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Global Age Patterns of Under-5 Mortality (GAPU5M) Site Profiles Series: Maternal and Child Health Surveillance System (MCHSS), China

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Disciplines

Demography, Population, and Ecology | Health Policy | Maternal and Child Health | Social and Behavioral Sciences | Sociology

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A. Context

The Chinese National Maternal and Child Health Surveillance System (MCHSS) was established in 1996 based on three independent surveillance systems: (1) the Child Mortality Surveillance System that started in 1991; (2) population-based maternal mortality surveillance system; and (3) hospital-based birth defect surveillance system (Basten 2010, National Bureau of Statistics, 2014).

In 2009, the number of surveillance sites expanded from 116 (37 urban and 79 rural) to 336 counties/districts (126 urban and 210 rural) in 30 provinces (autonomous regions and municipalities) in Mainland China (Gibbons et al. 2010; Rudan et al. 2010). Based on their geography and economic development, these sites can be further categorized into three regions: East, Midland (Central) and West, with the East region being the most developed and the West region the least. The East region includes Beijing, Tianjin, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, and Guangdong; the Midland includes Hebei, Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan and Hainan; and the West includes Inner Mongolia, Guangxi, Sichuan, Chongqing, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang (see **Figure 1**).

China's landscapes vary significantly across its vast width. In the East region there are extensive and densely populated alluvial plains, while on the West broad grasslands predominate. Southern China is dominated by hills and low mountain ranges, while the central-east hosts the deltas of China's two major rivers, the Yellow River and the Yangtze River. To the West sit major mountain ranges, most notably the Himalayas.

China has achieved a rapid reduction in child mortality in the last two decades, from 700,000 deaths in 1996 to 181,600 in 2015; the under-five mortality rate (U5MR) has also declined during the same period from 50.8 per 1,000 live births to 10.7 (He et al. 2017). **Figure 2** shows these trends also disaggregated by region. Previous studies (e.g. Feng et al. 2012; Song et al. 2016; Rudan et al. 2010; Wang et al. 2011) report similar results. In 2015, the leading causes of death among neonates (0-27 days) were preterm birth complications (16.0%), intrapartum-related events (14.1%) and congenital abnormalities (9.2%). Among children aged 1-59 months, the leading causes were injuries (12.1%), congenital abnormalities (10.4%) and pneumonia (9.3%), in addition to other conditions (10.3%). Neonate deaths represented 51.5% of the child deaths in 2015, and 1-59 months the remaining 48.5% (He et al. 2017).

Figure 1. Study locations of the MCHSS. Original map by He et al. (2017)

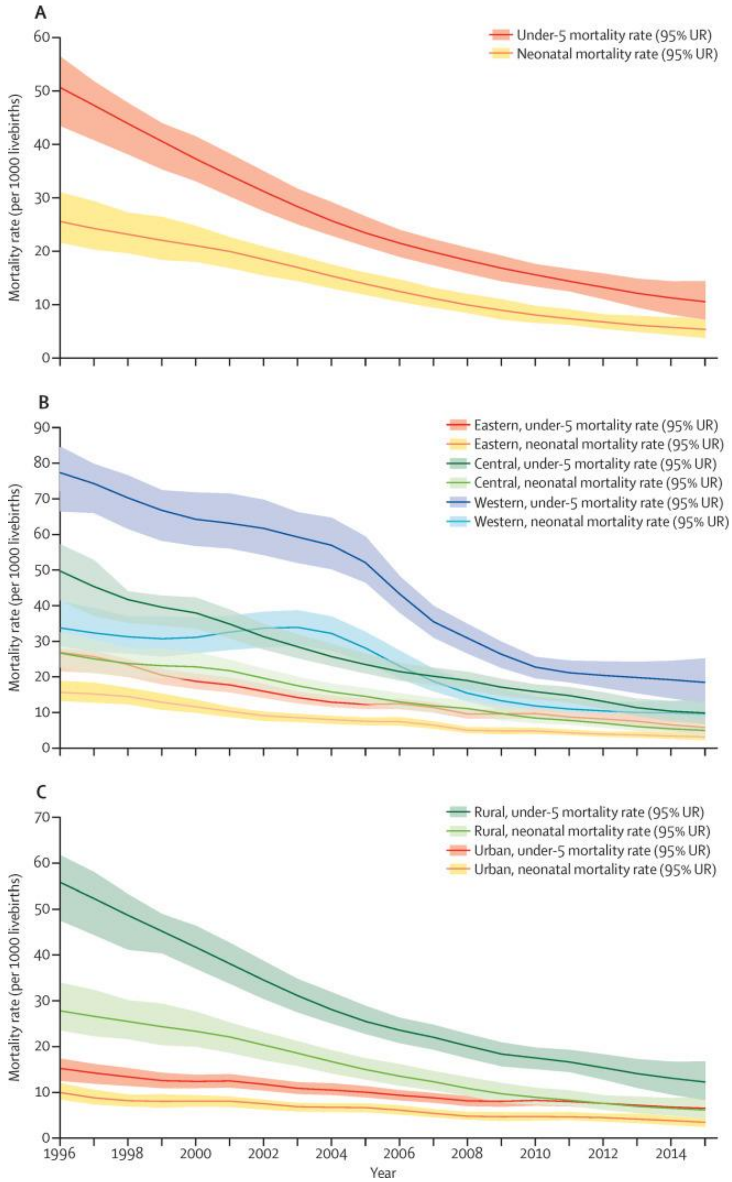

Figure 2. Age-specific mortality rates in children younger than 5 years in China, 1996–2015. Original figure by He et al. (2017)

B. Study design

This section provides a summary of the contents available in the supplementary materials of He et al. (2017) and Song et al. (2016). The reader is referred to these two publications for additional details.

In 1991, child mortality surveillance sites were selected using a multi-stage sampling. First, all provinces in China were stratified into the three mentioned regions: East, Midland, and West. The stratification was based on geographic location, economic status and infant mortality. All urban districts and rural counties within each region were further stratified into six strata: East rural, East urban, Mid rural, Mid urban, West rural, West urban.

Population under surveillance within each stratum was calculated based on stratum-specific infant mortality and crude birth rates. Prefectural-level cities and rural counties were sampled according to the following criteria to obtain representative sample within each stratum: 1) the number of cities/counties sampled with probability proportional to the number of cities/counties in each stratum, and a minimum of two cities/counties; 2) sampled cities/counties were distributed evenly across all 30 provinces considering feasibility; 3) weighted mean infant mortality of study sample was close to that of study population within each stratum; and 4) selected cities/counties had adequate human and financial resources and capability to manage and maintain surveillance sites. Within each stratum, the weighted infant mortality was close to the empirical stratum-specific infant mortality and the sample was considered nationally representative.

The total surveillance sites increased from 81 cities/counties in 1991 to 116 sites representing 123 cities/counties in 1996 with the instauration of the MCHSS; one to two cities/counties added in each province/autonomous region/municipality. In 1996-2009, the unit of surveillance was municipalities/cities in urban areas and counties in rural areas. In 2001, 17 sites from 14 provinces were replaced with new ones of similar economic status, geographic characteristics and population size from the same stratum due to administrative changes and practical considerations. Since 2009 – together with the expansion to 336 sites – the unit of surveillance in urban areas has changed to districts while that in rural areas remained at the county level. **Table 1** presents the evolution of the MCHSS since 1991.

Data collection and causes of death (COD)

The surveillance contents, case definitions, reporting methods, and quality control are unified across all surveillance sites within MCHSS. The basic contents include:

1. The number of live births, the number of children aged 1-4 years and the overall population;
2. The number of deaths for children younger than five years of age and their corresponding COD;
3. The timing, locations and distribution of deaths of children younger than five years of age;
4. The basic situation of health care services for children younger than five years.

Exact dates of birth and death, as well as the exact age at death in a daily scale, were recorded in a standardized Child Death Registration Card (see **Figure 3**). Next, ages at death were aggregated into six mutually exclusive categories: 0-6 days, 7-27 days, 1-5 months, 6-11 months, 12-23 months, and 24-59 months.

Table 1. Evolution of the MCHSS

Year	1991	1996	2001	2006/07	2009	2013
Event	Child mortality surveillance network established	Child mortality, maternal mortality, and congenital abnormality surveillance networks combined	Site update[1]	MCHSS expansion initiated[2]	MCHSS expansion completed[2]	Site update[3]
Number of sites under surveillance	81	116	116 (with 17 sites from 14 provinces replaced)	123 with 13 sites updated[4]	336	334
Number of urban districts under surveillance	25	37	37 (2 sites replaced)	56 (12 switched from rural sites)	126	124
Number of rural counties under surveillance	56	79	79 (15 sites replaced)	67 (1 switched from urban site)	210	210
Number of population under surveillance (millions)	8.5	12.7	14.0	16.7	44.9	47.1

[1] To account for economic development, and changes in administrative boundaries and urban-rural classification while maintaining the total number of population under surveillance, 17 and 2 surveillance sites were re-selected in 2001 and 2009, respectively.
[2] Expansion in surveillance sites was not reflected in the data until 2009.
[3] Total number of sites changed from 336 to 334 due to site combination. Population under surveillance did not change.
[4] The changes in urban/rural classification for 13 sites were due to administrative changes for these areas based on administrative area codes published by National Bureau of Statistics of China in 2007. Before 2009, the unit of surveillance was municipalities/cities/counties. After 2009, it changed to districts/counties.

There are no birth registration cards, but an under-five roster in which all live births and under-five in-migrants are recorded on a rolling basis. This roster is updated quarterly every year to reflect changes on vital status, migration status and age (see **Figure 4**). Specifically, it is documented whether each child is still alive, dead, migrated out of the surveillance area or aged out (MCHSS Manual 2013).

The system does not conduct any surveillance on stillbirths. The definition of livebirths is as follows. Before October 1st 2013, newborn babies with a gestational age of 28 weeks (if gestational age unavailable, a birth weight of at least 1,000 grams is used as selection criteria) are included in the under-five roster when at delivery they present at least one of the four following signs of life: heartbeat, breathing, umbilical cord beating, and voluntary muscle contraction. After Oct 1st 2013, despite of gestational age, babies with any sign(s) of life would need to be reported on the child death card. However, in practice, live births with less than 28 weeks of gestational age (or less than 1,000 grams of birth weight) are only recorded on the under-five roster, and left out in the aggregated statistics at any level of the surveillance system (MCHSS Manual 2013).

This definition implies an underestimation of livebirths, which can underestimate neonatal and under-5 mortality rates and the contribution of major neonatal causes, especially preterm birth complications. In addition, considering age patterns of under-five mortality, the underestimation affects younger age groups more severely (e.g. first week of life) than older age groups (e.g. week two to week four or life). However, as noted by He et al. (2017), “given the relatively small burden of those born alive before 28 weeks, this bias is likely to be small” (p. 195), something they confirmed by carrying out a sensitivity analysis.

For each community/village, one doctor is responsible for recording every newborn child, child death, or inbound/outbound migration of a child during the surveillance period. Once a death occurs, the community/village doctor is responsible for reporting it to the community health center/township hospital within ten days. Upon receiving this report, a specialist in charge of maternal and child health organizes a home visit to verify the death within seven days. The national unified Child Death Registration Card shown in **Figure 3** is used to record the death related information. When a child dies at home or on the way to a hospital, a “Questionnaire of Child Death Outside of Medical Institutions” is used to conduct a verbal autopsy. The established COD is then recorded in the Death Registration Card. When a child dies in a hospital, the Death Registration Card would be completed based on the diagnosis from the hospital. All death causes are recorded as the primary COD and coded based on 35 causes categorized by MCHSS specifically for children. ICD-10 would be assigned automatically in the electronic reporting system after the causes are entered in the computer system.

__________District/County□□□□□□

No. □□□□□□□□

Address:____Township/District____Street/Village

Father's name:_______ Mother's name_______

Child's name:________

(1) Registered permanent residence (2) Non-local registered permanent residence for less than one year (3) Non-local registered permanent residence for more than one year □

Sex: 1.Male 2.Female □

Date of birth:

Year		Month		Day	

Birth weight: ______g

(1) measured (2) estimated □

Gestational weeks: ______weeks

Place of birth:

(1) provincial/municipal hospital (2) district/county hospital (3) community/township health center (4) village clinic (5) on the way (6) in home □

Date of death:

Year		Month		Day	

Age at death: ___years___months___days

Cause of death:

(a) Disease or condition directly leading to death

____

(b) Disease or condition leading to (a)____________

(c) Disease or condition leading to (b)____________

(d) Disease or condition leading to (c)____________

Underlying cause of death____________

Classification Code □□

ICD-10 code □□□□□

Place of death: (1) hospital/clinic (2) on the way (3) in home □

Premortality treatment: (1) inpatient treatment (2) outpatient treatment (3) without treatment □

Level of hospital: (1) provincial/municipal hospital (2) district/county hospital (3) community/township health center (4) village clinic (5) without treatment □

Reason for untreated: (Single Choice)

(1) financial hardship (2) traffic inconvenience (3) time limited (4) parents unaware of the serious condition (5) manners and customs (6) others (specify) □

Basis for diagnosis: (1) pathological autopsy (2) clinical diagnosis (3) inference □

Basis or evidence to infer the causes of death: (Please describe in details, using the blank on the back.)

____

____

Report unit_____________ Name of reporter__________ Date of report___________

Figure 3. Child Death Registration Card used in the MCHSS.
Source: Translated from MCHSS Manual (2013) and supplementary materials in He et al. (2017)

Figure 4. Card of the under-fiver roster for the population under surveillance.
Source: Adapted from MCHSS Manual (2013)

Data quality control

Quality control of the MCHSS consists of two parts: the attention is firstly focused on a possible under-reporting of either live births or deaths, and then the focus is placed on a possible COD misclassification. During data triangulation and cross validation across multiple local sources, a number of techniques are used to improve the completeness of births and deaths reporting. These include focus group discussion with village doctors, household visits, medical records review of livebirths and stillbirths, pregnancy and delivery history, Apgar scores for newborns, review of civil registrations records, vaccination records and history, and records from Family Planning Offices, Centers of Disease Control, Public Security Bureaus, Civil Affairs Bureaus, and New Rural Cooperative Medical Scheme Service Offices, etc. (National office MCHSS, 2013). Since 2010, neonatal death audit has been implemented in MCHSS in health departments and maternal and child health facilities at and above the district/county level to validate causes of neonatal deaths and improve neonatal survival.

We believe the estimates are reliable in general, although some anomalies were observed in some regions with regards to congenital abnormalities. In particular, this is noticeable in the West rural region, as observed in the bump of the light blue shadow in Panel B of **Figure 2**. Nonetheless, surveillance systems have improved over time, especially since 2004 when a national program to subsidize congenital heart surgery in hospitals was launched. As a result, more babies are attended in hospitals and the disease is better recorded. Moreover, the percentage of causes of death that are ascertained by medical certification have increased over time (He et al. 2017).

C. Internal and external quality check

The main challenge of the MCHSS data concerns the expansion of the surveillance sites from 116 (37 urban and 79 rural) to 336 counties/districts (126 urban and 210 rural) between 2008 and 2009, which implies a notable increase of the population and number of deaths under surveillance, as observed in **Figure 5**. Consequently, data from 2008 or earlier cannot be used to build life tables and produce mortality estimates from 2009 onwards.

Figure 6 shows the distribution of deaths by age and strata over time using raw data from the MCHSS. The 0-6 days age group is the one with a higher proportion in all regions. In general, proportion are reasonably stable for all age groups over time, although a decline in 0-6 days deaths is observed at the end of the period, which is especially noticeable in the Mid-rural and West-urban strata. Regarding sex ratios at birth, MCHSS data suggests some imbalance in rural areas in early years, as shown in **Figure 7**. However, this sex ratio at birth distortions seem to have lowered down after 2012, perhaps thanks to the end of the one-child policy in China. These trends are consistent with estimates from UNICEF and the UN Population Division that also report an increase of the sex ratio distortions since the 1980s, reaching a peak in the period 2005-2010, and followed by a decline in the subsequent decade (see **Figure 8**).

An alternative data source is the Disease Surveillance Points (DSP), which is the Chinese all-age mortality surveillance. However, there is a general consensus that MCHSS is more reliable for under five mortality whereas DSP is more widely used for 5-19 years.

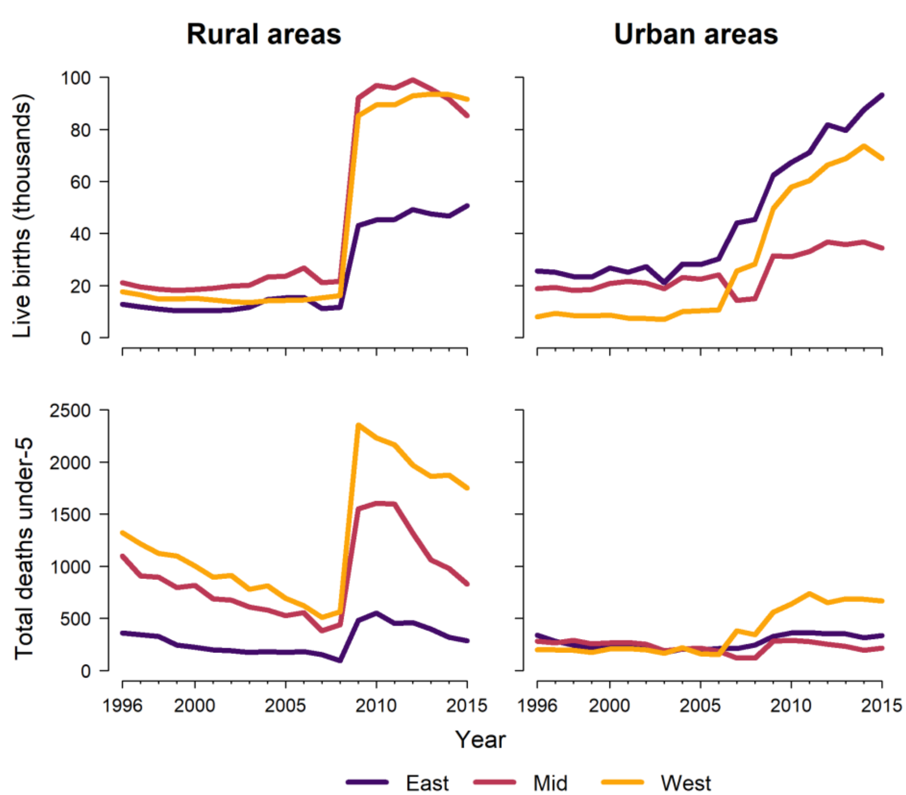

Figure 5. Number of live births and under five deaths, raw data from the MCHSS, 1996-2015

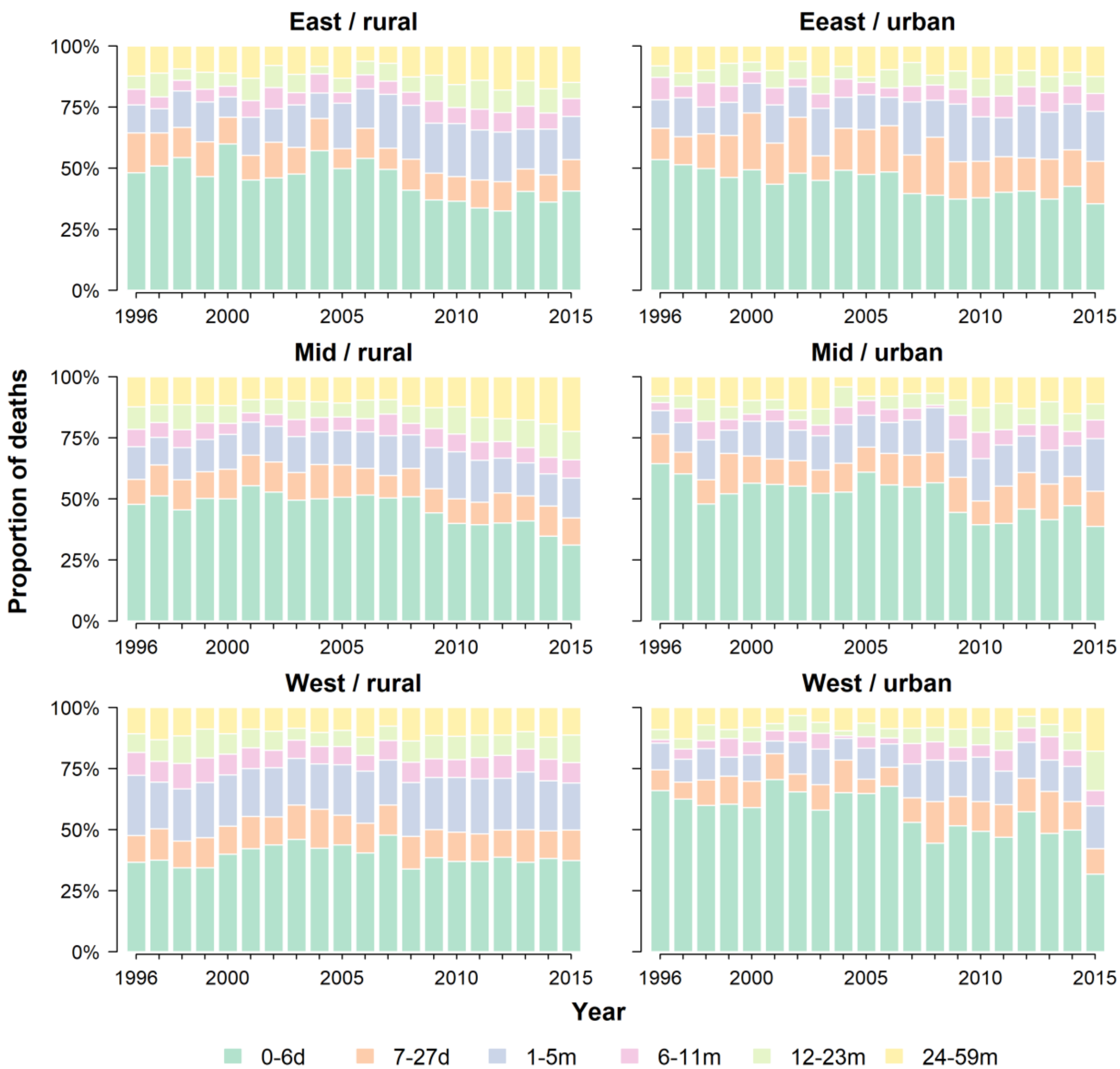

Figure 6. Proportion of deaths by age group and strata, raw data from the MCHSS, 1996-2015

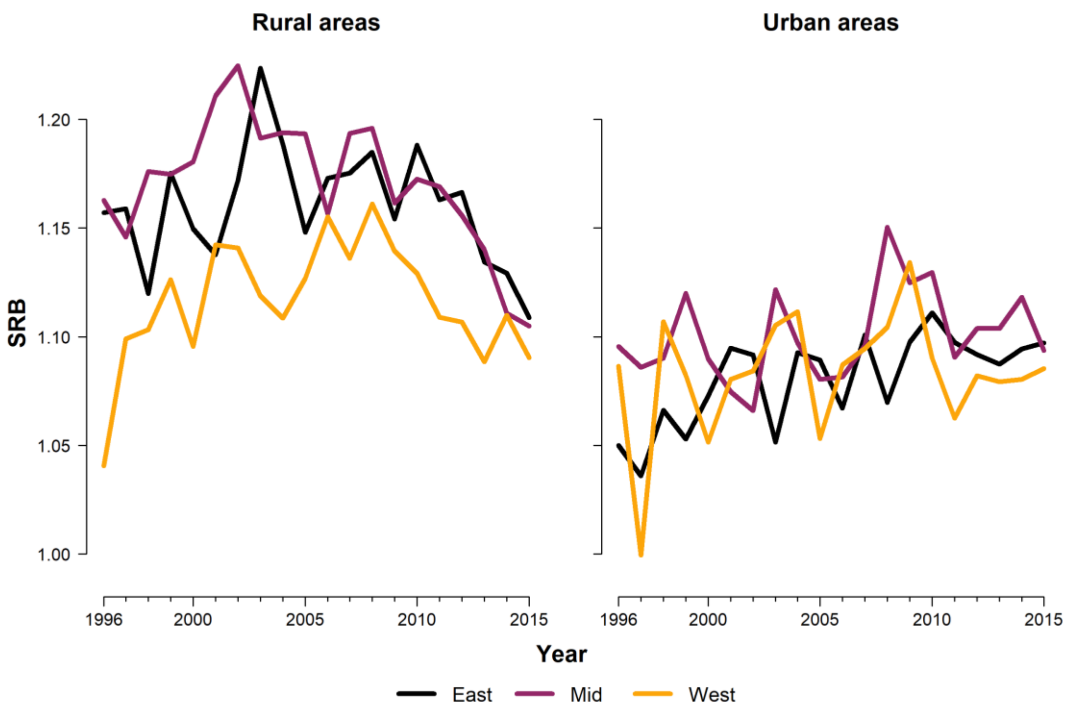

Figure 7. Sex ratios at birth, raw data from the MCHSS, 1996-2015

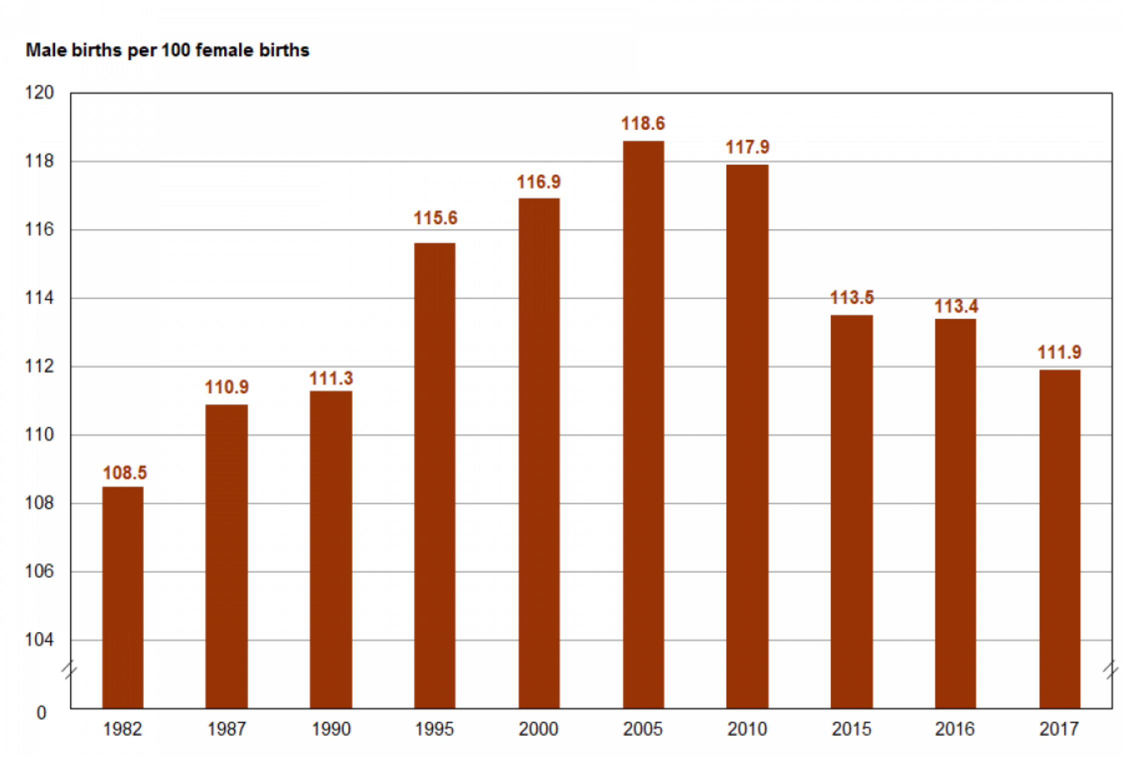

Figure 8. Sex ratio at birth in China, 1982–2017. Source: UNICEF, available at https://www.unicef.cn/en/figure-19-sex-ratio-birth-19822017

D. Adjustments

To estimate age-specific death rates one needs deaths and exposures (individuals exposed to the risk of dying). Only births and deaths are reported in the MCHSS, so in order to estimate the exposures for each age category we reconstructed birth cohorts from the available data. Note that, since we are estimating under-5 mortality, data from the previous 5 years are necessary to approximate the exposures and build period life tables for a given year. However, because of the surveillance expansion between 2008 and 2009, data from 2008 or earlier cannot be combined with data from 2009 onwards. Hence, we decided to produce mortality estimates only for the periods 2001-2008 and 2014-2015. Migration has not been considered in part because migration flows in China have been characterized by the "left-behind children" effect, wherein children under-five do not tend to migrate with their parents. In addition, the eligibility criteria of the MCHSS contemplates mothers who have migrated to a surveillance site for more than one year are. Hence, MCHSS only misses mothers and children who have not been migrating for more than one year, and we suspect that is a small percentage.

Death rates estimation

First, we calculate the number of individuals alive in each age group at the end of each time interval ($N_x(t)$ values of the Lexis diagram) by reconstructing birth cohorts from survey data. The procedure works as follows:

1. Six age groups are available in the MCHSS for children under five: 0-6 days, 7-27 days, 1-5 months, 6-11 months, 12-23 months, and 24-59 months.
2. Because data is retrieved in annual basis, some adjustments are necessary. Assuming the exposures to be proportional to the length of the age interval, we calculated the following "proportions of deaths within each age interval that correspond to individuals who entered the age interval that calendar year": $p_{0-6d} = 0.990418$; $p_{7-27d} = 0.952088$; $p_{1-5m} = 0.71167$; and $p_{6-11m} = 0.25$.
3. For a given year t, using these proportions together with the number of births $B(t)$ and deaths below age 1 from that year, we obtain the number individuals in age 0 to 11 months at the end of calendar year t,
$$N_{0-11m}(t) = B(t) - D_{0-6d}(t) \times p_{0-6d} - D_{7-27d}(t) \times p_{7-27d} - D_{1-5m}(t) \times p_{1-5m} - D_{6-11m}(t) \times p_{6-11m}.$$
4. That way, we obtain $N_{0-11m}(t)$ estimates for the end of years 1996 to 2015.
5. Assuming exposures to be proportional to the length of the age intervals, we calculate the $N_x(t)$ values for finer age groups: 0-6 days, 7-27 days, 1-5 months, and 6-11 months.
6. Next, using the $N_{0-11m}(t)$ estimates and the corresponding deaths in the following calendar year $t+1$, we calculate the number of individuals in age 12 to 23 months at the end of $t+1$, given by
$$N_{12-23m}(t+1) = N_{0-11m}(t) - D_{0-6d}(t+1) \times (1 - p_{0-6d}) - D_{7-27d}(t+1) \times (1 - p_{7-27d}) - D_{1-5m}(t+1) \times (1 - p_{1-5m}) - D_{6-11m}(t) \times (1 - p_{6-11m}) - D_{12-23m}(t) \times 0.5.$$
7. That way, we obtain $N_{12-23m}(t)$ estimates for the end of years 1997 to 2015.

8. Finally, following a similar procedure and assuming deaths are distributed equally within each calendar year, we calculate $N_{24-59m}(t)$, the number of individuals alive in ages 24 to 59 months a the end of calendar years 2000 to 2015.

As a result, for years 2000 to 2015 we get $N_x(t)$ estimates for all six age groups: 0-6 days, 7-27 days, 1-5 months, and 6-11 months, 12-23 months, and 24-59 months. However, because of the surveillance expansion, data from 2008 or earlier cannot be combined with data from 2009 onwards. Accordingly, we dropped estimates from 2009-2012.

In a second step, we calculate the mid-year population for each age group x, given by

$$L_x(t) = \frac{N_x(t-1) + N_x(t)}{2},$$

for $t = 2001\text{-}2008, 2014, 2015$. Finally, for these 10 years and 6 age groups we get the age-specific central death rates

$$M_x(t) = \frac{D_x(t)}{L_x(t)}.$$

Additional details, as well as the R code, are available upon request.

E. Best mortality estimates for the site

Following the methodology described in the previous section, **Figure 9** and **Figure 11** show the age-specific all-cause mortality estimates, disaggregated by sex and strata, using raw data from the MCHSS. **Figure 10** and **Figure 12** display the corresponding cumulative probabilities of death. In general, mortality is higher in rural areas compared to urban areas, especially in the West region. No remarkable differences are observed between males and females, except perhaps in the East region.

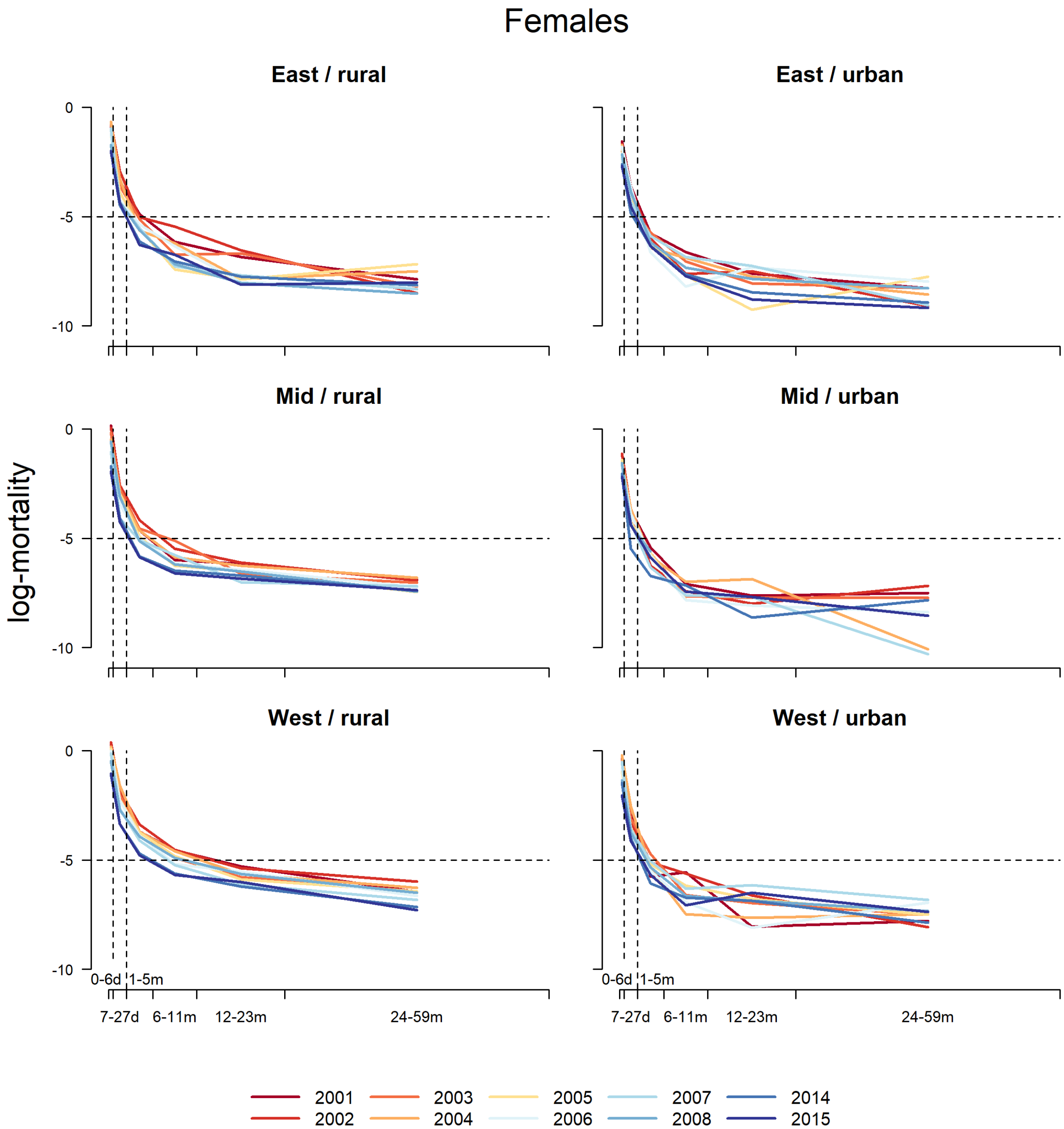

Figure 9. Mortality estimates (log central death rates), females, 2001-2008 and 2014-2015

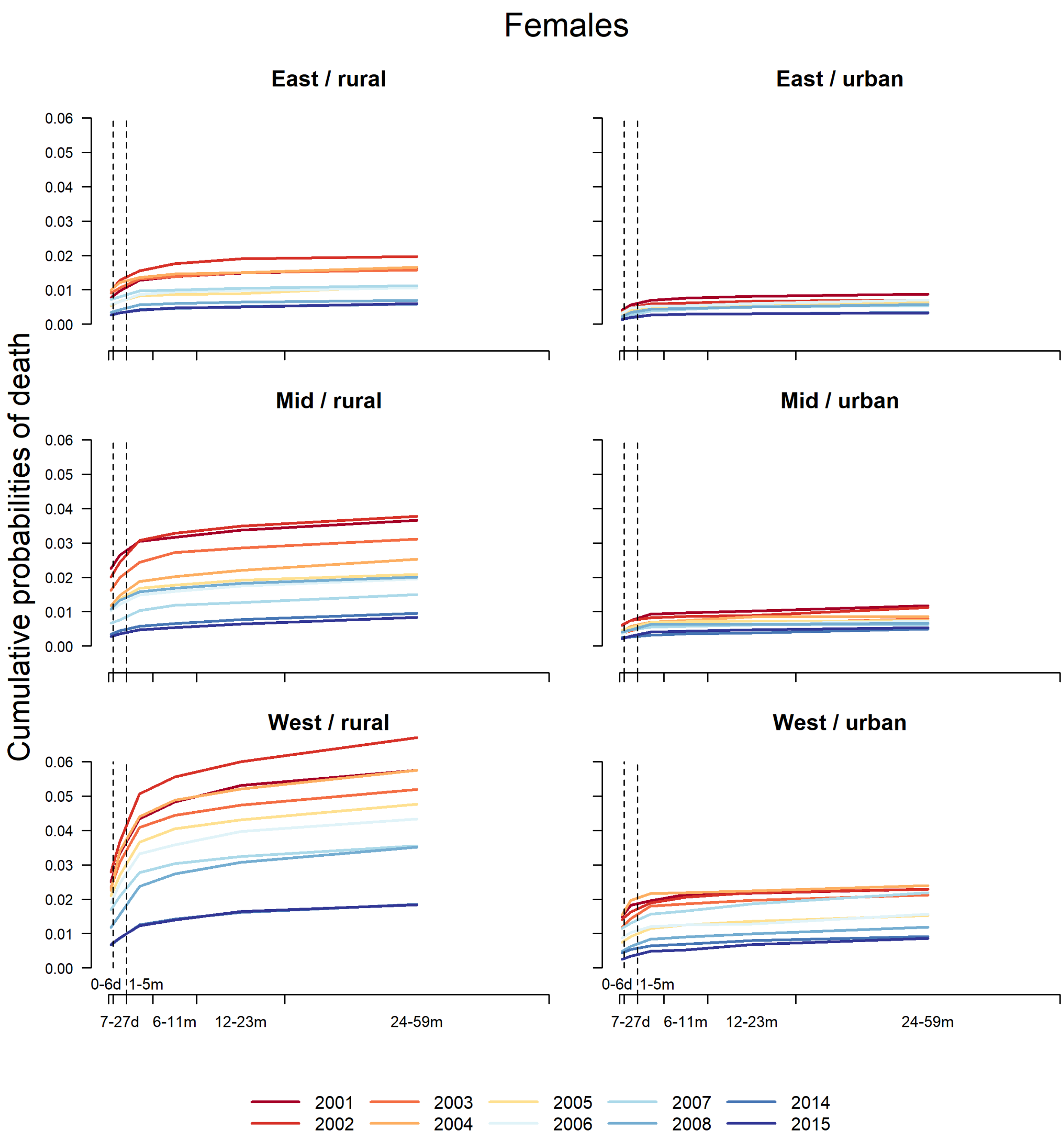

Figure 10. Cumulative probabilities of death, females, 2001-2008 and 2014-2015

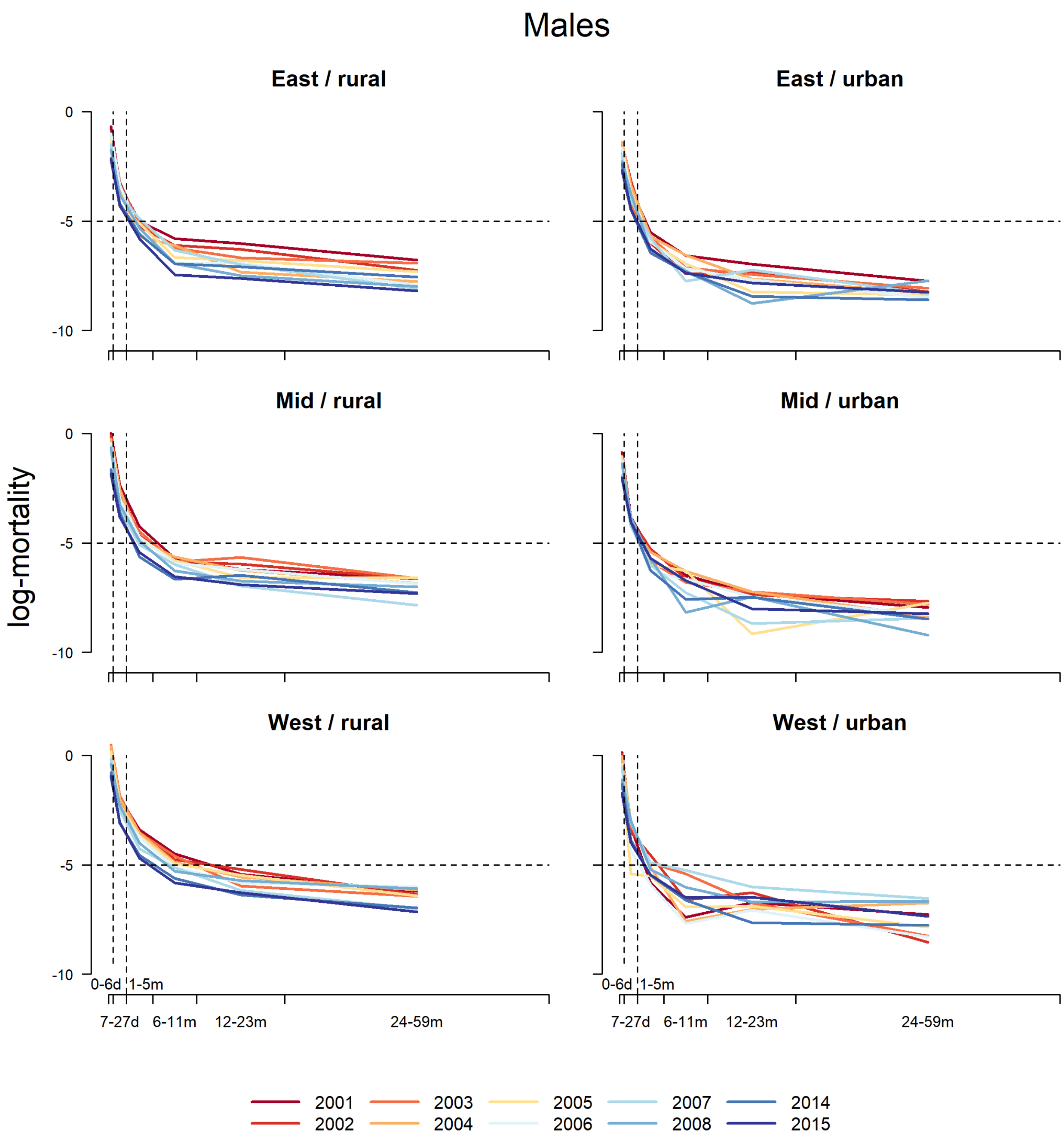

Figure 11. Mortality estimates (log central death rates), males, 2001-2008 and 201-2015

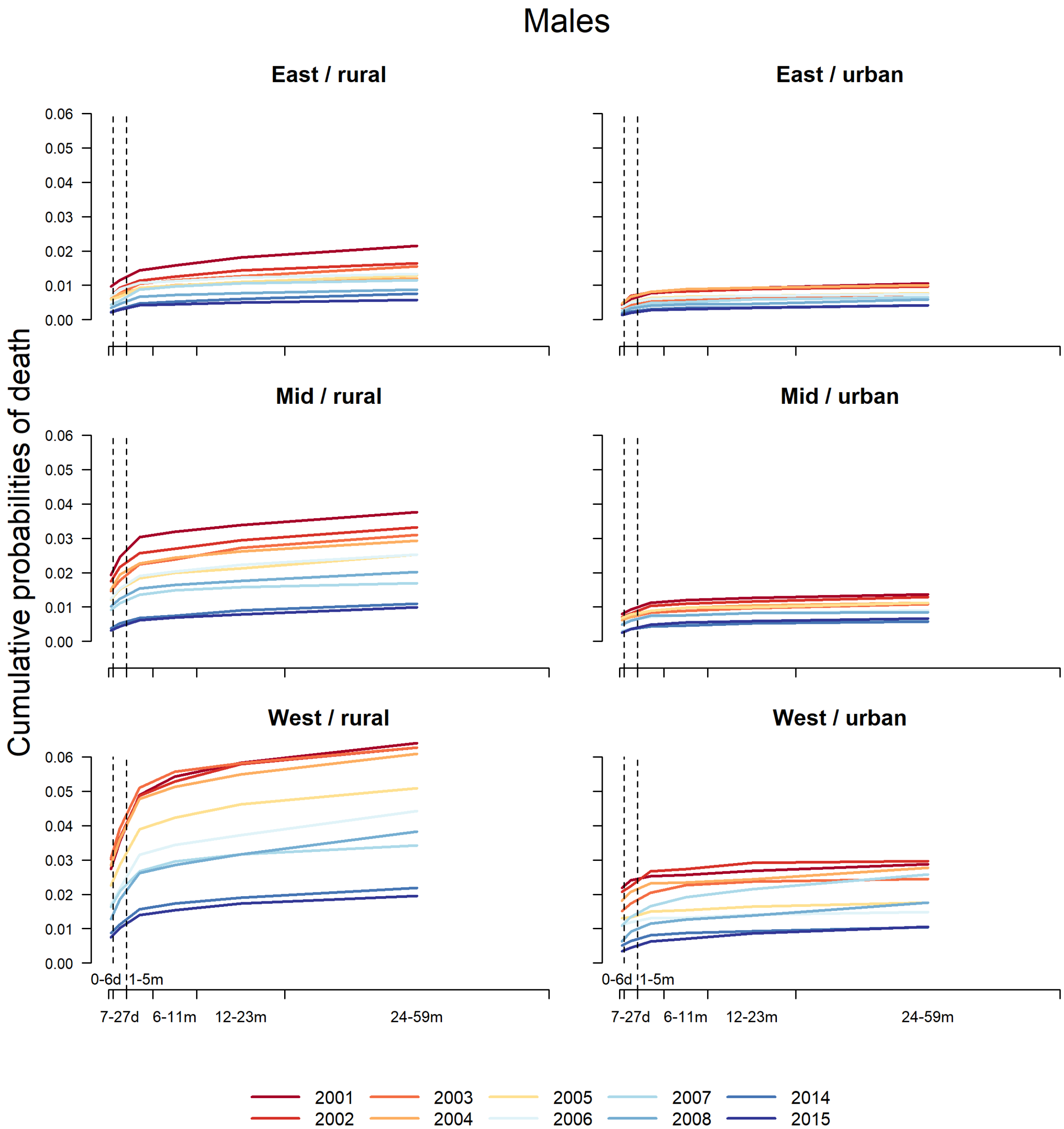

Figure 12. Cumulative probabilities of death, males, 2001-2008 and 2014-2015

F. Main publications for the site (with focus on study design and child health/mortality)

1. Song, P., Theodoratou, E., Li, X., Liu, L., Chu, Y., Black, R. E., ... & Chan, K. Y. (2016). Causes of death in children younger than five years in China in 2015: an updated analysis. *Journal of Global Health*, *6*(2).
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