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Geographic disparities in pneumonia-specific under-five mortality rates in Mainland China from 1996 to 2015: a population-based study

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SUMMARY

Objectives: This study aimed to investigate the disparities in pneumonia-specific under-five mortality rates (U5MRs) among and within three geographic regions in Mainland China from 1996 to 2015.
Methods: Data were obtained from the national Under-Five Child Mortality Surveillance System and grouped into 2-year periods. The Cochran–Armitage trend test and Cochran–Mantel–Haenszel test were used to assess trends and differences in the pneumonia-specific U5MRs among and within geographic regions. Relative risks (RRs) and 95% confidence intervals (95% CIs) were calculated.
Results: The pneumonia-specific U5MR decreased by 90.6%, 89.0%, and 83.5% in East, Middle, and West China, respectively, with a larger decrease in rural areas. The pneumonia-specific U5MR was highest in West China, and was 7.2 (95% CI 5.9–8.7) times higher than that in East China in 2014–2015. In 2014–2015, the RRs were 1.7 (95% CI 1.2–2.5), 1.6 (95% CI 1.1–2.1), and 3.4 (95% CI 2.8–4.0) between rural and urban areas in East, Middle, and West China, respectively.
Conclusions: Pneumonia-specific U5MRs decreased from 1996 to 2015 across China, particularly in rural areas. However, disparities remained among and within geographic regions. Additional strategies and interventions should be introduced in West China, especially the rural areas, to further reduce the pneumonia-specific U5MR.

Introduction

Globally, pneumonia was the second leading cause of death in children under 5 years of age in 2013, with an estimated 0.935 million deaths, accounting for 14.9% of total deaths in under-fives (Liu et al., 2015). It is recognized as a 'disease of the poor', as pneumonia is more likely to affect children living in conditions of poverty and starvation, or who reside in remote regions (Wardlaw et al., 2006). The burden of childhood pneumonia is reported to be lower in developed regions where interventions are well implemented compared to developing regions (Izadnegahdar et al., 2013; Madhi et al., 2013; Rudan et al., 2013). In 2010, the pneumonia-specific under-five mortality rate (U5MR) in Europe was 2‰, whereas it was 20‰ in Africa (Liu et al., 2012). Furthermore, geographic disparities in pneumonia deaths exist not only among different countries but also within countries. For example, the pneumonia-specific U5MR in the southern USA is higher than that in other regions of the USA (Dowell et al., 2000), and the pneumonia-specific mortality rate among children aged 1–59 months is four-fold higher in central India compared to southern India (Million Death Study Collaborators et al., 2010).

Liu et al. estimated that the pneumonia-specific U5MR in China decreased sharply from 2000 to 2013; however, the absolute number of under-five pneumonia deaths in China each year is substantial due to the large population base (Liu et al., 2015). One of the Sustainable Development Goals (SDG3) clearly states the aim of ending preventable deaths in newborns and children under-five by 2030 (United Nations, 2015). In view of the vast territory and unbalanced regional economic development in China, it is important to understand the geographic disparities in pneumonia-specific U5MRs within the country.

This study focused on the geographic disparities in pneumonia-specific U5MRs from 1996 to 2015 in Mainland China with the aim

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of providing suggestions regarding priority interventions to eliminate deaths from pneumonia among children younger than 5 years of age and sharing this information with other developing countries.

Methods

Data sources

Data were obtained from the national Under-Five Child Mortality Surveillance System (U5CMSS) of China. This population-based system utilizes a multistage stratified sampling method to select surveillance sites. First, Mainland China was divided into three geographic regions (i.e., East, Middle, and West China) based on criteria from National Development and Reform Commission of China. Second, each geographic region was further divided into urban and rural areas. In total, 123 counties/districts were selected to cover a total population of 14 million individuals (i.e. 5.9, 5.7, and 2.4 million in East, Middle, and West China, respectively) from 31 provinces/autonomous regions/municipalities across Mainland China for the period 1996–2006; starting in 2007, the surveillance sites were expanded to 334 counties/districts, covering a total population of 45 million individuals (i.e. 13.7, 12.4, and 18.9 million in East, Middle, and West China, respectively). Third, two or three communities or townships were selected in each surveillance county/district for under-five child mortality surveillance. Figure 1 shows the distribution of surveillance sites in the three geographic regions of Mainland China.

The U5CMSS has established a level-by-level (i.e., village, township/community, county/district, municipality, province, and nation) reporting and review network, with a strict level-by-level quality control process according to the protocol. Details regarding the sampling methods, surveillance subjects, data collection, and the quality control process have been described elsewhere (He et al., 2017; Wang et al., 2011; Wang et al., 2005).

Verification of the causes of death

Doctors from township hospitals or community health service centers conducted household surveys for under-five deaths. The doctors kept detailed records on child death registration cards, including signs, symptoms, diagnosis, and treatments before child death. If any medical service was sought for the child prior to death, the cause of death was determined by the diagnosis from the hospital at the highest level, primarily via confirmation by X-ray or by other auxiliary examinations. If no medical service was sought before death, the pneumonia diagnosis was determined by clinical symptoms based on the definition described in *Zhu Futang Practice of Pediatrics* (Zhu et al., 1985) The algorithm for the diagnosis of a pneumonia case was as follows: coughing or difficulty breathing with fast breathing or indrawing of the chest. If multiple causes of death existed, the underlying cause of death was used, defined as (a) the disease or injury that initiated the train of morbid events leading directly to death, or (b) the circumstances of the accident or violence that produced the fatal injury (World Health Organization, 1996). Medical practitioners from the county/district maternal and children's hospital institutions reviewed the reported child death registration cards quarterly and verified the causes of death.

Statistical analysis

Although the surveillance sites were expanded from 123 to 334 in 2007 and health workers from 211 new surveillance sites were trained, the quality of the data was not stable until 2009. Therefore, data from the 123 original sites were used to analyze the pneumonia-specific U5MRs in the years 1996–2008 and data from the 334 overall surveillance sites were used to analyze the pneumonia-specific U5MRs in the years 2009–2015. To increase the sample size for deaths from pneumonia and to obtain a robust estimation, the study period was grouped into 2-year intervals.

The pneumonia-specific U5MR was calculated as the number of under-five deaths due to pneumonia per 100 000 live births and adjusted by 3-year average under-reporting rate based on the annual national quality control result. The rate was separated by urban and rural population in each geographic region and weighted by the proportion of urban and rural population from the National Census to obtain the overall estimation.

The time trends in pneumonia-specific U5MR and proportion of children who sought attention at any medical service prior to death in each geographic region were tested with the Cochran–Armitage trend test (Ruan, 2004). The differences in pneumonia-specific U5MRs among and within geographic regions were examined by Cochran–Mantel–Haenszel test (Agresti, 1990). Relative risks (RRs) and 95% confidence intervals (95% CIs) were calculated with the Chi-square test and used to compare the risk of death due to pneumonia among and within different geographic regions. All analyses were performed using SPSS version 16.0 software (SPSS Inc., Chicago, IL, USA). Statistical significance was assessed by two-tailed tests at an α-level of 0.05.

Results

The pneumonia-specific U5MR in Mainland China decreased from 1001.7 per 100 000 live births in 1996–1997 to 162.8 in 2014–2015, and it decreased significantly across all geographic regions (all $p < 0.001$). The rate decreased by 90.6% (from 437.1 to 41.0 per 100 000 live births) in East China, 89.0% (from 913.7 to 100.8 per 100 000 live births) in Middle China, and 83.5% (from 1782.7 to 294.6 per 100 000 live births) in West China. Significant disparities in pneumonia-specific U5MRs were observed in different geographic regions, with the highest rate in West China, followed by Middle China and East China. Compared with East China, the RR of the pneumonia-specific U5MR increased to its peak during the years 2002–2003 and 2004–2005 (Middle China: RR 3.8, 95% CI 3.0–4.8; West China: RR 13.8, 95% CI 10.5–18.0) and then decreased, with a slight rise of 2.5 (95% CI 2.0–3.1) and 7.2 (95% CI 5.9–8.7) during 2014–2015 in Middle and West China, respectively (Table 1).

Pneumonia-specific U5MRs in both urban and rural areas within each geographic region decreased consistently over time, particularly in rural areas. The rate decreased by 71.9%, 59.1%, and 64.7% in urban areas and by 91.1%, 89.5%, and 81.6% in rural areas in East, Middle, and West China, respectively. Although disparities between urban and rural areas remained in each geographic region, with the highest pneumonia-specific U5MRs in rural areas in West China, there was a trend towards a narrowing of the disparity over the last two decades. The time trends of the RRs of the pneumonia-specific U5MR in different geographic regions were similar to the overall trend when separated into urban and rural areas. More disparities were seen among different geographic regions. Among all the comparisons, the largest disparities existed in the rural areas between West and East China. Furthermore, significant disparities were observed within each geographic region, with consistently higher pneumonia-specific U5MRs in rural areas than in urban areas. Compared with urban areas, the RRs of pneumonia-specific U5MRs decreased from 5.4 (95% CI 4.0–7.5), 6.2 (95% CI 4.8–8.0), and 6.6 (95% CI 5.0–8.7) in the years 1996–1997 to 1.7 (95% CI 1.2–2.5), 1.6 (95% CI 1.1–2.1), and 3.4 (95% CI 2.8–4.0) in the years 2014–2015 in the rural areas in East, Middle, and West China, respectively (Table 2).