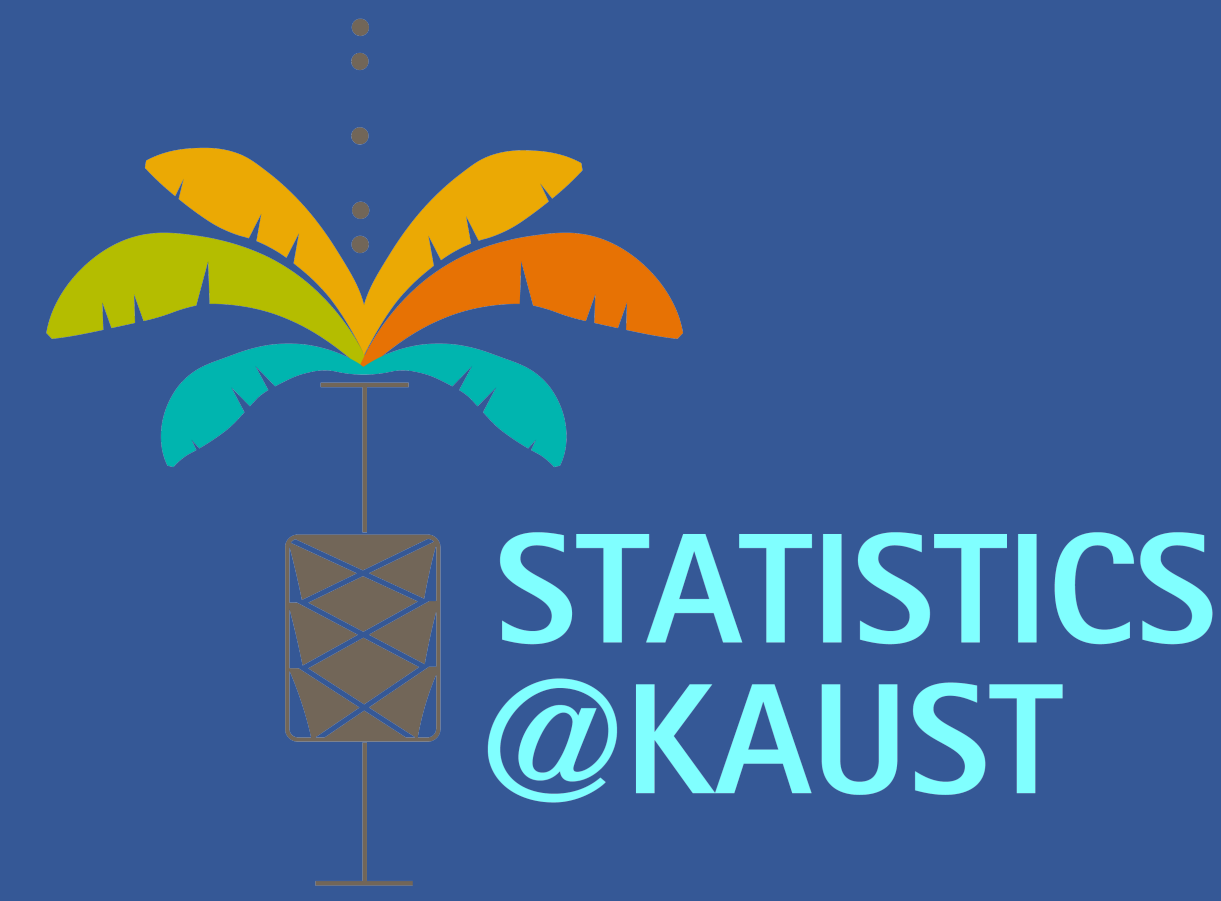# Under-5 Mortality Rate Estimation by Residence using Bayesian Model

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Introduction

U5MR
► Under-5 mortality rate;
► Defined as: probability of dying before age 5.

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;

U5MR disparity
► To better understand who and where the most disadvantaged and vulnerable children are;
► 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);

Urban and rural definition
► An indicator to determine whether the household interviewed is in urban or rural areas;
► Adopt the country-specific urban-rural definition;
► Follows the criteria provided by the corresponding national statistical offices.
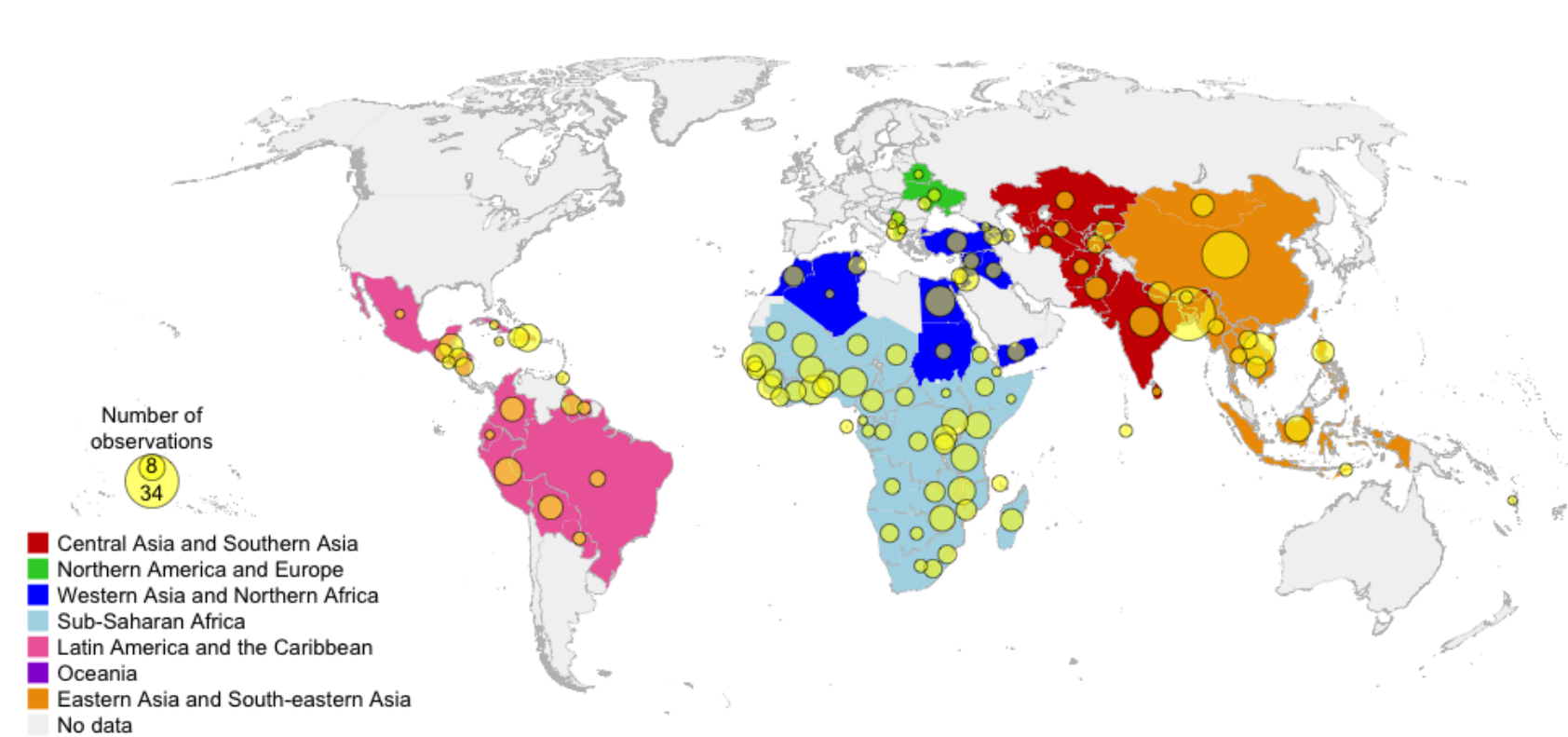
Data

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

► Urban U5MR: 528 data points, 109 countries;
► # observations per country: 1 to 34;
► Reference year range: 1982–2016;
► Data type: survey, vital registration systems;
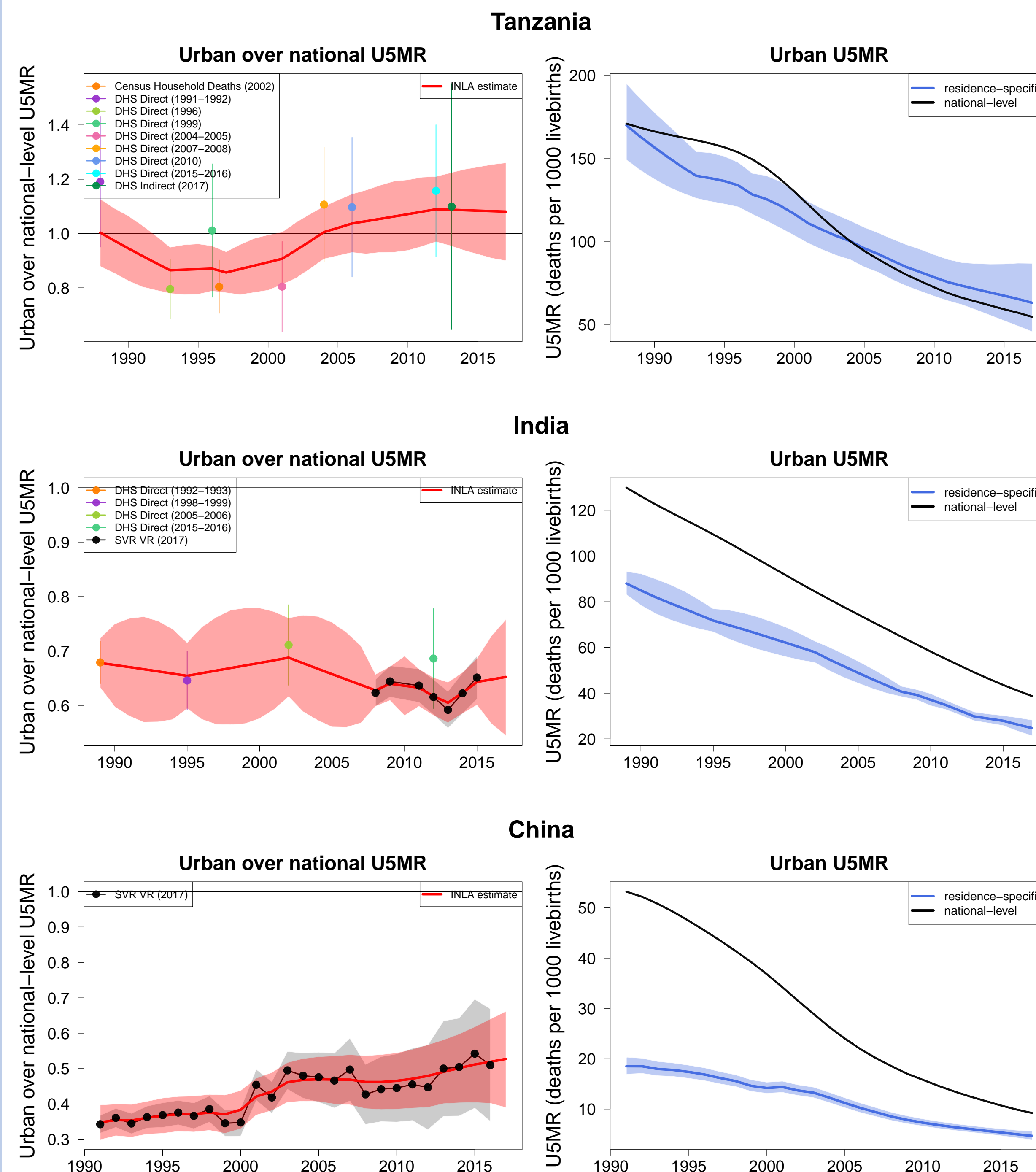► Exclude data with reference date beyond 5 years prior to survey.

About us

KAUST Biostatisitcs Group
► PI: Prof Hernando Ombao
► `https://cemse.kaust.edu.sa/biostats`

Results: country estimates

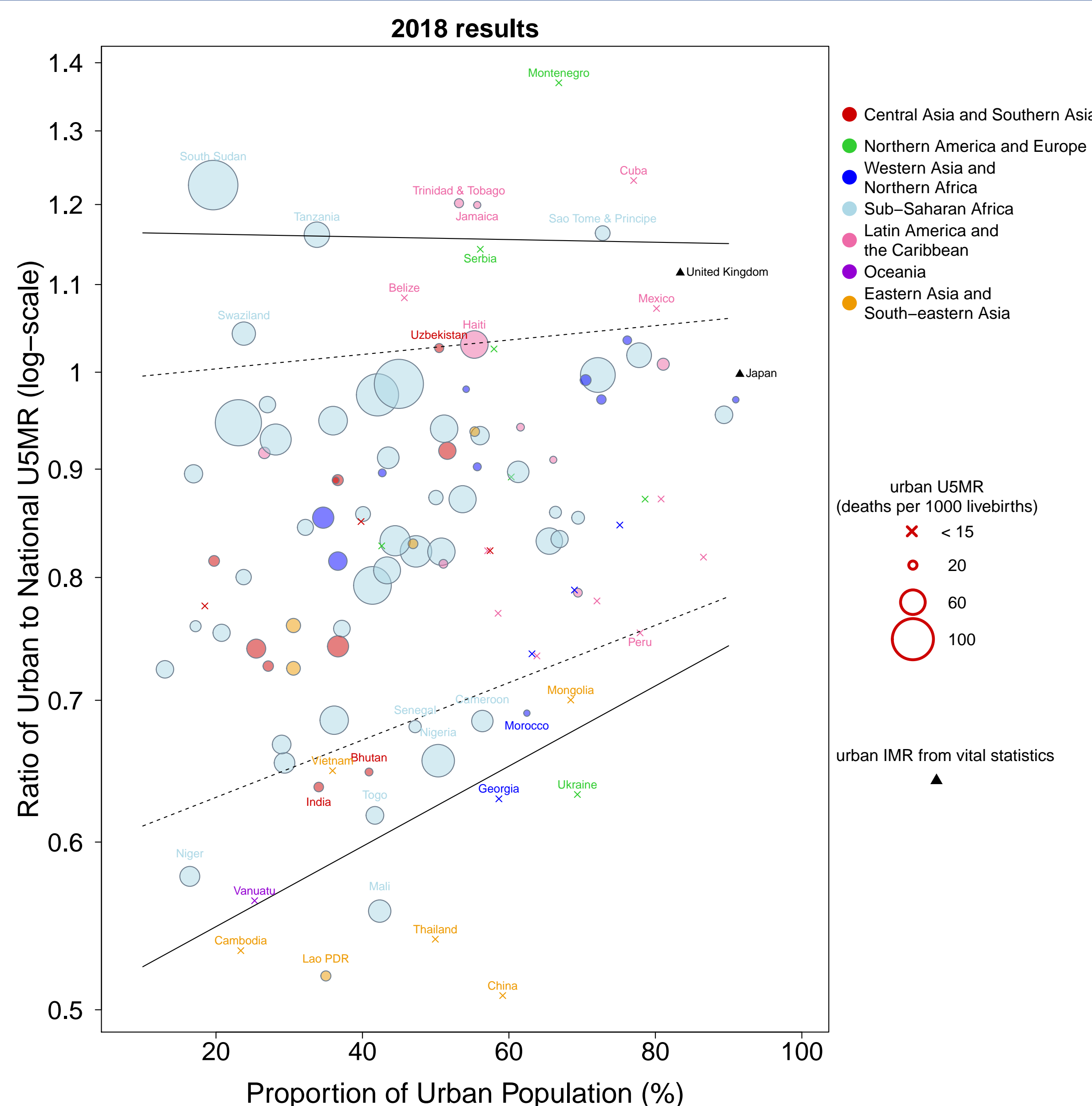## Results: U5MR disparity and urbanization

Figure: Black triangle dots are the ratio of urban to total infant mortality rate (IMR) from developed countries. The solid lines and dashed lines are the 95% and 80% bounds respectively.

Acknowledgements

Method

Model for urban U5MR
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;
► $R_{c,t}$: ratio of urban U5MR to national-level U5MR;
► Model $R_{c,t}$ instead of $Q_{c,t}$ to minimize level biases from data.

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

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

$\mu_{c,t}$ is modeled as a multivariate linear regression function. 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 UN World Urbanization Prospect;
► $y_{c,t}$: national U5MR on log scale, from UN IGME estimates;
► α_c and β_c are mutually independent and are assigned with non-informative priors.

Data Model
For observation $i = 1, \cdots, 528$:

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

► 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).

Computing
We fit the model in the open source software `R 3.5.1` and `R-package R-INLA` (Rue H. et al 2009).

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. 2014 Sep 1;2(9):e521-30.
► Chao F, You D, Pedersen J, Hug L, Alkema L. National and regional under-5 mortality rate by economic status for low-income and middle-income countries: a systematic assessment. The Lancet Global Health. 2018 May 1;6(5):e535-47.
► Rue H, Martino S, Chopin N. Approximate Bayesian Inference for Latent Gaussian Models Using Integrated Nested Laplace Approximations (with discussion). Journal of the Royal Statistical Society B. 2009;71:319-392.

2019 Statistics and Data Science Workshop, KAUST, Nov 18-20 2019, Thuwal, Saudi Arabia