Under-5 Mortality Rate Estimation by Residence for 112 Countries using a Bayesian Time Series Model

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Introduction

U5MR

- Under-5 mortality rate: probability of dying before age 5.

U5MR disparity

- To better understand who and where the most disadvantaged and vulnerable children live.
- The progress in reducing U5MR since 1990 has been remarkable but uneven between:
  - boys and girls (Alkema L. et al 2014).
  - household economic status (Chao F. et al 2018).

Objective

- Estimate the levels and trends of U5MR by urban and rural area across countries from 1990 to 2018.
- Assess the disparities in U5MR between urban and rural areas.
- Identify country-years with outlying disparity.

Data

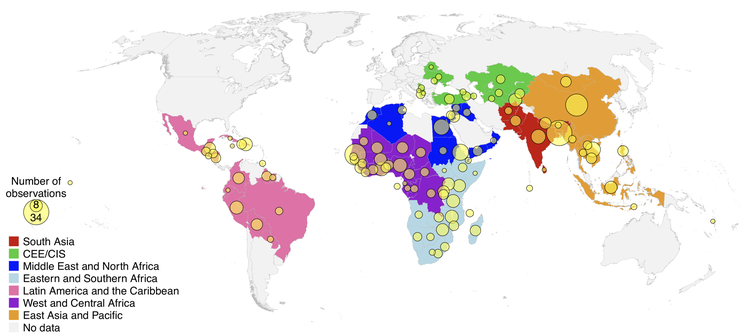


Figure: **Data availability for urban U5MR.**

- Urban U5MR: 570 data points, 112 countries.
- # observations per country: 1 to 34.
- Reference year range: 1982–2016.
- Data type: survey, census, and vital registration system.

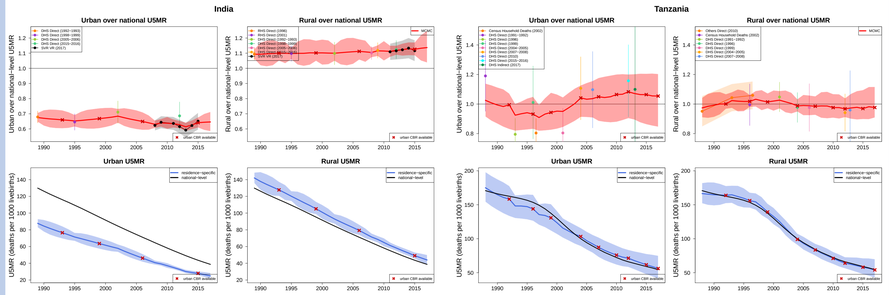
Contact

Twitter

- Webpage: https://www.fengqingchao.com/
- Feel free to reach out if you have any question regarding this study.

Results

Country estimates In most countries with estimates, rural U5MR is higher urban U5MR (e.g. India). But a few have similar urban and rural U5MR such as Tanzania.



U5MR urban-rural-disparity on absolute and relative scales

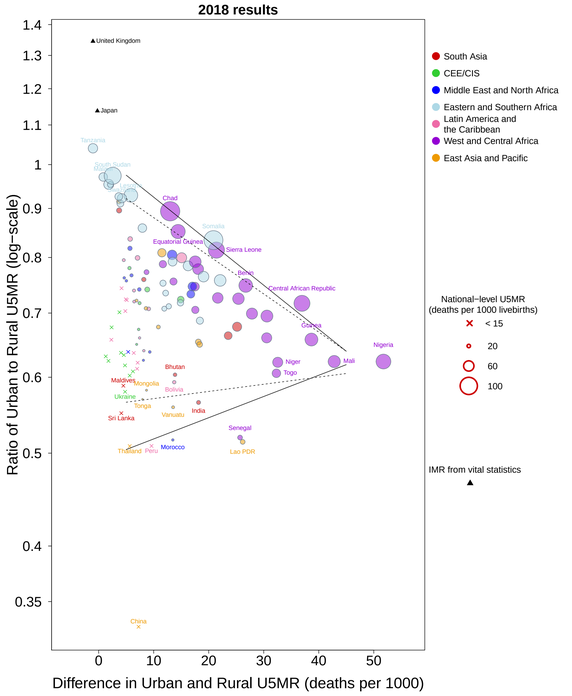


Figure: Black triangle dots are the ratio of urban to rural IMR from developed countries. The solid lines and dashed lines are the 95% and 80% bounds. Bounds are smoothed by Friedman's SuperSmoother approach.

- As national U5MR increases, the urban-rural U5MR difference increases.
- As the urban-rural U5MR difference decreases, the urban-rural U5MR ratio becomes more diverse while most ratios are below 1.
- Countries with low urban-rural U5MR differences and low urban-rural U5MR ratios: China, Thailand, Peru, and Morocco.
- Infant mortality rate (IMR) info approximates U5MR disparities in developed countries.

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Method

Model for urban and rural U5MR

The residence-specific U5MR for country c year t is assumed to relate to national-level U5MR as:

$$Q_{k,c,t} = Q_{\text{total},c,t} R_{k,c,t}, \text{ for } k \in \{\text{urban}, \text{rural}\},$$

- $Q_{k,c,t}$: residence-specific U5MR, urban or rural.
- $Q_{\text{total},c,t}$: national U5MR, from the UN IGME estimates.
- $R_{k,c,t}$: ratio of residence-specific U5MR to national-level U5MR.

$R_{k,c,t}$ is modelled on log-scale with an AR(1) time series structure. For $c \in \{1, \cdots, C\}$ and $k \in \{\text{urban}, \text{rural}\}$:

$$\log(R_{k,c,t}) = \mu_{k,c,t} + V_{k,c,t},$$
$$V_{k,c,t} \sim \mathcal{N}(\rho V_{k,c,t-1}, \sigma^2_\epsilon).$$

$\mu_{k,c,t}$ is modeled as a multivariate linear regression function:

$$\mu_{k,c,t} = \alpha_c x_{c,t} + \beta_c y_{c,t}, \text{ for } k = \text{urban},$$
$$\mu_{k,c,t} = \delta_c x_{c,t} + \gamma_c y_{c,t}, \text{ for } k = \text{rural}.$$

- $x_{c,t}$: $\log(U_{c,t})$, where $U_{c,t}$ is urban population proportion, from UN World Urbanization Prospect.
- $y_{c,t}$: $\log(Q_{\text{total},c,t})$, from UN IGME estimates.
- α_c, β_c, δ_c, γ_c are mutually independent and are assigned with non-informative priors.

Incorporate residency-specific crude birth rate

For country-years where residency-specific crude birth rate (CBR) data is available, we incorporate the residency-specific CBR data into the estimation model of residency-specific U5MR.

$$CBR_{\text{urban},c,t} = \frac{(1 - \exp\{V_{\text{rural},c,t}\}) CBR_{\text{total},c,t}}{(\exp\{V_{\text{urban},c,t}\} - \exp\{V_{\text{rural},c,t}\}) U_{c,t}}.$$

Data Model

$$v_{k,i} \sim \mathcal{N}(V_{k,c[i],t[i]}, s^2_{k,i}), \text{ for } i = 1, \cdots, n_k, \text{ for } k \in \{\text{urban}, \text{rural}\}$$

- $v_{k,i} = \log(r_{k,i})$: the i-th observed ratio of the resident-specific to national U5MR, on log-scale.
- $s^2_{k,i}$: sampling variance for the i-th observation (a given value).

References

- Alkema L, Chao F, You D, Pedersen J, Sawyer CC. 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), pp.e521-e530.
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