Causes of deaths in children younger than 5 years in China in 2008

Igor Rudan*, Kit Yee Chan*, Jian S F Zhang, Evropi Theodoratou, Xing Lin Feng, Joshua A Salomon, Joy E Lawn, Simon Cousens, Robert E Black, Yan Guo†, Harry Campbell‡, on behalf of WHO/UNICEF’s Child Health Epidemiology Reference Group (CHERG)

Summary

Background Previous estimates of the global burden of disease for children have not included much information from China, leading to a large gap in data. We identified the main causes of deaths in neonates (<1 month), postneonatal infants (1–11 months), and children (<5 years) in China using information that was available to the public.

Methods The Child Health Epidemiology Reference Group in collaboration with colleagues from Peking University systematically searched Chinese databases that were available to the public. Information was obtained from the Chinese Ministry of Health and Bureau of Statistics websites, Chinese National Knowledge Infrastructure database, and Chinese Health Statistics yearbooks for 1990–2008. We also obtained information from 206 high-quality community-based longitudinal studies of different causes of deaths in children (<5 years) that were written in the Chinese language. A statistical model was developed to estimate the total number of deaths in children according to provinces, age groups, and main causes.

Findings During 1990–2008, the mortality rates in neonates, postneonatal infants, and children were reduced by 70% (from 34·0 to 10·2 per 1000 livebirths), 72% (from 53·5 to 14·9 per 1000 livebirths), and 71% (from 64·6 to 18·5 per 1000 livebirths), respectively, meeting the targets set in the Millennium Development Goal 4. The leading causes of deaths in 2008 were pneumonia, birth asphyxia, and preterm birth complications, each accounting for 15–17% of all deaths. Congenital abnormalities and accidents increased in importance during this period, contributing to 11% and 10% of child deaths, respectively. Sudden infant death syndrome contributed to 5% of deaths in children.

Interpretation Publicly available Chinese databases contain much important information that has been underused in the estimation of global and regional burden of disease. On the basis of trends, preterm birth complications are expected to become the leading cause of child mortality in China, whereas deaths from congenital abnormalities, accidents, and sudden infant death syndrome are predicted to continue increasing in importance in the long term.

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Introduction Official data from China and the UN indicate that China has made progress in reducing the number of child deaths during the past decade, and has achieved the Millennium Development Goal 4 (MDG4) in the process.1–3 However, WHO and UNICEF’s Child Health Epidemiology Reference Group (CHERG) reported that China was a large gap in the availability of health information about the burden of disease, particularly child health, even though nearly 15% of children in the world live there.4 Improved understanding of the causes of child deaths in China is therefore important to prevent substantial errors in estimation of the overall global burden of disease. The main reason for the gap is not known—it might be a lack of studies of sufficient quality in the Chinese population, or the publication of policy-relevant research in mostly national journals, without translation from Chinese to other languages.

In the past few years, China has made substantial progress towards providing full-text access to the large amount of information reported in its Chinese-language academic journals.5 More than 5000 academic periodicals are published in China (excluding Hong Kong, Macau, and Taiwan), and almost 1000 of these are biomedical and health journals.6,7 Western databases typically used by CHERG for the estimation of the global burden of disease, such as PubMed or Journal Citation Reports, have fewer than 100 journals from mainland China, many of which are in English.8 However, full text from more than 500 Chinese journals is now available online to the public through several databases—eg, the China National Knowledge Infrastructure,9 Wanfang,9 Chinese Medical Current Content,10 Chinese Biomedical Literature Database,11 VIP information,12 and iLibrary.13 Additionally, important information can be accessed by the public from the Chinese Government websites, such as the Ministry of Health and Bureau of Statistics.14 Complex datasets of policy-relevant information from various sources (local and national government reports, estimates from international organisations, and published grey literature) are assembled, analysed, and presented in novel ways on specialised sites to inform health policy. Gmpinder is one of the best examples of these sites.15

We report the estimates of mortality rates in neonates (<1 month), postneonatal infants (1–11 months), and infants (1–11 months), and...
children (<5 years) in China during 1990–2008; report
trends in cause-specific child mortality rates in 2000–08;
and use information from studies to establish the main
causes of deaths in neonates, postneonatal infants, and
children (1–4 years) at the national and province levels
during 2008.

Methods
Sources of information
CHERG systematically searched the information
available to the public about the causes of child deaths in
China. The search was done in collaboration with
researchers from Peking University, Beijing, China, and
the University of Melbourne, VIC, Australia. Our
estimates were based on several sources of information,
which are described in detail in the webappendix (pp 1–2);
the strengths and limitations of these sources are also
discussed in the webappendix. We used the information
from the Chinese Maternal and Child Mortality
Surveillance (MCMS) system (figure I) for national-level
mortality rates (per 1000 livebirths) in neonates,
postneonatal infants, and children (<5 years) during
(18·5 per 1000) was similar to the estimate reported by
UN agencies (20·1 per 1000).1 However, we relied on the
rate reported by MCMS (ie, within-country evidence)
because we were satisfied with their quality of national-
level estimates since they included an active process of
correction for possible under-reporting. Although some
under-reporting might have occurred, it was unlikely to
be substantial (webappendix pp 1–2).

Of three available sources of data for the number of
livebirths, two were from China and one from the UN. In
2008, 13·3 million livebirths were routinely reported
through the Chinese Ministry of Health.3 A registry of
the Ministry of Public Security reported 16·1 million
livebirths in 2008, and included correction for under-
reporting based on a yearly surveillance report that was
done in eight provinces.15 The UN’s projection for China
for 2008 was 18·2 million livebirths.1–2 We chose the
number on the basis of the most reliable evidence from
within China (ie, 16·1 million livebirths). This number
might still be an underestimate, but not a substantial one
(webappendix pp 1–2).

Child (<5 years) mortality rates in provinces were
obtained from Gapminder,6 which modelled the rates for
31 provinces in 2006 on four sources of information from
within China. In provinces, the number of deaths, based
on estimates by Gapminder, and livebirths showed a
near-perfect fit (99%) to CHERG’s estimate of the total

Figure 1: Map of China showing 2377 administrative units and their level of development
Urban units are more developed than are rural units; rural units type I are the most developed, and type IV are the least developed. Surveillance for maternal and child
deaths during 1996–2007 was undertaken in 116 administrative units (37 urban and 79 rural).

See Online for webappendix
number of deaths in children (<5 years) that was based on other sources (webappendix pp 1–2).

The estimates of proportional contribution of the most common causes of death to the overall mortality rates in children (<5 years) were derived from independent, community-based, longitudinal multicause studies. We searched the medicine and hygiene catalogue of the China National Knowledge Infrastructure database for 1990–2008 (accessed March, 2009).1 We used five variations of the word child in the Chinese language—“ertong”, “xiaoer”, “youer”, “yingyouer”, and “yinger”—corresponding to different levels of maturity. Each of these search terms was used with the words death (“siwang”) and survival (“shengcun”). 1662 results were obtained from the search with all appropriate combinations of the search terms. First, we excluded studies that were not community-based. Hospital-based studies are not representative of the overall population in China because of incomplete access to health care, especially in poor regions where most deaths occurred.17 Additionally, we excluded studies of only one cause of death because they might result in an overestimation of the proportion of deaths from the cause of interest.17 Second, adhering to standard CHERG methods, we excluded studies that were duplicates, that did not have numerical estimates in their summaries, or in which fewer than 50 deaths were reported.4,17 Third, we continued the process of exclusion by removing the studies in which all-cause mortality was reported without a breakdown by cause; that were not prospective or longitudinal in design; and in which overall rates of child mortality (<5 years) were not reported at the study site.21,22 For statistical modelling, we used data from 206 high-quality studies in 28 of 31 provinces that were reported during 2000–08. The process of literature review and the geographical locations of these studies are shown in the webappendix (p 3 and p 4, respectively).

Statistical models
We estimated the number of child deaths according to proportional causes in different age groups and provinces using statistical modelling (webappendix pp 5–8). First, we estimated the total numbers of deaths (denominators) in neonates, postneonatal infants, and children (<5 years) in China by multiplying the mortality rates from MCMS (figure 2) by the number of livebirths.11,21,22 Second, we developed eight statistical models, based on the 206 studies, to establish an association between the proportion of the frequent causes of child deaths and the overall child (<5 years) mortality rate at each study site (webappendix pp 5–8). We applied these models to attribute all child deaths in 2008 to a specific cause—ie, birth asphyxia, preterm birth complications, neonatal sepsis, pneumonia, diarrhoea, congenital abnormalities, accidents, sudden infant death syndrome, or other (figure 3; webappendix pp 5–8). We used the information from MCMS to show how the overall child (<5 years) mortality rate was related to the socioeconomic development of the administrative units included in MCMS (figure 4). We used national-level mortality rates in children (<5 years) from figure 2 and a statistical model based on the 206 studies (webappendix pp 6–8) to report trends in cause-specific mortality during 2000–08 (figure 5). We then defined the number of deaths in each province during 2008 by multiplying estimates of the mortality rates in children (<5 years) from Gapminder by the number of livebirths in the province. We then developed four models, based on the 206 studies, for predicting the proportion of deaths in neonates, postneonatal infants, and children (1–4 years) that were based on the overall child (<5 years) mortality rate in the province (webappendix pp 7–8). We used this model to assign the total number of deaths in a province according to the different age groups. We applied further statistical models, based on 206 studies, to attribute the deaths within provinces and within the three age groups to causes (figure 6; webappendix pp 7–8). The fit to the denominators for total number of child deaths in each province was achieved by replacement of the least predictive statistical model (based on R²) with the remaining number of deaths within each province (webappendix pp 7–8).

Role of the funding source
The sponsors had no involvement in the study design; collection, analysis, and interpretation of data; writing of
Acknowledgments

The corresponding authors had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

In China, during 1990–2008, mortality rates in neonates, postneonatal infants, and children (<5 years) were reduced by 70% (from 34·0 to 10·2 per 1000 livebirths), 72% (from 53·5 to 14·9 per 1000 livebirths), and 71% (from 64·6 to 18·5 per 1000 livebirths), respectively, with achievement of the MDG4 targets in 2006 (figure 2). The rate of progress was especially pronounced during 1990–95 (31% reduction in mortality rate in children <5 years) and 2002–07 (48% reduction).

Figure 3 (A to D) shows differences in the main causes of deaths in 2008 based on the age of the child. The webappendix (pp 6–7) shows the cause-specific changes related to the reduction in overall rate of child mortality. In neonates, birth asphyxia caused the largest proportion of deaths (figure 3A), and the second largest category was deaths from other causes (eg, neonatal tetanus, intracranial haemorrhage, scleroderma, accidents, accidental asphyxia, and meningitis). The third largest cause of mortality was perinatal birth complications and the fourth was congenital abnormalities. In postneonatal infants, pneumonia was the main cause of death, although congenital abnormalities, sudden infant death syndrome, diarrhoea, and accidents also contributed substantially (figure 3B). In children aged 1–4 years, accidental deaths (mainly drowning, poisoning, burns, falls, and traffic accidents) were the most frequent causes, followed by pneumonia and congenital abnormalities. The most prominent contributor in the other causes category in this age group was childhood tumours (figure 3C). Overall, the most common causes of death in children (<5 years) were pneumonia, birth asphyxia, and perinatal birth complications, with each contributing to 15–17% of all deaths, followed by congenital diseases (11%), accidents (10%), and sudden infant death syndrome (5%; figure 3D).

Figure 4 shows the association between the socioeconomic development of Chinese administrative units (figure 1) and mortality rate (per 1000 livebirths) in children (<5 years) during 2000–04 according to the MCMS system. The classification of the areas into two urban and four rural types was developed by the Information and Statistics Centre of the Ministry of Health (webappendix pp 1–2). Children born in poor rural areas were three to six times more likely to die before their fifth birthday than were those born in urban or better-off rural areas (figure 4).

Figure 5 shows the trends in cause-specific mortality in China in 2000–08. Overall child (<5 years) mortality rates per 1000 livebirths decreased from 39·7 in 2000 to 18·5 in 2008. The proportion of deaths from infectious causes—ie, pneumonia, diarrhoea, and neonatal sepsis—also decreased greatly with this reduction in overall mortality rate, whereas the proportion of deaths resulting from the complications of preterm birth rose slightly. The proportion of deaths from congenital abnormalities increased much faster.

Figure 6 shows the causes of child deaths in 31 provinces (ranked according to mortality rates in all children aged 0–4 years) in 2008 based on our model output. Child (<5 years) mortality rates per 1000 livebirths ranged from

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fewer than five in Shanghai (ie, better than in many western countries) to more than 38 in Sichuan and Guizhou—eight times higher. Although congenital abnormalities are now the leading cause of child deaths in the six wealthiest provinces (Shanghai, Tianjin, Beijing, Jilin, Jiangsu, and Guangdong), the poorest provinces still have a large burden of deaths from pneumonia, birth asphyxia, and accidents.

Discussion

In China, during 2008, the most frequent causes of deaths in children (<5 years) were pneumonia, birth asphyxia, and preterm birth complications. Congenital abnormalities, accidents, and sudden infant death syndrome also increased as causes of deaths.

The accuracy of the reports about the causes of child mortality was attributed to the use of several methods of quality control, which were specific to China (webappendix pp 1–2). Use of these methods ensured that the records of child deaths reported within those studies were complete, and cause of death was consistently assigned. Within the MCMS system, at least one trained female health worker or village doctor was assigned to each community or village, and was responsible for providing basic health information to mothers-to-be and new mothers, organising hospital visits, and ensuring that all child births and deaths were registered. When a child dies at home, parents are required by law to report the death and obtain a death certificate for the child. Within the surveillance system, every death had to be investigated by a medical practitioner. Additionally, every 3 months, 6 months, or 12 months, a team of physicians and epidemiologists reviewed all the reported deaths and their causes. All these factors and the unusually large sample sizes reported for most studies contributed to the reasonably high predictive power of our model and narrow CIs for estimates of proportional child (<5 years) mortality rates assigned to the causes that are typical of China.

There are still large disparities between urban and rural areas of China in the availability of essential data (such as registration of births and deaths), and access to high-quality health care (figure 4; figure 5). The progress towards reduction of the child mortality rate in China is strongly determined by the degree of socioeconomic development (figure 4). Additionally, in 2006, per-person health expenditures for urban residents were three times greater than those for rural residents.18 Urban residents also had three times as many hospital beds and medical personnel per 1000 people; and 23% of child deaths occurred at home in urban areas compared with 57% in rural areas. Even in the rural areas there were inequities: in rural area I (most developed), 40% of child deaths occurred at home and a further 10% on the way to the hospital; in rural area IV these proportions were 71% and 5%, respectively.19

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**Figure 5**: Trends in proportional contribution of most common causes of child deaths in China to the total number of deaths during 2000–08
Although the association between China’s one child family policy, and its implications for reporting and abortion practices is worth investigation, we do not believe that it has a direct relevance to the estimates of livebirths that are presented in this report because of the way in which we derived them. The reported rate of progress in reduction of child mortality rate is likely to be real. It becomes particularly relevant when compared with many other countries that have similar overall mortality rates and gross domestic products, and much smaller population sizes, but where the progress has not been nearly as impressive as that in China.2

Diarrhoea was not a common cause of child deaths in China (only 3% in 2008), which might be partly attributed to the common cultural practice of boiling water (eg, for tea and food preparation) and other hygiene practices.22–24 Additionally, our findings strongly suggest that accidents are a major cause of mortality in children older than 11 months. Accidents as a cause of child deaths globally merit and require more attention, and have been neglected.25 Preterm birth complications will become the most frequent cause of death in the short term because increasing numbers of people are gaining access to primary health care, and the number of deaths caused by pneumonia therefore is steadily decreasing. However, in the long term, the numbers of people who will start gaining access to secondary health care will also increase. Birth asphyxia will then decrease in importance as a cause of death and will be replaced with congenital abnormalities. Accidents and sudden infant death syndrome will probably continue to increase in importance (figure 5).

Our findings have provided new and potentially important insights that might be relevant to the international child health community outside China. Publicly available Chinese databases contain much important information that is relevant to international health policy, and therefore should not be overlooked in the future. Although CHERG has been working for many years with the experts from WHO and UNICEF, trying to obtain useful information from low-income and middle-income countries to produce epidemiological estimates that are relevant to children.
worldwide, the high quantity and quality of methods used in the studies from within China were impressive. Now that academic information in China is available to the public through searchable databases, there can be no further justification for omitting Chinese studies from global estimates of any disease burden, especially with the population size of China. We learned through this exercise that China has larger size and higher quality of the studies than many of those that were done in other low-income and middle-income countries.

Although the focus of the international health community with respect to child survival is on provision of vaccines, case management, and nutritional and other novel health interventions, substantial reductions occurred in child mortality rates in western countries in the first three decades of the 20th century without the availability of any of those interventions. Social and economic determinants of health are therefore very important for improvement of child survival, but they are not well understood. The progress achieved in China during the past two decades in reduction of the child mortality rate with data for many useful indicators gathered at the province level, such as those related to the emergence of infrastructure, development of health systems, progress in education of the population, increased personal and household wealth, introduction of the one-child policy, and increased intervention coverage will enable us to study the role of those determinants in parallel with vaccination and the introduction of other health interventions. China provides a model with potential for future studies of social, economic, demographic policy, and determinants of child survival related to health systems, and for comparison of their importance during a period of progress in reduction of its child mortality rate.

Contributors
IR, KYC, YG, and HC designed the study and wrote the report. JSFZ and XLF led the systematic review of the literature and data extraction from Chinese databases. ET and SC designed the models and did the statistical analyses. JEL and REB provided important intellectual input at different stages of the work and commented on the drafts of the report. JAS contributed to interpretation of data and critical revision of the report.

Conflicts of interests
We declare that we have no conflicts of interest.

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