Lessons learned from the B3 development and application to model time trends in differentials

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Sex-specific under-5 mortality rate (U5MR)

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- Estimate sex ratio (ratio of male to female mortality rate) for infant, child and under 5 mortality (IMR, CMR, U5MR) for all countries.
- Due to data quality/availability (e.g. Jordan): curve fitting approach & data quality model are needed.
- Countries with outlying sex ratios where gender discrimination exists (e.g. India): need to model a global expected sex ratio.
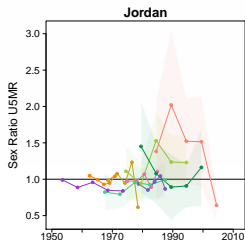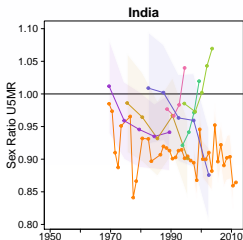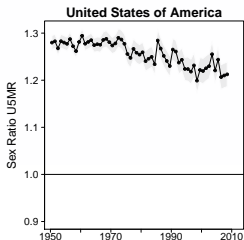
Sex-specific U5MR estimation: method

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- **Data**: all available data (with measures of uncertainty) on infant, child or under-five mortality by sex from vital registration, surveys and census, for all countries.
- **Full model**:
  - Observed sex ratio = true sex ratio (process model) + measurement error (data model).
- **Data model** for measurement error: accounts for sampling and non-sampling errors, and outlying data points;
- **Process model** for the true sex ratios:
  - Sex ratios for IMR and CMR are modeled as the product of:
    1. the global expected sex ratio for that country-year, and
    2. a country-year-specific multiplier.
  - The U5MR sex ratio is derived from sex-specific IMR and CMR.

Global relation: sex ratios and total mortality

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The global relation between sex ratios and total mortality are estimated with a flexible B-splines regression model and define the expected sex ratio for any country-year, based on the total mortality rate for that year.
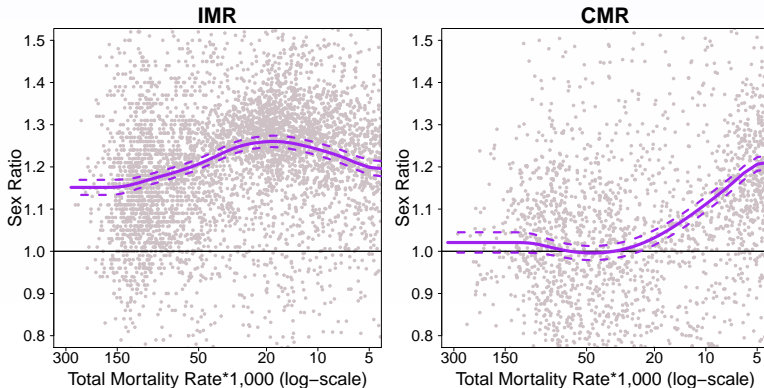
# Global relation: sex ratios and total mortality

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Global relation between sex ratios and total mortality is modeled as
a penalized B-splines regression function with settings:

- Symmetric 3rd-order polynomials;
- Equally spaced knots on the log-scaled input;
- Splines are obtained within [2.5%; 97.5%] percentiles of input;
- Penalize the 2nd-order differences in adjacent splines
  coefficients.
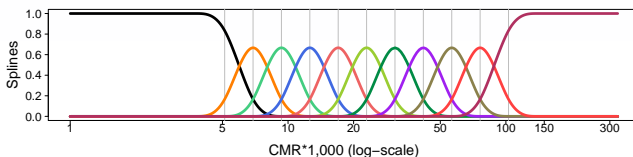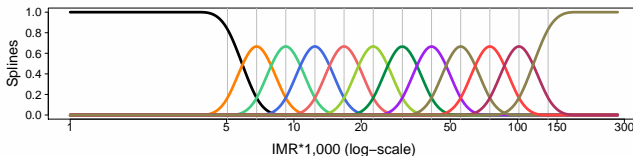
Difference across/within countries over time
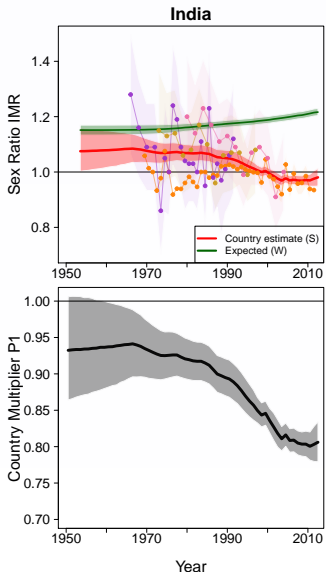
India

- Country-year-specific multiplier fluctuates around a country-specific level, estimated with a hierarchical model.
- Within-country fluctuations over time are modeled with a time series model, e.g. to capture trend in India.
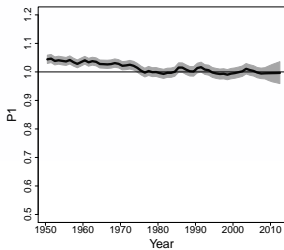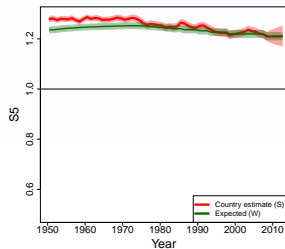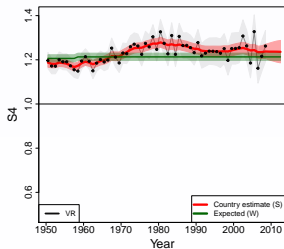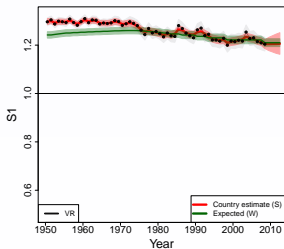
Illustration for country estimates
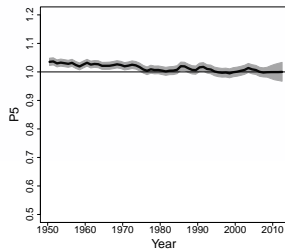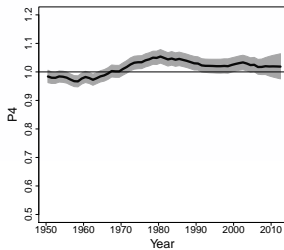
Illustration for country estimates

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India

Illustration for country estimates

Lessons learned

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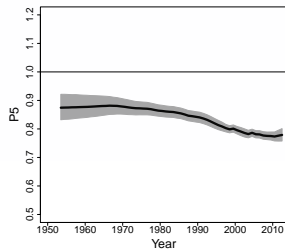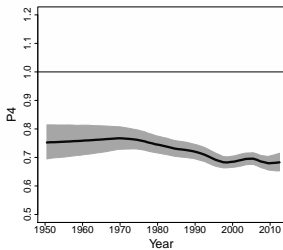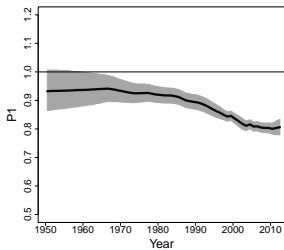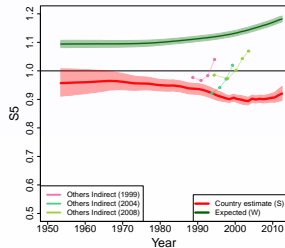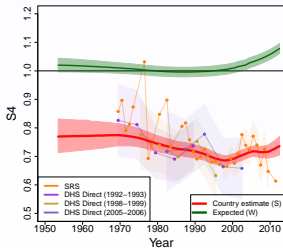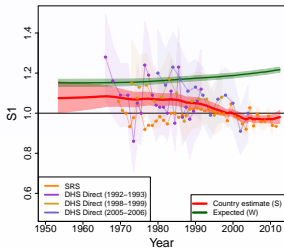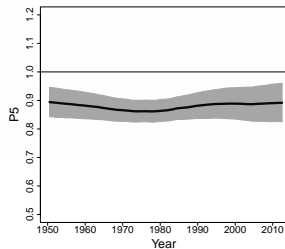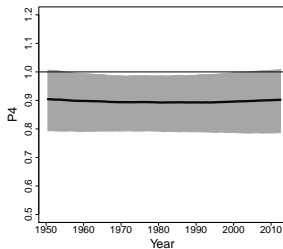
- The B-splines settings are important for model fitting:
  - Interval length between splines:
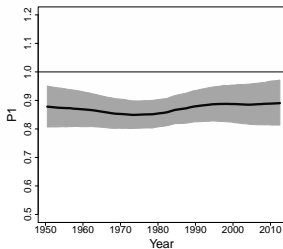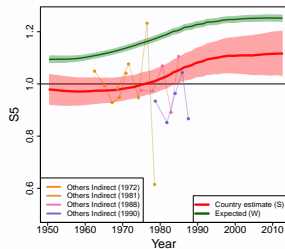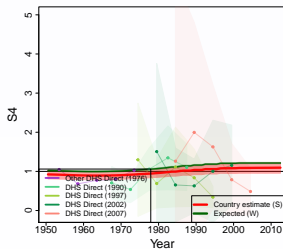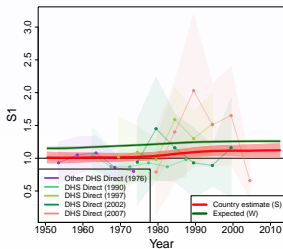   - Smaller: more parameters to estimate, model run is slower.
    - Larger: the model fitting is less smooth.
  - The order of penalization: depends on data.
  - Range of modeling the splines function:
    - We assume splines to be constant at low and high ends of the splines input (here is national IMR and CMR).
- Start with one-country run to set splines settings instead of global run (all countries in the model).
- INLA is a good alternative (under exploration):
  - R-package INLA.
  - Very fast: < 10 minutes for global run for 1 age group.
  - But may not be able to model multiple sets of indicators simultaneously.

For more details, refer to our publication:
Alkema, L., Chao, F., You, D., Pedersen, J., & Sawyer, C. C. (2014). National, regional, and global sex ratios of infant, child, and under-5 mortality and identification of countries with outlying ratios: a systematic assessment. *The Lancet Global Health, 2*(9), e521-e530.

Thank you!

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