Under-5 Mortality Rate Estimation by Place of Residence

Fengqing Chao

fengqingchao.com

King Abdullah University of Science and Technology (KAUST)

Introduction

KAUST

Section 1

Introduction

Background: under-5 mortality rate

KAUST

Under-5 Mortality Rate Estimation by Place of Residence

Under-5 mortality rate (U5MR)

- U5MR: probability of dying before age 5;
- An important indicator to assess right of child to survive and health system:
  - Millennium Development Goals (MDG) 1990–2015: target – reduce by two thirds; reality – reduced more than half;
  - Sustainable Development Goal (SDG) 2016–2030: reduce to 25 per 1,000 live births.
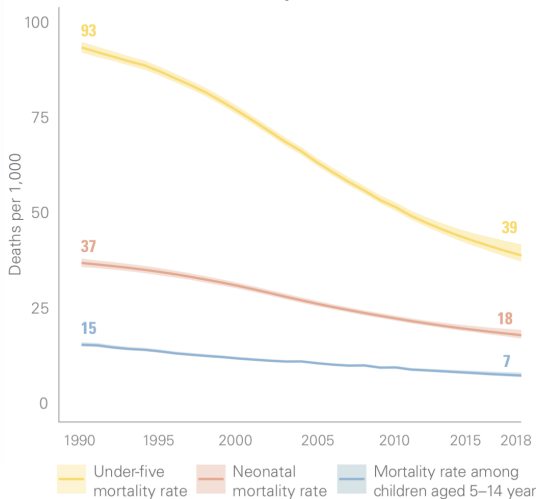
Global U5MR reduced dramatically since 1990

KAUST

Figure 1: Source: Levels & Trends in Child Mortality: Report 2019. Estimates developed by the UN Inter-agency Group for Child Mortality Estimation.

U5MR varies greatly across countries

KAUST
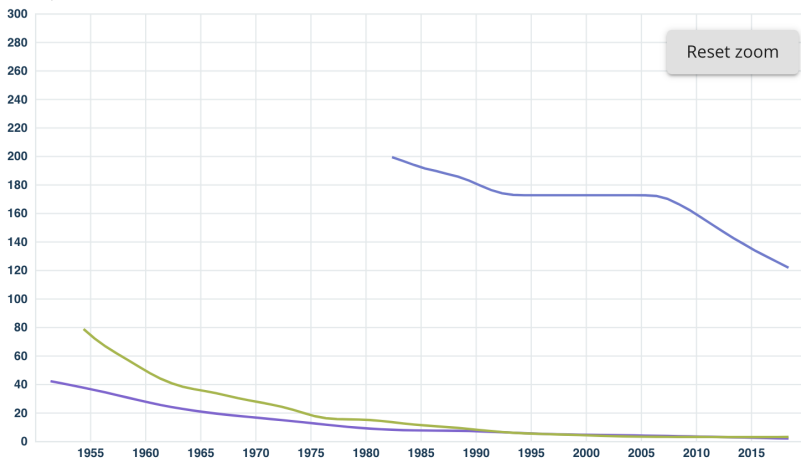

Figure 2: Purple: Finland. Green: Singapore. Blue: Somalia. Source: Levels & Trends in Child Mortality: Report 2019. Estimates developed by the UN Inter-agency Group for Child Mortality Estimation.

U5MR disparity within a country

KAUST

- Need to better understand who and where the most disadvantaged and vulnerable children are, and how U5MR disparity changes overtime;
- The progress in reducing U5MR since 1990 has been remarkable but uneven between:
  - boys and girls[1];
  - household economic status[2];
  - urban and rural residences.
- This project is to assess the disparity in U5MR by resident status.

---

[1]Alkema L. et al 2014, *The Lancet Global Health, 2*(9), pp.e521-e530.
[2]Chao F. et al 2018, *The Lancet Global Health, 6*(5), pp.e535-e547.

Objectives

KAUST

- Estimate U5MR by urban and rural area across countries during 1990–2018;
- Identify countries with outlying urban-rural disparity in U5MR.

Data

Section 2

Data

Data

KAUST

- In survey data: an indicator to determine whether the household interviewed is in urban or rural areas;
- Urban U5MR: 528 data points, 109 countries;
- Reference year range: 1982–2016;
- Exclude data with reference date beyond 5 years prior to survey.

Source type	# obs.
DHS Direct	305
Others Direct	68
Indirect	69
VR/SRS	59
total	**528**

Table 1: **Urban U5MR database.** DHS: Demographic and Health Survey. VR: Vital Registration. SRS: Sample Registration System.
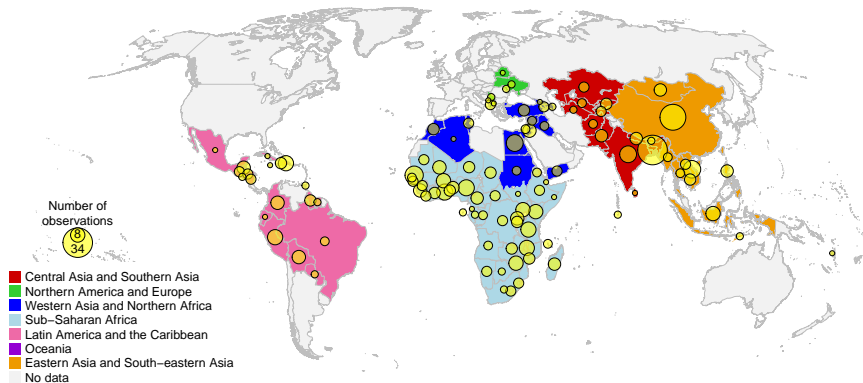
Data

Figure 3: **Urban U5MR observations by country.** Countries with data are colored according to the region. Circle size is proportional to the number of observations available for each country.
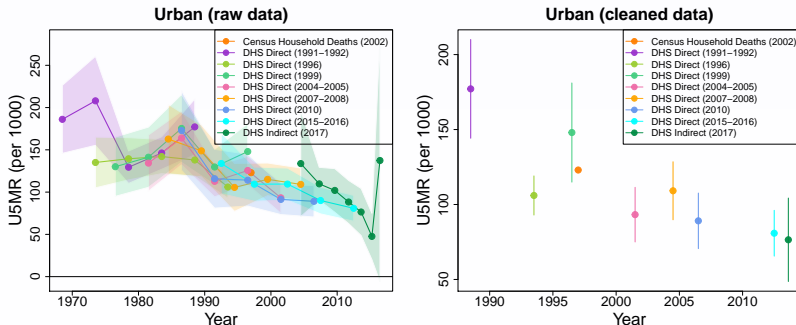
Data

Figure 4: **Urban U5MR observations for Tanzania.** Left: observations before data cleaning. Right: observations after data cleaning. We only include data within 5 years prior survey year for each data series. Data series are differentiated by color. The shades/vertical lines refers to the sampling error associated with each observation.
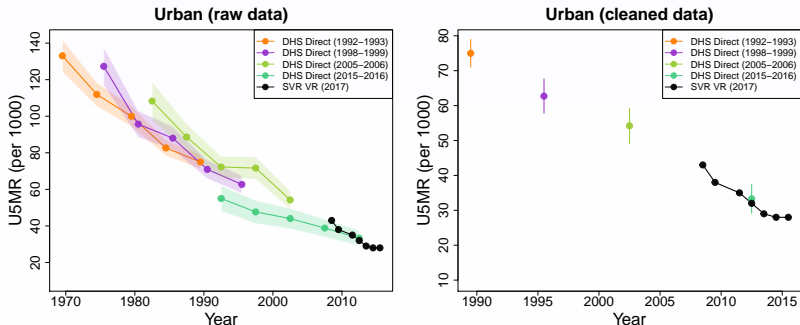
Data

Figure 5: **Urban U5MR observations for India.** Left: observations before data cleaning. Right: observations after data cleaning. We only include data within 5 years prior survey year for each data series. Data series are differentiated by color. The shades/vertical lines refers to the sampling error associated with each observation.
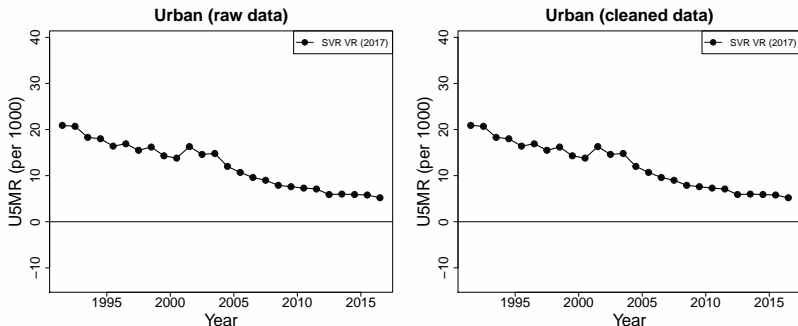
Data

China

Figure 6: **Urban U5MR observations for China.** Left: observations before data cleaning. Right: observations after data cleaning. We keep all data from China since they are from vital registration (VR) and each VR data is based on administrative record in the past year. Data series are differentiated by color. The shades/vertical lines refers to the sampling error associated with each observation.

Method

KAUST

Section 3

Method

Model for urban U5MR

KAUST

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

$$Q_{c,t} \;\; = \;\; Q_{\text{total},c,t} \cdot R_{c,t}.$$

- $Q_{c,t}$: urban U5MR;
- $Q_{\text{total},c,t}$: national U5MR, from the UN IGME estimates published in 2019;
- $R_{c,t}$: ratio of urban U5MR to national-level U5MR;
  - Model $R_{c,t}$ instead of $Q_{c,t}$ to minimize level biases from data.

Model for urban U5MR

KAUST

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

$$
\begin{aligned}
R_{c,t} &= \exp\left\{V_{c,t}\right\}, \text{ for } t = 1, \cdots, T, \\
V_{c,t} &= \mu_{c,t} + \epsilon_{c,t}, \text{ for } t = 1, \cdots, T, \\
\epsilon_{c,t} &\sim \mathcal{N}(0, \frac{\sigma_\epsilon^2}{1 - \rho^2}), \text{ for } t = 1, \\
\epsilon_{c,t} &\sim \mathcal{N}(\rho \cdot \epsilon_{c,t-1}, \sigma_\epsilon^2), \text{ for } t = 2, \cdots, T.
\end{aligned}
$$

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

Model for urban U5MR

KAUST

For $c = 1, \cdots, C$ and $t = 1, \cdots, T$:

$$\mu_{c,t} = \alpha_c \cdot x_{c,t} + \beta_c \cdot y_{c,t}.$$

- $x_{c,t}$: proportion of population residing in urban area on log scale, from the UN World Urbanization Prospects 2018 report.
- $y_{c,t}$: national U5MR on log scale, from the UN Inter-agency Group for Child Mortality Estimation (UN IGME) estimates 2019 report.

Prior distributions:

$$
\begin{aligned}
\alpha_c &\sim \mathcal{U}(-5, 5), \text{ for } c = 1, \cdots, C, \\
\beta_c &\sim \mathcal{U}(-5, 5), \text{ for } c = 1, \cdots, C, \\
\rho &\sim \mathcal{U}(0, 1), \\
\sigma_\epsilon &\sim \mathcal{U}(0, 0.05).
\end{aligned}
$$

Data model

KAUST

Data model

$$\log(r_i) \quad \sim \quad N(\log(R_{c[i],t[i]}), \sigma_i^2).$$

- r_i: the i-th observed ratio of the urban to national U5MR;
- σ_i^2: sampling variance for the i-th observation (a given value).

Model fitting
R-package R-INLA (Integrated Nested Laplace Approximations).

Results

KAUST

Section 4

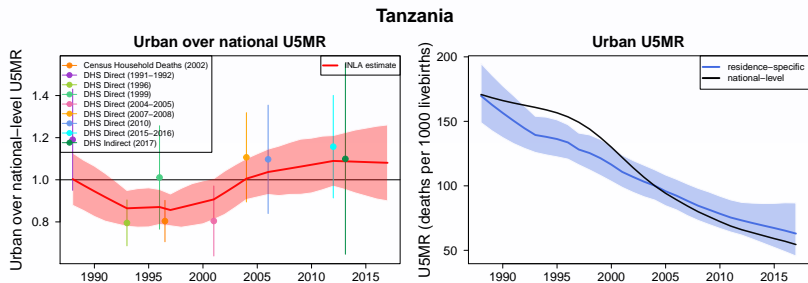Results

Illustration for country estimates

KAUST

Figure 7: **Model results for Tanzania.** Left: ratio of urban to national U5MR. Observations are shown for the ratio. The vertical lines refers to the sampling error associated with each observation. Red curve is the median estimate of the ratio. Shade is the 90% uncertainty interval. Right: urban U5MR in blue (median estimate in curve and 90% uncertainty interval in shade) and national U5MR in black. The median estimates of national U5MR are shown and are from the UN IGME 2019 report.
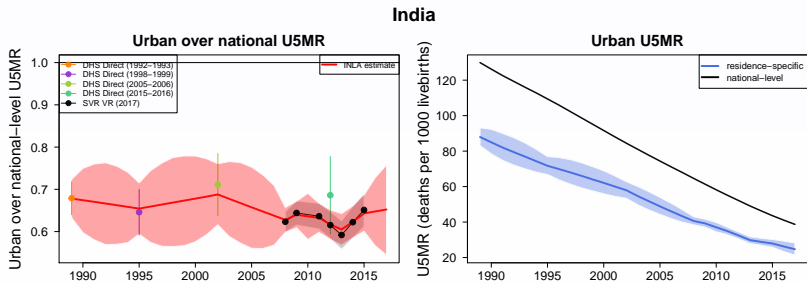
Illustration for country estimates

Figure 8: **Model results for India.** Left: ratio of urban to national U5MR. Observations are shown for the ratio. The vertical lines refers to the sampling error associated with each observation. Red curve is the median estimate of the ratio. Shade is the 90% uncertainty interval. Right: urban U5MR in blue (median estimate in curve and 90% uncertainty interval in shade) and national U5MR in black. The median estimates of national U5MR are shown and are from the UN IGME 2019 report.
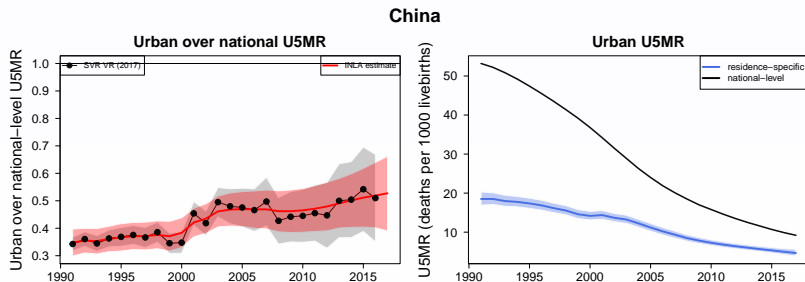
Illustration for country estimates

Figure 9: **Model results for China.** Left: ratio of urban to national U5MR. Observations are shown for the ratio. The vertical lines refers to the sampling error associated with each observation. Red curve is the median estimate of the ratio. Shade is the 90% uncertainty interval. Right: urban U5MR in blue (median estimate in curve and 90% uncertainty interval in shade) and national U5MR in black. The median estimates of national U5MR are shown and are from the UN IGME 2019 report.
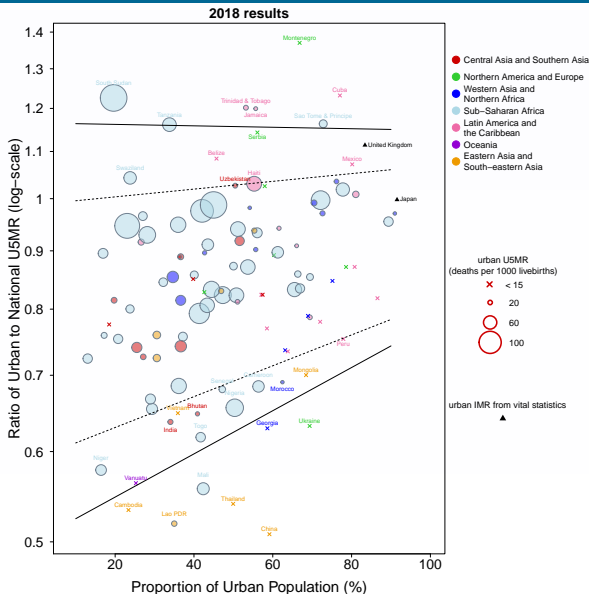
Urban-national U5MR disparity and urbanization

KAUST

Figure 10: **2018 results overview.** Countries are coloured by regions. Circle size is proportional to the number of observations available for each country. Black triangle dots are the ratio of urban to total infant mortality rate (IMR) from developed countries. The two solid lines are the 95% bounds, and the two dashed lines are the 80% bounds. Both sets of bounds are smoothed by the Friedman's SuperSmoother approach.

Summary

Section 5

Summary

Summary

Conclusion

- We estimate urban U5MR for 109 countries during 1990–2018;
- We assess the disparities of U5MR between urban and national levels.

Collaborators This is a joint work with:

- **Danzhen You** from the UNICEF.
- **Lucia Hug** from the UNICEF.
- **Jon Pedersen** from Fafo.
- **Hernando Ombao** from KAUST.
- **Leontine Alkema** from UMass, Amherst.

Thank you!

Fengqing Chao
fengqingchao.com

King Abdullah University of Science and Technology

STATISTICS
@KAUST