Estimating cause-specific child mortality in 2000-2015 with projections to 2030 – what can we learn from progress in the MDG 4 and how we could attain the SDG child survival target

Li Liu,1,2 Shefali Oza,3 Dan Hogan,4 Yue Chu,2 Jamie Perin,2 Jun Zhu,5 Joy Lawn,3 Simon Cousens,3 Colin Mathers,4 Robert E. Black2

1Department of Population Family and Reproductive Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland
2The Institute for International Programs, Department of International Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland
3London School of Hygiene and Tropical Medicine, London, UK
4Department of Health Statistics and Informatics, World Health Organization, Geneva, Switzerland
5National Office of Maternal and Child Health Surveillance of China, Chengdu, China

Correspondence to: Dr. Li Liu, Department of Population, Family and Reproductive Health, and The Institute for International Programs, Department of International Health, Johns Hopkins Bloomberg School of Public Health, 615 N Wolfe Street, Baltimore, MD 21205, USA liu26@jhu.edu
Short abstract
We estimated cause-specific child mortality for 194 countries in 2000-2015 and projected to 2030 to evaluate the Millennium Development Goals (MDG) 4 and inform the Sustainable Development Goals’ child survival target. We compiled child cause-of-death data from multiple sources, including vital registration (VR) and verbal autopsy (VA) studies. We used adequate VR data as is. We applied a multinomial logistic regression (MLR) to estimate cause-specific mortality fractions for countries with inadequate VR, with VR data as model inputs for those with under-five mortality rate (U5MR)<35 per 1,000 live births, and with VA data as model inputs for those with U5MR>=35. Preterm birth complications, pneumonia, and intrapartum related events are the leading causes of child mortality in 2015. Only 9 of the 20 causes estimated have been declining at an annual rate of reduction in 2000-2015 sufficient to achieve the MDG 4. Additional insights on countries’ success and challenges are discussed.
Extended abstract

Introduction

2015 marks the end of the Millennium Development Goals (MDG) era and the beginning of the Sustainable Development Goals (SDG) period. Enormous strides have been made since 1990 in improving child survival, the fourth target of the MDG (MDG 4). However, the actual progress, 53% at the global level, (You etc, 2015) fell short of the target of reducing under-five mortality rate (U5MR) by two-thirds in 1990-2015. (MDG report 2000).

As we transition from the MDG 4 to the SDG child survival target of reducing U5MR to no more than 25 per 1,000 live births in all countries in 2030 (SDG child survival target. Available at: http://www.un.org/sustainabledevelopment/summit/, accessed on 11Sept2015), information on not only levels, but also causes of child mortality is critical to deepen our understanding of the progress or the lack of in improving child survival during the past couple of decades. Insights into countries’ success and challenges in reducing cause-specific child mortality could be particularly valuable for formulating context-specific strategies for countries to further accelerate progress toward ending preventable child deaths in the post-2015 era.

In this paper, we update the annual estimates of child mortality by cause to 2000-2015 to evaluate progress toward the MDG 4, and project cause-specific mortality rates to 2030 to inform strategies to achieve the SDG child survival target. The paper pays special attention to countries and causes that have achieved the annual rate of reduction sufficient to achieve the MDG 4 in 2000-2015. It also highlights those shoulder high burden of under-five deaths to shed light on possible pathways to achieve the post-2015 child survival target.

Methods

We compiled child cause-of-death data from multiple sources, including e.g. vital registration (VR), sample registration, health and demographic surveillance sites, and national and subnational verbal autopsy (VA) studies. VR data were obtained from the WHO Mortality Database. Other data were extracted from primarily publically available data sources, mainly through standardized systematic review.

We used adequate VR data as is or with minor adjustment. For the remaining countries, we modeled estimates guided by the Child Survival Framework (Mosley and Chen, 1987). We applied a multinomial logistic regression (MLR) to estimate cause-specific mortality fractions (CSMFs) for countries with some but inadequate VR system and low under-five mortality rate (U5MR<35 per 1,000 live births), with adequate VR data and primarily distal determinants of child mortality as model inputs. We employed a similar MLR approach to estimate CSMFs for countries with inadequate VR system and high U5MR (U5MR>=35 per 1,000 live births), with VA data and distal and proximate (mainly childhood life saving interventions) determinants as the model inputs. We multiplied CSMFs with child mortality
estimated by the United Nations’ Interagency Group on Child Mortality Estimation (IGME) to derive number of deaths by cause.

This year for the first time, we replaced modeled estimates with empirical estimates from the China Maternal and Child Mortality Surveillance System (MCMSS) with adjustment for China. We developed a subnational level model for India exclusively using subnational child cause-of-death data. The model generated state-level estimates which were aggregated to derive national estimates.

For low burden causes, such as HIV/AIDS, measles, pertussis, which were hard to stably estimate through our models, we adopted estimates produced by the corresponding WHO technical programs.

We based our model selection on cross validation and out-of-sample prediction. We anticipate to have uncertainty estimates available at the time of the presentation.

**Results**

In 2015, among the 5.9 million children who didn’t live to celebrate their fifth birthday, 2.681 million (45.1%) died in the neonatal period (Figure 1). The leading causes of children under five are preterm birth complications (1.056 million, 17.8%), pneumonia (0.922 million, 15.5%), and intrapartum related events (0.689 million, 11.6%), diarrhoea (0.526 million, 8.9%), sepsis/meningitis (0.526 million, 8.8%), and congenital malformation (0.504 million, 8.5%) (Table 1). Among neonates, the leading causes are preterm birth complications (0.946 million, 15.9% of under-five deaths), intrapartum related events (0.635 million, 10.7%), sepsis/meningitis (0.410 million, 6.9%), and congenital malformation (0.299 million, 5.0%) (Figure 1). Among children died in the 1-59-month period, the leading causes are pneumonia (0.760 million, 12.8%), diarrhea (0.509 million, 8.6%), injury (0.331 million, 5.6%), and malaria (0.306 million, 5.2%).

Child causes of deaths changed gradually at the globally level in 2000-2015 (Figure 2). The three leading causes of under-five mortality changed from pneumonia (1.677 million, 17.4%), preterm birth complications (1.348 million, 13.8%), and diarrhoea (1.145 million, 12.2%) in 2000 to preterm birth complications, pneumonia, and intrapartum related events in 2015 reported above. U5MR declined from 77.8 to 42.5 per 1,000 livebirths or by 45.3% in this period. Pneumonia, diarrhea, neonatal intrapartum related events, malaria, measles, and neonatal preterm birth complications all reduced by more than 30%, with each contributing 16.5%, 15.6%, 10.1%, 9.9%, 9.2%, and 8.3% to the reduction in under-five all-cause mortality since 2000. Collectively, reductions in these causes are responsible for 70.0% of the total reduction in U5MR in 2000-2015 (Figure 3).

The average annual rate of reduction (ARR) of U5MR in 2000-2015 is 4.0%, short of the 4.4% required to reach the MDG 4 in 1990-2015. All-cause mortality rates of neonates have been declining at a slower rate during this period than those of children 1-59 months, at 3.1% versus 4.7% respectively. Benchmarking with 4.4%,
causes having been declining at a rate sufficient to reach the MDG4 since 2000 include measles (ARR=13.0%), neonatal tetanus (ARR=11.0%), HIV/AIDS (ARR=6.9%), postneonatal meningitis (ARR=6.6%), neonatal diarrhea (ARR=6.3%), malaria (ARR=6.3%), postneonatal diarrhea (6.1%), postneonatal pneumonia (4.8%), neonatal pneumonia (4.5%) (Figure 4). In contrast, for example, neonatal congenital malformation has only been reducing at an ARR of 1.1%.

Country-specific results will be available at the time of the presentation.

Tables and Figures
Table 1: Estimated numbers of deaths by cause and cause-specific mortality rate in 2015

Figure 1. Global causes of child deaths in 2015
Figure 2. Global cause-specific mortality fraction in 2000-2015
Figure 3. Global trends in cause-specific mortality rates in neonates and children aged 1–59 months, 2000–15
Figure 4. Global cause-specific ARR in 2000-2015 (bench marked to 4.4%)
Table 1. Estimated numbers of deaths by cause and cause-specific mortality rate in 2015

<table>
<thead>
<tr>
<th>Cause</th>
<th>Estimated number (UR; millions)</th>
<th>Cause specific mortality rate (Per 1,000 live births)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Neonates aged 0-27 days</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preterm birth complications</td>
<td>0.946</td>
<td>6.770</td>
</tr>
<tr>
<td>Intrapartum-related events</td>
<td>0.635</td>
<td>4.547</td>
</tr>
<tr>
<td>Sepsis/meningitis</td>
<td>0.410</td>
<td>2.937</td>
</tr>
<tr>
<td>Congenital abnormalities</td>
<td>0.299</td>
<td>2.139</td>
</tr>
<tr>
<td>Other conditions</td>
<td>0.177</td>
<td>1.268</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>0.162</td>
<td>1.159</td>
</tr>
<tr>
<td>Tetanus</td>
<td>0.035</td>
<td>0.247</td>
</tr>
<tr>
<td>Diarrhoea</td>
<td>0.017</td>
<td>0.125</td>
</tr>
<tr>
<td><strong>Children aged 1-59 months</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pneumonia</td>
<td>0.760</td>
<td>5.443</td>
</tr>
<tr>
<td>Other conditions</td>
<td>0.655</td>
<td>4.691</td>
</tr>
<tr>
<td>Diarrhoea</td>
<td>0.509</td>
<td>3.643</td>
</tr>
<tr>
<td>Injury</td>
<td>0.331</td>
<td>2.367</td>
</tr>
<tr>
<td>Malaria</td>
<td>0.306</td>
<td>2.193</td>
</tr>
<tr>
<td>Congenital abnormalities</td>
<td>0.206</td>
<td>1.471</td>
</tr>
<tr>
<td>Meningitis</td>
<td>0.115</td>
<td>0.826</td>
</tr>
<tr>
<td>Preterm birth complications</td>
<td>0.110</td>
<td>0.790</td>
</tr>
<tr>
<td>AIDS</td>
<td>0.086</td>
<td>0.614</td>
</tr>
<tr>
<td>Measles</td>
<td>0.074</td>
<td>0.531</td>
</tr>
<tr>
<td>Intrapartum-related events</td>
<td>0.054</td>
<td>0.388</td>
</tr>
<tr>
<td>Pertussis</td>
<td>0.054</td>
<td>0.387</td>
</tr>
</tbody>
</table>

Uncertainty range (UR) is defined as the 2.5-97.5 centile.

Other conditions among children aged 1-59 months included congenital malformation, causes originated during the perinatal period, cancer, pertussis, severe malnutrition and other specified causes.

Intrapartum-related events were formerly referred to as “birth asphyxia”.

1 Estimated number of preterm deaths in children younger than 5 years overall including the neonatal period is 1.056 million.

2 Estimated number of intrapartum-related events deaths in children younger than 5 years overall including the neonatal period is 0.689 million.

3 Estimated number of sepsis/meningitis deaths in children younger than 5 years overall including the neonatal period is 0.526 million.

4 Estimated number of congenital deaths in children younger than 5 years overall including the neonatal period is 0.504 million.

5 Estimated number of other disorders deaths in children younger than 5 years overall including the neonatal period is 0.832 million.

6 Estimated number of pneumonia deaths in children younger than 5 years overall including the neonatal period is 0.922 million.

7 Estimated number of diarrhea deaths in children younger than 5 years overall including the neonatal period is 0.526 million.
Figure 1. Global causes of child deaths in 2015

- Neonatal death: 45.1%
- Pneumonia: 12.8%
- Preterm: 15.9%
- Intrapartum related events: 10.7%
- Sepsis/meningitis: 6.9%
- Tetanus: 0.6%
- Diarrhea: 8.6%
- Malaria: 5.2%
- Injury: 5.6%
- Measles: 1.2%
- Other: 11.0%
- Congenital: 3.5%
- AIDS: 1.4%
- Pertussis: 0.9%
Figure 2. Global cause-specific mortality fraction in 2000-2015

Figure 3. Global cause-specific mortality fraction in 2000-2015

---

**Neonatal Fractions**

- Pneumonia
- Other
- Congenital
- Intrapartum related events
- Preterm
- Pertussis
- Meningitis
- AIDS
- Malaria
- Injury
- Measles
- Diarrhea
- Neonatal Diarrhea
- Neonatal Tetanus
- Neonatal congenital
- Neonatal Other disorders
- Neonatal Sepsis/meningitis
- Neonatal Intrapartum related events
- Neonatal Preterm
- Neonatal Pneumonia
Figure 3. Global trends in cause-specific mortality rates in neonates and children aged 1–59 months, 2000–15

*About 70% of the reduction comes from pneumonia, diarrhoea, malaria and measles among 1-59-month olds and neonatal intrapartum related events.

*Deaths per 1,000 live births
Figure 4. Global cause-specific ARR in 2000-2015 (bench marked to 4.4%)