of 1946 and 1953
  - Population
  - % Literate by age
  - School enrollment
- Census of 1971
  - Literacy
  - Completed education
  - District of birth

Limitations of data

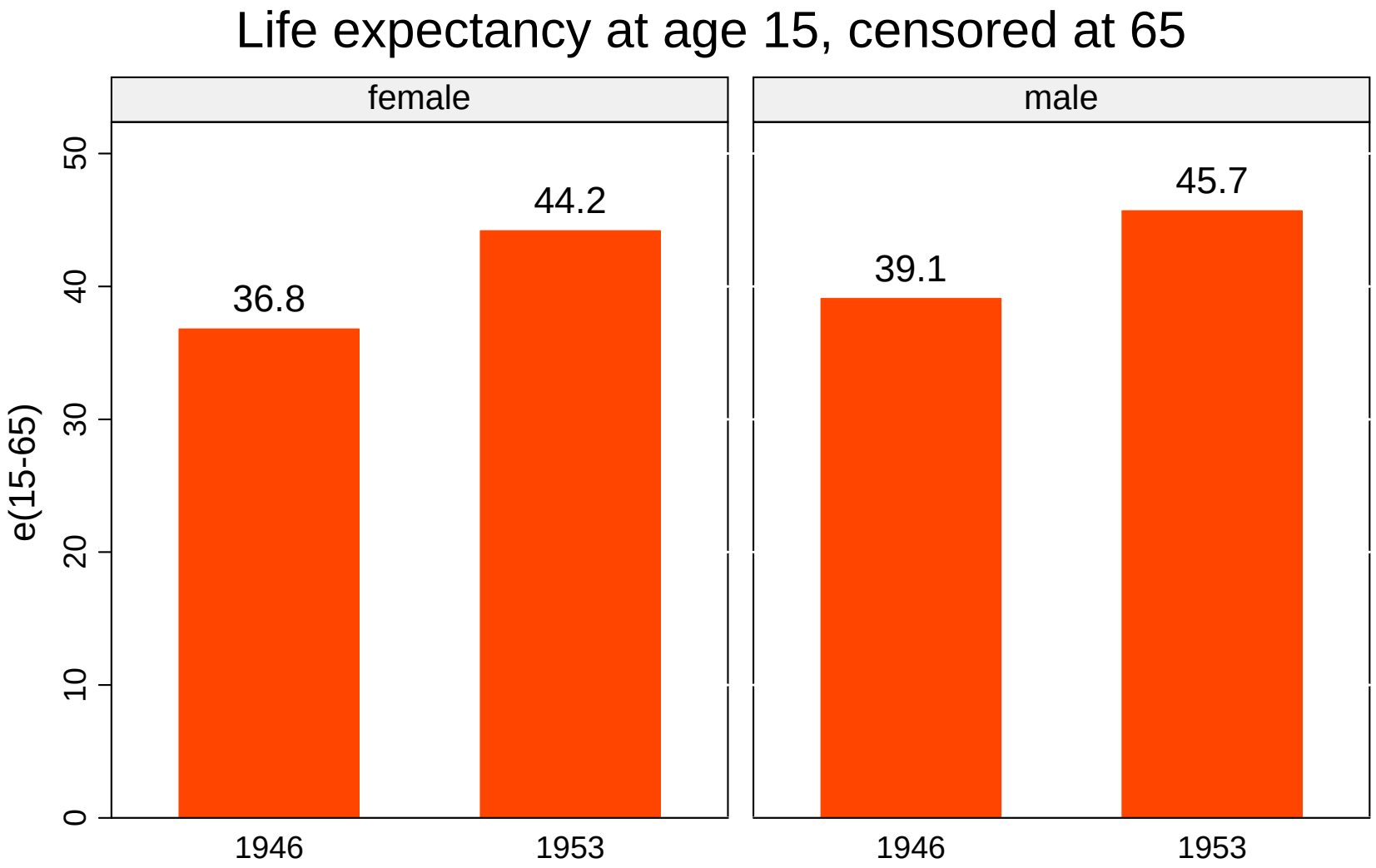
- No data on completed schooling in 1946 and 1953 census
- No district-level data on education or health infrastructure or utilization

Life expectancy measures

- Use mortality tables to calculate life expectancy
- Notation:

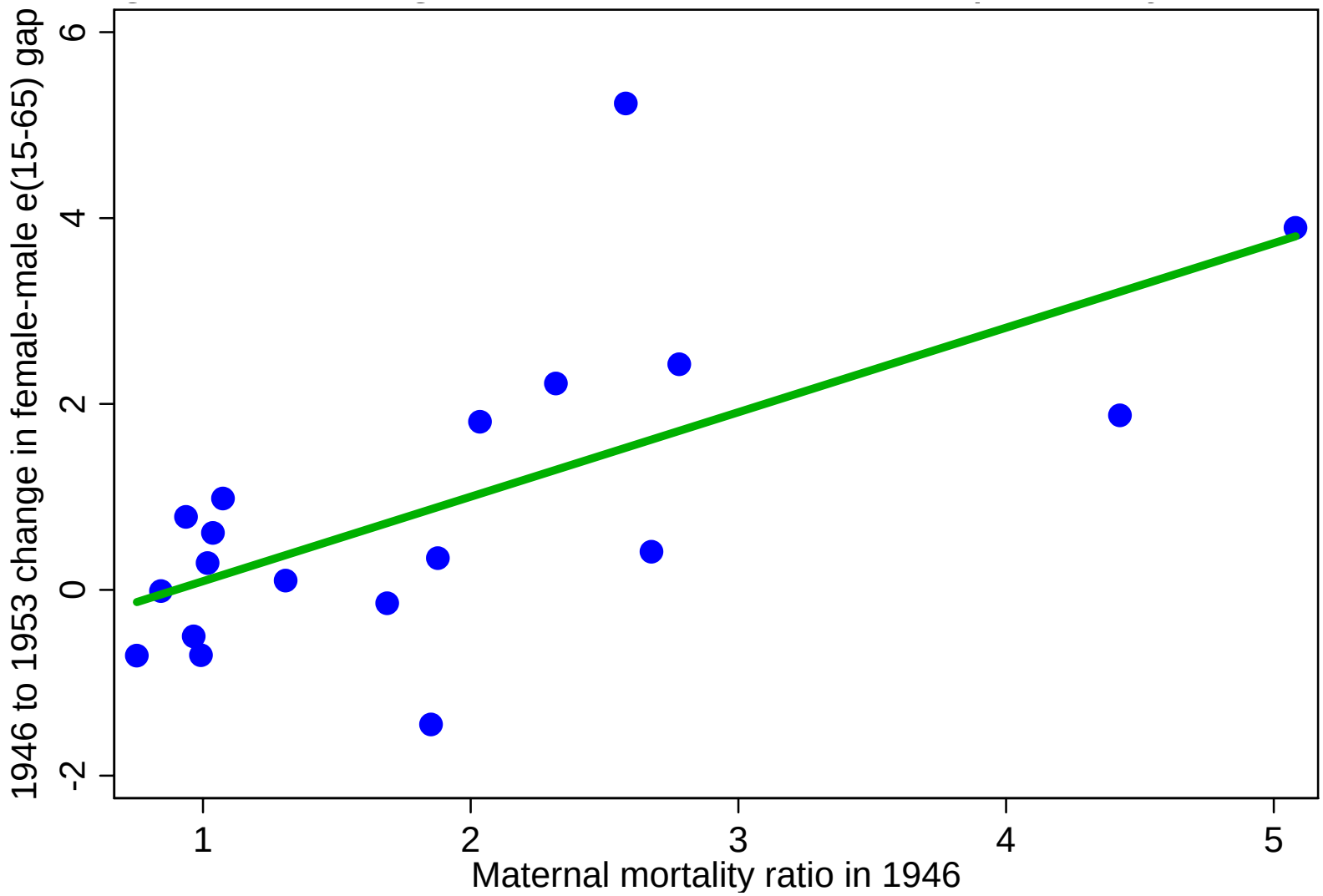
  e(15-65) is life expectancy, conditional on survival to 15 and censored at 65

- Use ages 15 to 65 as period over which returns to education mainly earned



Female e(15-65) rose by 7.4 years & male e(15-65) by 6.6 years

Changes in female-male life expectancy versus MMR



Life expectancy gains from MMR declines

- By how much did declines in MMR increase e(15-65) for females?

- Method 1: Calculate counterfactual life expectancy
  - In 1946, MMR was 26% of deaths for ages 15-45
  - Reduce this risk by 70% $\rightarrow$ 1.4 year gain in female e(15-65)

- Method 2: Regression
  - Fewer assumptions (about MMR by age, competing risks)
  - Probe omitted variable bias using other life expectancy measures

Empirical strategy: DDD

- Time, gender, district

$$e_{dgt} = \beta_1 \cdot MMR_{dt} \times female + \mu_{dg} + \gamma_{dt} + \nu_{gt} + \varepsilon_{dgt}$$

  N = 76 (19 districts × 2 genders × 2 years)

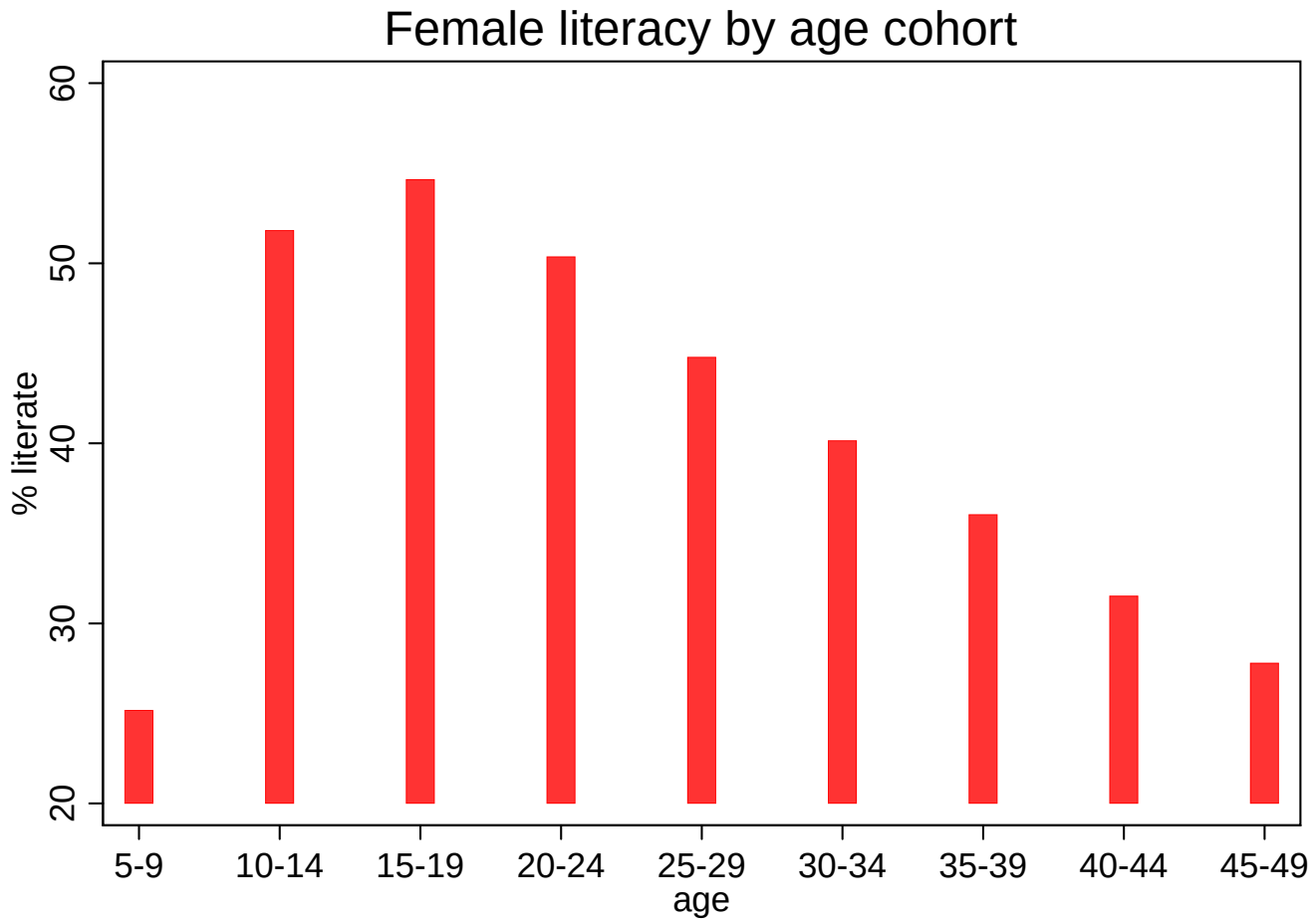
- Use 3-year running average for MMR (and other annual data) to reduce measurement error

- Control for gender-specific death rates for malaria & nutritional diseases (anemia, helminths, diarrhea, vitamin deficiencies)
  - Concern is school-age morbidity rates
  - Could be over-controlling

Effect of MMR on life expectancy

Dependent variable:	Basic	Add malaria death rates	Add nutritional diseases	Add nutritional diseases and malaria death rates
Δe(15-65)	-1.204***	-1.302***	-1.135***	-1.369***
ΔMMR*female	[0.198]	[0.307]	[0.181]	[0.444]
Δe(45-65)	0.054	-0.033	0.115	-0.041
ΔMMR*female	[0.089]	[0.120]	[0.090]	[0.204]
Δe(0-15)	-0.088*	-0.081	-0.072**	-0.022
ΔMMR*female	[0.050]	[0.065]	[0.031]	[0.050]
ΔIMR	0.133	0.081	0.306*	0.228
ΔMMR*female	[0.164]	[0.192]	[0.159]	[0.247]

Up to what age do people become literate?



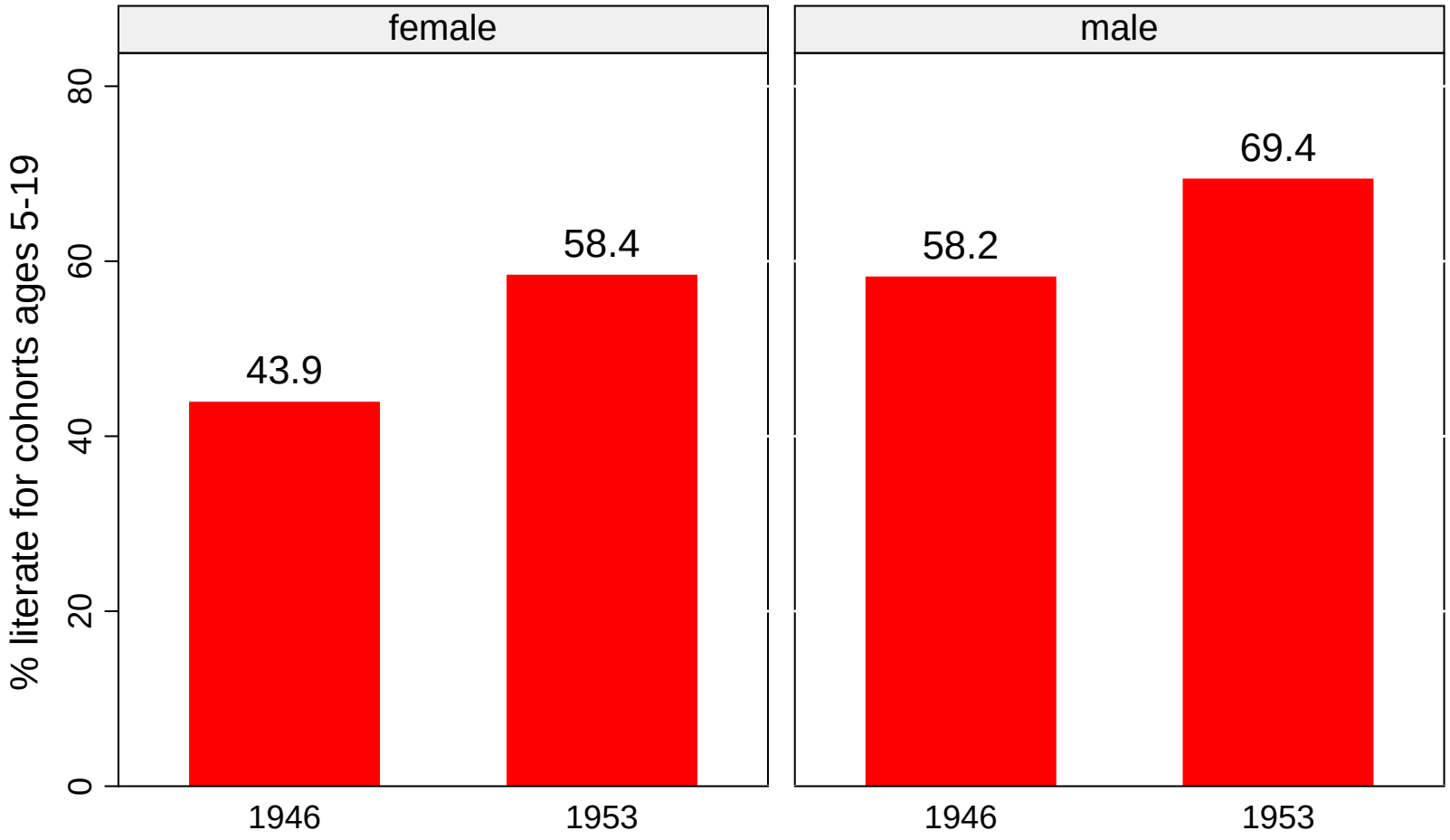
Age effects: literacy $\uparrow$ across age cohorts

Birth cohort effects: literacy $\downarrow$ across age cohorts

Literacy as outcome

- Use age 5-19 years as treated group
- If age 19 when outcomes observed in 1953, you were age 13 when MMR decline began in 1947
- Almost no childbearing among those age 15-19 in 1953 (age 8-12 in 1946)

% literate among treated age cohorts



Female literacy rose by 14.5 ppts & male lit. rose by 11.2 ppts

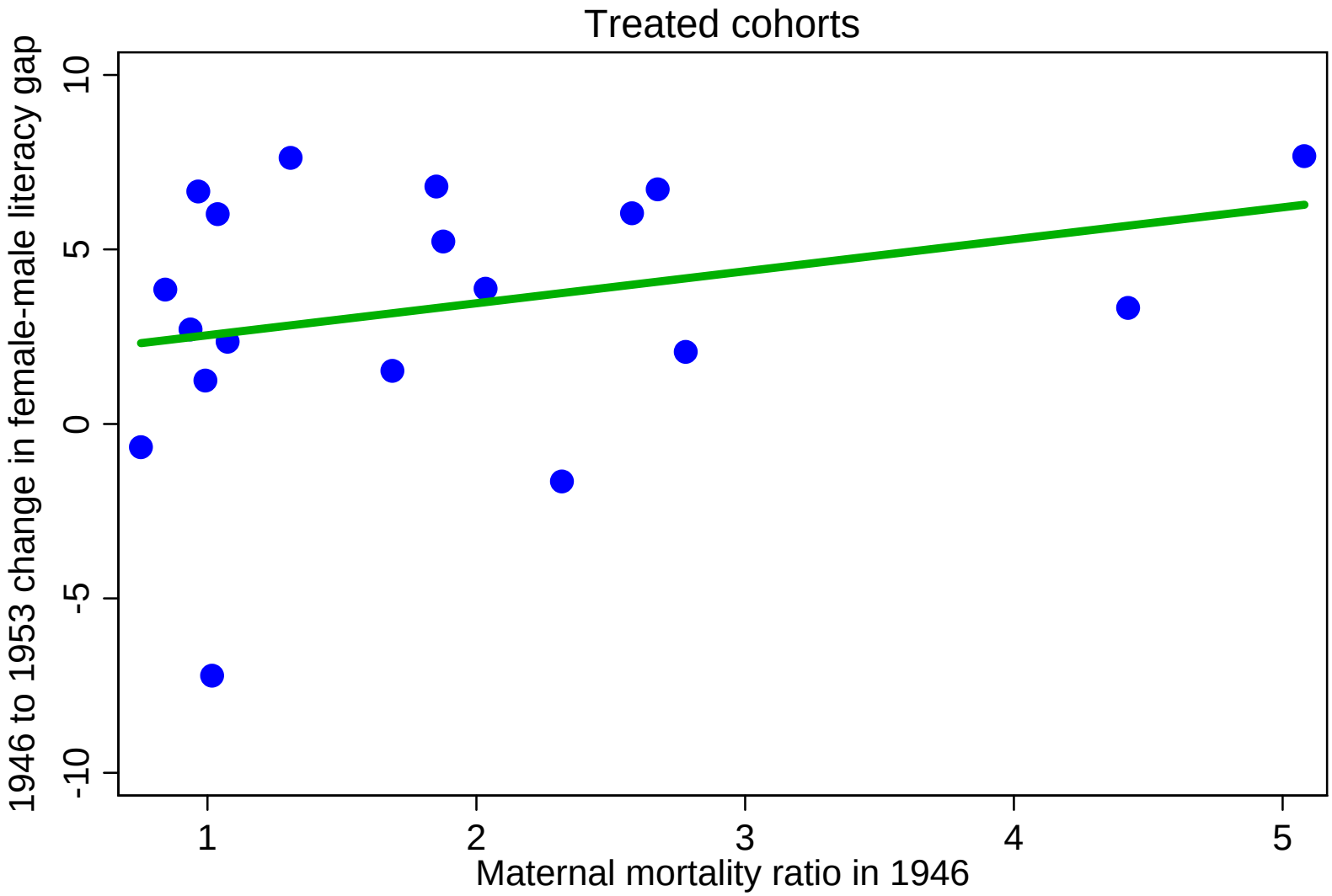
Estimating equation for literacy

- Behavior unlikely to respond instantly; use 3-year lagged MMR

$$lit_{adgt} = \beta_1 \cdot LaggedMMR_{dt} \times female_g + \mu_{dg} + \gamma_{dt} + \nu_{gt} + \varepsilon_{adgt}$$

- a is 5-year age group; also include dummies for age interacted with district, gender, and time
- Obsns in regression are for treated ages, eg, 5-9, 10-14, 15-19, so N $=$ 19 districts $\times$ 2 genders $\times$ 2 years $\times$ 3 age groups
- Cluster on district-gender
- As placebo test, will repeat using older cohorts whose literacy was predetermined

Changes in female-male literacy versus MMR



Effect of MMR on literacy

	Basic	Add nutritional diseases & malaria death rates	1946 level as IV for 1946-53 drop
Ages 5-19 (treated group)			
	-0.879*	-1.652**	-1.008**
lagged MMR*female	[0.453]	[0.656]	[0.470]
Placebo test: Ages 25-44			
	-0.151	0.273	-0.149
lagged MMR*female	[0.469]	[0.450]	[0.476]

Magnitudes

- MMR declined by 1.3 points during 1946-53
- Increased female literacy by 1.1 percentage point, or 2.5%
- 1/3 of relative gains in literacy for females over period
- Elasticity of literacy with respect to e(15-65) = 0.6
  - MMR led to 1.5 year increase in female e(15-65), or 4.1%

School enrollment

	Basic	Add nutritional diseases & malaria death rates	1946 level as IV for 1946-53 drop
% in school (ages 5 to 24)			
lagged MMR*female	-0.904*	-0.686	-0.979**
	[0.458]	[0.995]	[0.460]

0.9 % increase in probability of attending school $\times$ 20 years $=$ .18 years of schooling, corresponding to 1.2 extra years of life

Threats to validity

- Labor demand effect, e.g., demand for midwives
  - Estimated effect is that 16,500 extra girls became literate
  - Increase from 400 to about 900 midwives
- Less developed districts just catching up on all fronts
  - Placebo test on older cohorts: there were no pre-trends
  - 1946 MMR not correlated with 1946 gender gap in literacy

Threats to validity (continued)

- Effect of MMR on girls' literacy due to to fewer orphan girls
  - Take extreme case: every orphaned girl is illiterate, and no effect of maternal death on boys
  - Much smaller effect size than estimated effect
- Girls freed up from home production when family members are healthier

Estimates with 1971 Census

- Advantages
  - Completed years of schooling
  - District of birth
- Disadvantages
  - Attrition
  - Missing schooling data (correlated with MMR)
  - No before-after data; use older cohorts as comparison group
- Assign older cohorts the 1953 level of MMR in their birth district and young cohorts (5-19 in 1953) the 1953 level

$$educ_{adg} = \beta \cdot MMR_{da} \times female_g + \lambda_{ad} + \theta_{ag} + \gamma_{dg} + \varepsilon_{adg}$$

Attrition and missing data in 1971 Census

Dependent variable:	Survival rate (cell size in 1971/ cell size in 1953)		Education missing in 1971	
lagged MMR*female	0.0106	0.0127	0.0246**	0.0195**
	[0.0137]	[0.0131]	[0.0076]	[0.0078]
Literacy in 1953		0.0007		-0.0019**
		[0.0015]		[0.0007]

Education results with 1971 Census

Dependent variable	Literate	Years of education		
Model	OLS	OLS	Heckman selection correction	
lagged MMR*female	-2.711**	0.016	-0.133**	-0.132**
	[0.8437]	[0.028]	[0.057]	[0.057]
Excluded variables	n/a	n/a	District of 1971 residence dummies	District of residence missing, ethnicity missing & religion missing

Magnitudes

- MMR declined by 1.3 points during 1946-53
- Increased female education by 0.17 years, or 4.1%
- Elasticity of education with respect to e(15-65) = 1.0

Effects on birth rate

- No third difference of gender

$$birthrate_{dt} = \beta_0 + \beta_1 \cdot LaggedMMR_{dt} + \gamma_t + \delta_d + \upsilon_{dt}$$

- Control for changes in male e(0-65)
- Same programs that reduced MMR also affected infant mortality

Effect of MMR on birth rate

	DD with male e(0-65) as control	+ malaria & nutritional death rates	+ lagged IMR
Dependent variable: Birth rate			
lagged MMR	-5.15*	-4.43*	-4.34
	[2.55]	[2.45]	[2.67]

Avg birth rate in 1946: 179 births per 1000 women ages 15-45

MMR decline over 1946-53 led to 4% increase in birth rate
(explains 1/3 of increase in fertility over period)

Conclusions

- Human capital is responsive to longevity
  - Elasticity of literacy with respect to life expectancy is 0.6
  - 1 extra year of life $\Rightarrow$ 0.12 to 0.15 more years of schooling
- For cost-benefit analysis of policies to improve health, incentive effects on investment are an important component
- Recent longevity declines in many countries (HIV, war) have an added deleterious effect of dampening incentive to invest

Implications for HIV/AIDS in Africa

- How much does mortality risk from HIV/AIDS depress educational attainment?
- S. Africa today: 40% of deaths ages 15-49 are AIDS related
- Implies that AIDS has reduced e(15-65) by 3 years or 10%
- Elasticity of human capital w.r.t. e(15-65) of 0.6 to 1.0 $\Rightarrow$

  6% to 10% decline in education, or 0.3 to 0.5 yrs
- If return to education is 5% $\Rightarrow$

  1.5% to 2.5% reduction in income

Extra slides

Figure 8: Relationship between maternal mortality and literacy gender gaps in 1946

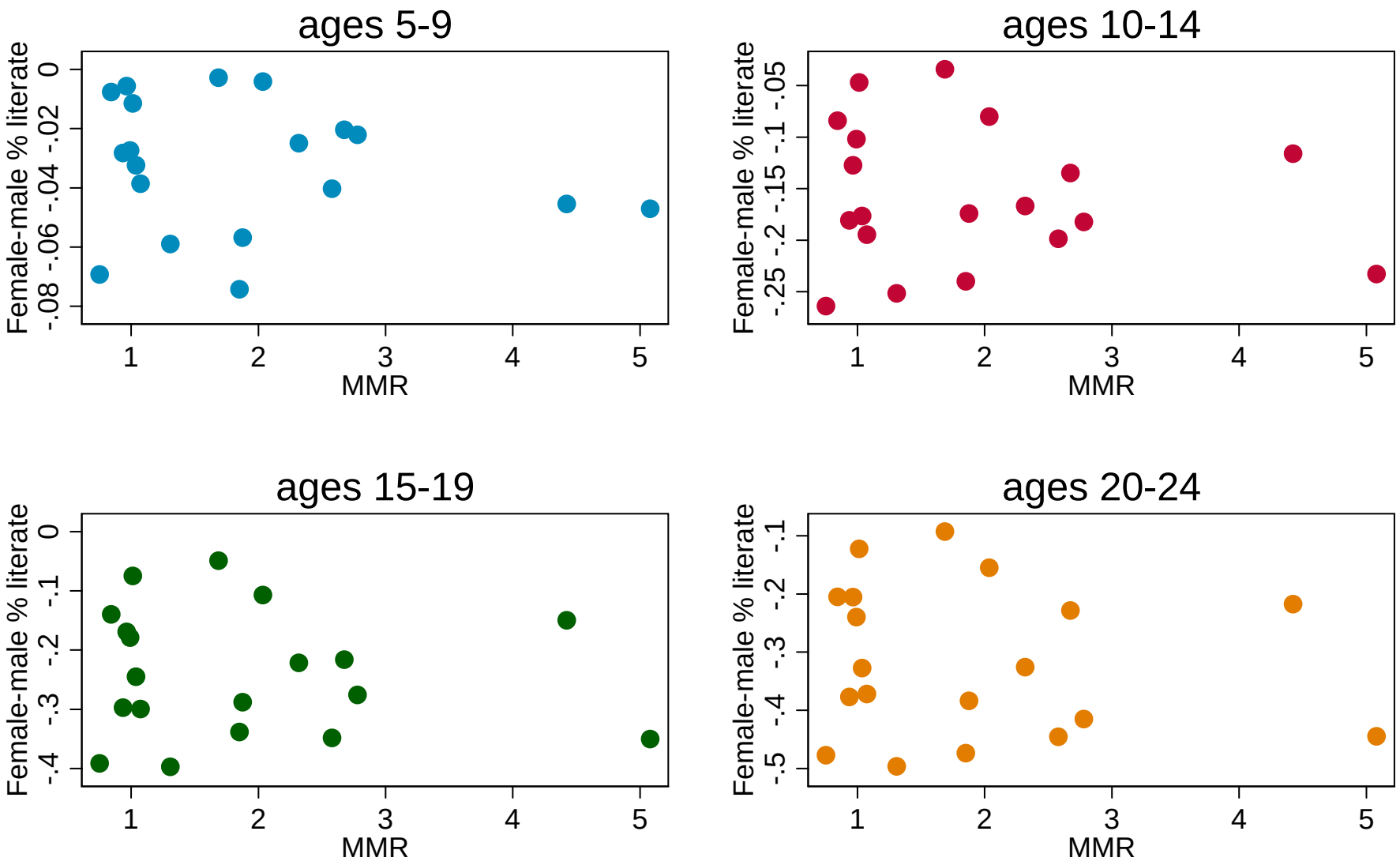


Figure 6: Birth rate and excess female mortality by age

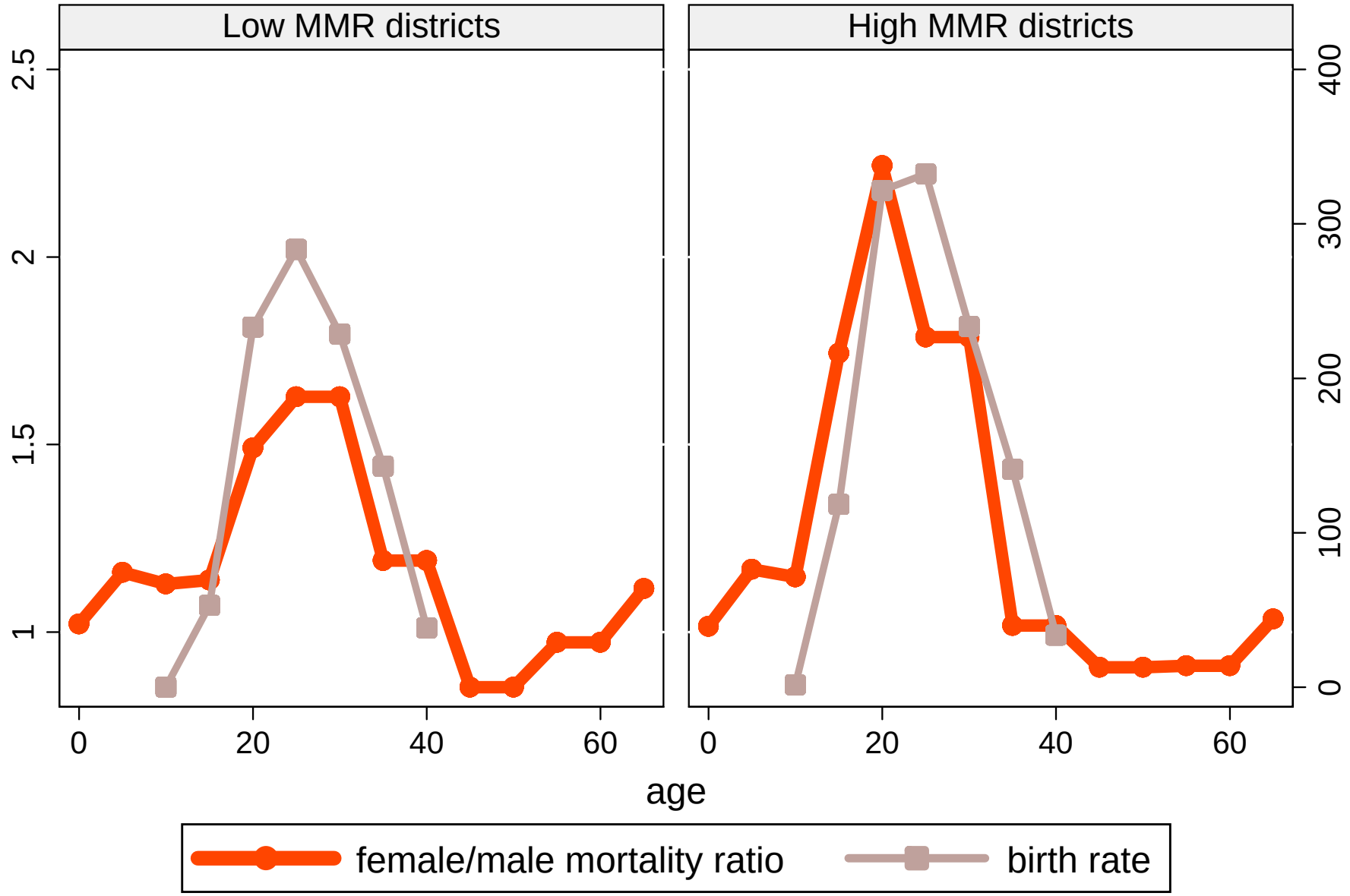


Figure 1: Expansion of health services in Sri Lanka

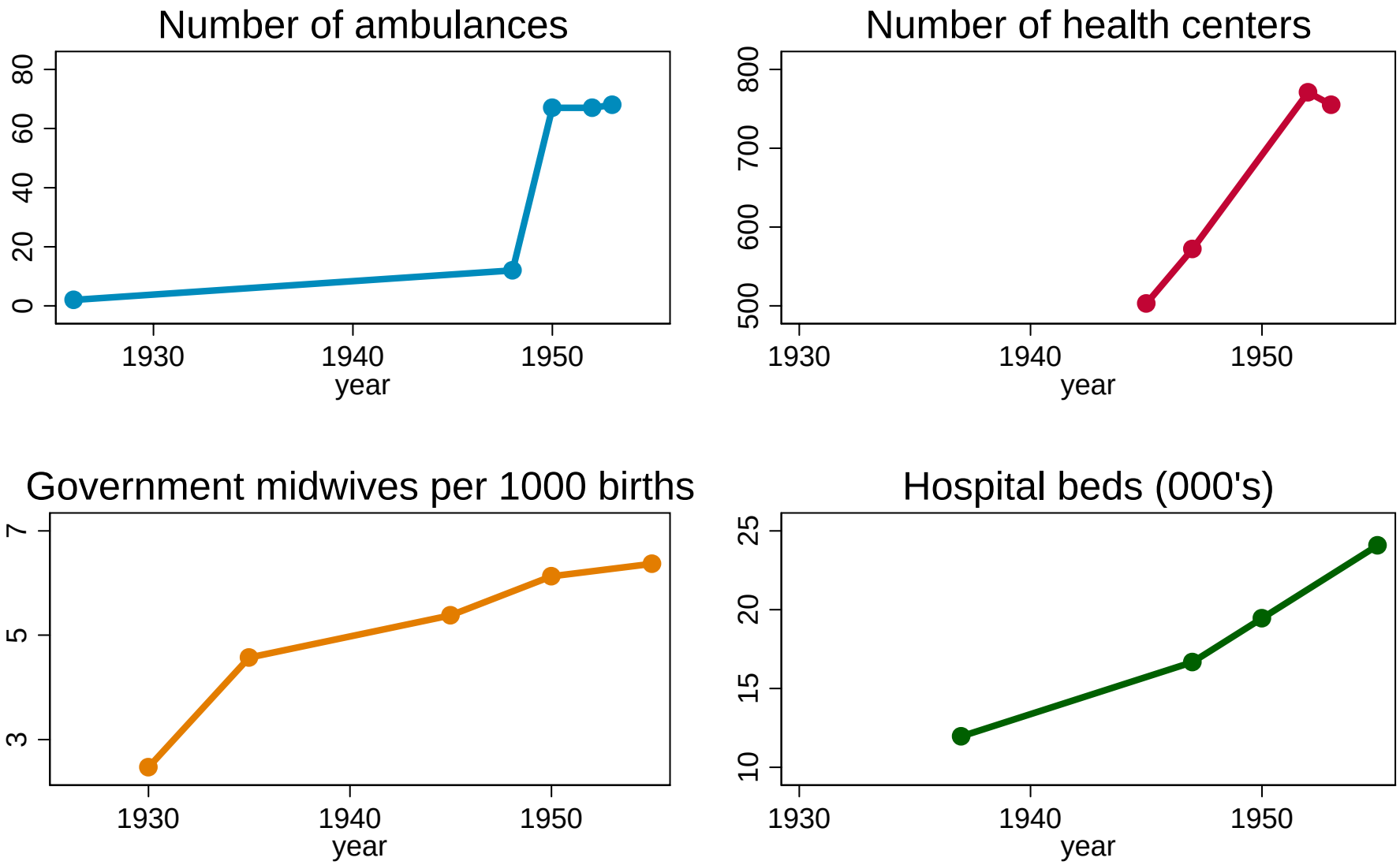
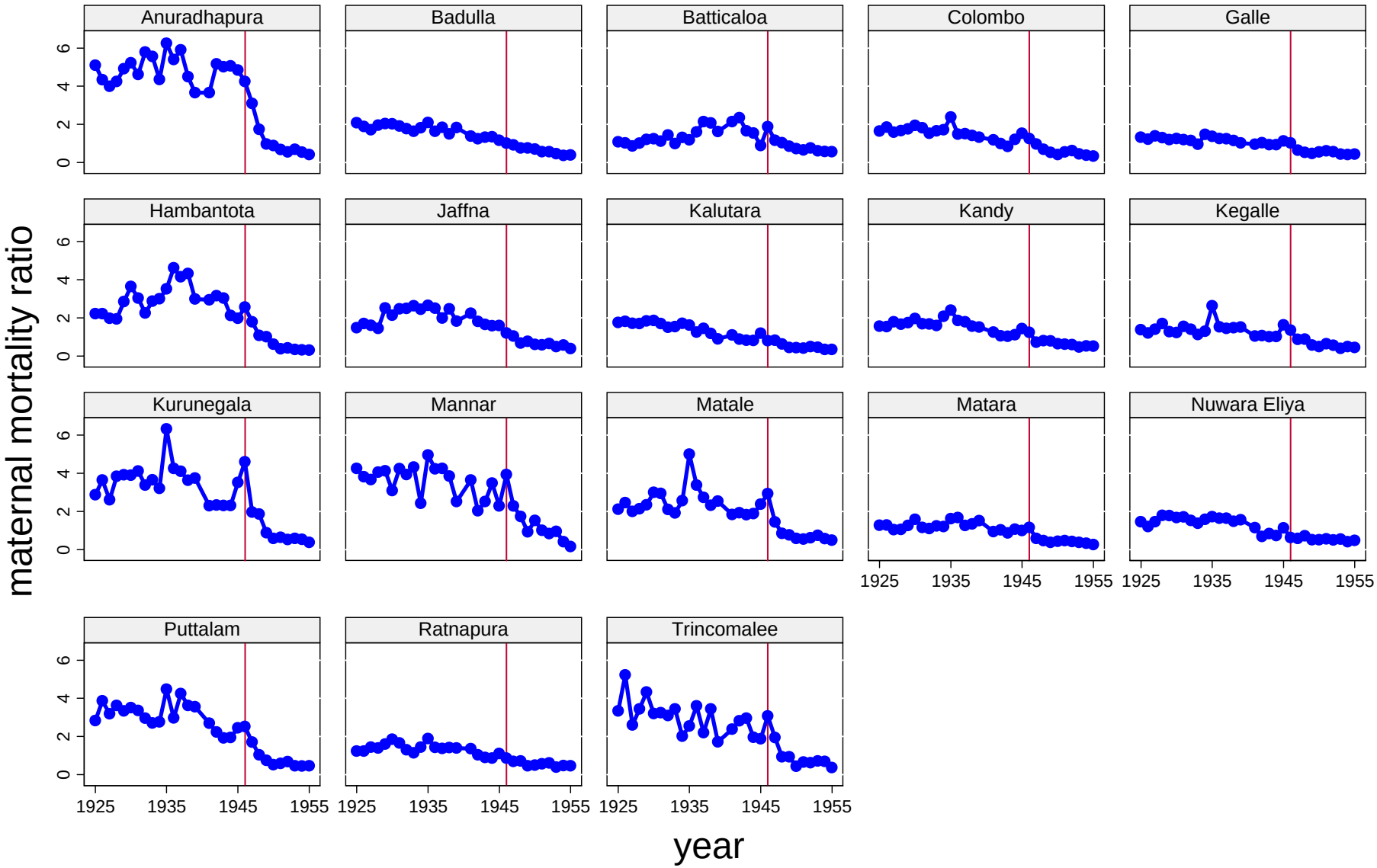


Figure 3a: Maternal mortality by district, 1925-1955



Graphs by district