

Estimating and Projecting Disparities in Pre- and Post-natal Survival using Bayesian Methods

Fengqing Chao

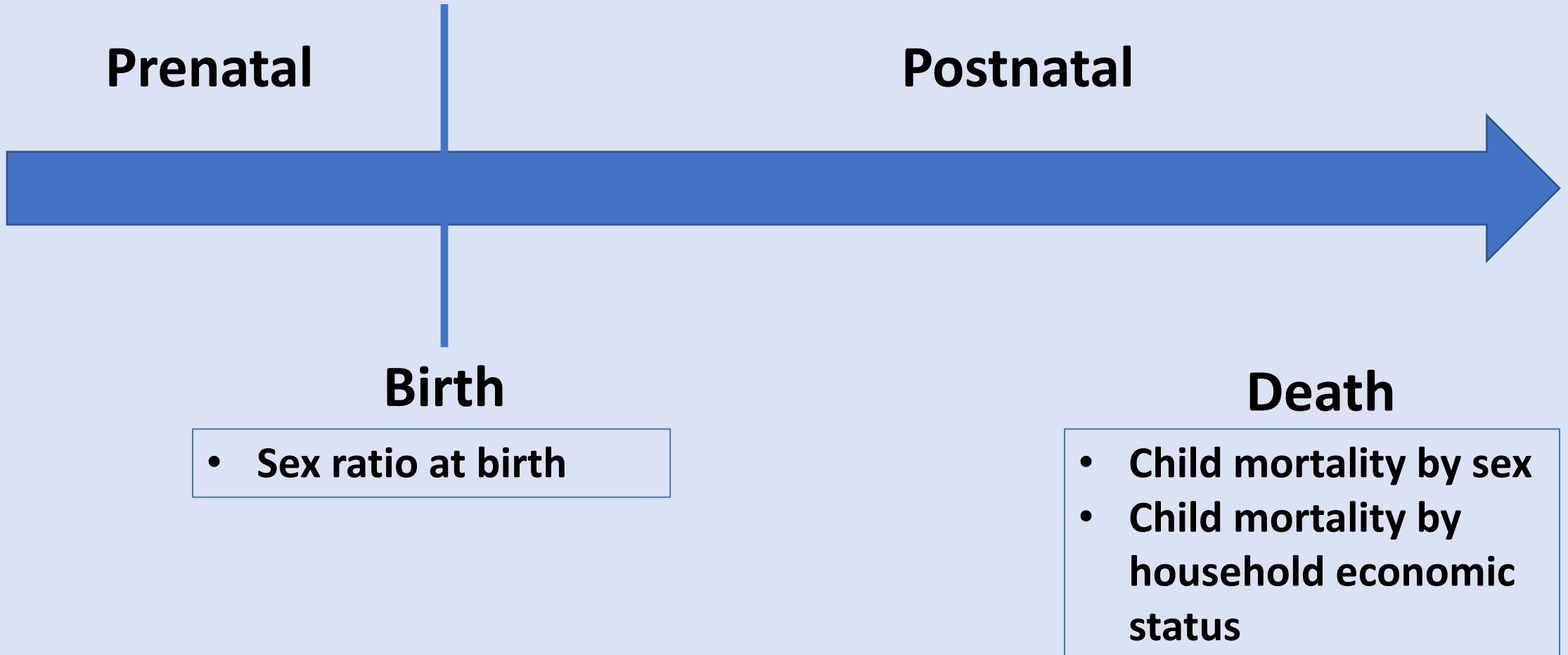
Research Talk (virtual), Yale-NUS College

Dec 14th, 2020

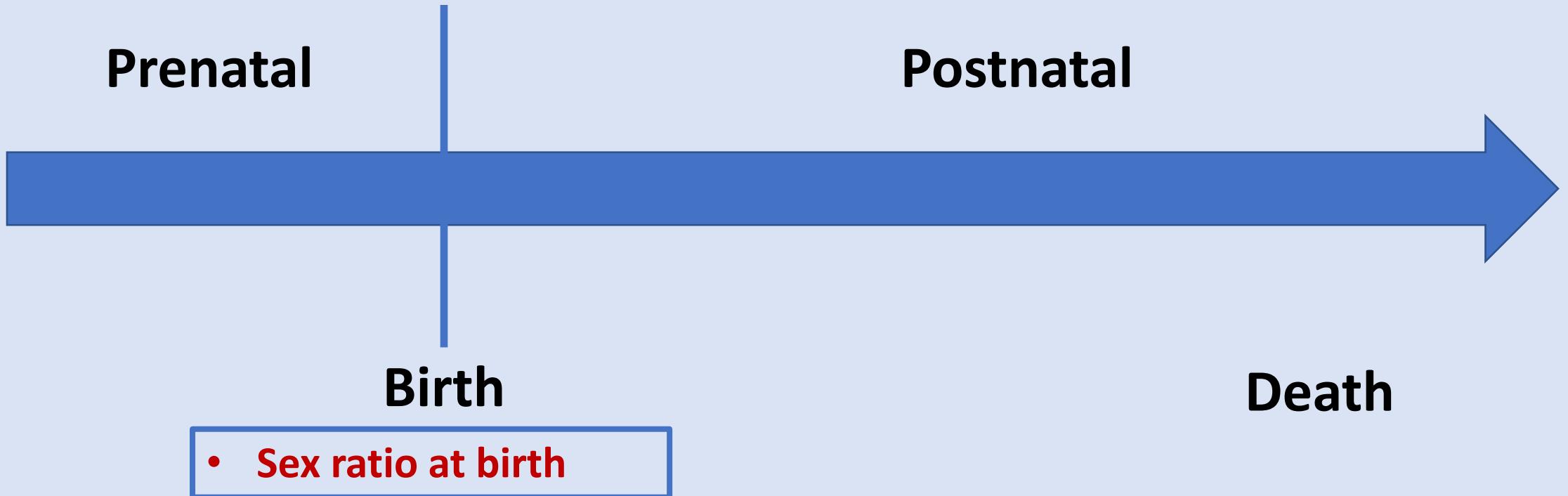
Research Areas

- Statistical approaches: Bayesian methods, regression, time series
- Demography
- Global health

Current Research: Disparity in Prenatal and Postnatal Survival



A Boy or a Girl? Sex Ratio at Birth and Prenatal Sex Discrimination

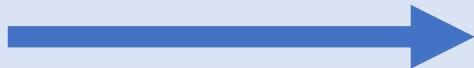


Sex Ratio at Birth (SRB) - It is Not 50/50

Naturally

100
Female
Births

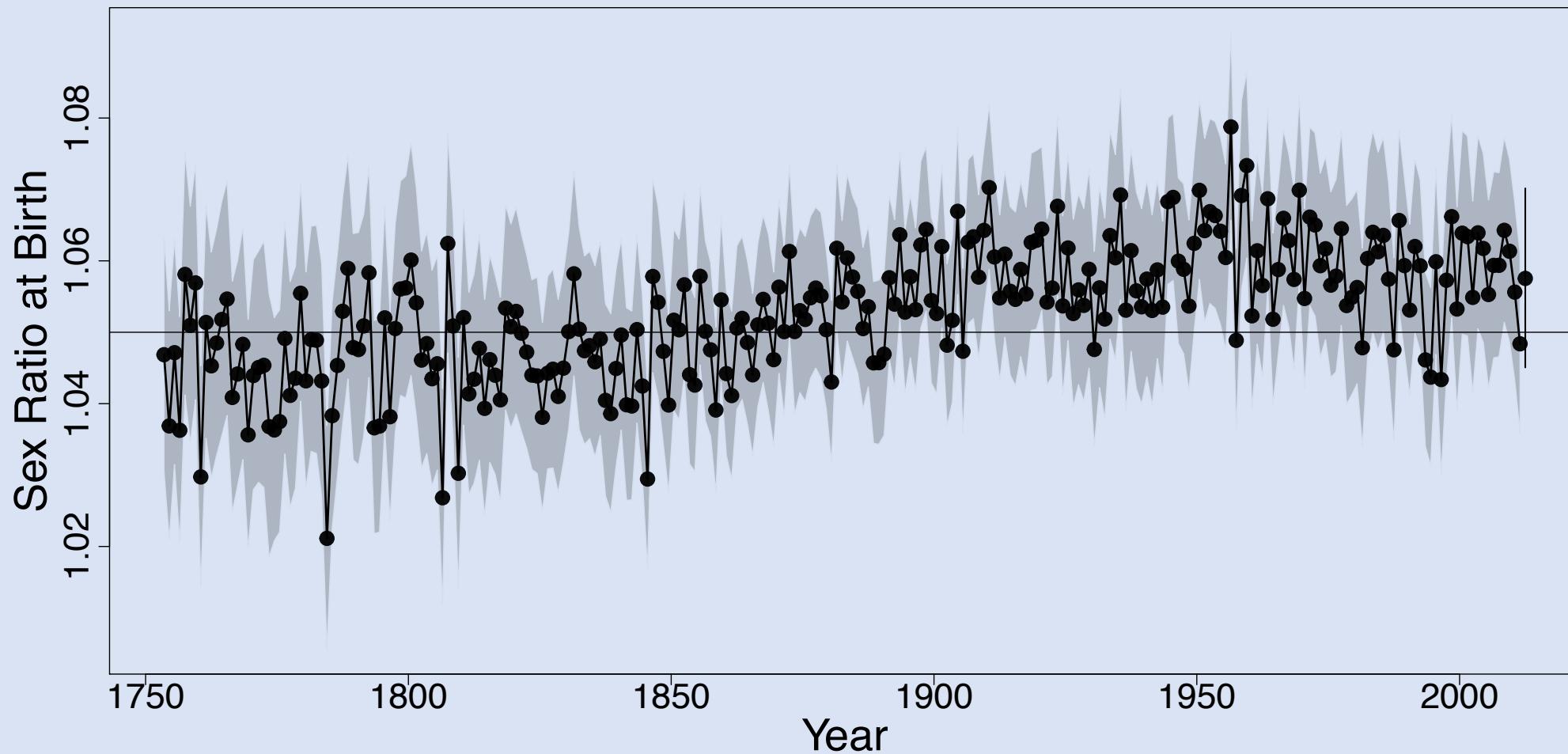
103~107
Male
Births



SRB = Boys/Girls
1.03~1.07

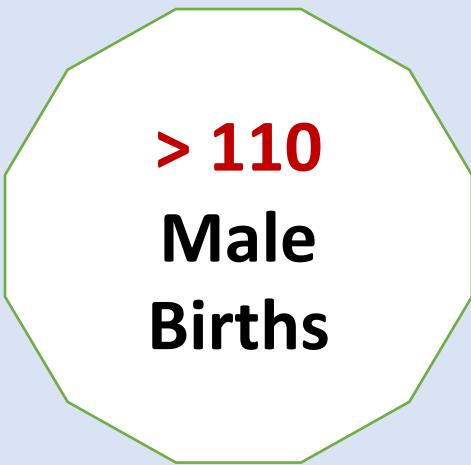
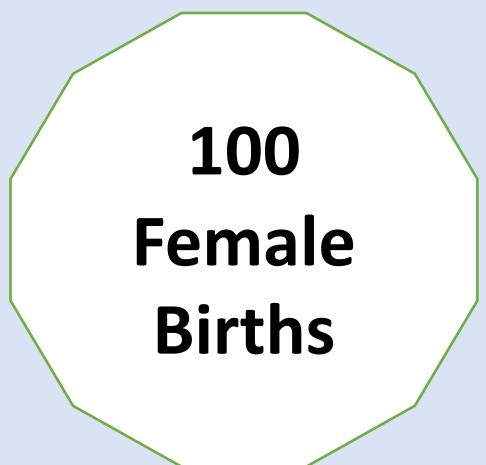
Natural SRB 1.03~1.07

Sweden



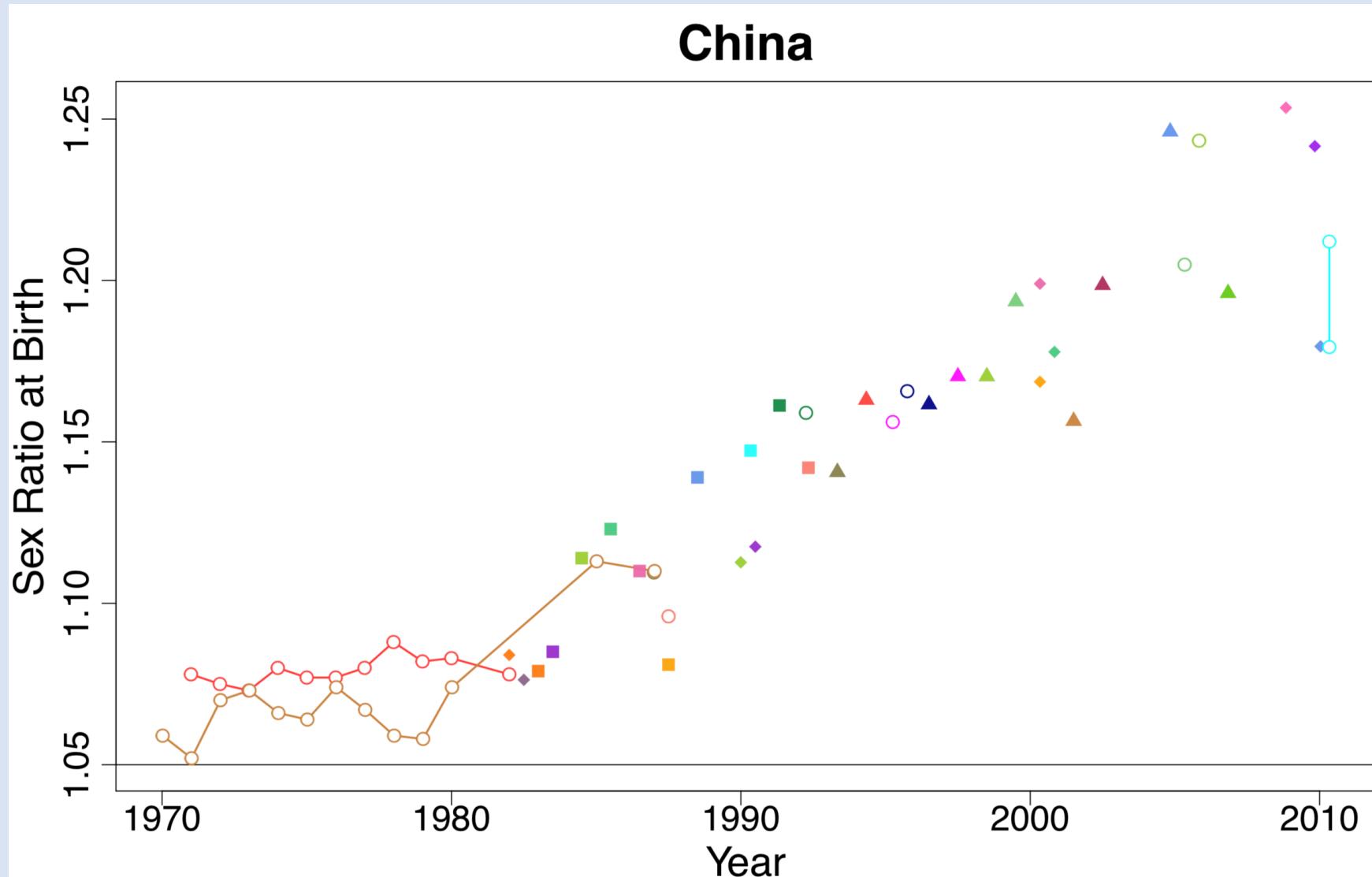
Inflated SRB in Some Countries

In reality,
in some countries



SRB:
>1.10

Inflated SRB in Some Countries



Sex Ratio at Birth (SRB) – Why the Inflation?

Naturally



100
Female
Births

**SRB = boys/girls
1.03~1.07**

Willingness
Son preference

Necessary
Fertility decline

Means
Abortion + Sex
detection

**Sex-selective
abortion**

In reality,
in some countries

103~107
Male
Births

<94
Female
Births

**Missing
female
birth**

**SRB:
>1.10**

Sex Ratio at Birth (SRB) – A Distorted Reality

- Serious social consequences with

prolonged distorted SRB:

- Human trafficking
- Marriage squeeze
- Violation of human right

• Breaks population sex balance at the beginning of the life course:

- Missing female births due to sex selection



40,800 female births doomed in Vietnam every year

By Minh Nga July 19, 2020 | 05:24 pm GMT+7



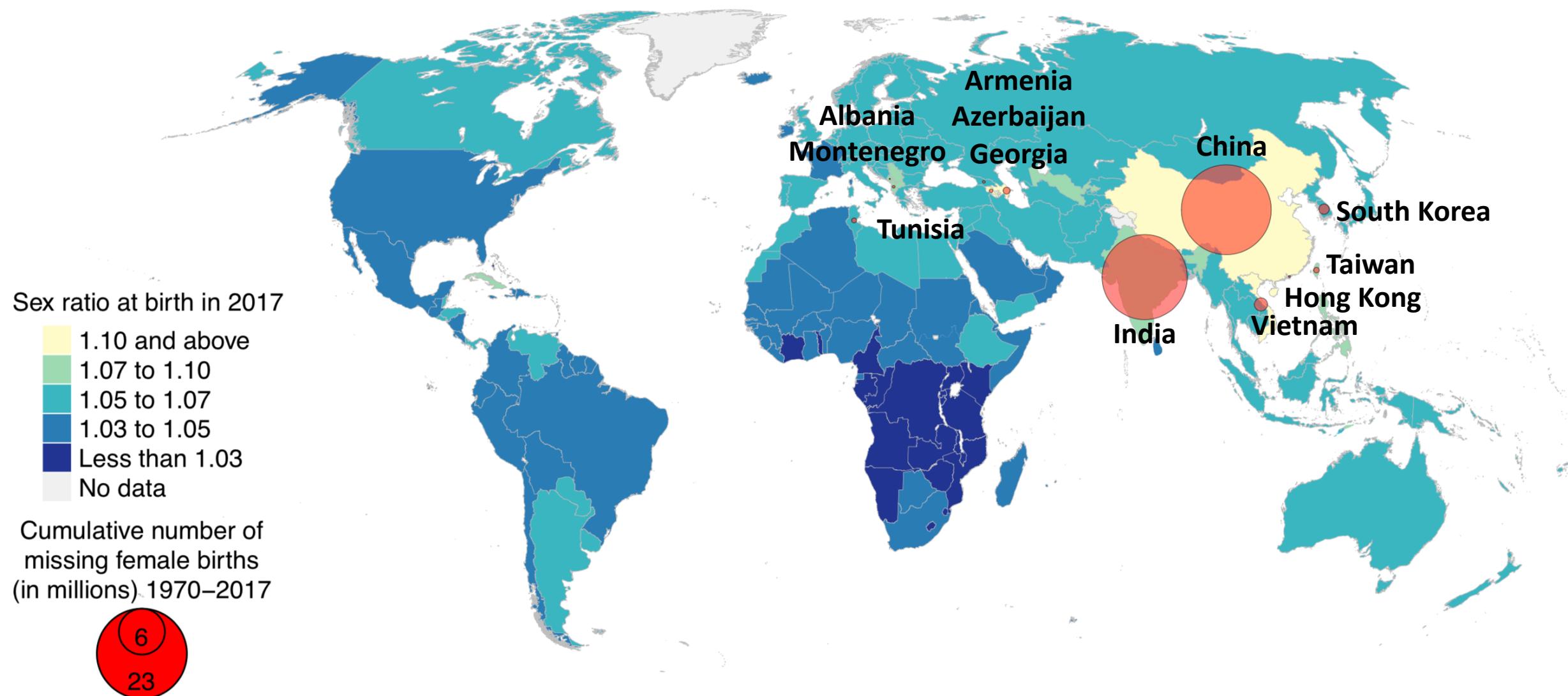
Why many Indian and Chinese men may need to delay marriage or remain bachelors

Radheshyam Jadhav | Pune | Updated on July 01, 2020 | Published on July 01, 2020

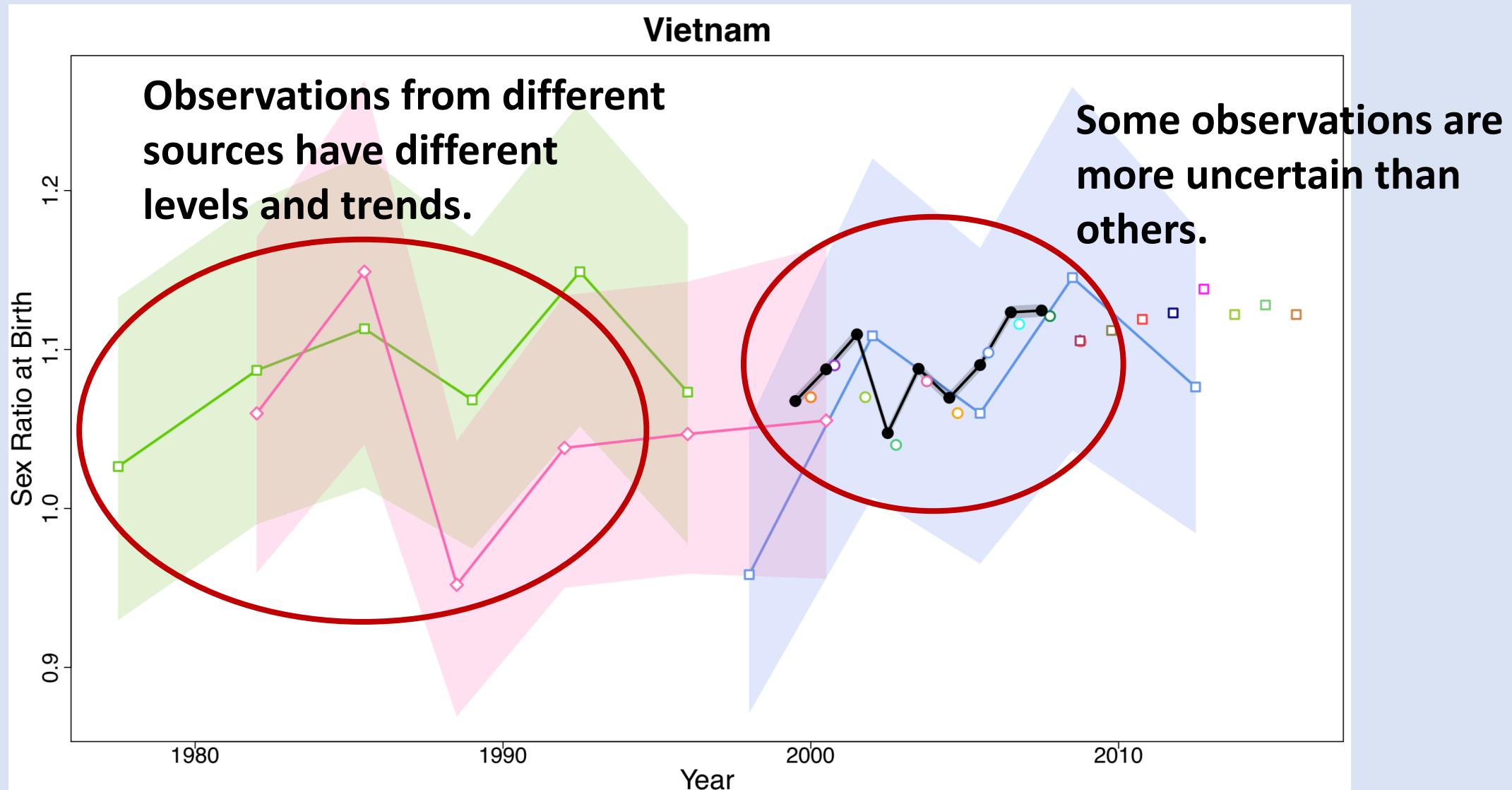
Sources: Three women (2020), from [The Conversation](#). 40,800 female births (2020), from [VNExpress](#).

Why many Indian and Chinese men (2020), from [The Hindu Business Line](#).

45 Million Missing Female Births during 1970-2017



Data Model for SRB – Motivations



Data Model for SRB

Accounts for uncertainty associated with observations

$$\log(y_i) \sim N(\log(\Theta_{c[i],t[i]}), \omega_{s[i]}^2 + v_i^2)$$

Index $c[i], t[i]$: country, year
for the i -th observation

y_i : i -th SRB
observation

True SRB

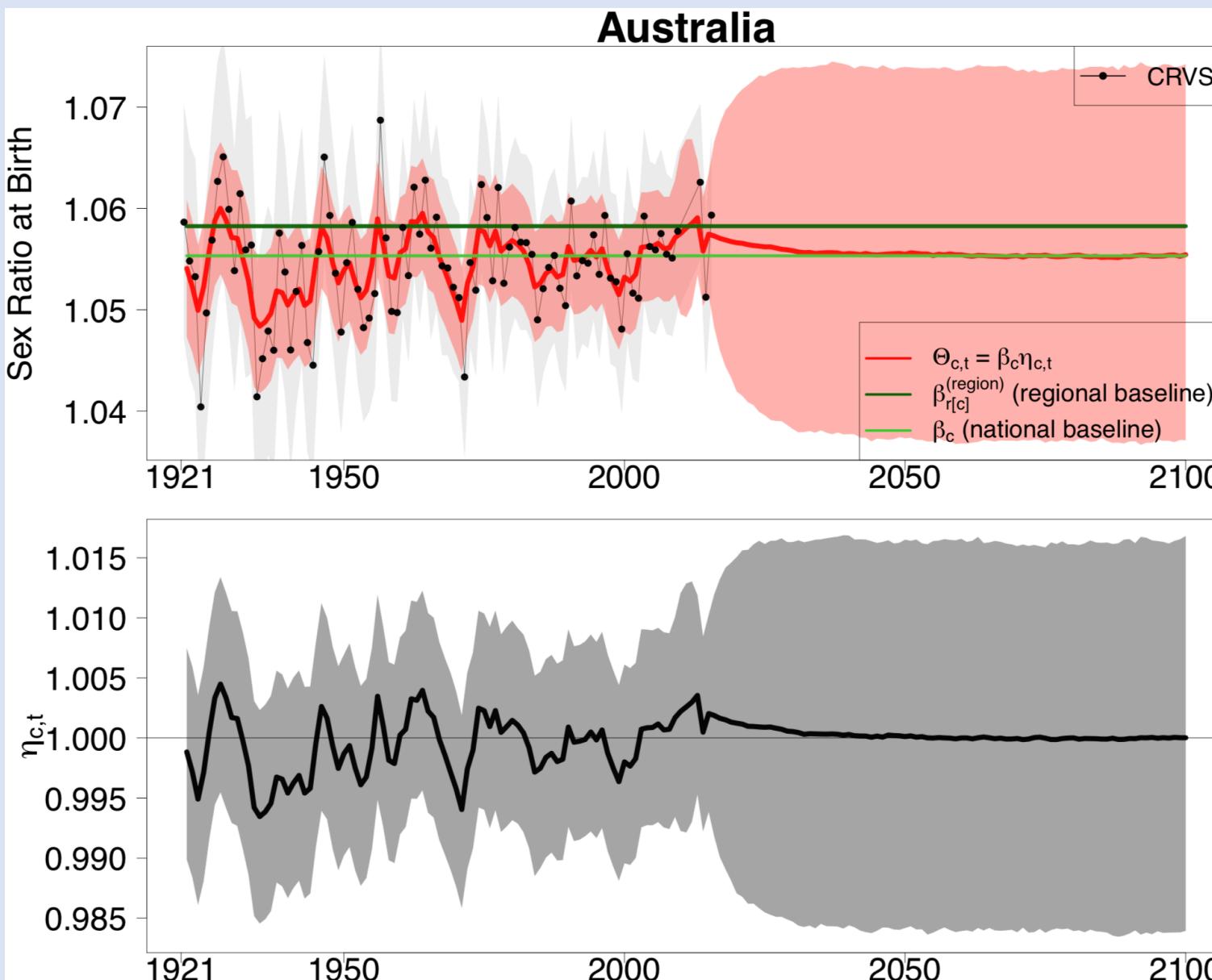
- ω_s^2 : Non-sampling error variance, e.g. non-response, data input error
- Index s : data source types, e.g. administrative records, survey, census

Sampling error variance due to sampling design, pre-computed

Bayesian Hierarchical Model for SRB

- Baseline model: for countries/areas without SRB inflation;
- Inflation model: for selected countries/areas with past/current/potential future SRB inflation.

Baseline Model Overview



$$\Theta_{c,t} = \beta_c \eta_{c,t}$$

Index c : country
Index t : time, year

- β_c is country-specific baseline:
 - Constant within country
 - Differ across countries within a region
- $\eta_{c,t}$ is year-by-year natural fluctuation:
 - An autoregressive AR(1) time series process

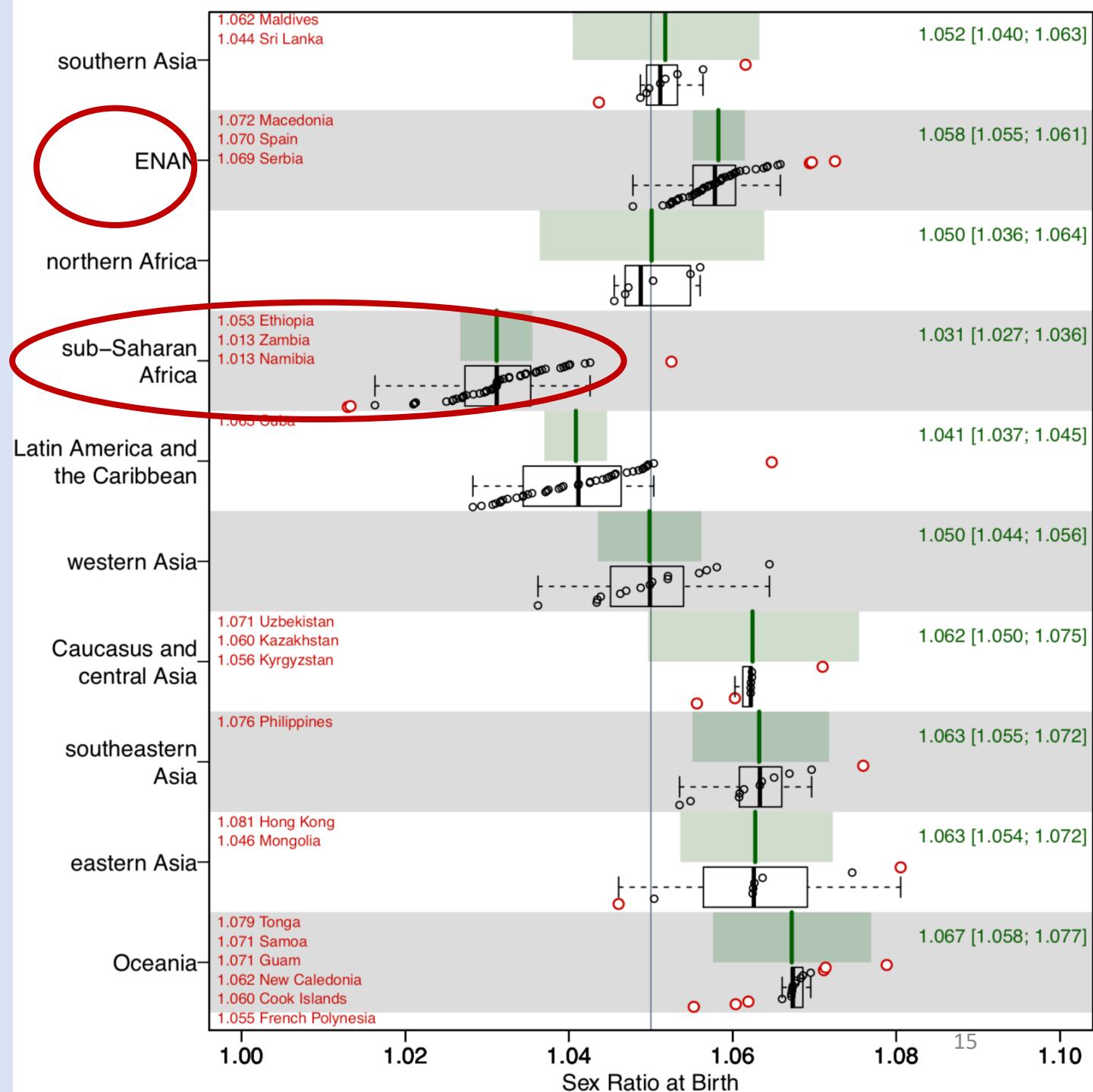
Baseline Model

$$\Theta_{c,t} = \beta_c \eta_{c,t}$$

Country-specific SRB baseline:

$$\beta_c \sim N(\beta_{r[c]}^{(region)}, \sigma_\beta^2)$$

- Mean at $\beta_{r[c]}^{(region)}$, regional SRB baseline
 - Group countries into regions based on their majority ethnicity
 - To account for the heterogeneity in baseline SRB across ethnicity groups



Baseline Model

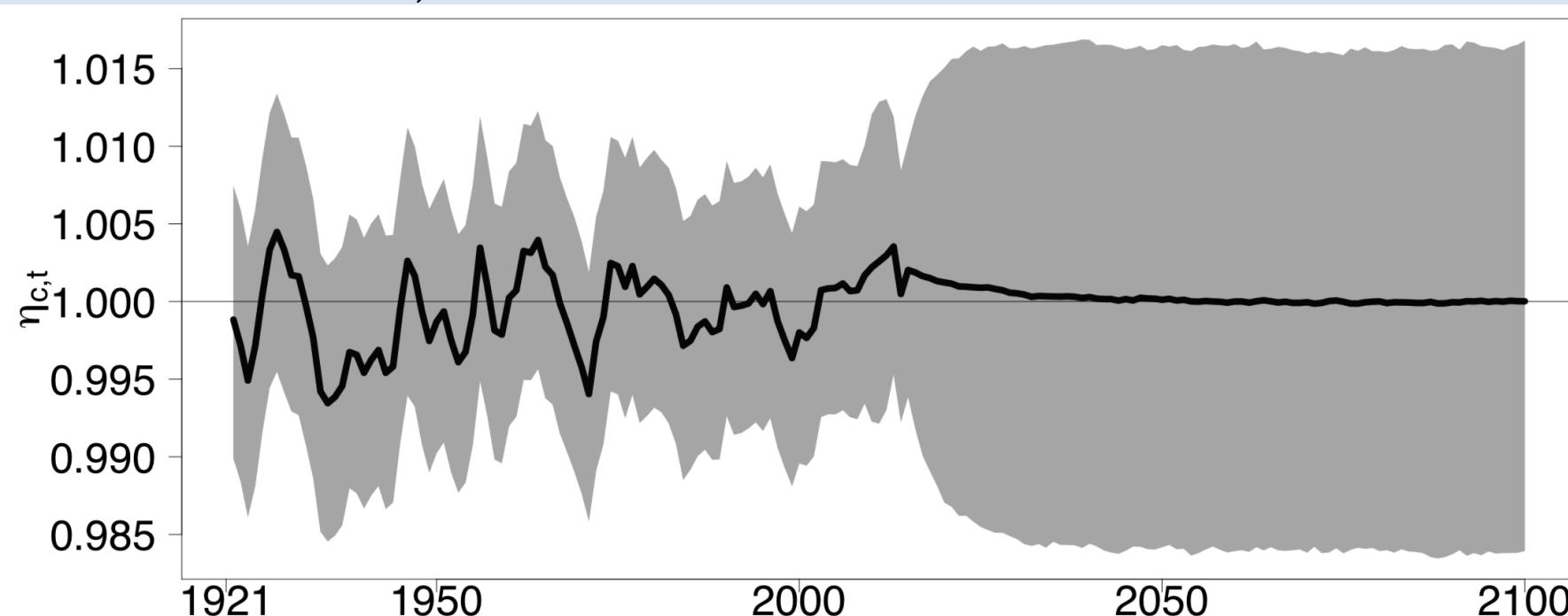
$$\Theta_{c,t} = \beta_c \eta_{c,t}$$

Within country year-by-year natural fluctuation:

$$\log(\eta_{c,t}) \sim N\left(0, \frac{\sigma_\epsilon^2}{1 - \rho^2}\right), t = 1950$$

$$\log(\eta_{c,t}) = \rho \log(\eta_{c,t-1}) + \epsilon_{c,t}, t > 1950$$

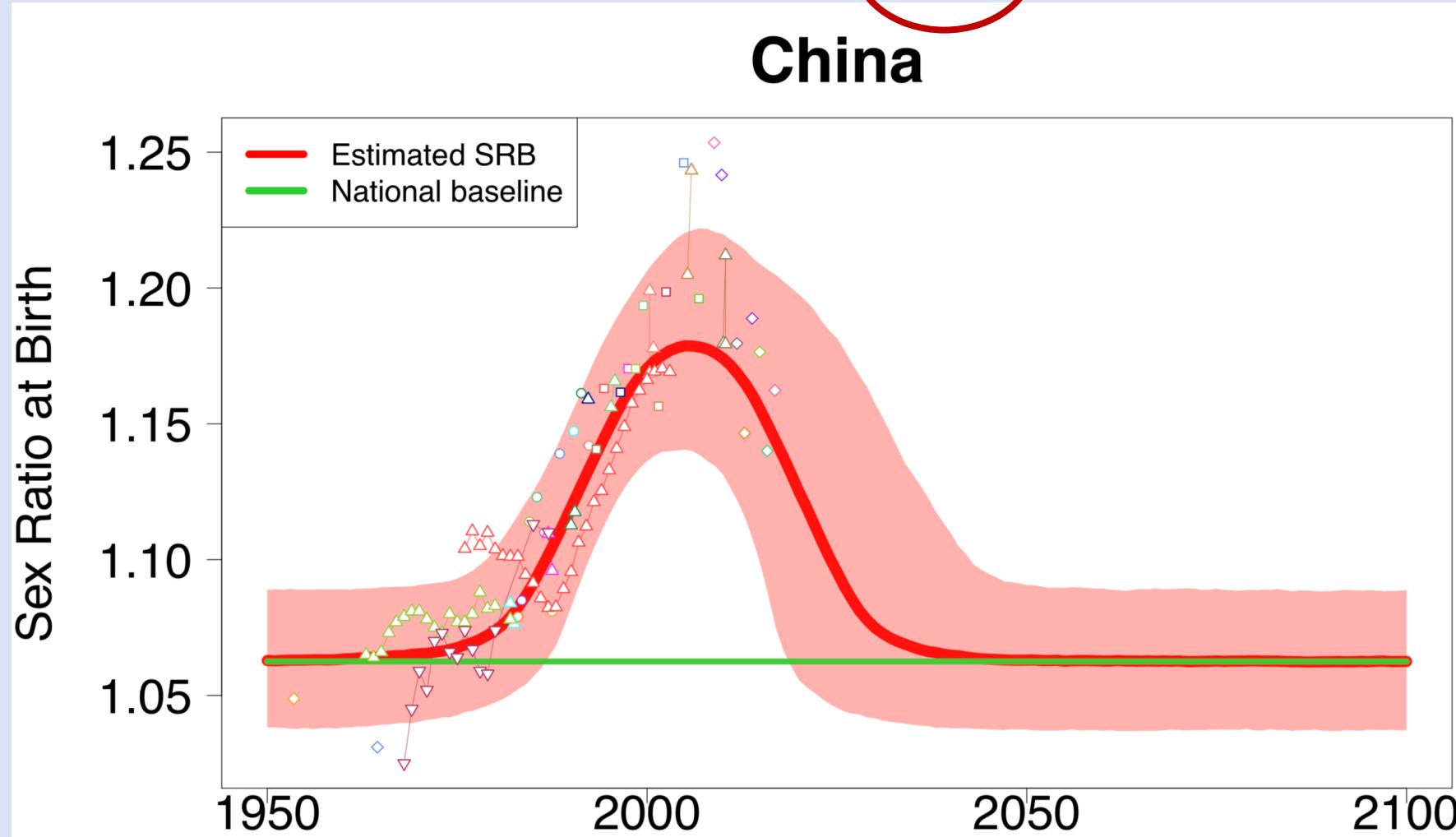
$$\epsilon_{c,t} \sim^{iid} N(0, \sigma_\epsilon^2)$$



Inflation Model – Motivation

$$\Theta_{c,t} = \beta_c \eta_{c,t} + \delta_c \Omega_{c,t}$$

China



Inflation Model

$$\Theta_{c,t} = \beta_c \eta_{c,t} + \delta_c \Omega_{c,t}$$

For countries at risk of SRB inflation: strong son preference.

Country-specific SRB inflation binary detector:

- 0: no inflation
- 1: with inflation

$$\delta_c \sim Bernoulli(\pi_c)$$

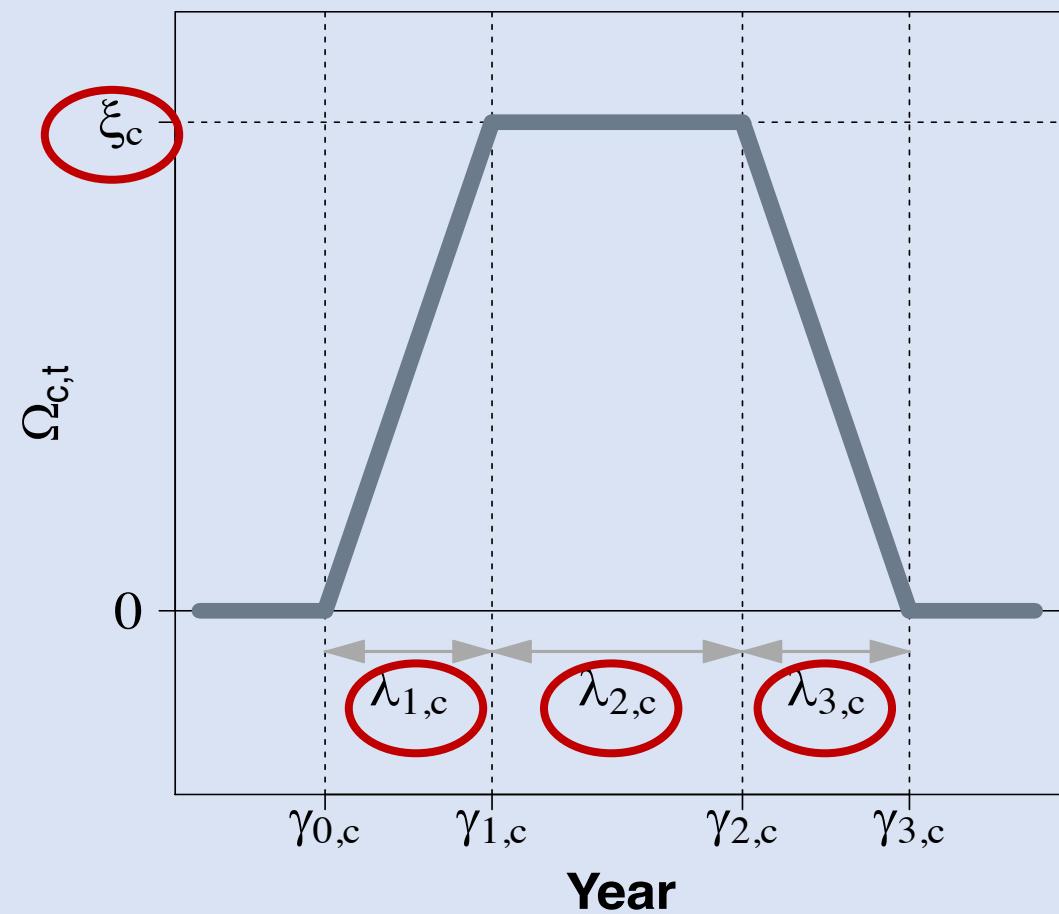
$$\text{logit}(\pi_c) \sim N(\mu_\pi, \sigma_\pi^2)$$

Inflation Model

$$\Theta_{c,t} = \beta_c \eta_{c,t} + \delta_c \Omega_{c,t}$$

Upward SRB inflation factor: trapezoid function

Sex ratio transition model



- Country-specific increase, stagnation, decrease, max inflation

$$\lambda_{1,c} \sim N(\mu_{\lambda 1}, \sigma_{\lambda 1}^2) T(0,)$$

$$\lambda_{2,c} \sim N(\mu_{\lambda 2}, \sigma_{\lambda 2}^2) T(0,)$$

$$\lambda_{3,c} \sim N(\mu_{\lambda 3}, \sigma_{\lambda 3}^2) T(0,)$$

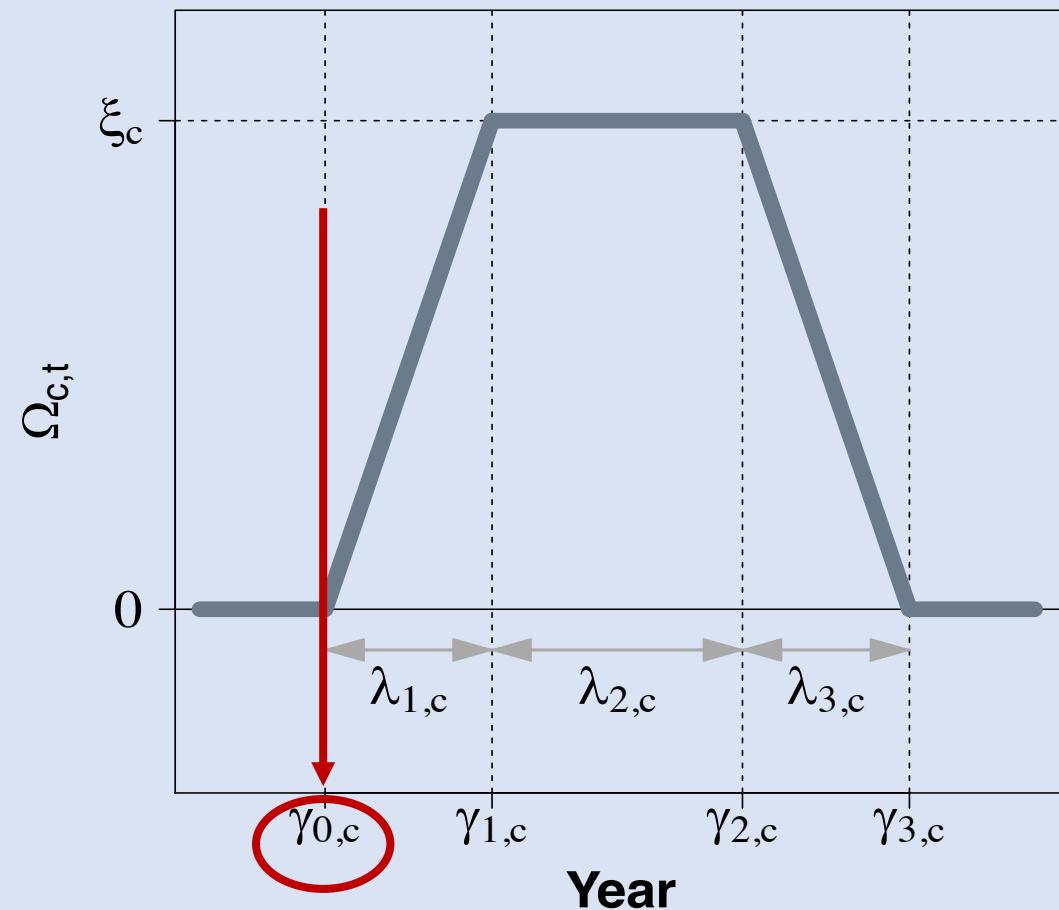
$$\xi_c \sim N(\mu_{\xi}, \sigma_{\xi}^2) T(0,)$$

Inflation Model

$$\Theta_{c,t} = \beta_c \eta_{c,t} + \delta_c \Omega_{c,t}$$

Upward SRB inflation factor: trapezoid function

Sex ratio transition model



- Country-specific start year includes fertility decline effect:

$$\gamma_{0,c} \sim t_3(f_{c,2.9}, \sigma_\gamma^2) T(f_{c,6},)$$

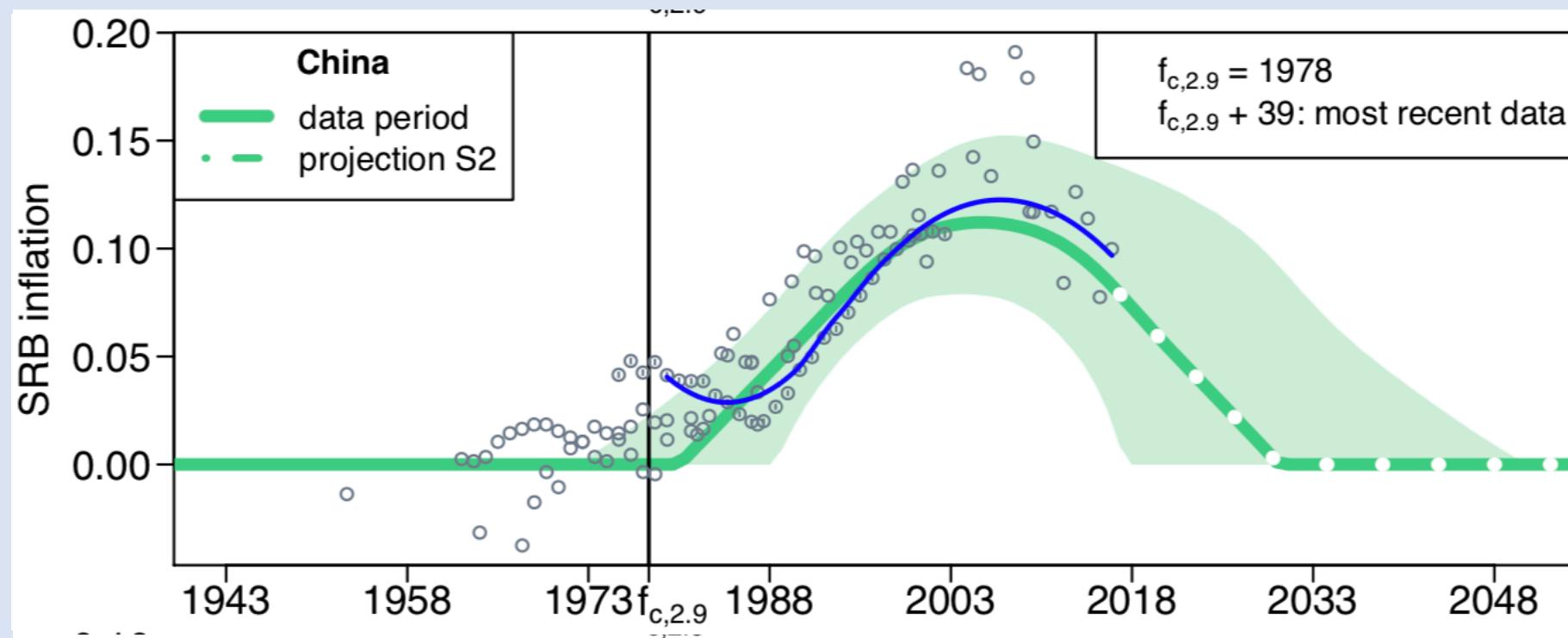
$f_{c,2.9}$: year in which TFR declines to 2.9

$f_{c,6}$: year in which TFR declines to 6

*TFR: total fertility rate

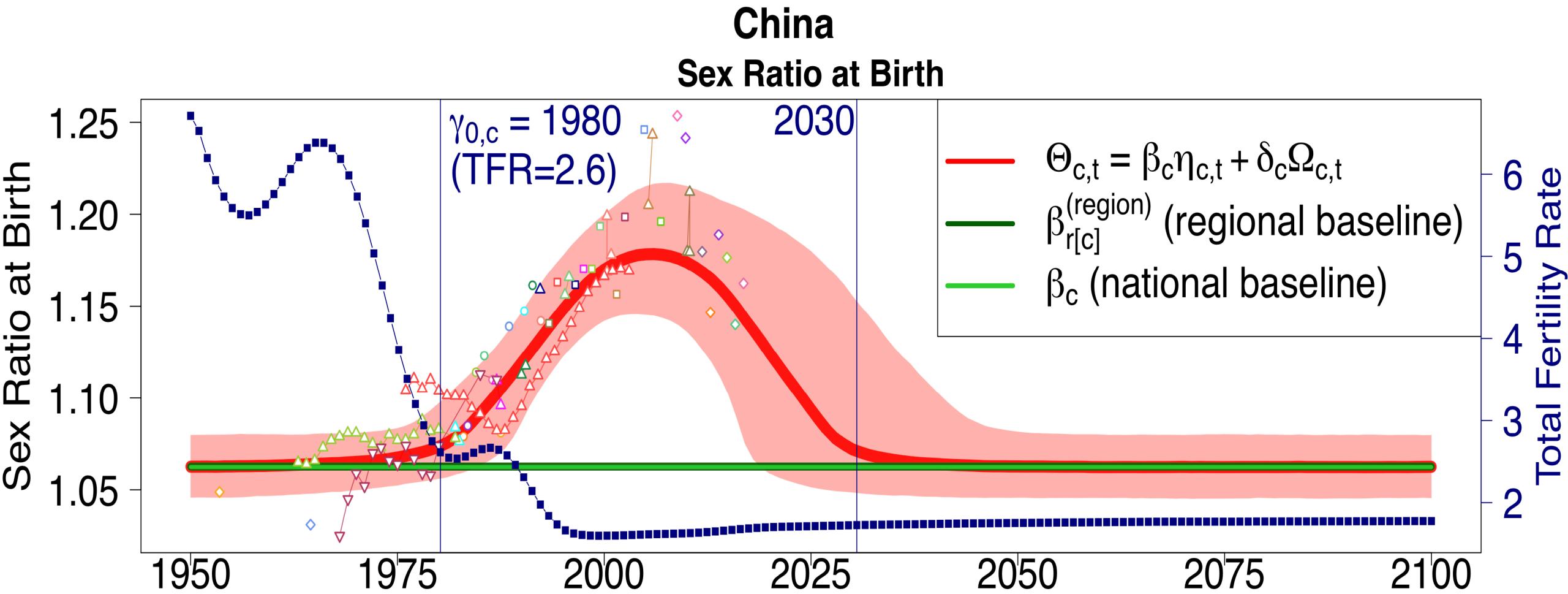
Inflation Model and Data

Parametric form of $\Omega_{c,t}$ captures the observed shape of inflated SRB



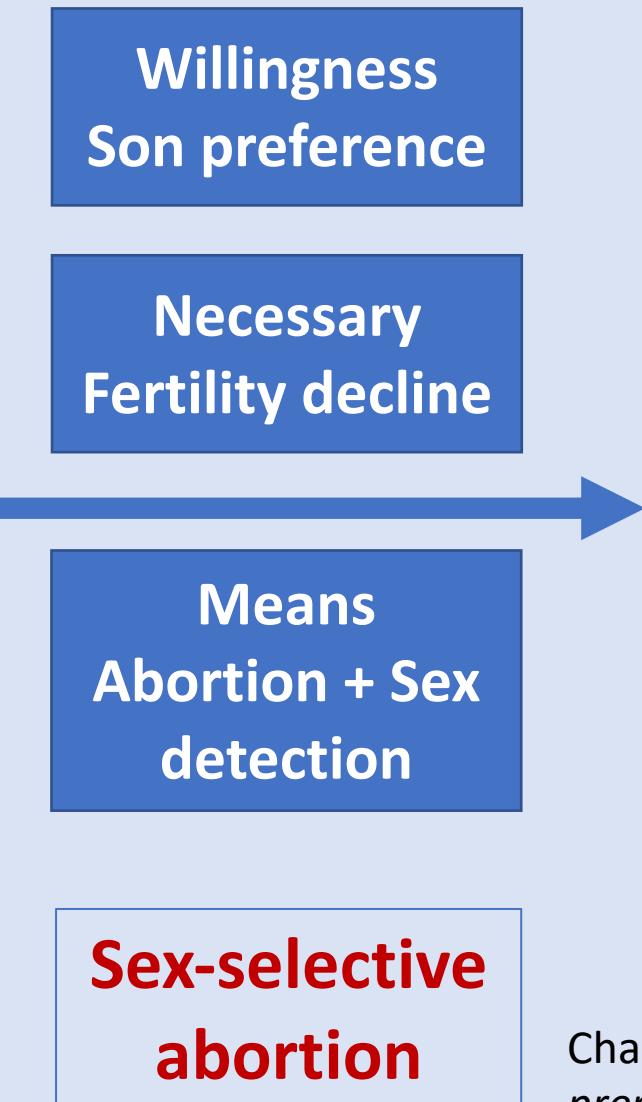
Data: $y_i - \hat{\beta}_c$

SRB Estimation and Projection Results for China



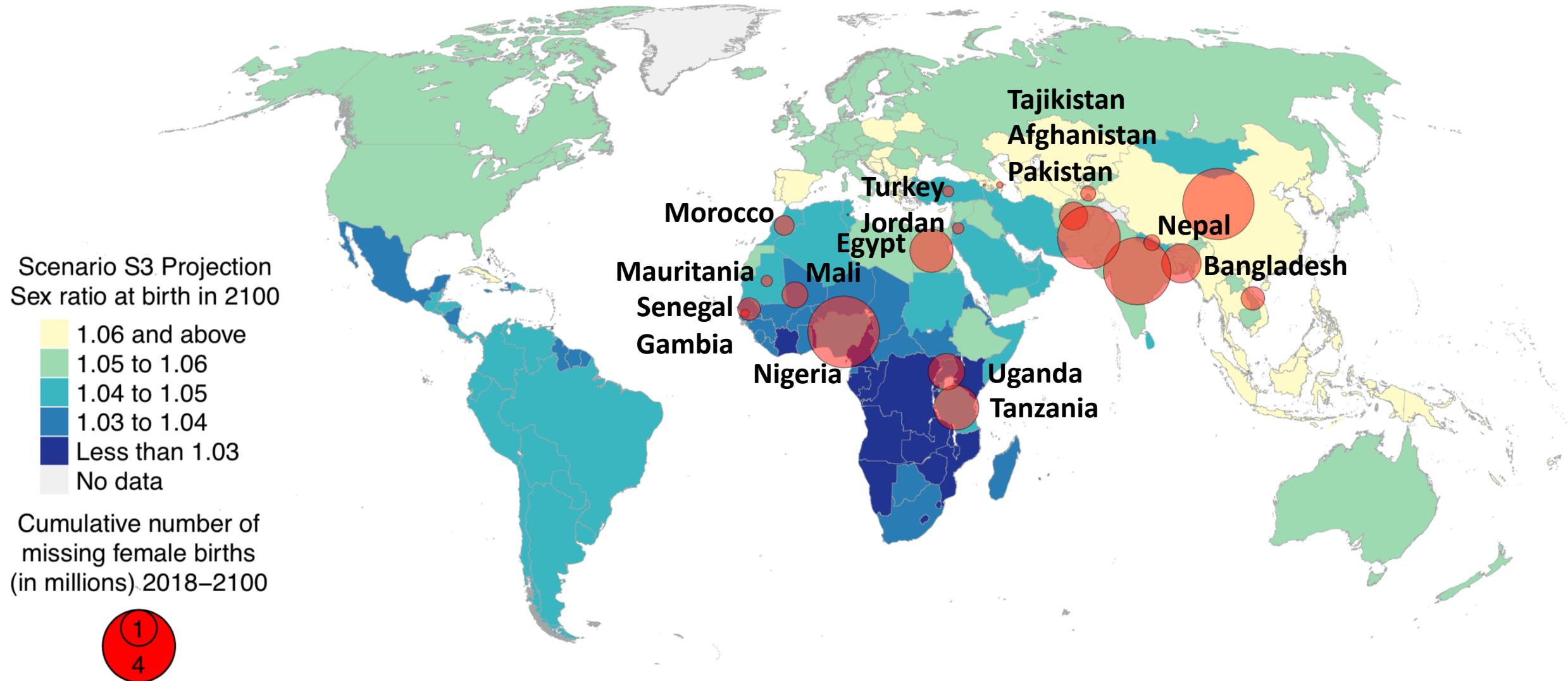
Scenario-Based SRB Projection till 2100

Some at-risk countries have normal SRB



- At-risk countries may have inflated SRB in the future
 - Mostly African countries
 - Scenario-based SRB projections:
 - No inflation $\delta_c = 0$
 $\Theta_{c,t} = \beta_c \eta_{c,t}$
 - With inflation $\delta_c = 1$
 $\Theta_{c,t} = \beta_c \eta_{c,t} + \Omega_{c,t}$

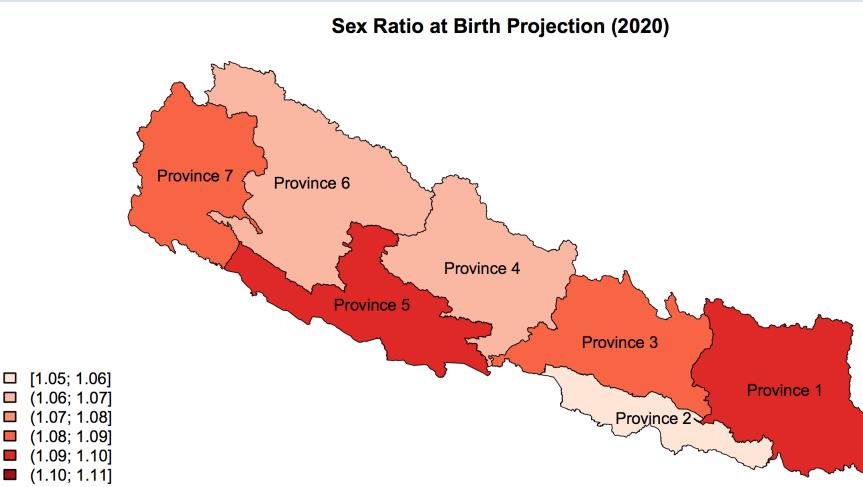
SRB & Missing Female Births Projection till 2100



SRB inflation within a country

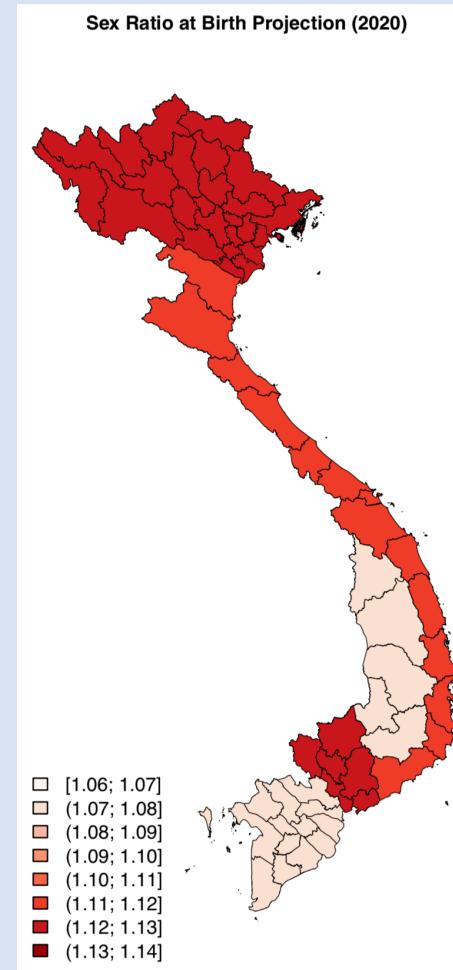
Bayesian hierarchical models with modifications can be used for estimating SRB inflation on subnational level.

Nepal



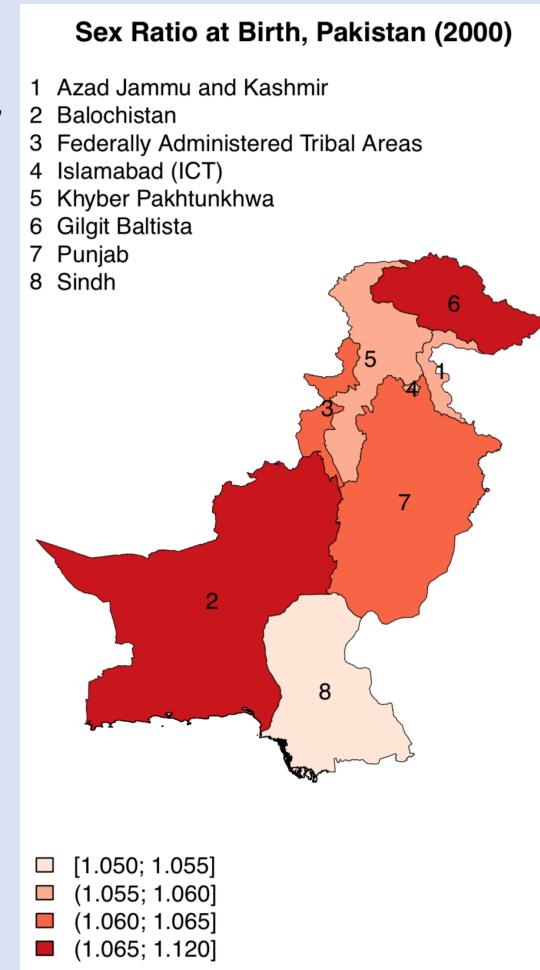
Chao, F., KC, S., & Ombao, H. (2020). *arXiv preprint arXiv:2007.00437*.

Vietnam



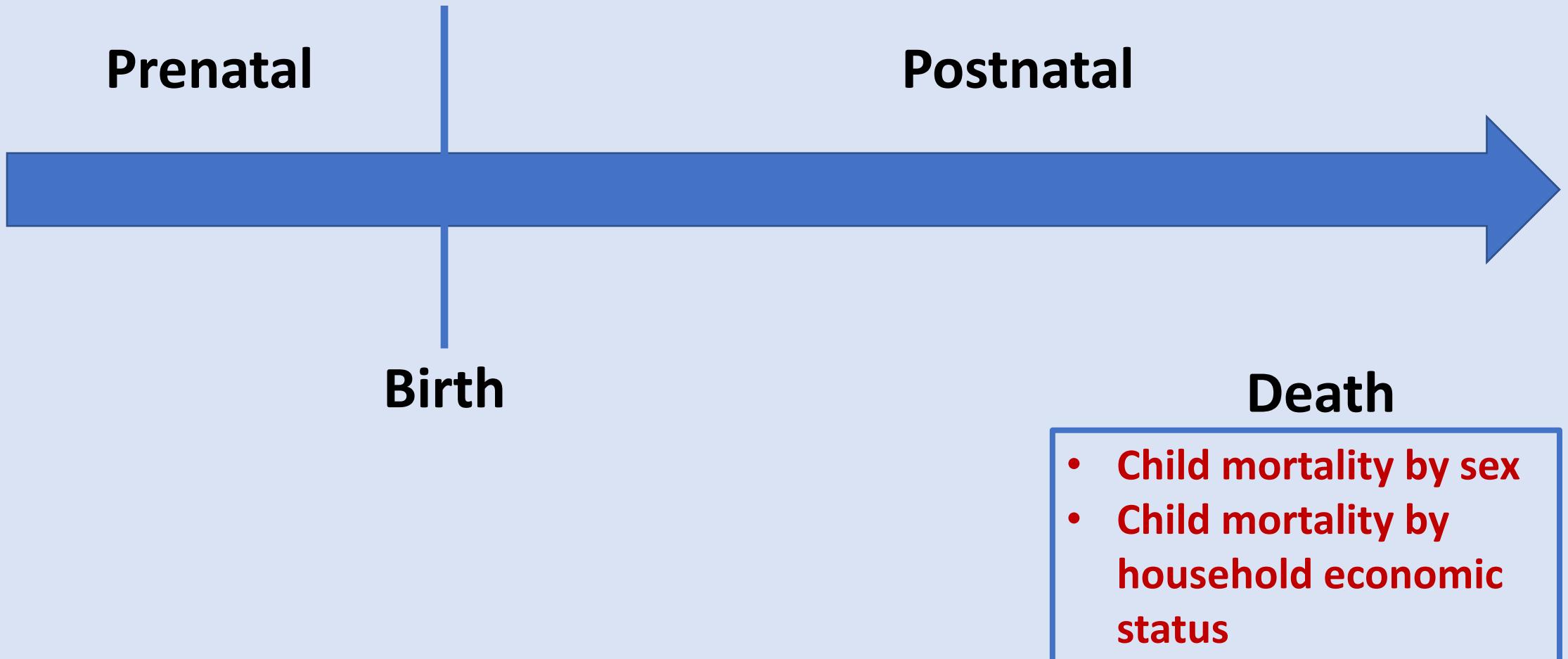
Chao, F.,
Guilmoto, C. Z.,
& Ombao, H.
Manuscript in
preparation.

Pakistan

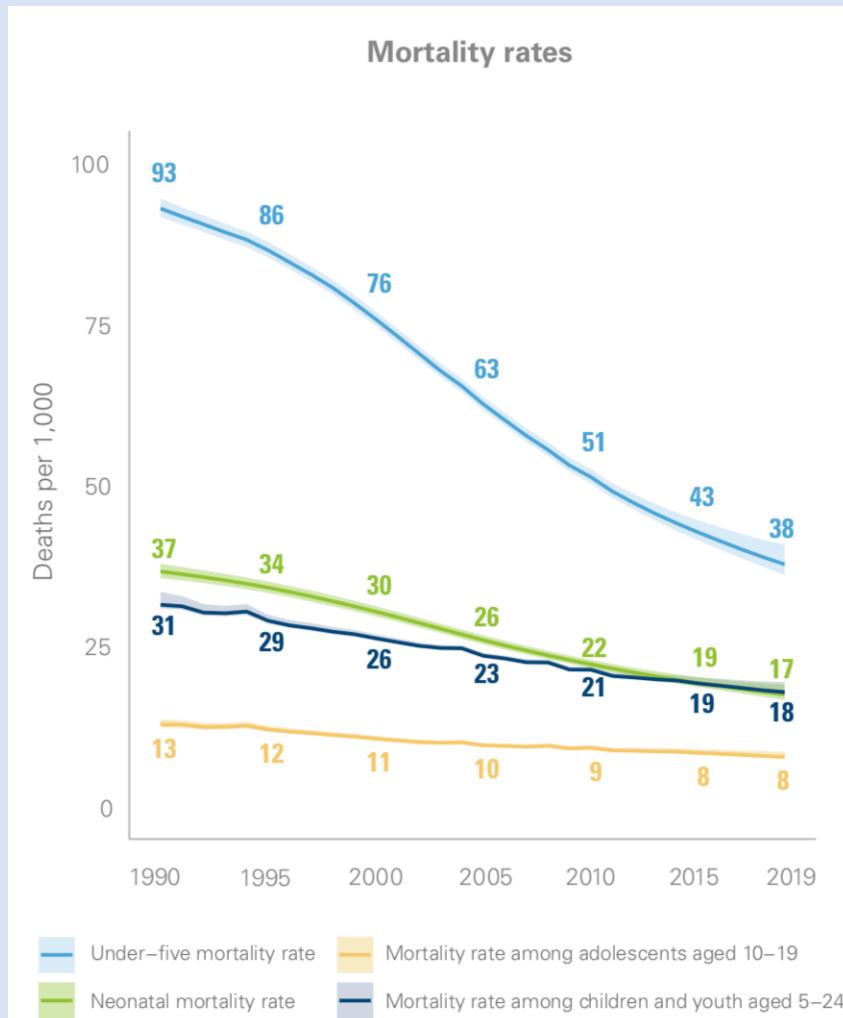


Chao, F.,
Wazir, M. A. &
Ombao, H.
Manuscript
in
preparation.

Looking into Child Mortality Disparity



Under-5 Mortality Rate (U5MR)



- Most deaths before age of 5 are due to preventable or treatable causes
 - Infectious diseases: Pneumonia, diarrhoea and malaria
 - Basic lifesaving interventions: childbirth delivery care, postnatal care, vaccinations
- U5MR has dropped by almost 60% since 1990

Image credit: UN IGME. Levels & Trends in Child Mortality: Report 2020.

Great Disparity in U5MR Remains Across Countries

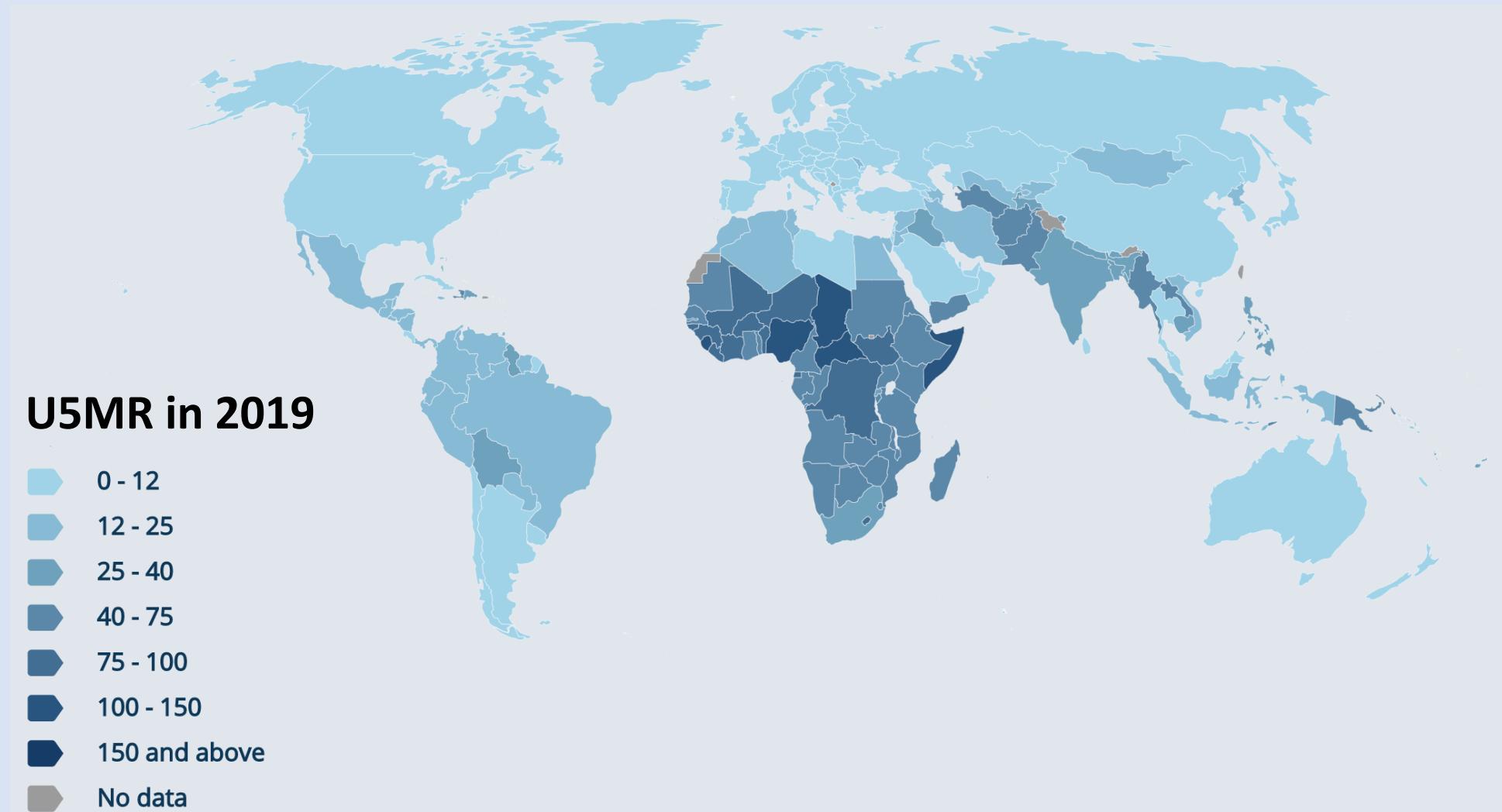
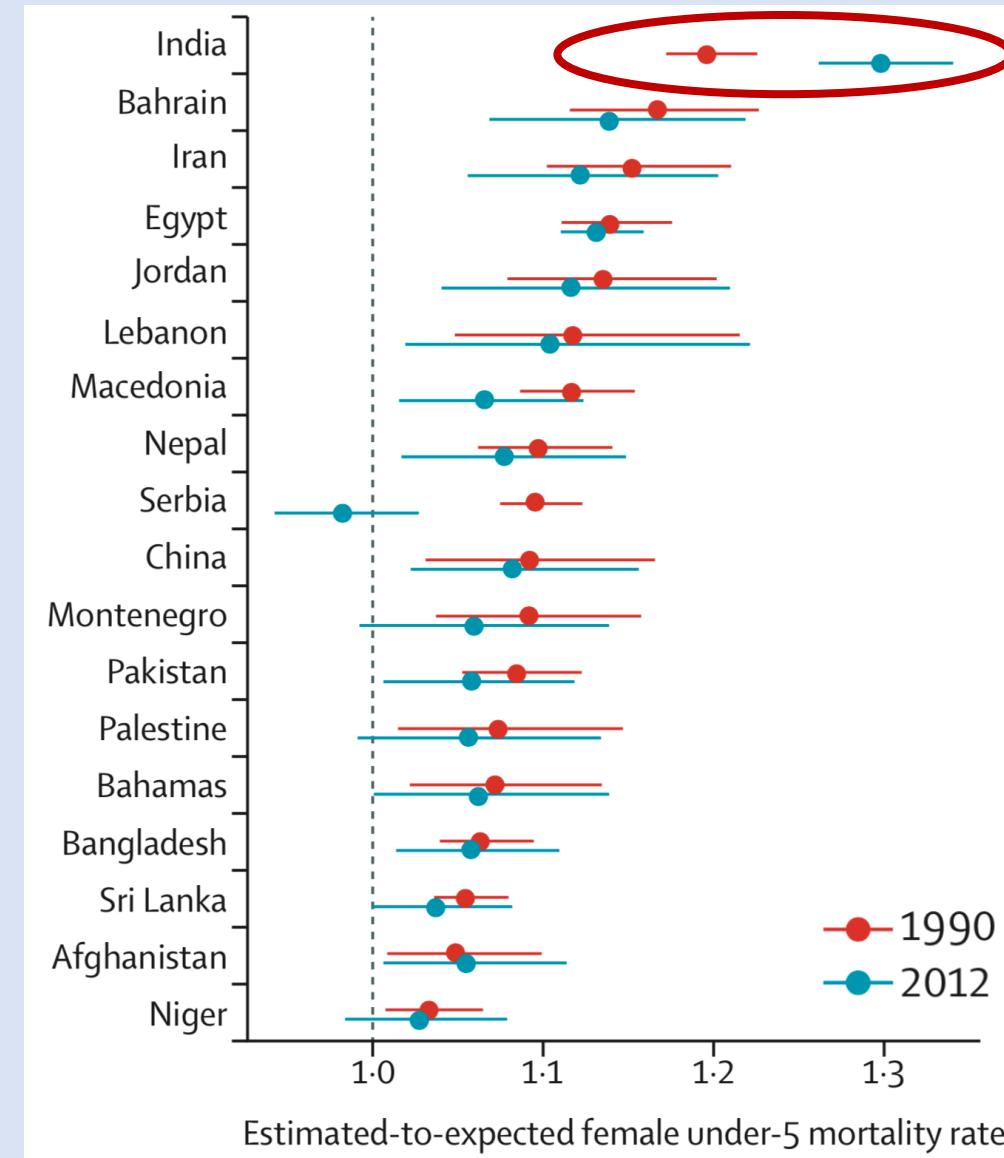


Image credit: UN IGME. Levels & Trends in Child Mortality: Report 2020.

U5MR Disparity Between Girls and Boys

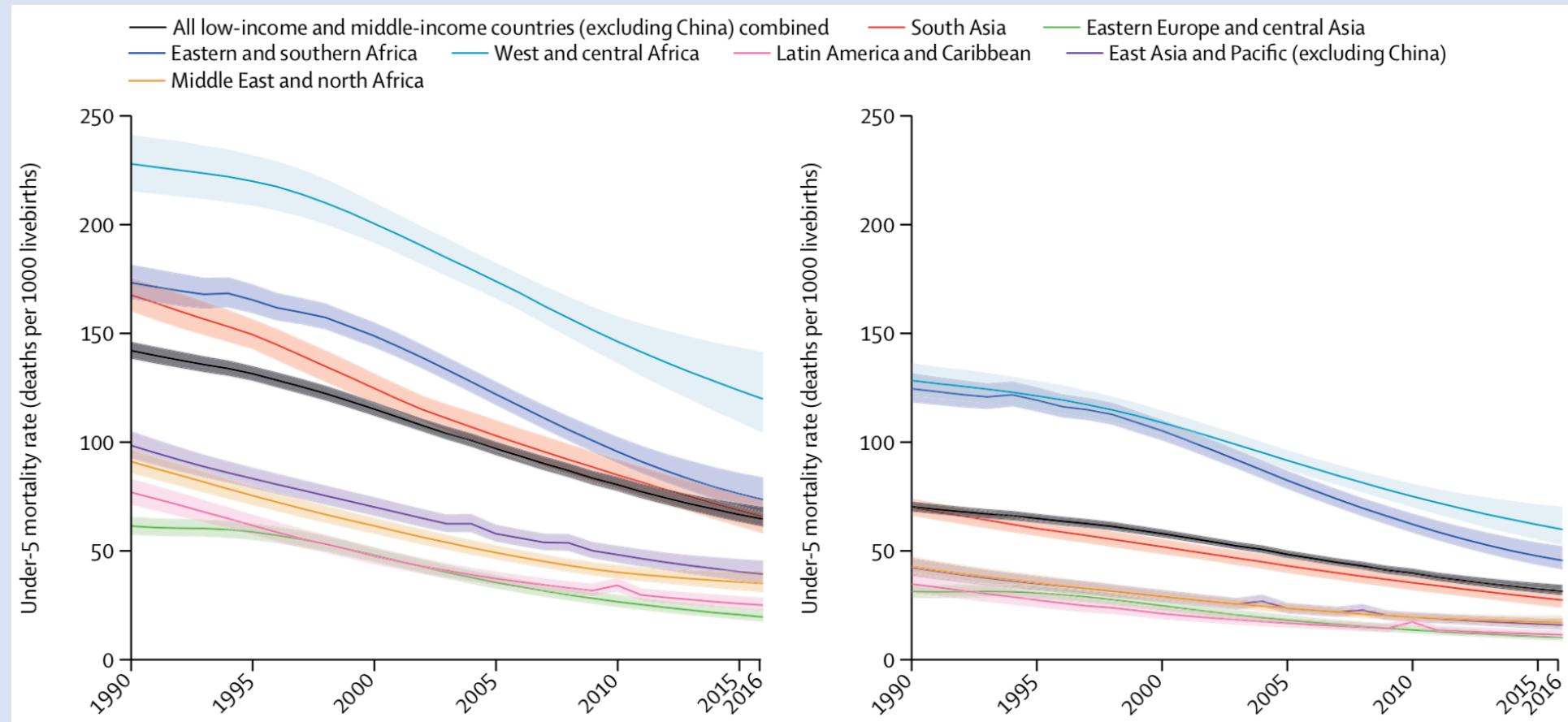
Identify the Most Disadvantaged, Vulnerable Children

- Naturally, boys have higher mortality than girls before age of 5.
- Postnatal sex discrimination can change the pattern.
- In some countries, the risk of dying before age 5 for girls is higher than expected.

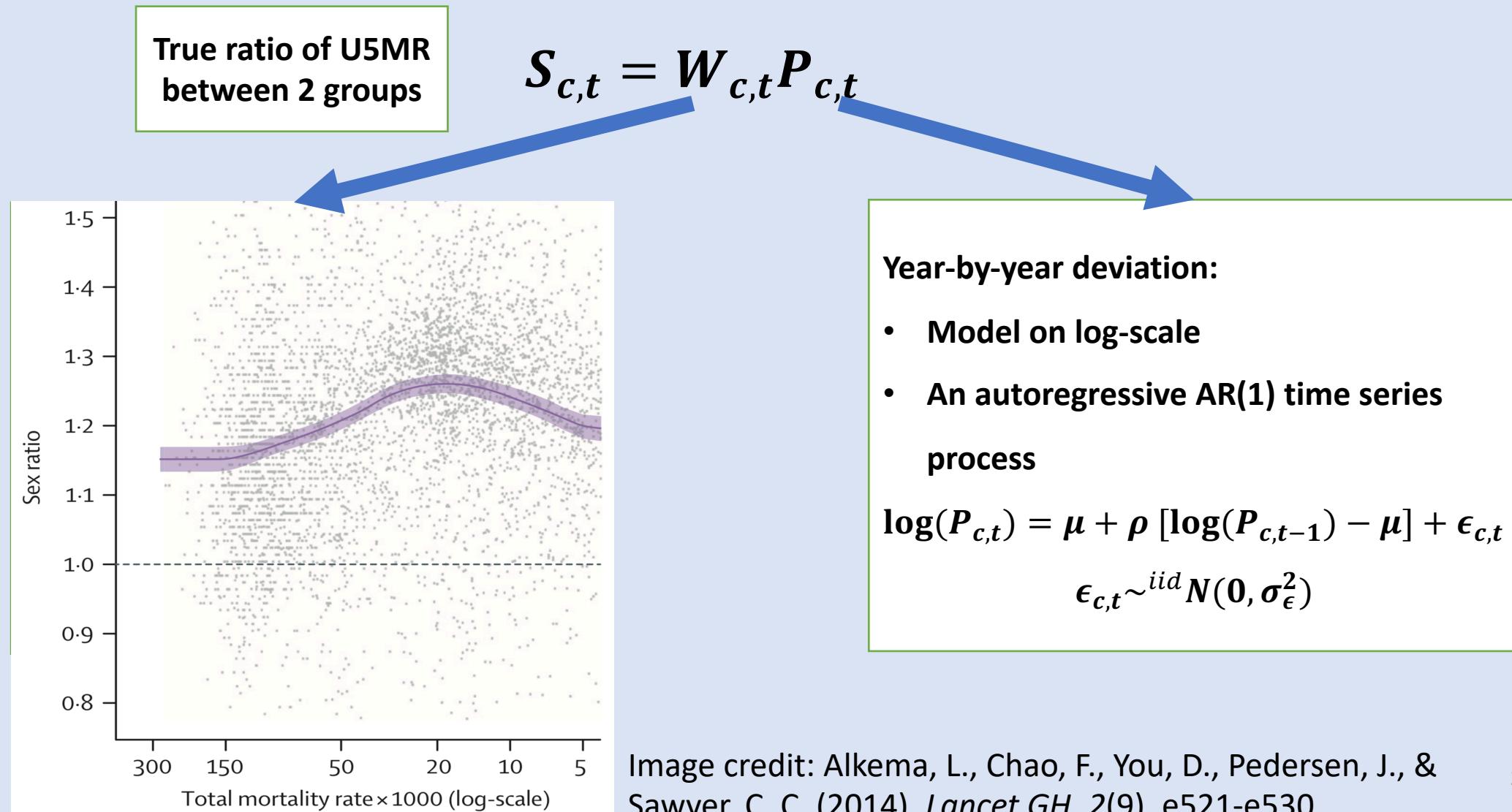


U5MR Disparity Between Household Economic Status Identify the Most Disadvantaged, Vulnerable Children

Great disparity in U5MR between the poorest and the richest households.

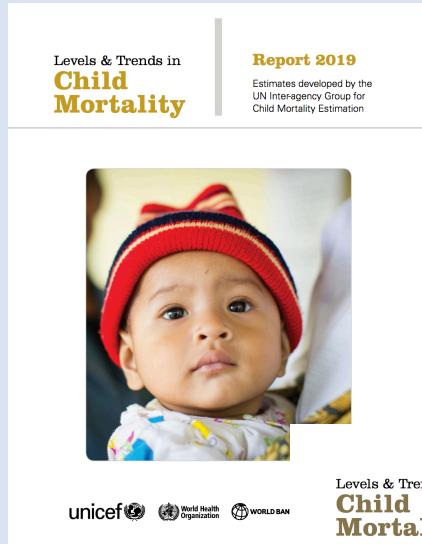
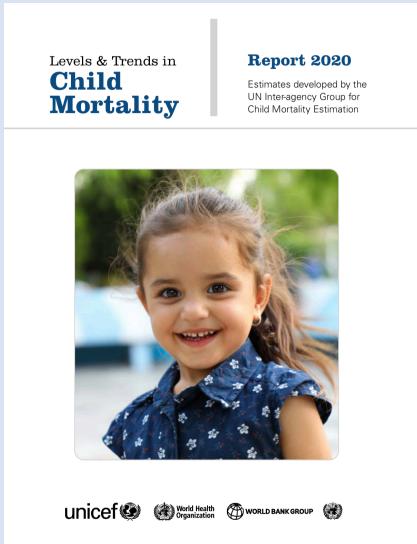


U5MR Disparity Bayesian Model



Research to the Real World

U5MR disparity studies*† have been used by the UNICEF to inform policy makers and resource allocation.

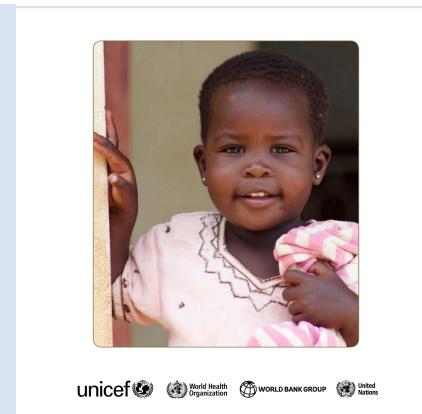


UNICEF reports:
childmortality.org



*Chao, F., You, D., Pedersen, J., Hug, L., & Alkema, L. (2018). *Lancet GH*, 6(5), e535-e547.

†Alkema, L., Chao, F., You, D., Pedersen, J., & Sawyer, C. C. (2014). *Lancet GH*, 2(9), e521-e530.



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