Estimates of global, regional, and national morbidity, mortality, and aetiologies of diarrhoeal diseases: a systematic analysis for the Global Burden of Disease Study 2015

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Summary

Background The Global Burden of Diseases, Injuries, and Risk Factors Study 2015 (GBD 2015) provides an up-to-date analysis of the burden of diarrhoeal diseases. This study assesses cases, deaths, and aetiologies spanning the past 25 years and informs the changing picture of diarrhoeal disease worldwide.

Methods We estimated diarrhoeal mortality by age, sex, geography, and year using the Cause of Death Ensemble Model (CODEm), a modelling platform shared across most causes of death in the GBD 2015 study. We modelled diarrhoeal morbidity, including incidence and prevalence, using a meta-regression platform called DisMod-MR. We estimated aetiologies for diarrhoeal diseases using a counterfactual approach that incorporates the aetiology-specific risk of diarrhoeal disease and the prevalence of the aetiology in diarrhoea episodes. We used the Socio-demographic Index, a summary indicator derived from measures of income per capita, educational attainment, and fertility, to assess trends in diarrhoeal mortality. The two leading risk factors for diarrhoea—childhood malnutrition and unsafe water, sanitation, and hygiene—were used in a decomposition analysis to establish the relative contribution of changes in diarrhoea disability-adjusted life-years (DALYs).

Findings Globally, in 2015, we estimate that diarrhoea was a leading cause of death among all ages (1·31 million deaths, 95% uncertainty interval [95% UI] 1·23 million to 1·39 million), as well as a leading cause of DALYs because of its disproportionate impact on young children (71·59 million DALYs, 66·44 million to 77·21 million). Diarrhoea was a common cause of death among children under 5 years old (499 000 deaths, 95% UI 447 000–558 000). The number of deaths due to diarrhoea decreased by an estimated 20·8% (95% UI 15·4–26·1) from 2005 to 2015. Rotavirus was the leading cause of diarrhoea deaths (199 000, 95% UI 165 000–241 000), followed by Shigella spp (164 300, 85 000–278 700) and Salmonella spp (90 300, 95% UI 34 100–183 100). Among children under 5 years old, the three aetiologies responsible for the most deaths were rotavirus, Cryptosporidium spp, and Shigella spp. Improvements in safe water and sanitation have decreased diarrhoeal DALYs by 13·4%, and reductions in childhood undernutrition have decreased diarrhoeal DALYs by 10·0% between 2005 and 2015.

Interpretation At the global level, deaths due to diarrhoeal diseases have decreased substantially in the past 25 years, although progress has been faster in some countries than others. Diarrhoea remains a largely preventable disease and cause of death, and continued efforts to improve access to safe water, sanitation, and childhood nutrition will be important in reducing the global burden of diarrhoea.

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Research in context

Evidence before this study
This manuscript builds on previous GBD publications with updated data and methods. Diarrhoeal diseases are a leading cause of morbidity and mortality, especially in children younger than 5 years, and the global burden has been estimated by several groups, including the Maternal and Child Health Epidemiology Estimation group and the Global Burden of Disease Study (GBD) 2013. Diarrhoea mortality has declined substantially since 1990, but morbidity has not declined as rapidly. Diarrhoeal mortality attributable to aetiologies has mainly been based on categorical attribution from non-molecular diagnostic methods with low overall attribution.

Added value of this study
This study provides a comprehensive assessment of diarrhoea burden based on the findings of GBD 2015, including new and more robust evidence on the mortality, morbidity, and risk factors associated with diarrhoea and 13 aetiologies and is the first cause-specific description of diarrhoea from the GBD group. Moreover, it introduces molecular diagnostic case definitions for diarrhoeal aetiologies. In addition to descriptions of trends in morbidity and mortality, this analysis uses a Socio-demographic Index to relate changes in diarrhoea burden to demographic transitions and assesses the effect of changing population characteristics and risk factor exposure to decompose trends in diarrhoea mortality.

Implications of all the available evidence
This study provides a detailed picture of the decreasing diarrhoeal burden over time and 13 aetiologies across all geographies while relating these trends to changes in risk factor exposure. This work allows for an in-depth understanding of national health challenges and areas for intervention. The findings will have great implications for strategies and programmes to address the burden of diarrhoea at the global, country, and local level.

Mortality
The Global Burden of Disease Cause of Death (CoD) database consists of all available data from surveillance systems, vital registration systems, and verbal autopsy (appendix p 2). Raw data are processed to reconcile disparate coding schemes (such as the International Classification of Diseases [ICD] 9 and 10) and to redistribute poorly coded causes of death, among other corrections.

We estimated diarrhoeal disease mortality in the Cause of Death Ensemble model framework (CODEm). CODEm is a spatiotemporal modelling platform that produces a wide range of sub-models based on CoD data and space–time covariates. Covariates are selected independently for each sub-model, and the selection is based on an algorithm that captures plausible relationships between the aetiologies and diarrhoeal mortality and provides a diverse set of plausible models (appendix p 5). These sub-models are evaluated using in-sample and out-of-sample validity, root mean square error, and input datapoint coverage. The best performing sub-models provide a greater relative number of draws to the final 1000 draws for the model of diarrhoea mortality. We assessed our diarrhoeal disease CoD models using in-sample and out-of-sample predictive performance. This modelling process is described in more detail in the appendix (p 3).

There is a final step in modelling causes of death called CoDCorrect, which ensures internal consistency among all causes of death in GBD. Like all mortality models in GBD, diarrhoea mortality models are single-cause. The sum of all mortality models must be equal to the all-cause mortality envelope. We corrected diarrhoea mortality estimates, and other causes of mortality, by rescaling them in accordance with the uncertainty around the cause-specific mortality rate.

Morbidity
Diarrhoeal cases are defined as passing three or more loose stools in a 24 h period.5 Input data for these models were from population representative surveys, hospital inpatient and outpatient records (ICD9 codes 001–009.9 and ICD10 codes A00–A09), health care utilisation (USA only), excess mortality from the GBD 2015 CoD estimates for diarrhoea, and a systematic literature review of cohort and cross-sectional studies (appendix p 9).

We estimated diarrhoeal disease incidence and prevalence for each location, age, and sex from 1990 to 2015 using an...
Aetiologies

We estimated diarrhoeal disease aetiologies separately from overall diarrhoea mortality. Aetiologies included enteric adenovirus (serotypes 40 and 41), Aeromonas spp, Entamoeba histolytica (amoebiasis), Campylobacter spp enteritis (Campylobacter), cryptosporidiosis (Cryptosporidium spp), typical enteropathogenic Escherichia coli (ETEC), enterotoxigenic E coli (ETEC; both ST and LT), norovirus, non-typhoidal Salmonella spp, rotaviral enteritis (rotavirus), shigellosis (Shigella spp), Vibriocholerae (cholera), and Clostridium difficile. The modelling strategy for diarrhoeal aetiologies is described in more detail in the appendix (pp 11–26).

We used a counterfactual approach that allows for interactions between pathogens and accounts for the distribution of pathogens in healthy individuals. We estimated a population attributable fraction (PAF), for each aetiology, which is the product of pathogen presence and the odds ratio (OR) of diarrhoea given its detection:

$$
PAF = \text{Proportion} \times \left(1 - \frac{1}{\text{OR}}\right)
$$

Where OR is the OR of diarrhoea given the presence of a pathogen and Proportion is the modelled proportion of diarrhoea episodes where the pathogen is present.

For GBD 2015, we used a systematic reanalysis of the Global Enteric Multicenter Study (GEMS) that used quantitative polymerase chain reaction (qPCR) as the diagnostic tool for pathogen detection to estimate the ORs of diarrhoea given pathogen detection. GEMS is a seven site, case-control study of moderate-to-severe diarrhoea in children younger than 5 years in south Asia and sub-Saharan Africa. Validation studies have shown that the use of molecular diagnostics is more sensitive than is traditional laboratory diagnostic methods for the detection of diarrhoeal pathogens.11,14 We used a mixed-effects conditional logistic regression model, matching for case-control pairs, random effects for GEMS sites, and accounting for all pathogens to calculate the OR by age for each of our aetiologies. OR did not vary by time or geography, a change from GBD 2013 when we used region-specific ORs.15

We did a systematic literature review of the proportion of diarrhoea cases that tested positive for each aetiology (appendix p 19) and used the meta-regression tool DisMod-MR to model the proportion of positive diarrhoea cases, for each aetiology separately, by location, year, age, and sex. We used rotavirus vaccine coverage as a covariate in the rotavirus proportion model only. Because most of the studies published on this topic used a case definition based on non-molecular diagnostics, we used the sensitivity and specificity of these methods compared with our qPCR case definition (appendix p 15) to correct the proportion estimates for exposure misclassification due to diagnostic error.16,17

$$
\text{Proportion}_{true}=\frac{\text{Proportion}_{observed}+\text{Specificity}-(\text{Sensitivity}+\text{Specificity}-1)}{\text{Sensitivity}+\text{Specificity}-1}
$$

We estimated a distinct fatal and non-fatal PAF for each aetiology assuming that diarrhoea episodes with hospital admission are a reasonable proxy for the cause of fatal cases since data on the cause of diarrhoea mortality after death were not available. Finally, we multiplied PAFs by the fatal and non-fatal diarrhoea envelopes to establish cases and deaths by aetiology.

We modelled V cholerae independently from the other aetiologies because of its epidemic tendency and imperfect reporting frequency. We used a systematic literature review to estimate the expected number of cholera cases for each country–year. We compared this expected number of cholera cases to the number reported to WHO and used this under-reporting fraction to correct the cholera case notification data for all countries.18 We modelled the case fatality ratio of cholera using DisMod-MR and applied these values to the cholera case envelope to estimate the number of cholera deaths.

We also modelled C difficile independently from the aetiologies because it was not included as a pathogen in GEMS. We did a systematic literature review for the prevalence and incidence of C difficile and used inpatient and outpatient hospital visits coded for C difficile. We modelled the natural history of C difficile infection, including incidence and mortality, in DisMod-MR for each location, year, age, and sex.
| Country                  | Deaths 2005–15 | Mortality rate (per 100,000) | Percentage change, 2005–15 | DALYs 2005–15 | Number 2005–15 | Mortality rate (per 100,000) | Percentage change, 2005–15 | DALYs 2005–15 |
|-------------------------|----------------|-----------------------------|-----------------------------|---------------|----------------|-----------------------------|-----------------------------|---------------|
| **Global**              |                |                             |                             |               |                |                             |                             |               |
| Central Europe, eastern Europe, and central Asia | | | | | | | | |
| Albania                 | 23             | (130 000 to 137 000)        | 64·5% (–30·5 to –32·7)       | 347           | (232 000 to 240 000) | 66·2% (–36·5 to –36·6)       | 57             | (4 400 to 3 700) |
| Armenia                 | 101            | (70 000 to 114 000)         | 75·2% (–52·1 to –58·5)       | 1324           | (201 000 to 176 000) | 64·7% (–54·3 to –51·9)       | 87             | (1 600 to 1 000) |
| Azerbaijan              | 176            | (107 000 to 263 000)        | 62·5% (–77·8 to –41·4)       | 17 641         | (11 177 000 to 249 850) | 59·0% (–73·5 to –38·6)       | 201            | (10 210 to 28 890) |
| Belarus                  | 15             | (9 000 to 24 000)           | 77·7% (–86·5 to –68·8)       | 579            | (408 000 to 7 758 000) | 46·9% (–59·1 to –34·5)       | 17             | (130 000 to 194 000) |
| Bosnia and Herzegovina  | 2              | (6 000 to 20 000)           | 59·0% (–81·3 to –12·4)       | 315            | (214 000 to 456 000) | 46·7% (–80·8 to –30·3)       | 8              | (4 500 to 7 400) |
| Bulgaria                | 79             | (5 100 to 12 00)            | 43·4% (–64·3 to –13·7)       | 9             | (2 000 to 1 800) | 37·2% (–55·2 to –12·8)       | 4              | (2 200 to 3 300) |
| Croatia                 | 10             | (7 000 to 13 000)           | 31·8% (–50·0 to –8·6)        | 166            | (127 000 to 214 000) | 19·7% (–34·1 to –4·8)        | 173            | (1 220 to 2 100) |
| Czech Republic          | 20             | (1 500 to 28 000)           | 48·7% (–71·0 to –10·7)       | 383            | (290 000 to 483 000) | 45·5% (–87·0 to –70·2)       | 11             | (3 000 to 1 400) |
| Estonia                 | 2              | (1 000 to 2 000)            | 55·1% (–69·7 to –34·8)       | 73             | (52 000 to 96 000) | 25·6% (–36·2 to –15·3)       | 18             | (1 400 to 2 300) |
| Georgia                 | 124            | (8 700 to 16 300)           | 54·8% (–68·6 to –31·8)       | 162             | (1 247 000 to 267 000) | 46·0% (–59·7 to –26·7)       | 237            | (19 400 to 28 600) |
| Hungary                 | 39             | (2 500 to 55 000)           | 46·0% (–36·5 to –34·1)       | 520            | (379 000 to 7 687 000) | 13·3% (–23·2 to –24·7)       | 118            | (25 000 to 140 000) |
| Kazakhstan              | 93             | (3 600 to 6 999)            | 48·7% (–65·4 to –22·7)       | 118            | (8 400 000 to 10 496 000) | 39·2% (–55·5 to –16·6)       | 1218           | (93 000 to 167 000) |
| Kyrgyzstan              | 175            | (12 600 to 22 870)          | 35·7% (–52·4 to –13·5)       | 74             | (13 159 000 to 21 840 000) | 32·5% (–48·5 to –11·5)       | 156            | (2 960 to 4 420) |
| Latvia                  | 4              | (2 000 to 5 000)            | 65·4% (–78·2 to –45·8)       | 9             | (7 160 to 128 000) | 40·3% (–53·1 to –27·8)       | 35             | (0 100 to 0 200) |
| Lithuania               | 6              | (4 000 to 9 000)            | 42·3% (–40·3 to –13·1)       | 15             | (119 000 to 207 000) | 23·8% (–35·3 to –10·9)       | 6              | (0 200 to 0 300) |

Table 1 continues on next page.
| Country         | Deaths (2015-16) | Number (per 1000000) | Mortality rate (2015-16) | Percentage change, 2005-15 | DALYs (2015-16) | Number (per 1000000) | Mortality rate (2015-16) | Percentage change, 2005-15 | DALYs (2015-16) |
|-----------------|------------------|----------------------|--------------------------|-----------------------------|----------------|----------------------|--------------------------|-----------------------------|----------------|
| Macedonia       | 5014             | 22.4                 | -52%                     | (-680 to -29.4)             | 76             | 2.4                  | -48%                     | (-625 to -28.0)             | 6847            |
| Moldova         | 856             | 2.8                  | -42%                     | (-597 to -21.4)             | 9              | 0.2                  | -42%                     | (-560 to -20.1)             | 1269            |
| Mongolia        | 879             | 0.6                  | -17%                     | (-397 to -9.0)              | 3              | 0.1                  | -52%                     | (-680 to -28.1)             | 1234            |
| Montenegro      | 734             | 0.3                  | -52%                     | (-687 to -3.0)              | 3              | 0.1                  | -6%                      | (-68 to -28.1)              | 355             |
| Poland          | 134             | 0.3                  | -21%                     | (-559 to -3.0)              | 120            | 0.3                  | 80%                      | (-490 to 12.9)             | 348             |
| Romania         | 3575            | 0.2                  | -68%                     | (-757 to -5.5)              | 575            | 0.3                  | -38%                     | (-490 to -9.8)             | 439            |
| Russia          | 2366            | 0.2                  | -36%                     | (-600 to -2.4)              | 477            | 0.3                  | -38%                     | (-490 to -9.8)             | 4265           |
| Serbia          | 576             | 0.9                  | -14%                     | (-377 to 7.1)               | 330            | 0.4                  | 45%                      | (-178 to 8.5)              | 1134           |
| Slovakia        | 363             | 0.5                  | -20%                     | (-406 to 3.0)               | 203            | 0.4                  | 6%                       | (-131 to 28.9)             | 829             |
| Slovenia        | 1856            | 0.2                  | -24%                     | (-557 to -2.4)              | 43             | 0.1                  | 3%                       | (-670 to 16.0)             | 127             |
| Tajikistan      | 801             | 1.7                  | -35%                     | (-599 to -9.3)              | 986            | 1.6                  | -38%                     | (-590 to -4.3)             | 87             |
| Turkmenistan    | 1099            | 0.9                  | -73%                     | (-834 to 58.3)              | 195            | 0.2                  | -73%                     | (-822 to 59.0)             | 185             |
| Ukraine         | 15263           | 0.9                  | -73%                     | (-834 to 58.3)              | 37             | 0.3                  | -73%                     | (-822 to 59.0)             | 185             |
| Uzbekistan      | 2871            | 1.0                  | -27%                     | (-517 to 7.0)               | 287            | 0.2                  | -29%                     | (-437 to -10.4)            | 287             |
| High-income     | 6837            | 1.2                  | -30%                     | (-364 to -24.4)             | 257012         | 2.4                  | 47%                      | (164 to 75.4)             | 36212          |
| Andorra         | 0               | 0.0                  | -45%                     | (-176 to 8.2)               | 0              | 0.0                  | 60%                      | (131 to 13.6)              | 72             |
| Argentina       | 13504           | 5.1                  | -30%                     | (-450 to 16.9)              | 658            | 1.5                  | -28%                     | (-204 to 17.9)             | 22362          |

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| All ages | Deaths | Number | Mortality rate (per 100 000) | Percentage change, 2005–15 | DALYs | Percentage change, 2005–15 |
|---------|--------|--------|-------------------------------|-----------------------------|-------|-----------------------------|
| Australia | 115 | 0.7 | -23.3% | -18.4% | 11475 | 3.9% |
| Austria | 43 | 1.1 | 34.9% | 32.4% | 4395 | 34.9% |
| Belgium | 6.2 | 1.0 | -23.4% | -20.7% | 6213 | 61.1% |
| Brunei | 0.5 | 0.1 | -28% | -2.7% | 442 | 3.7% |
| Canada | 14.4 | 0.8 | -24% | -10% | 13131 | 23.5% |
| Chile | 10.3 | 0.9 | -46.7% | -52.2% | 10987 | 4.2% |
| Cyprus | 0.9 | 0.4 | -35.6% | -35.0% | 809 | 3.7% |
| Denmark | 3.9 | 0.8 | -17.2% | -25.0% | 3781 | 2.5% |
| Finland | 0.6 | 0.2 | -43.6% | -31.3% | 817 | 13.3% |
| France | 36.9 | 0.9 | -36.7% | -32.1% | 3905 | 10.6% |
| Germany | 17.3 | 0.5 | -51.7% | -43.0% | 18934 | 11.6% |
| Greece | 0.4 | 0.0 | -38.9% | -25.9% | 46 | 4.0% |
| Greenland | 0.1 | 0.1 | -11.2% | -11.0% | 6 | 10.0% |
| Iceland | 0.1 | 0.1 | -43.1% | -37.2% | 10 | 19.0% |
| Ireland | 2.6 | 0.7 | -44% | -1.3% | 150 | 0.5% |
| Israel | 8.5 | 1.0 | -35% | -1.6% | 839 | 1.2% |
| Italy | 10.5 | 0.4 | -15.7% | -11.2% | 1134 | 11.8% |

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| All ages | Deaths | Number | Mortality rate (per 100 000) | Percentage change, 2005–15 | DALYs | Percentage change, 2005–15 |
|---------|--------|--------|-------------------------------|-----------------------------|-------|-----------------------------|
| Australia | 115 | 0.7 | -23.3% | -18.4% | 11475 | 3.9% |
| Austria | 43 | 1.1 | 34.9% | 32.4% | 4395 | 34.9% |
| Belgium | 6.2 | 1.0 | -23.4% | -20.7% | 6213 | 61.1% |
| Brunei | 0.5 | 0.1 | -28% | -2.7% | 442 | 3.7% |
| Canada | 14.4 | 0.8 | -24% | -10% | 13131 | 23.5% |
| Chile | 10.3 | 0.9 | -46.7% | -52.2% | 10987 | 4.2% |
| Cyprus | 0.9 | 0.4 | -35.6% | -35.0% | 809 | 3.7% |
| Denmark | 3.9 | 0.8 | -17.2% | -25.0% | 3781 | 2.5% |
| Finland | 0.6 | 0.2 | -43.6% | -31.3% | 817 | 13.3% |
| France | 36.9 | 0.9 | -36.7% | -32.1% | 3905 | 10.6% |
| Germany | 17.3 | 0.5 | -51.7% | -43.0% | 18934 | 11.6% |
| Greece | 0.4 | 0.0 | -38.9% | -25.9% | 46 | 4.0% |
| Greenland | 0.1 | 0.1 | -11.2% | -11.0% | 6 | 10.0% |
| Iceland | 0.1 | 0.1 | -43.1% | -37.2% | 10 | 19.0% |
| Ireland | 2.6 | 0.7 | -44% | -1.3% | 150 | 0.5% |
| Israel | 8.5 | 1.0 | -35% | -1.6% | 839 | 1.2% |
| Italy | 10.5 | 0.4 | -15.7% | -11.2% | 1134 | 11.8% |

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| Country     | Mortality rate (per 100 000) | DALY (100 000s) | Number Increase, 2005–15 | Percentage change, 2005–15 |
|-------------|------------------------------|-----------------|--------------------------|---------------------------|
| **Children younger than 5 years** |                              |                  |                          |                           |
| Japan       | 39·9                         | 308 ·2           | 11                       | 1·2                       |
| Luxembourg  | 0·6                          | 0·7              | 0·2                      | 32·1                      |
| Malta       | 0·5                          | 0·7              | 0·2                      | 32·1                      |
| Netherlands | 3·1                          | 3·1              | 0·2                      | 32·1                      |
| New Zealand | 0·1                          | 0·1              | 0·2                      | 32·1                      |
| Norway      | 2·9                          | 2·9              | 0·2                      | 32·1                      |
| Portugal    | 0·7                          | 0·7              | 0·2                      | 32·1                      |
| Singapore   | 0·8                          | 0·8              | 0·2                      | 32·1                      |
| South Korea | 8·5                          | 8·5              | 0·2                      | 32·1                      |
| Spain       | 10·5                         | 10·5             | 0·2                      | 32·1                      |
| Switzerland | 2·6                          | 2·6              | 0·2                      | 32·1                      |
| **All ages** |                              |                  |                          |                           |
| Japan       | 39·9                         | 308 ·2           | 11                       | 1·2                       |
| Luxembourg  | 0·6                          | 0·7              | 0·2                      | 32·1                      |
| Malta       | 0·5                          | 0·7              | 0·2                      | 32·1                      |
| Netherlands | 3·1                          | 3·1              | 0·2                      | 32·1                      |
| New Zealand | 0·1                          | 0·1              | 0·2                      | 32·1                      |
| Norway      | 2·9                          | 2·9              | 0·2                      | 32·1                      |
| Portugal    | 0·7                          | 0·7              | 0·2                      | 32·1                      |
| Singapore   | 0·8                          | 0·8              | 0·2                      | 32·1                      |
| South Korea | 8·5                          | 8·5              | 0·2                      | 32·1                      |
| Spain       | 10·5                         | 10·5             | 0·2                      | 32·1                      |
| Switzerland | 2·6                          | 2·6              | 0·2                      | 32·1                      |

Table 1 continues on next page...
| Country                  | Number (per 100000) | Percentage change, 2005–15 | Death rate (per 100000) | DALYs (100 000) | Percentage change, 2005–15 | Number (per 100000) | Percentage change, 2005–15 | DALYs (100 000) | Percentage change, 2005–15 |
|-------------------------|---------------------|-----------------------------|-------------------------|----------------|-----------------------------|---------------------|-----------------------------|----------------|-----------------------------|
| Antigua and Barbuda     | 36                  | -28%                        | 13362                   | 117668         | -50%                        | 19313               | 157953                      | 124042         | -65%                        |
| Barbados                | 15                  | -32%                        | 2035                    | 2896           | -55%                        | 3214                 | 42469                       | 31604          | -56%                        |
| Belize                  | 5                   | -57%                        | 13                   | 215             | -39%                        | 77                  | 394                         | 241            | -32%                        |
| Bermuda                 | 2                   | -60%                        | 0                      | 0               | -59%                        | 0                   | 0                           | 0              | -58%                        |
| Bolivia                 | 16                  | -66%                        | 258                    | 2766           | -56%                        | 812                  | 7884                        | 7804           | -52%                        |
| Brazil                  | 27                  | -67%                        | 357                    | 670            | -54%                        | 143                  | 796                         | 796            | -53%                        |
| Dominican Republic      | 22                  | -68%                        | 226                    | 369            | -53%                        | 101                  | 126                         | 126            | -52%                        |
| Ecuador                 | 35                  | -70%                        | 69                    | 356            | -54%                        | 27                   | 268                         | 268            | -53%                        |
| El Salvador             | 20                  | -74%                        | 144                    | 330            | -54%                        | 12                   | 126                         | 126            | -52%                        |
| Grenada                 | 7                   | -80%                        | 19                    | 19             | -68%                        | 2                    | 2                           | 2              | -60%                        |
| Guatemala               | 12                  | -92%                        | 152                    | 152            | -67%                        | 12                   | 12                          | 12              | -67%                        |
| Guyana                  | 9                   | -95%                        | 57                    | 57             | -68%                        | 5                   | 5                           | 5              | -63%                        |
| Guatemala               | 29                  | -95%                        | 20                    | 20             | -72%                        | 13                   | 13                          | 13              | -65%                        |

(Table 1 continues on next page)
Table 1: Estimates of incidence, all-cause mortality, and disability-adjusted life years (DALYs) for children younger than 5 years and all ages from surveillance data, 2005–15

| Country                  | Deaths (100 000) | DALYs | Deaths (100 000) | DALYs |
|--------------------------|------------------|-------|------------------|-------|
| **Children younger than 5 years** |                  |       |                  |       |
| Haiti                    | 2370 (1473 to 3765) | 34.2 | 212393 (1311430 to 3320128) | 29.4 |
| Honduras                 | 2482 (1702 to 3493) | 17.9 | 26219 (189996 to 345959) | 14.7 |
| Jamaica                  | 164 (103 to 257) | 2.7 | 21332 (15058 to 30343) | 2.7 |
| Mexico                   | 40941 (9635 to 12467) | 9.8 | 1119976 (894446 to 1263913) | 10.6 |
| Nicaragua                | 981 (643 to 1473) | 6.2 | 311323 (267868 to 122946) | 5.4 |
| Panama                   | 868 (612 to 1230) | 6.2 | 23670 (192488 to 20254) | 6.5 |
| Paraguay                 | 907 (590 to 1368) | 9.8 | 210367 (173444 to 248880) | 10.4 |
| Peru                     | 291 (174 to 395) | 5.2 | 32682 (264491 to 415413) | 5.7 |
| Puerto Rico              | 41 (31 to 52) | 1.8 | 8590 (67080 to 10734) | 1.7 |
| **All ages**             |                  |       |                  |       |
| Haiti                    | 2370 (1473 to 3765) | 34.2 | 212393 (1311430 to 3320128) | 29.4 |
| Honduras                 | 2482 (1702 to 3493) | 17.9 | 26219 (189996 to 345959) | 14.7 |
| Jamaica                  | 164 (103 to 257) | 2.7 | 21332 (15058 to 30343) | 2.7 |
| Mexico                   | 40941 (9635 to 12467) | 9.8 | 1119976 (894446 to 1263913) | 10.6 |
| Nicaragua                | 981 (643 to 1473) | 6.2 | 311323 (267868 to 122946) | 5.4 |
| Panama                   | 868 (612 to 1230) | 6.2 | 23670 (192488 to 20254) | 6.5 |
| Paraguay                 | 907 (590 to 1368) | 9.8 | 210367 (173444 to 248880) | 10.4 |
| Peru                     | 291 (174 to 395) | 5.2 | 32682 (264491 to 415413) | 5.7 |
| Puerto Rico              | 41 (31 to 52) | 1.8 | 8590 (67080 to 10734) | 1.7 |
| **(Continued from previous page)** |                  |       |                  |       |

(continued on next page)
| Children younger than 5 years | Allages |
|-------------------------------|---------|
| **Deaths** | **Number** | **Deaths** | **Number** |
| **Mortality rate** | **(per 100 000s)** | **Percentage change, 2005–15** | **Mortality rate** | **(per 100 000s)** | **Percentage change, 2005–15** |
| **(per 100 000 people)** | | | **(per 100 000 people)** | | |
| Afghanistan | 23 676.5 | -48.0% | 36 8 47.6 | 1070 1 | 23 10 2 48.0 | 1070 1 | 23 10 2 48.0 |
| (18 135.3 to 30 620.0) | | | (195 54 to 204 5) | | | (195 54 to 204 5) | |
| Algeria | 601.9 | -12.9% | 36 8 7 21 9 | 172.7 | 81.4 | 172.7 | 81.4 |
| (35 8 to 996.6) | | | (7 6 to 21 9) | | | (7 6 to 21 9) | |
| Bahrain | 30 | -14.3% | 30 | 1 | 0.9 1 | 0.9 1 |
| (19 4 to 41) | | | (19 4 to 41) | | | (19 4 to 41) | |
| Egypt | 4023.4 | -24.7% | 32 4 52 3 | 270 1 40 6 24 3 | 270 1 40 6 24 3 |
| (207 1 40 6 24 3) | | | (23 0 to 52 3) | | | (23 0 to 52 3) | |
| Iran | 238.0 | -17.6% | 35 | 81.9 | 0.9 1 | 0.9 1 |
| (125 7 to 414 6) | | | (1 9 6) | | | (1 9 6) | |
| Iraq | 1239.9 | -42.4% | 21.7 | 30.6 | 6.2 10 | 6.2 10 |
| (728 6 to 3912.5) | | | (12 7 to 33 4) | | | (12 7 to 33 4) | |
| Jordan | 24.4 | -46.0% | 25 | 13.5 | 11 8 | 11 8 |
| (15 4 to 36 9) | | | (1 6 3) | | | (1 6 3) | |
| Kuwait | 41 | -17.7% | 1 1 | 20.0 | 3 | 20.0 | 3 |
| (2 9 to 58) | | | (0 8 to 16) | | | (0 8 to 16) | |
| Lebanon | 65.6 | -35.6% | 18 | 51 | 8 | 51 |
| (3 11 to 13 3) | | | (0 8 to 35) | | | (0 8 to 35) | |
| Libya | 32.5 | -49.7% | 4 9 | 9 3 | 7 8 | 7 8 |
| (16 8 to 54 5) | | | (2 5 to 8 2) | | | (2 5 to 8 2) | |
| Morocco | 2942.8 | -57.3% | 8.6 | 56.3 | 52.9 | 52.9 |
| (175 9 to 464 0) | | | (5 2 to 13 6) | | | (5 2 to 13 6) | |
| Oman | 37 | -44.2% | 10 | 39 | 3 4 | 3 4 |
| (2 2 to 6 0) | | | (0 6 to 1 6) | | | (0 6 to 1 6) | |
| Palestine | 165 | -36.9% | 23 | 79 | 6 | 79 |
| (10 7 to 25 0) | | | (1 5 to 3 5) | | | (1 5 to 3 5) | |
| Qatar | 0.9 | -61.1% | 0.8 | 12 | 1 | 1 |
| (0 5 to 1 6) | | | (0 4 to 1 4) | | | (0 4 to 1 4) | |
| Saudi Arabia | 103.5 | -37.0% | 3 4 | 33.1 | 3 | 33.1 |
| (79 8 to 131 6) | | | (2 6 to 4 3) | | | (2 6 to 4 3) | |

(Table 1 continues on next page)
| Country         | Deaths | Number | DP to | DALYs | Number | Percentage change, 2005–15 | Percentage change, 2005–15 |
|----------------|--------|--------|-------|--------|--------|---------------------------|---------------------------|
| Sudan          | 762.05 | 1248   | (70.0 to 205.2) | 1564 | 69370.71 | -39.3% (-61.7 to 9.9) | -38.3% (-60.1 to 3.5) |
| Syria          | 49.7   | 3.2    | (29.2 to 81.9) | 276 | 13522 | -30.2% (-29.1 to 15.9) | 0.5% (0.3 to 0.6) |
| Tunisia        | 37.3   | 3.8    | (22.7 to 56.0) | 135 | 6675 | -34.4% (-55.1 to -9.2) | -90% (0.7 to 0.9) |
| Turkey         | 24.2   | 0.3    | (13.7 to 43.9) | 881 | 44237 | -54.9% (-69.5 to -34.5) | 0.7% (0.1 to 0.5) |
| United Arab     | 2.4    | 0.5    | (0.2 to 1.0)   | 55  | 16806 | 41.7% (17.1 to 66.0) | 685% (0.6 to 0.7) |
| Yemen          | 274.1  | 7.4    | (15.3 to 80.3) | 1961 | 287288 | -38.0% (-65.6 to 29.0) | -380% (-64.4 to 24.9) |
| South Asia     | 143.342 | 85.7 | (72.6 to 100.3) | 32126 | 13069650 | -29.2% (-48.7 to -2.8) | -30.1% (-49.2 to 11.3) |
| Bangladesh     | 38.267 | 25.0   | (16.4 to 36.3) | 2795 | 396218 | -55.7% (-70.4 to -35.6) | -32.4% (-44.3 to -19.3) |
| Bhutan         | 26.8   | 0.45   | (10.1 to 53.8) | 315 | 3154 | -53.1% (-68.9 to -22.0) | -13.1% (0.7 to 17.9) |
| India          | 104.643 | 84.2 | (71.2 to 98.5) | 2079 | 497488 | -42.0% (-50.9 to -31.2) | -21.9% (-37.1 to -13.1) |
| Nepal          | 1256.9 | 44.2   | (28.8 to 63.0) | 927 | 9127 | -66.7% (-78.7 to -51.5) | -34.4% (-46.2 to -18.6) |
| Pakistan       | 33589.2 | 1353  | (92.6 to 185.8) | 753 | 306175 | -20.8% (-46.1 to 15.5) | -37.1% (0.1 to 37.0) |
| Southeast Asia | 16.8058 | 11.5  | (8.9 to 14.3) | 1228 | 1430744 | -52.9% (-63.5 to -38.6) | -20.8% (0.1 to 10.9) |
| American Samoa | 0.1    | 1.0    | (0.9 to 1.0)   | 0.1 | 301  | 1.7% (15.6 to 23.4) | 0.1% (0.0 to 0.1) |
| Cambodia       | 456.9  | 25.7   | (14.0 to 43.8) | 264 | 46334 | -68.5% (-83.1 to -48.3) | 8.1% (6.3 to 10.5) |
| Note: Continues on next page |        |        |        |        |        |                           |                           |
| Countries                        | Deaths 2005 | Mortality rate per 10,000 | Percentage change, 2005–15 | DALYs 2005 | Deaths 2015 | Mortality rate per 10,000 | Percentage change, 2005–15 | DALYs 2015 |
|---------------------------------|-------------|--------------------------|-----------------------------|------------|-------------|--------------------------|-----------------------------|------------|
| China                           | 1919.7      | (1558.2 to 2353.5)       | -71.0%                      | 2482       | 23084.7     | (19287.5 to 276998.8)    | -64.5%                      | 5851.5     |
| Federated States of Micronesia  | 0.4         | (0.2 to 0.7)             | -55.3%                      | 0.1        | 39.9       | (39.5 to 90.2)            | -43.2%                      | 27         |
| Fiji                            | 26.3        | (13.6 to 48.1)           | -20%                        | 0.9        | 2476.3     | (1366.3 to 4460.6)       | -2.4%                       | 89         |
| Guam                            | 0.2         | (0.1 to 0.3)             | 25.0%                       | 0.1        | 35.2       | (26.7 to 45.7)            | 18.0%                       | 1.8        |
| Indonesia                       | 8559.4      | (4931.2 to 12391.6)      | -59.5%                      | 47.8       | 89.6       | (55.4 to 145.4)           | -45.9%                      | 56.9       |
| Kiribati                        | 7.3         | (3.0 to 15.4)            | -37.9%                      | 0.2        | 668.1      | (301.7 to 1357.7)         | -36.5%                      | 23         |
| Laos                            | 811.8       | (484.3 to 1539.8)        | -57.1%                      | 10        | 72275.5    | (40115.2 to 117729.3)     | -56.1%                      | 1159.1     |
| Malaysia                        | 50.2        | (29.3 to 85.3)           | -35.9%                      | 21.2       | 995.2      | (799.5 to 13423.2)        | -11.8%                      | 385.1      |
| Maldives                        | 2.0         | (1.2 to 3.3)             | -53.8%                      | 0.3        | 299.1      | (177.5 to 566.5)          | -42.1%                      | 7.6        |
| Marshall islands                | 0.7         | (0.3 to 1.3)             | -65.6%                      | 0.1        | 79.2       | (46.4 to 125.8)           | -57.9%                      | 26         |
| Mauritius                       | 4.4         | (2.8 to 5.7)             | -28.4%                      | 0.6        | 537.8      | (385.2 to 673.7)          | -26.8%                      | 26.7       |
| Myanmar                         | 1292.1      | (714.5 to 2155.9)        | -72.7%                      | 50.6       | 123803.8   | (73735.7 to 196053.8)     | -70.9%                      | 77142     |
| North Korea                     | 63.6        | (23.1 to 156.8)          | -62.0%                      | 16.4       | 785.3      | (5814.6 to 17682.6)       | -50.6%                      | 1993       |
| Northern                        | 0.1         | (0.0 to 0.2)             | -9.0%                       | 0          | 17.4       | (12.2 to 23.3)            | 22.9%                       | 0.5        |
| Mariana Islands                 | 0.00        | (0.00 to 0.00)           | 0.0%                        | 0          | 0.0        | (0.0 to 0.0)              | 0.0%                        | 0.0        |
| Papua New Guinea                | 373.8       | (166.9 to 709.3)         | -52.5%                      | 10.6       | 34697.4    | (169006.0 to 63846.0)     | -50.6%                      | 2253.4     |
| Philippines                     | 2286.4      | (2223.3 to 36000.0)      | -46.6%                      | 142.7      | 28533.9    | (224662.9 to 348885.9)    | -45.0%                      | 3728.4     |
| Samoa                           | 0.3         | (0.1 to 0.7)             | -55.9%                      | 0.2        | 821.0      | (543.4 to 1263.9)         | -28.0%                      | 4.6        |

(Continued from previous page)
### DALYs, Deaths, and Episodes (100 000s) Percentage change, 2005–15

| Country          | Number | Deaths | Mortality rate (per 100 000) | Percentage change, 2005–15 | Episodes | Percentage change, 2005–15 | DALYs | Percentage change, 2005–15 |
|------------------|--------|--------|-------------------------------|-----------------------------|----------|-----------------------------|-------|-----------------------------|
| **Children younger than 5 years** |         |        |                               |                             |          |                             |       |                             |
|                  |        |        |                               |                             |          |                             |       |                             |
| **All ages**     |        |        |                               |                             |          |                             |       |                             |
|                  |        |        |                               |                             |          |                             |       |                             |
| (Continued from previous page) |        |        |                               |                             |          |                             |       |                             |

Seychelles

| Number | Deaths | Mortality rate (per 100 000) | Percentage change, 2005–15 | Episodes | Percentage change, 2005–15 | DALYs | Percentage change, 2005–15 |
|--------|--------|-----------------------------|-----------------------------|----------|-----------------------------|-------|-----------------------------|
| 30     | 2      | 12.0                        | -31.9% (–51.8 to –4.9)     | 237      | -11.2% (–24.7 to 42)        | 13    | -11.4% (–30.7 to 133)       |

Solomon Islands

| Number | Deaths | Mortality rate (per 100 000) | Percentage change, 2005–15 | Episodes | Percentage change, 2005–15 | DALYs | Percentage change, 2005–15 |
|--------|--------|-----------------------------|-----------------------------|----------|-----------------------------|-------|-----------------------------|
| 15     | 2      | 146.0                       | -42.5% (–69.8 to 29.5)     | 1286     | -37.7% (–63.3 to 22.4)      | 40    | -28.5% (–48.3 to 13)        |

Sri Lanka

| Number | Deaths | Mortality rate (per 100 000) | Percentage change, 2005–15 | Episodes | Percentage change, 2005–15 | DALYs | Percentage change, 2005–15 |
|--------|--------|-----------------------------|-----------------------------|----------|-----------------------------|-------|-----------------------------|
| 18     | 1      | 11.0                        | -76.8% (–83.6 to 67.3)     | 10       | -58.3% (–66.9 to 49.8)      | 47    | -49.5% (–70.2 to 23.3)      |

Taiwan

| Number | Deaths | Mortality rate (per 100 000) | Percentage change, 2005–15 | Episodes | Percentage change, 2005–15 | DALYs | Percentage change, 2005–15 |
|--------|--------|-----------------------------|-----------------------------|----------|-----------------------------|-------|-----------------------------|
| 6      | 1      | 7.0                         | 25.8% (–39.5 to 165.9)     | 32       | 2.0% (–20.9 to 381)         | 18    | 0.5% (–18.4 to 89.7)        |

Thailand

| Number | Deaths | Mortality rate (per 100 000) | Percentage change, 2005–15 | Episodes | Percentage change, 2005–15 | DALYs | Percentage change, 2005–15 |
|--------|--------|-----------------------------|-----------------------------|----------|-----------------------------|-------|-----------------------------|
| 10     | 1      | 5.0                         | -10.0% (–32.1 to 21.3)     | 1795     | -55.7% (–73.6 to 0.6)       | 26    | -54.2% (–79.9 to 1.6)       |

Timor-Leste

| Number | Deaths | Mortality rate (per 100 000) | Percentage change, 2005–15 | Episodes | Percentage change, 2005–15 | DALYs | Percentage change, 2005–15 |
|--------|--------|-----------------------------|-----------------------------|----------|-----------------------------|-------|-----------------------------|
| 11     | 1      | 5.7                         | -2% (–5.9 to 8.3)           | 1260     | 2.0% (–20.0 to 26.4)        | 16    | 0.6% (–17.0 to 24.9)        |

Tonga

| Number | Deaths | Mortality rate (per 100 000) | Percentage change, 2005–15 | Episodes | Percentage change, 2005–15 | DALYs | Percentage change, 2005–15 |
|--------|--------|-----------------------------|-----------------------------|----------|-----------------------------|-------|-----------------------------|
| 0.5    | 1      | 3.7                         | -10.8% (–42.4 to 51.0)     | 326      | -26.1% (–59.1 to 32.9)      | 2      | -12.6% (–33.9 to 14.2)      |

Vanuatu

| Number | Deaths | Mortality rate (per 100 000) | Percentage change, 2005–15 | Episodes | Percentage change, 2005–15 | DALYs | Percentage change, 2005–15 |
|--------|--------|-----------------------------|-----------------------------|----------|-----------------------------|-------|-----------------------------|
| 6      | 1      | 4.9                         | -21.3% (–49.3 to 58.7)     | 100      | -11.0% (–20.4 to 29.9)      | 2      | -11.6% (–50.2 to 40)        |

Vietnam

| Number | Deaths | Mortality rate (per 100 000) | Percentage change, 2005–15 | Episodes | Percentage change, 2005–15 | DALYs | Percentage change, 2005–15 |
|--------|--------|-----------------------------|-----------------------------|----------|-----------------------------|-------|-----------------------------|
| 13.2   | 1      | 17.0                        | -60.2% (–71.6 to 47.9)     | 1361     | -56.7% (–73.5 to 38.5)      | 27    | -21.6% (–20.9 to 11.0)      |

Sub-Saharan Africa

| Number | Deaths | Mortality rate (per 100 000) | Percentage change, 2005–15 | Episodes | Percentage change, 2005–15 | DALYs | Percentage change, 2005–15 |
|--------|--------|-----------------------------|-----------------------------|----------|-----------------------------|-------|-----------------------------|
| 19.1   | 1      | 16.0                        | -13.3% (–27.3 to 10.1)     | 1239     | -2.5% (–27.9 to 0.4)        | 27    | -15.9% (–36.4 to 5.5)       |

Angola

| Number | Deaths | Mortality rate (per 100 000) | Percentage change, 2005–15 | Episodes | Percentage change, 2005–15 | DALYs | Percentage change, 2005–15 |
|--------|--------|-----------------------------|-----------------------------|----------|-----------------------------|-------|-----------------------------|
| 6      | 1      | 12.6                        | -32.0% (–61.2 to 26.1)     | 250      | -11.2% (–85.4 to 50.2)      | 10    | -10.1% (–65.2 to 27.0)      |

Benin

| Number | Deaths | Mortality rate (per 100 000) | Percentage change, 2005–15 | Episodes | Percentage change, 2005–15 | DALYs | Percentage change, 2005–15 |
|--------|--------|-----------------------------|-----------------------------|----------|-----------------------------|-------|-----------------------------|
| 12     | 1      | 146.0                       | -32.0% (–46.7 to 5.4)      | 120      | -13.9% (–35.6 to 27.5)      | 6     | -10.7% (–64.4 to 34.9)      |

Botswana

| Number | Deaths | Mortality rate (per 100 000) | Percentage change, 2005–15 | Episodes | Percentage change, 2005–15 | DALYs | Percentage change, 2005–15 |
|--------|--------|-----------------------------|-----------------------------|----------|-----------------------------|-------|-----------------------------|
| 14     | 1      | 146.0                       | -32.0% (–46.7 to 5.4)      | 120      | -13.9% (–35.6 to 27.5)      | 6     | -10.7% (–64.4 to 34.9)      |

Burkina Faso

| Number | Deaths | Mortality rate (per 100 000) | Percentage change, 2005–15 | Episodes | Percentage change, 2005–15 | DALYs | Percentage change, 2005–15 |
|--------|--------|-----------------------------|-----------------------------|----------|-----------------------------|-------|-----------------------------|
| 20     | 1      | 25.0                        | -32.4% (–37.6 to 11.9)     | 120      | -13.9% (–35.6 to 27.5)      | 6     | -10.7% (–64.4 to 34.9)      |

Burundi

| Number | Deaths | Mortality rate (per 100 000) | Percentage change, 2005–15 | Episodes | Percentage change, 2005–15 | DALYs | Percentage change, 2005–15 |
|--------|--------|-----------------------------|-----------------------------|----------|-----------------------------|-------|-----------------------------|
| 40     | 1      | 19.2                        | -11.0% (–47.4 to 51.3)     | 136      | -10.0% (–45.8 to 49.9)      | 5      | -9.9% (–38.1 to 27.3)       |

(Continued from previous page)
## Children younger than 5 years

| Country | Deaths | Episides | DALYs | All ages | Number | Mortality rate (per 100 000) | Percentage change, 2005–15 | Number | Mortality rate (per 100 000) | Percentage change, 2005–15 | Number | Percentage change, 2005–15 |
|---------|--------|----------|-------|----------|--------|-----------------------------|-----------------------------|--------|-----------------------------|-----------------------------|--------|-----------------------------|
| Cameroon | 6292   | 164.9    | -24.4%| 882      | 557630 | (336578 to 8424713)         | -24.0%                      | 10087  | 43.1                        | -23.5%                      | 2079   | 725802                      |
| Cape Verde | 9.7    | 1182     | -51.4%| 0.9      | 10508  | (7087 to 15679)             | -47.2%                      | 30      | 5.9                         | -41.0%                      | 28     | 2049                        |
| Central African Republic | 1697.6 | 23.87   | 5.6%  | 18.8     | 1591358| (880120 to 2415410)         | 5.1%                        | 174     | 5.7                         | -15.4%                      | 38     | 69061                       |
| Chad     | 157817 | 9337     | 8.9%  | 73       | 1365263| (9061130 to 1892323)        | 8.9%                        | 20046  | 46.1                        | 6.9%                         | 154    | 1571897                     |
| Comoros  | 84      | 68.4     | -44.8%| 2.6      | 7876   | (4238 to 13603)             | -42.3%                      | 323     | 40.8                        | -30.2%                      | 76     | 163980                      |
| Congo (Brazzaville) | 379.3  | 48.7     | -33.1%| 17.4     | 36408  | (207180 to 616676)          | -29.4%                      | 1189   | 25.7                        | -14%                         | 38     | 69061                       |
| Côte d’Ivoire | 3885.6 | 163.8    | -16.0%| 84.1     | 534417 | (320702 to 790667)          | -15.5%                      | 10166  | 45.2                        | -11.6%                      | 203     | 775500                      |
| DR Congo | 19117  | 136.3    | -18.3%| 451.3    | 1751494| (1091830 to 2662321)        | -16.4%                      | 35634  | 46.0                        | -9.9%                       | 83      | 2451530                     |
| Djibouti | 128.2   | 122.9    | -46.9%| 2.7      | 114759 | (580160 to 17792)           | -45.9%                      | 457     | 45.6                        | -13.4%                      | 76      | 216074                      |
| Equatorial Guinea | 64.2   | 50.1     | -35.6%| 27       | 61393  | (31343 to 110845)           | -32.1%                      | 143     | 17.1                        | -21.6%                      | 65     | 99961                       |
| Eritrea  | 1788.7  | 215.7    | -16.4%| 16       | 156365 | (935682 to 2351835)         | -16.0%                      | 47599  | 90.8                        | 9.7%                        | 44      | 270185                      |
| Ethiopia | 14662.4 | 375.1    | -63.2%| 26.6     | 1223512| (790989 to 1982650)         | -62.1%                      | 46786  | 47.1                        | -40.3%                      | 84      | 2452575                     |
| Gabon    | 68.6    | 28.0     | -40.4%| 46       | 7064   | (40958 to 116487)           | -35.5%                      | 294     | 27.9                        | -7.9%                       | 11      | 152341                      |
| Ghana    | 16618   | 41.8     | -41.5%| 76.6     | 164857 | (992275 to 248251)          | -38.7%                      | 38467  | 14.0                        | -33.5%                      | 35      | 271210                      |
| Guinea   | 29846   | 14.8     | -32.4%| 45       | 266560 | (1714411 to 382676)         | -31.6%                      | 59995  | 47.7                        | -19.8%                      | 107     | 391461                       |
| (Table 1 continues on next page)
| Country       | Deaths Number | Mortality rate (per 100000) | Percentage change, 2005–15 | DALYs Number | Percentage change, 2005–15 | Number | Mortality rate (per 100000) | Percentage change, 2005–15 | DALYs Number | Percentage change, 2005–15 |
|--------------|--------------|-----------------------------|----------------------------|--------------|-----------------------------|--------|-----------------------------|----------------------------|--------------|-----------------------------|
| Guinea-Bissau| 12049        | -144%                       | (–45.7 to –31.4)           | 63           | -143%                       | 104378 | (66905 to 69769)           | (–45.3 to 30.8)           | 59734        | (19073 to 49769)           |
| Kenya        | 89155        | -28.9%                      | (–39.8 to –16.9)           | 1216         | -28.1%                      | 794200 | (618078 to 895072)         | (–38.7 to –16.3)           | 57358        | (39478 to 113974)          |
| Lesotho      | 8039         | -33.4%                      | (–53.5 to –8.1)            | 59           | -33.3%                      | 70426  | (49886 to 97368)           | (–52.7 to –8.2)            | 6311         | (15970 to 12635)           |
| Liberia      | 12252        | -36.4%                      | (–40.5 to –13.6)           | 17           | -35.4%                      | 109419 | (618045 to 158384)         | (–59.3 to –0.4)            | 5726         | (37971 to 87786)           |
| Madagascar   | 6723         | -14.8%                      | (–48.2 to 36.0)            | 79           | -14.1%                      | 59065  | (37971 to 87786)           | (–47.0 to 35.3)            | 42           | (2352 to 3132)             |
| Malawi       | 54090        | -22.7%                      | (–50.4 to 17.8)            | 71           | -22.3%                      | 47350  | (310996 to 709470)         | (–49.1 to 16.8)            | 55           | (37291 to 78786)           |
| Mali         | 7314         | -18.2%                      | (–48.6 to 26.9)            | 61           | -17.9%                      | 64058  | (410767 to 951604)         | (–49.7 to 26.0)            | 49           | (47785 to 845)             |
| Mauritania   | 708         | -39.6%                      | (–62.0 to –7.4)            | 13           | -36.1%                      | 9936   | (422810 to 91715)          | (–60.1 to 7.3)             | 50           | (4488 to 84)               |
| Mozambique   | 43930        | -44.8%                      | (–67.8 to –7.9)            | 26           | -43.7%                      | 3946   | (240335 to 650720)         | (–67.2 to –8.1)            | 55           | (39177 to 19801)           |
| Namibia      | 4053         | -11.8%                      | (–55.0 to –40.7)           | 7           | -10.6%                      | 36493  | (22159 to 55377)           | (–46.7 to 45.7)            | 33           | (2310 to 462)              |
| Niger        | 19864        | -15.6%                      | (–55.0 to –40.7)           | 100          | -15.2%                      | 171067 | (1179117 to 239294)        | (–48.1 to 22.2)            | 30           | (282 to 1687)              |
| Nigeria      | 10267       | -20.2%                      | (–54.4 to 16.4)            | 504          | -20.0%                      | 8865   | (633728 to 1179547)        | (–60.6 to 16.4)            | 31           | (6070 to 998)              |
| Rwanda       | 3507         | -48.3%                      | (–71.5 to –10.0)           | 256          | -47.3%                      | 14465  | (802669 to 249870)         | (–69.6 to –11.2)           | 33           | (292 to 47)                |
| São Tomé and| 195          | -51.7%                      | (–70.2 to –21.5)           | 65           | -49.2%                      | 1852   | (121027 to 27061)          | (–67.2 to –10.3)           | 118          | (35 to 472)                |
| Principe     | 645          | (–70.2 to –21.5)            | (0.6 to 0.8)               | 35           | -48.2%                      | 184    | (13117 to 2477)            | (–59.0 to 17.9)            | 41           | (17 to 19)                 |
| Senegal      | 4817         | -43.1%                      | (–60.7 to –18.4)           | 165          | -42.1%                      | 3814   | (267104 to 513474)         | (–59.8 to –17.9)           | 54           | (1337 to 1467)             |

(Continued from previous page)
### Table 1: Deaths, episodes, and DALYs attributable to diarrhoeal disease in 2015, by country

| Country         | Deaths (100,000) | DALYs (100,000) | Number | Percentage change, 2005–15 | Deaths (100,000) | DALYs (100,000) | Number | Percentage change, 2005–15 |
|-----------------|-----------------|----------------|--------|---------------------------|-----------------|----------------|--------|---------------------------|
| **Children younger than 5 years** |                 |                |        |                           |                 |                |        |                           |
| Sierra Leone    | 2189.0          | 216.0          | 21.4   | -39.4%                    | 1927.9          | 194.0          | 241    | -64.2%                    |
| Somalia         | 91407.0         | 448.0          | 41.7   | 3.6%                      | 790.9           | 3.7%           | 1103.1  | -28.7%                    |
| South Africa    | 3026.2          | 56.8           | 76.8   | -70.1%                    | 278.8           | -68.6%         | 3520.6  | -59.5%                    |
| South Sudan     | 7313.9          | 384.2          | 48.3   | -15.4%                    | 67.0           | 41.0%          | 904.7   | -14.6%                    |
| Swaziland       | 362.0           | 206.8          | 3.5    | -50.9%                    | 33.9           | -50.2%         | 461.6   | -58.4%                    |
| Tanzania        | 5852.2          | 62.9           | 179.8  | -28.9%                    | 570.5           | -26.8%         | 182.3   | -52.4%                    |
| The Gambia      | 398.7           | 106.0          | 93     | -38.9%                    | 36.3           | -37.2%         | 452.4   | -56.4%                    |
| Togo            | 1559.0          | 134.6          | 28.2   | -32.7%                    | 140.9           | -31.6%         | 201.8   | -55.6%                    |
| Uganda          | 7894.3          | 106.7          | 170.3  | -61.1%                    | 718.9           | -5.2%          | 1103.7  | -39.8%                    |
| Zambiar         | 3374.5          | 116.8          | 66.3   | -46.9%                    | 305.4           | -45.6%         | 196.4   | -67.5%                    |
| Zimbabwe        | 5222.2          | 210.9          | 60.6   | 15.3%                     | 467.3           | 15.9%          | 610.3   | -17.3%                    |

(Continued from previous page)

| **All ages** | Number | Percentage change, 2005–15 | Number | Percentage change, 2005–15 | Number | Percentage change, 2005–15 |
|--------------|--------|---------------------------|--------|---------------------------|--------|---------------------------|
| Sierra Leone | 2189.0 | -39.4%                    | 1927.9 | -64.2%                    | 194.0  | -64.2%                    |
| Somalia      | 91407.0| 3.6%                      | 790.9  | -28.7%                    | 3.7%   | -28.7%                    |
| South Africa | 3026.2 | -70.1%                    | 278.8  | -59.5%                    | -68.6% | -59.5%                    |
| South Sudan  | 7313.9 | -15.4%                    | 67.0   | -14.6%                    | 41.0%  | -14.6%                    |
| Swaziland    | 362.0  | -50.9%                    | 33.9   | -50.2%                    | -58.4% | -50.2%                    |
| Tanzania     | 5852.2 | -28.9%                    | 570.5  | -26.8%                    | -52.4% | -26.8%                    |
| The Gambia   | 398.7  | -38.9%                    | 36.3   | -37.2%                    | -56.4% | -37.2%                    |
| Togo         | 1559.0 | -32.7%                    | 140.9  | -31.6%                    | -55.6% | -31.6%                    |
| Uganda       | 7894.3 | -61.1%                    | 718.9  | -5.2%                     | -39.8% | -5.2%                     |
| Zambiar      | 3374.5 | -46.9%                    | 305.4  | -45.6%                    | -67.5% | -45.6%                    |
| Zimbabwe     | 5222.2 | 15.3%                     | 467.3  | 15.9%                     | -17.3% | 15.9%                     |

Data are from GBD 2015 estimates for both sexes, presented for children younger than 5 years and all ages. Data in parentheses are 95% uncertainty intervals. DALY = disability-adjusted life-year.
Risk factor decomposition

Risk factors for diarrhoeal diseases are modelled as part of GBD 2015 and have been described in detail previously.20,21 Risk factors are different from diarrhoea model covariates. Briefly, risk factors also follow a PAF counterfactual approach in which the prevalence of exposure is modelled from scientific literature and population representative surveys, and the relative risk of diarrhoea given risk exposure is taken from published meta-analyses. Although there are ten total risk factors for diarrhoea in GBD 2015, we used only the two leading risk factors for diarrhoea DALYs, unsafe water and sanitation and childhood undernutrition, in a decomposition analysis of the change in DALYs due to diarrhoea from 2005 to 2015. The decomposition is of five factors that contribute interdependently to diarrhoea burden, including undernutrition exposure, unsafe water or sanitation exposure, population growth, population ageing, and the underlying rate of DALYs from diarrhoea unexplained by the other factors. A combinatorial process calculates the relative contribution of each of these five factors to the change in diarrhoea DALYs.20,21 These analyses are not done at the draw level so uncertainty is not propagated through the risk factor decomposition.

Burden transition with development

Based on methods used to construct the Human Development Index, GBD 2015 used the Socio-demographic Index (SDI), a summary measure of development based on lag-dependent income per capita, average educational attainment, and total fertility rate.1,2 We used age-standardised estimates of the diarrhoea mortality rate for each year and most detailed geographical location to calculate the relationship between SDI and diarrhoea mortality using a simple least-squares regression with a cubic spline.

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all data in the study and had final responsibility for the decision to submit for publication.

Results

In 2015, diarrhoeal diseases were responsible for 1·31 million deaths (95% UI 1·23 million to 1·39 million; table 1). Among children younger than 5 years, diarrhoeal diseases were responsible for 499 000 deaths (447 000–558 000; table 1), representing 8·6% (7·7–9·5) of the 5·82 million deaths in this age group.1 Diarrhoea was the leading cause of death among children younger than 5 years in 2015 was 74·3 deaths (95% UI 66·6–83·0) per 100 000 and was slightly different between boys (74·1 deaths [64·4–85·1] per 100 000) and girls (74·5 deaths [65·0–85·5] per 100 000). Figure 1 shows mortality rates due to diarrhoea for children younger than 5 years by geography in 2015 and figure 2 shows all age mortality by geography. Under-5 mortality from diarrhoea was highest in sub-Saharan Africa and south Asia. Between 2005 and 2015, the number of deaths due to diarrhoea decreased by 34·3% (24·9–42·3) among children younger than 5 years and decreased by 20·8% among all ages (15·4–26·1). Figure 3 shows the rate of change in under-5 deaths due to diarrhoea between 2005 and 2015.

Mortality from diarrhoea varied by location. The highest rates of under-5 mortality due to diarrhoea were in sub-Saharan Africa and South Asia, in particular in Chad (594 deaths [95% UI 392–827] per 100 000) and Niger (485 deaths [330–677] per 100 000; figure 1). However, due to their moderate-to-high burden and large populations, India (105 000 deaths, 90 000–122 000) and Nigeria (103 000 deaths, 73 000–136 000) combined had 42% of the 499 000 global under-5 deaths due to diarrhoea in 2015 (table 1).

The mortality rate due to diarrhoea decreased by 39·2% (95% UI 24·0–51·2) among children younger than 5 years between 2005 (122·1 deaths [109·3–136·5] per 100 000) and 2015 (74·3 deaths [66·6–83·0] per 100 000) but with variation by region, which is shown against the SDI for each region in Figure 4A. Between 2005 and 2015, the fastest reductions in under-5 mortality rate due to diarrhoea were in east Asia and tropical and Andean Latin America (>65% reduction during this time period). The greatest absolute reduction in mortality rate due to diarrhoea was in sub-Saharan Africa. The diarrhoea mortality rate decreased by more than 100 deaths per 100 000 in western sub-Saharan Africa (from 445 to 277 deaths per 100 000), eastern sub-Saharan Africa (from 243 to 131 deaths per 100 000), and southern sub-Saharan Africa (from 214 to 113 deaths per 100 000; figure 3). Under-5 diarrhoea incidence decreased more slowly than did diarrhoea mortality due to diarrhoea (figure 4B). At the global level, diarrhoea incidence in this age group decreased by 10·4% (95% UI 9·1–11·6) between 2005 and 2015. Diarrhoea incidence decreased the fastest in western and eastern sub-Saharan Africa but was largely unchanged in the high-income super-region (figure 4B).

We estimated that there were 2·39 billion (95% UI 2·30 billion to 2·50 billion) episodes of diarrhoea in 2015, of which 957·5 million (871·1 million to 1·0575 billion) occurred in children younger than 5 years (table 1). From 2005 to 2015, diarrhoea incidence decreased by 30·4% (9·1–11·6) in children under-5 and by 5·9% (5·0–6·7) among all ages and both rates of change were less than the declines in mortality rates. In 2015, diarrhoeal diseases caused 715 900 000 DALYs (66 443 000–77 206 000) with most
Figure 1: Under-5 diarrhoea mortality rate per 100 000 population
(A) Under-5 mortality in 2015. (B) Under-5 mortality in 2005. ATG=Antigua and Barbuda. VCT=Saint Vincent and the Grenadines. LCA=Saint Lucia. TTO=Trinidad and Tobago.
TLS=Timor-Leste. FSM=Federated States of Micronesia.
Figure 2: All ages diarrhoea mortality rate per 100,000 population
(A) All-ages mortality in 2015. (B) All-ages mortality in 2005. ATG=Antigua and Barbuda. VCT=Saint Vincent and the Grenadines. LCA=Saint Lucia. TTO=Trinidad and Tobago. TLS=Timor-Leste. FSM=Federated States of Micronesia.
occurring in children younger than 5 years (45109000, 40694000–50119000; table 1). Most DALYs due to diarrhoea are from YLLs (65858000 [92·0%] DALYs due to diarrhoea).

Diarrhoeal episodes and deaths were attributed to 13 pathogens in GBD 2015. Aetiologies could be established for 96-1% of all deaths due to diarrhoea in children younger than 5 years and 72-0% of diarrhoeal deaths at all ages. The three most common aetiologies to which diarrhoea mortality was attributed in 2015 among children younger than 5 years were rotavirus (146 000 deaths, 95% UI 118 000–183 000; 29·3%, 24·6–35·9), Cryptosporidium spp (60 400 deaths, 13709·1–134506·4; 12·1%, 2·8–26·9), and Shigella spp (54 900 deaths, 27 000–94 700; 11·0%, 5·5–18·7%), which combined accounted for more than 50% of deaths due to diarrhoea in this age group (table 2). Figure 5 shows the number of under-5 deaths by aetiology and geography in 2015. Adenovirus was an important cause of death in children younger than 5 years, accounting for 9·2% (3·3–19·7) of deaths due to diarrhoea in this age group (46 000 deaths, 16 200–97 700). Among children aged 5–14 years, V cholerae was the leading cause of death (12 814 deaths, 9031–16 943; 24·8%, 17·6–32·3) and Shigella spp were the leading cause of death among adults aged 15–99 years (100 013 deaths, 47 119–173 200; 13·1%, 6·7–21·0).

Rotavirus was the leading cause of diarrhoea mortality in children younger than 5 years in most countries; among the ten countries with the highest diarrhoea mortality burden, only Pakistan and Ethiopia had leading causes of of diarrhoeal death that were not rotavirus (table 2). Between 2005 and 2015, rotavirus deaths among children younger than 5 years decreased by 44% (95% UI 33·0–52·0), representing the only aetiology for which the attributable fraction significantly decreased among children under-5 during this time. Rotavirus was also an important cause of diarrhoeal death at older ages—nearly 23% of rotavirus deaths occurred in people older than 5 years old (52 697 deaths, 47 400–57 700) and it was responsible for 199 000 deaths among all ages (165 000–241 000). Cryptosporidium spp were one of the leading causes in most of sub-Saharan Africa, but almost exclusively among children younger than 5 years; 93% of the 64 818 Cryptosporidium spp deaths occurred in children younger than 5 years. Shigella spp were notably different from rotavirus and Cryptosporidium spp in that only a third of their 164 300 deaths (95% UI 85 000–278 700) were in children younger than 5 years.

C difficile was the main aetiology of diarrhoeal death in high-income countries at all ages (figure 5) and was the only aetiology that increased in attributable fraction between 2005 and 2015 (39·8% increase, 95% UI 29·6–49·9), particularly among adults aged 70 years or older (60·8% increase, 49·0–71). Cholera mortality patterns have distinct geographic variation with the highest attributable fractions in sub-Saharan Africa and southeast Asia (figure 5).

The leading risk factors for diarrhoea were unchanged from 2005 to 2015. In 2015, unsafe water was responsible for 61·1 million DALYs (95% UI 49·4 million to 69·6 million; 85·4% of diarrhoeal DALYs) and unsafe sanitation was responsible for 40·0 million DALYs (36·0 million to 44·4 million). Among children younger than 5 years, wasting was the leading risk factor for DALYs due to diarrhoea, responsible for 86·3% (72·3–91·4; 38·9 million DALYs, 31·8–44·3) of the 45·1 million diarrhoea DALYs (40·7–50·1). Other risk factors for children were also responsible for under-5 DALYs, such as suboptimal breastfeeding (35·7%, 24·6–46·75), vitamin A deficiency (12·9%, 7·3–18·6), and zinc deficiency (6·5%, 0·6–13·8). The number of DALYs due to diarrhoea decreased for most countries between 2005 and 2015 (figure 6, figure 7, and figure 8 and table 1). Reductions in childhood undernutrition prevalence and improvements in safe water, sanitation, and hygiene (WaSH) have appreciably contributed to reductions in diarrhoea DALYs in many countries (figure 6–8). At the global level, between 2005 and 2015, diarrhoea DALYs attributable to unsafe water and poor sanitation have decreased by 13·4% and those attributable to childhood undernutrition have decreased 10·0% during this time.

Diarrhoea DALYs attributable to unsafe WaSH decreased in all countries, with the greatest reduction in Vietnam (35·2%; figure 6B), but sub-Saharan Africa lagged in WaSH-related diarrhoea DALYs, where the global minimum change occurred in the Central African Republic (0·6%; figure 7B). Outside high-income regions, the smallest reductions in DALYs attributable to WaSH were in eastern sub-Saharan Africa (7·2; 29·3% reduction) and the Caribbean (7·2% reduction). The largest regional reductions in DALYs attributable to WaSH occurred in South America: the decrease was 28·3% in southern Latin America and 20·8% in Andean Latin America. DALYs due to diarrhoea attributable to childhood undernutrition decreased in most countries, ranging from a 29·3% decrease in Zimbabwe to a 9·3% increase in Egypt, with substantial reductions in DALYs due to undernutrition-associated diarrhoea in many countries of sub-Saharan Africa, including the Democratic Republic of the Congo, Kenya, and Burkina Faso (figure 7B). The largest regional reductions in DALYs due to childhood undernutrition were in central sub-Saharan Africa (21·7% reduction) and the Caribbean (19·7% reduction).

Our results can be explored in further detail online with the Institute for Health Metrics and Evaluation’s GBD Compare visualisation platform.
| Country               | Adenovirus | Amoebiasis | Campylobacter spp enteritis | Cholera | Cryptosporidiosis | Enteropathogenic E coli infection |
|-----------------------|------------|------------|-----------------------------|---------|-------------------|---------------------------------|
|                       | Number     | Percentage | Number                      | Percentage | Number            | Number                          |
|                       | (16,217 to 97,033) | (9,999 to 105,465) | (729,37 to 59,103) | (10,292 to 625,158) | (28,835 to 39,761) | (808,3 to 701,8 to 932,9) |
|                       | 46,041.4   | 9.2%       | 16.6                        | 0.6%      | 5.8%              | 17.3%                          |
|                       | (16,217 to 97,033) | (41,141 to 197,137) | (-68,5 to 79,9)           | (-82,1 to 191,040) | (440,4 to 2330,6) | (9,4 to 27)                     |
|                       | 9,999.1    | 9.6%       | 202                         | 6.2%      | 9.7%              | 108,1                          |
|                       | (9,999 to 105,465) | (4,104 to 2,1) | (-52,0 to 75,3)           | (-1,0 to 7,8) | (2,5 to 6,0) | (184,9 to 649,48)              |
|                       | 105,465    | 10.3%      | 2,012                       | 2.1%      | 3.5%              | 3,9                            |
|                       | (105,465 to 26,037) | (1,314 to 10,37) | (23,900 to 25,996)        | (0,2 to 13) | (2,1 to 13,4) | (144,9 to 462,3)               |
|                       | 163,87     | 4.9%       | 63                          | 5.5%      | 2.0%              | 28                            |
|                       | (59,5 to 366,0) | (0,4 to 1,4) | (-6,2 to 15,5)            | (0,2 to 13) | (1,1 to 3,3) | (194,0 to 704)                 |
|                       | 20,193     | 10.2%      | 1,108,2                     | 7.6%      | 7.9%              | 28,6                          |
|                       | (566,0 to 4,904) | (0,4 to 0,7) | (31,5 to 78,5)            | (-1,0 to 7,9) | (1,0 to 3,4) | (146,2 to 22,4)                |
|                       | 350,85     | 6.6%       | 444,74                      | 2.1%      | 1.9%              | 307                           |
|                       | (23,900 to 25,996) | (1,314 to 10,37) | (16,3 to 107)             | (-1,0 to 7,9) | (1,2 to 6,3) | (138,7 to 1024,2)              |
|                       | 395,08     | 6.0%       | 1,444,2                     | 9.2%      | 2.9%              | 407                           |
|                       | (23,900 to 25,996) | (31,5 to 78,5) | (31,5 to 78,5)            | (1,2 to 6,3) | (1,2 to 6,3) | (138,7 to 1024,2)              |
|                       | 63         | 2.6%       | 2,299,9                     | 3.8%      | 1.5%              | 318                           |
|                       | (-6,2 to 15,5) | (0,2 to 13) | (-22,7 to 17,2)           | (0,2 to 9,5) | (1,0 to 2,7) | (138,7 to 1024,2)              |
|                       | 1158,1     | 3.2%       | 3,241,0                     | 5.8%      | 2.6%              | 347                           |
|                       | (-11,235 to 11,984) | (19,1 to 15,9) | (-23,7 to 17,9)           | (1,3 to 12,4) | (8,8 to 2,7) | (146,2 to 22,4)                |
|                       | 12,862     | 8.8%       | 3,247                       | 7.8%      | 29.6%             | 686                           |
|                       | (-6,2 to 12,6) | (0,2 to 9,5) | (-27,6 to 26,9)           | (4,8 to 11,8) | (4,8 to 11,8) | (138,7 to 1024,2)              |
|                       | 1134,6     | 0.3%       | 1,444,2                     | 7.8%      | 29.6%             | 2,531                         |
|                       | (-35,95 to 75,64) | (0,2 to 3,4) | (31,5 to 78,5)            | (1,2 to 6,3) | (1,2 to 6,3) | (138,7 to 1024,2)              |
|                       | 416,8      | 8.8%       | 420,7                       | 7.8%      | 29.6%             | 2,531                         |
|                       | (-477,0 to 269,6) | (0,2 to 3,4) | (-27,6 to 26,9)           | (1,2 to 6,3) | (1,2 to 6,3) | (138,7 to 1024,2)              |
|                       | 128,6       | 2.6%       | 410                          | 7.8%      | 29.6%             | 2,531                         |
|                       | (-6,5 to 26,1) | (0,2 to 3,4) | (-27,6 to 26,9)           | (1,2 to 6,3) | (1,2 to 6,3) | (138,7 to 1024,2)              |
|                       | 1,144,9     | 0.3%       | 138,3                       | 7.8%      | 29.6%             | 2,531                         |
|                       | (1,144,9 to 2,986,5) | (0,2 to 3,4) | (146,2 to 22,4)           | (1,2 to 6,3) | (1,2 to 6,3) | (138,7 to 1024,2)              |
|                       | 3,617       | 4.1%       | 668,1                       | 7.8%      | 29.6%             | 2,531                         |
|                       | (137,1 to 298,83) | (0,2 to 3,4) | (138,7 to 1024,2)         | (1,2 to 6,3) | (1,2 to 6,3) | (138,7 to 1024,2)              |
|                       | 7,056       | 8.2%       | 297,5                       | 4.1%      | 3.5%              | (146,2 to 22,4)               |
|                       | (125,4 to 163,8) | (0,2 to 3,4) | (138,7 to 1024,2)         | (1,2 to 6,3) | (1,2 to 6,3) | (138,7 to 1024,2)              |
|                       | 361,2       | 2.4%       | (6,5 to 99,19)             | 4.1%      | 3.5%              | (146,2 to 22,4)               |
|                       | (5,5 to 111,6) | (0,2 to 3,4) | (138,7 to 1024,2)         | (1,2 to 6,3) | (1,2 to 6,3) | (138,7 to 1024,2)              |
|                       | 124         | 0.1%       | (4,4 to 99,89)             | 4.1%      | 3.5%              | (146,2 to 22,4)               |
|                       | (0,5 to 12,2) | (0,2 to 3,4) | (138,7 to 1024,2)         | (1,2 to 6,3) | (1,2 to 6,3) | (138,7 to 1024,2)              |

(Table 2 continues on next page)
Data are presented globally and for the ten countries with the highest-burden of diarrhoeal deaths, taken from GBD 2015 for both sexes.

Table 2: Deaths due to diarrhoeal disease in children younger than 5 years by aetiology
Figure 4: Trends in under-5 diarrhoea mortality and incidence and SDI by region, 1990–2015

The diarrhoea mortality rate per 100 000 population (A) and incidence per child-year (B) for each region is shown. Points represent 5 year increments from 1990 to 2015. The black line is a least-squares cubic spline regression using the age-standardised diarrhoea mortality rate for each geographic location and represents the expected rate based on SDI alone, where estimates above the black line are higher than expected and those below are lower than expected on the basis of SDI alone. More information on the formulation and theory of the SDI is available in the GBD 2015 cause of death capstone paper. SDI=Socio-demographic Index. GBD=Global Burden of Disease.
| Country                  | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 |
|-------------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Global                  | C  | C  | Shigella | C  | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| High SDI                |    |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| High-middle SDI         |    |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| Middle SDI              |    |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| Low-middle SDI          |    |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| Low SDI                 |    |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| High income             |    |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| High income North America |   |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| Canada                  |    |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| Greenland               |    |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| USA                     |    |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| Australasia             |    |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| Australia               |    |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| New Zealand             |    |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| High income Asia Pacific |    |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| Brunei                  |    |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| Japan                   |    |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| Singapore               |    |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| South Korea             |    |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| Western Europe          |    |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| Andorra                 |    |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| Austria                 |    |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| Belgium                 |    |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| Cyprus                  |    |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| Denmark                 |    |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| Finland                 |    |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| France                  |    |    | Shigella |    | Campy | Cholera | ETEC | Campy | Shigella | Campy | Cholera | ETEC | C  |
| Articles |

| Country          | C diff | Cholera | Rota | Adeno | Shigella | Salm | ETEC | Adeno. | Campy | Crypto | EPEC | Ehist | Aero |
|------------------|--------|---------|------|-------|----------|------|------|--------|-------|--------|------|-------|------|
| Germany          | 35·5   | 13·5    | 0·7  | 1·7   | 0·6      | 0·3  | 0·1  | 0·3    | 0·1   | 0·1    | 0·3  | 0·2   | 0·3  |
| Greece           | 0·3    | 0·2     | 0·1  | 0·1   | 0·1      | 0   | 0   | 0·1    | 0·1   | 0·1    | 0·1  | 0·3   | 0·1  |
| Iceland          | 0·1    | 0·3     | 0·1  | 0·4   | 0·9      | 0   | 0   | 0·1    | 0·1   | 0·1    | 0·1  | 0·3   | 0·1  |
| Ireland          | 1·3    | 0·2     | 0·4  | 0·4   | 0·3      | 0   | 0   | 0·1    | 0·1   | 0·1    | 0·1  | 0·3   | 0·1  |
| Israel           | 0·1    | 0·1     | 0·1  | 0·1   | 0·1      | 0   | 0   | 0·1    | 0·1   | 0·1    | 0·1  | 0·3   | 0·1  |
| Italy            | 0·5    | 0·5     | 0·9  | 0·4   | 0·9      | 0   | 0   | 0·1    | 0·1   | 0·1    | 0·1  | 0·3   | 0·1  |
| Luxembourg       | 0·2    | 0·2     | 0·2  | 0·2   | 0·2      | 0   | 0   | 0·2    | 0·2   | 0·2    | 0·2  | 0·3   | 0·2  |
| Malta            | 0·2    | 0·2     | 0·2  | 0·2   | 0·2      | 0   | 0   | 0·2    | 0·2   | 0·2    | 0·2  | 0·3   | 0·2  |
| Netherlands      | 0·5    | 0·5     | 0·4  | 0·4   | 0·4      | 0   | 0   | 0·4    | 0·4   | 0·4    | 0·4  | 0·3   | 0·4  |
| Norway           | 1·7    | 0·3     | 0·1  | 0·1   | 0·1      | 0   | 0   | 0·1    | 0·1   | 0·1    | 0·1  | 0·3   | 0·1  |
| Portugal         | 0·1    | 0·1     | 0·1  | 0·1   | 0·1      | 0   | 0   | 0·1    | 0·1   | 0·1    | 0·1  | 0·3   | 0·1  |
| Spain            | 0·4    | 0·4     | 0·4  | 0·4   | 0·4      | 0   | 0   | 0·4    | 0·4   | 0·4    | 0·4  | 0·3   | 0·4  |
| Sweden           | 2·4    | 2·4     | 1    | 1     | 0·3      | 0   | 0   | 0·3    | 0·3   | 0·3    | 0·3  | 0·3   | 0·3  |
| Switzerland      | 2·6    | 2·6     | 0·7  | 0·7   | 0·7      | 0   | 0   | 0·7    | 0·7   | 0·7    | 0·7  | 0·3   | 0·7  |
| UK               | 0·3    | 0·3     | 1·4  | 1·4   | 1·4      | 0   | 0   | 1·4    | 1·4   | 1·4    | 1·4  | 0·3   | 1·4  |
| England          | 3·9    | 3·9     | 3·9  | 3·9   | 3·9      | 0   | 0   | 3·9    | 3·9   | 3·9    | 3·9  | 0·3   | 3·9  |
| Northern Ireland | 0·2    | 0·2     | 0·2  | 0·2   | 0·2      | 0   | 0   | 0·2    | 0·2   | 0·2    | 0·2  | 0·3   | 0·2  |
| Scotland         | 0·3    | 0·4     | 0·4  | 0·4   | 0·4      | 0   | 0   | 0·4    | 0·4   | 0·4    | 0·4  | 0·3   | 0·4  |
| Wales            | 0·3    | 0·2     | 0·2  | 0·2   | 0·2      | 0   | 0   | 0·2    | 0·2   | 0·2    | 0·2  | 0·3   | 0·2  |
| Southern Latin America | 0·4 | 0·3     | 0·3  | 0·3   | 0·3      | 0   | 0   | 0·3    | 0·3   | 0·3    | 0·3  | 0·3   | 0·3  |
| Argentina        | 0·3    | 0·3     | 0·3  | 0·3   | 0·3      | 0   | 0   | 0·3    | 0·3   | 0·3    | 0·3  | 0·3   | 0·3  |
| Chile            | 0·9    | 0·9     | 0·9  | 0·9   | 0·9      | 0   | 0   | 0·9    | 0·9   | 0·9    | 0·9  | 0·3   | 0·9  |
| Uruguay          | 0·3    | 0·3     | 0·3  | 0·3   | 0·3      | 0   | 0   | 0·3    | 0·3   | 0·3    | 0·3  | 0·3   | 0·3  |
| Central Europe, eastern Europe, and central Asia | 0·5 | 0·5     | 0·5  | 0·5   | 0·5      | 0   | 0   | 0·5    | 0·5   | 0·5    | 0·5  | 0·3   | 0·5  |
| Eastern Europe   | 0·3    | 0·3     | 0·3  | 0·3   | 0·3      | 0   | 0   | 0·3    | 0·3   | 0·3    | 0·3  | 0·3   | 0·3  |
| Belarus          | 0·1    | 0·1     | 0·1  | 0·1   | 0·1      | 0   | 0   | 0·1    | 0·1   | 0·1    | 0·1  | 0·3   | 0·1  |
| Estonia          | 0·2    | 0·2     | 0·2  | 0·2   | 0·2      | 0   | 0   | 0·2    | 0·2   | 0·2    | 0·2  | 0·3   | 0·2  |

(Figure 5 continues on next page)
|                |  |  |  |  |  |  |  |  |  |  |  |  |  |
|----------------|---|---|---|---|---|---|---|---|---|---|---|---|---|
|                | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10| 11| 12| 13|
| Latvia         | C diff 0.4 | 3 | 0.1 | Rota 0.1 | Salim 0.1 | ETCC 0.1 | Adeno 0.1 | Noro 0.1 | Crypto 0.1 | Shigella 0.1 | Campy 0.1 | Aero 0.1 | Ehec 0.1 |
| Lithuania      | C diff 0.6 | 3 | 0.2 | Rota 0.2 | Salim 0.2 | ETCC 0.2 | Adeno 0.2 | Noro 0.2 | Crypto 0.2 | Shigella 0.2 | Campy 0.2 | Aero 0.2 | Ehec 0.2 |
| Moldova        | C diff 2.8 | 5 | 1.5 | Rota 1.5 | Salim 1.5 | ETCC 1.5 | Adeno 1.5 | Noro 1.5 | Crypto 1.5 | Shigella 1.5 | Campy 1.5 | Aero 1.5 | Ehec 1.5 |
| Russia         | C diff 12.3 | 7 | 1.3 | Rota 1.3 | Salim 1.3 | ETCC 1.3 | Adeno 1.3 | Noro 1.3 | Crypto 1.3 | Shigella 1.3 | Campy 1.3 | Aero 1.3 | Ehec 1.3 |
| Ukraine        | C diff 26.3 | 9 | 5.1 | Rota 5.1 | Salim 5.1 | ETCC 5.1 | Adeno 5.1 | Noro 5.1 | Crypto 5.1 | Shigella 5.1 | Campy 5.1 | Aero 5.1 | Ehec 5.1 |
| Central Europe | Rota 24.1 | C diff 19 | Salim 19 | ETCC 19 | Adeno 19 | Noro 19 | Crypto 19 | Shigella 19 | Campy 19 | Aero 19 | Ehec 19 |
| Albania        | Rota 0.7 | Salim 0.7 | ETCC 0.7 | Adeno 0.7 | Noro 0.7 | Crypto 0.7 | Shigella 0.7 | Campy 0.7 | Aero 0.7 | Ehec 0.7 |
| Bosnia and Herzegovina | Rota 0.6 | Salim 0.6 | ETCC 0.6 | Adeno 0.6 | Noro 0.6 | Crypto 0.6 | Shigella 0.6 | Campy 0.6 | Aero 0.6 | Ehec 0.6 |
| Bulgaria       | C diff 25 | Rota 25 | Salim 25 | ETCC 25 | Adeno 25 | Noro 25 | Crypto 25 | Shigella 25 | Campy 25 | Aero 25 | Ehec 25 |
| Croatia        | C diff 9 | Rota 9 | Salim 9 | ETCC 9 | Adeno 9 | Noro 9 | Crypto 9 | Shigella 9 | Campy 9 | Aero 9 | Ehec 9 |
| Czech Republic | C diff 25 | Salim 25 | ETCC 25 | Adeno 25 | Noro 25 | Crypto 25 | Shigella 25 | Campy 25 | Aero 25 | Ehec 25 |
| Hungary        | Rota 14 | Salim 14 | ETCC 14 | Adeno 14 | Noro 14 | Crypto 14 | Shigella 14 | Campy 14 | Aero 14 | Ehec 14 |
| Macedonia      | Rota 1.4 | Salim 1.4 | ETCC 1.4 | Adeno 1.4 | Noro 1.4 | Crypto 1.4 | Shigella 1.4 | Campy 1.4 | Aero 1.4 | Ehec 1.4 |
| Montenegro     | Rota 0.1 | Salim 0.1 | ETCC 0.1 | Adeno 0.1 | Noro 0.1 | Crypto 0.1 | Shigella 0.1 | Campy 0.1 | Aero 0.1 | Ehec 0.1 |
| Poland         | C diff 28 | Rota 28 | Salim 28 | ETCC 28 | Adeno 28 | Noro 28 | Crypto 28 | Shigella 28 | Campy 28 | Aero 28 | Ehec 28 |
| Romania        | Rota 13.9 | Salim 13.9 | ETCC 13.9 | Adeno 13.9 | Noro 13.9 | Crypto 13.9 | Shigella 13.9 | Campy 13.9 | Aero 13.9 | Ehec 13.9 |
| Serbia         | C diff 12 | Rota 12 | Salim 12 | ETCC 12 | Adeno 12 | Noro 12 | Crypto 12 | Shigella 12 | Campy 12 | Aero 12 | Ehec 12 |
| Slovakia       | C diff 5.5 | Rota 5.5 | Salim 5.5 | ETCC 5.5 | Adeno 5.5 | Noro 5.5 | Crypto 5.5 | Shigella 5.5 | Campy 5.5 | Aero 5.5 | Ehec 5.5 |
| Slovenia       | C diff 0.1 | Rota 0.1 | Salim 0.1 | ETCC 0.1 | Adeno 0.1 | Noro 0.1 | Crypto 0.1 | Shigella 0.1 | Campy 0.1 | Aero 0.1 | Ehec 0.1 |
| Central Asia   | Salim 680.5 | ETCC 170.5 | Adeno 170.5 | Noro 170.5 | Crypto 170.5 | Shigella 170.5 | Campy 170.5 | Aero 170.5 | Ehec 170.5 |
| Armenia        | Salim 35 | ETCC 35 | Adeno 35 | Rota 35 | Noro 35 | Crypto 35 | Shigella 35 | Campy 35 | Aero 35 | Ehec 35 |
| Azerbaijan     | Salim 42.8 | ETCC 42.8 | Adeno 42.8 | Noro 42.8 | Crypto 42.8 | Shigella 42.8 | Campy 42.8 | Aero 42.8 | Ehec 42.8 |
| Georgia        | Chekera 37 | Rota 37 | Salim 37 | ETCC 37 | Adeno 37 | Noro 37 | Crypto 37 | Shigella 37 | Campy 37 | Aero 37 | Ehec 37 |
| Kazakhstan     | Chekera 48.3 | ETCC 48.3 | Adeno 48.3 | Noro 48.3 | Crypto 48.3 | Shigella 48.3 | Campy 48.3 | Aero 48.3 | Ehec 48.3 |
| Kyrgyzstan     | Salm 43.2 | ETCC 43.2 | Adeno 43.2 | Noro 43.2 | Crypto 43.2 | Shigella 43.2 | Campy 43.2 | Aero 43.2 | Ehec 43.2 |
| Mongolia       | Chekera 1.1 | Rota 1.1 | Salim 1.1 | ETCC 1.1 | Adeno 1.1 | Noro 1.1 | Crypto 1.1 | Shigella 1.1 | Campy 1.1 | Aero 1.1 | Ehec 1.1 |
| Tajikistan     | Salm 214.3 | ETCC 214.3 | Adeno 214.3 | Noro 214.3 | Crypto 214.3 | Shigella 214.3 | Campy 214.3 | Aero 214.3 | Ehec 214.3 |

(Figure 5 continues on next page)
| Country                        | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  | 13  |
|-------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Turkmenistan                  |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Uzbekistan                    |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Latin America and Caribbean   |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Central Latin America         |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Colombia                      |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Costa Rica                    |     |     |     |     |     |     |     |     |     |     |     |     |     |
| El Salvador                   |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Guatemala                     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Honduras                      |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Mexico                        |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Nicaragua                     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Panama                        |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Venezuela                     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Andean Latin America          |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Bolivia                       |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Ecuador                       |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Peru                          |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Caribbean                     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Antigua and Barbuda           |     |     |     |     |     |     |     |     |     |     |     |     |     |
| The Bahamas                   |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Barbados                      |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Belize                        |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Bermuda                       |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Cuba                          |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Dominica                      |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Dominican Republic            |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Grenada                       |     |     |     |     |     |     |     |     |     |     |     |     |     |

(Figure 5 continues on next page)
| Region                          | Country          | Rota | Cholera | Cryptot | ETEC | Aroc | Shigella | EPEC | Campy | Ehist | Campy | C diff | Campy | EPEC | EPEC |
|--------------------------------|------------------|------|---------|---------|------|------|----------|------|-------|-------|-------|--------|-------|------|------|
| Guyana                         |                  |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| Haiti                          |                  |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| Jamaica                        |                  |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| Puerto Rico                    |                  |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| Saint Lucia                    |                  |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| Saint Vincent and the Grenadines|                 |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| Suriname                       |                  |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| Trinidad and Tobago            |                  |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| Virgin Islands                 |                  |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| Tropical Latin America         |                  |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| Brazil                         |                  |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| Paraguay                       |                  |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| Southeast Asia, east Asia, and Oceania |        |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| East Asia                      |                  |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| China                          |                  |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| North Korea                    |                  |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| Taiwan                         |                  |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| Southeast Asia                 |                  |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| Cambodia                       |                  |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| Indonesia                      |                  |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| Laos                           |                  |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| Malaysia                       |                  |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| Maldives                       |                  |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| Mauritius                      |                  |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| Myanmar                        |                  |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| Philippines                    |                  |      |         |         |      |      |          |      |       |       |       |        |       |      |      |
| Sri Lanka                      |                  |      |         |         |      |      |          |      |       |       |       |        |       |      |      |

(Figure 5 continues on next page)
| Country                  | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 |
|--------------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Seychelles              | Cholera | 0.1 | Rota | 0.0 | di | 0.0 | Shigella | 0.0 | Adenos | 0.0 | ETEC | 0.0 | Aere | 0.1 |
| Thailand                 | Cholera | 43.9 | Rota | 12.3 | di | 4.8 | Campy | 0.8 | Adenos | 0.7 | Shigella | 3.3 | ETEC | 0.0 |
| Timor-Leste              | Cholera | 35.5 | Rota | 32.7 | di | 31.4 | Shigella | 15.8 | ETEC | 14.6 | Adenos | 10.3 | di | 3.2 | Campy | 2.9 | Ehis | 3.7 | Campy | 1.5 | Aere | 0.1 | di | 0.1 | di | 0.1 | Campy | 1.2 | EPEC | 0.1 |
| Vietnam                  | Cholera | 127.9 | Rota | 87.3 | di | 39.5 | Shigella | 16.6 | Adenos | 14.4 | di | 0.0 | Campy | 5.6 | ETEC | 5.5 | EPEC | 5.4 | Campy | 1.7 | di | 0.9 | Campy | 0.0 |
| Oceania                  | Shigella | 341.6 | Rota | 269.7 | di | 105.9 | Adenos | 51.1 | di | 60.2 | Campy | 35.7 | ETEC | 29.9 | Ehis | 22.3 | Campy | 19.1 | Campy | 19.5 | Aere | 0.1 | EPEC | 0.0 | Campy | 0.0 |
| American Samoa           | Shigella | 0.3 | Rota | 0.0 | di | 0.0 | Campy | 0.0 | Adenos | 0.0 | di | 0.0 | Campy | 0.0 | ETEC | 0.0 | Aere | 0.0 | di | 0.0 | Campy | 0.0 | EPEC | 0.0 | Campy | 0.0 |
| Federated States of Micronesia | Shigella | 0.2 | Rota | 0.1 | di | 0.1 | Campy | 0.1 | Adenos | 0.1 | di | 0.0 | Campy | 0.0 | ETEC | 0.0 | Aere | 0.0 | di | 0.0 | Campy | 0.0 | EPEC | 0.0 | Campy | 0.0 |
| Fiji                     | Rota | 27.7 | Shigella | 3.7 | di | 3.2 | Campy | 2.7 | ETEC | 1.7 | di | 1.3 | Campy | 1.1 | Aere | 0.2 | Campy | 0.0 | EPEC | 0.0 | Campy | 0.0 | Campy | 0.0 |
| Guam                     | Cholera | 0.0 | Shigella | 0.0 | Rota | 0.0 | di | 0.0 | Campy | 0.0 | Adenos | 0.0 | di | 0.0 | Campy | 0.0 | ETEC | 0.0 | Aere | 0.0 | di | 0.0 | Campy | 0.0 | EPEC | 0.0 | Campy | 0.0 |
| Kiribati                 | Shigella | 1.9 | Rota | 1.7 | di | 0.9 | Campy | 0.0 | Adenos | 0.7 | di | 0.0 | Campy | 0.0 | ETEC | 0.0 | Aere | 0.0 | di | 0.0 | Campy | 0.0 | EPEC | 0.0 | Campy | 0.0 |
| Marshall Islands         | Shigella | 0.2 | Rota | 0.1 | di | 0.1 | Campy | 0.1 | Adenos | 0.1 | di | 0.0 | Campy | 0.0 | ETEC | 0.0 | Aere | 0.0 | di | 0.0 | Campy | 0.0 | EPEC | 0.0 | Campy | 0.0 |
| Northern Mariana Islands | Shigella | 0.1 | Rota | 0.0 | di | 0.0 | Campy | 0.0 | Adenos | 0.0 | di | 0.0 | Campy | 0.0 | ETEC | 0.0 | Aere | 0.0 | di | 0.0 | Campy | 0.0 | EPEC | 0.0 | Campy | 0.0 |
| Papua New Guinea         | Shigella | 128.3 | Rota | 108.6 | di | 86.9 | Adenos | 42.7 | di | 35.5 | Campy | 29.9 | ETEC | 24.7 | Ehis | 18.8 | Campy | 18.2 | Campy | 25.0 | Aere | 1.2 | Campy | 0.1 | Campy | 0.1 |
| Samoa                    | Shigella | 0.2 | Rota | 0.1 | di | 0.0 | Campy | 0.0 | Adenos | 0.0 | di | 0.0 | Campy | 0.0 | ETEC | 0.0 | Aere | 0.0 | di | 0.0 | Campy | 0.0 | EPEC | 0.0 | Campy | 0.0 |
| Solomon Islands          | Shigella | 3.5 | Rota | 3.4 | di | 1.5 | Campy | 1.1 | Adenos | 1.1 | di | 0.0 | Campy | 0.0 | ETEC | 0.0 | Aere | 0.0 | di | 0.0 | Campy | 0.0 | EPEC | 0.0 | Campy | 0.0 |
| Tonga                    | Shigella | 0.3 | Rota | 0.1 | di | 0.1 | Campy | 0.0 | Adenos | 0.0 | di | 0.0 | Campy | 0.0 | ETEC | 0.0 | Aere | 0.0 | di | 0.0 | Campy | 0.0 | EPEC | 0.0 | Campy | 0.0 |
| Vanuatu                  | Rota | 1.8 | Rota | 1.7 | di | 1.3 | Campy | 1.2 | Adenos | 0.8 | di | 0.0 | Campy | 0.0 | ETEC | 0.0 | Aere | 0.0 | di | 0.0 | Campy | 0.0 | EPEC | 0.0 | Campy | 0.0 |
| North Africa and Middle East | Rota | 346.2 | Cholera | 269.1 | di | 273.3 | ETEC | 263.9 | di | 165.6 | Shigella | 142.3 | di | 120.2 | EPEC | 160.2 | Aere | 15.2 | Campy | 25.0 | Campy | 18.1 | Campy | 304.7 |
| Afghanistan              | Rota | 140.1 | Cholera | 1169.0 | di | 1122.4 | Adenos | 58.8 | di | 58.4 | Shigella | 33.3 | di | 29.5 | Campy | 14.5 | Campy | 12.6 | Aere | 13.8 |
| Algeria                  | Cholera | 4.7 | Rota | 1.1 | di | 1.0 | Campy | 0.8 | Adenos | 0.7 | di | 0.0 | Campy | 0.0 | ETEC | 0.0 | Aere | 0.0 | di | 0.0 | Campy | 0.0 | EPEC | 0.0 | Campy | 0.0 |
| Bahrain                  | Cholera | 2.8 | Rota | 0.6 | di | 0.5 | Campy | 0.3 | Adenos | 0.3 | di | 0.0 | Campy | 0.0 | ETEC | 0.0 | Aere | 0.0 | di | 0.0 | Campy | 0.0 | EPEC | 0.0 | Campy | 0.0 |
| Egypt                    | ETEC | 682.0 | Rota | 417.9 | di | 376.5 | Shigella | 176.4 | di | 533.7 | Shigella | 142.4 | di | 365.2 | Campy | 121.2 | Campy | 33.3 | Campy | 37.9 |
| Iran                     | Rota | 269.7 | Cholera | 203.5 | di | 213.5 | Adenos | 123.5 | di | 110.9 | Shigella | 61.7 | di | 42.3 | Campy | 245.5 | Campy | 14.4 | Campy | 9.8 |
| Jordan                   | Cholera | 13.3 | Rota | 0.8 | di | 4.9 | ETEC | 2.3 | Adenos | 2.3 | di | 1.7 | Campy | 0.6 | Shigella | 0.3 | EPEC | 0.2 | Aere | 0.1 | Campy | 0.0 | Campy | 0.0 |
| Kuwait                   | Rota | 2.6 | Rota | 1.1 | di | 0.7 | Campy | 0.0 | Adenos | 0.4 | di | 0.0 | Campy | 0.0 | ETEC | 0.0 | Aere | 0.0 | di | 0.0 | Campy | 0.0 | EPEC | 0.0 | Campy | 0.0 |
| Lebanon                  | Rota | 5.9 | Rota | 1.5 | di | 1.2 | Campy | 0.6 | Adenos | 0.0 | di | 0.0 | Campy | 0.0 | ETEC | 0.0 | Aere | 0.0 | di | 0.0 | Campy | 0.0 | EPEC | 0.0 | Campy | 0.0 |
| Articles | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|-----------|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Libya     |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Morocco   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Palestine |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Oman      |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Qatar     |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Saudi Arabia |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Sudan     |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Syria     |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Tunisia   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Turkey    |   |   |   |   |   |   |   |   |   |   |   |   |   |
| United Arab Emirates |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Yemen     |   |   |   |   |   |   |   |   |   |   |   |   |   |
| South Asia |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Bangladesh |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Bhutan    |   |   |   |   |   |   |   |   |   |   |   |   |   |
| India     |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Nepal     |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Pakistan  |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Sub-Saharan Africa |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Southern sub-Saharan Africa |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Botswana  |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Lesotho   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Namibia   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| South Africa |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Swaziland |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Zimbabwe  |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Western sub-Saharan Africa |   |   |   |   |   |   |   |   |   |   |   |   |   |

(Figure 5 continues on next page)
| Location          | Year of Study | Disease Type | Serotype/Strain | Country | Country Code | Region | Country Code | Region | Country Code | Region | Country Code | Region | Country Code | Region | Country Code | Region |
|-------------------|---------------|--------------|-----------------|---------|--------------|--------|--------------|--------|--------------|--------|--------------|--------|--------------|--------|--------------|--------|
| Benin             | 2016          | Shigella     | 508             | Rota    | Adenovirus   | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |
| Burundi           | 2015          | Adenovirus   | 507             | Rota    | Campylobacter| Asia   | China       | Asia   | China       | Asia   | China       | Asia   | China       | Asia   | China       | Asia   |
| Cameroon          | 2016          | Shigella     | 506             | EPEC    | Adenovirus   | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |
| Cape Verde        | 2017          | Campylobacter| 505             | Adenovirus | Campylobacter | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |
| Chad              | 2017          | Shigella     | 504             | Campylobacter | Campylobacter | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |
| Côte d'Ivoire     | 2016          | Adenovirus   | 503             | Rota    | Campylobacter | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |
| The Gambia        | 2017          | Campylobacter| 502             | Adenovirus | Campylobacter | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |
| Ghana             | 2017          | Shigella     | 501             | EPEC    | Adenovirus   | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |
| Guinea            | 2016          | Adenovirus   | 500             | Rota    | Campylobacter | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |
| Guinea-Bissau     | 2015          | Campylobacter| 499             | Adenovirus | Campylobacter | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |
| Liberia           | 2016          | Shigella     | 498             | Campylobacter | Campylobacter | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |
| Mali              | 2016          | Adenovirus   | 497             | Rota    | Campylobacter | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |
| Mauritania        | 2015          | Campylobacter| 495             | Adenovirus | Campylobacter | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |
| Niger             | 2017          | Shigella     | 494             | Campylobacter | Campylobacter | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |
| Nigeria           | 2016          | Adenovirus   | 493             | Rota    | Campylobacter | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |
| São Tomé and Príncipe | 2016 | Campylobacter | 492             | Adenovirus | Campylobacter | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |
| Senegal           | 2017          | Shigella     | 491             | Campylobacter | Campylobacter | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |
| Sierra Leone      | 2016          | Adenovirus   | 490             | Rota    | Campylobacter | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |
| Togo              | 2016          | Campylobacter| 489             | Adenovirus | Campylobacter | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |
| Eastern sub-Saharan Africa | 2017 | Adenovirus | 488             | Rota    | Campylobacter | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |
| Burundi           | 2016          | Shigella     | 487             | Campylobacter | Campylobacter | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |
| Comoros           | 2016          | Adenovirus   | 486             | Rota    | Campylobacter | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |
| Djibouti          | 2016          | Shigella     | 485             | Campylobacter | Campylobacter | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |
| Entreté           | 2017          | Adenovirus   | 484             | Rota    | Campylobacter | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |
| Ethiopia          | 2016          | Shigella     | 483             | Campylobacter | Campylobacter | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |
| Kenya             | 2017          | Adenovirus   | 482             | Rota    | Campylobacter | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |
| Madagascar        | 2017          | Shigella     | 481             | Campylobacter | Campylobacter | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa | Swine       | Africa |

(Figure 5 continues on next page)
Discussion

GBD 2015 provides the most comprehensive assessment of the global burden of diarrhoeal diseases to date. The results show that deaths due to diarrhoea among children younger than 5 years decreased by 34-3% between 2005 and 2015 and decreased by 20-8% among people of all ages. Despite substantial reductions, diarrhoea remains an important preventable burden of disease, particularly in south Asia and sub-Saharan Africa. With immediate and sustained actions to decrease both the incidence and mortality attributed to diarrhoea, including appropriate case management, the burden of this prominent public health threat could still be further substantially reduced.

Rotavirus is the most common cause of mortality due to diarrhoea. Between 2005 and 2015, under-5 mortality due to rotavirus decreased by 43-6%, faster than the decrease in all-diarrhoea mortality. This decrease is probably due in large part to the introduction of rotavirus vaccine and the scale-up of vaccination related to support from Gavi.
the Vaccine Alliance. With Gavi support by the end of 2015, 37 countries had introduced the vaccine, but only about 20% of under-5 children in Gavi-eligible countries have received the rotavirus vaccine. As of March, 2017, 91 countries have introduced the rotavirus vaccine. Our results suggest that development of additional vaccines might be warranted.

Cryptosporidium spp were the second most common cause of diarrhoea deaths among children younger than 5 years. Few therapeutic options for Cryptosporidium spp exist and there are no vaccine candidates, an apparent gap in treatment and prevention. Several candidate combination vaccines against ETEC and Shigella spp are in development and such a vaccine might prevent a large burden of diarrhoeal disease, including in older children and adults given that nearly two-thirds of deaths due to Shigella spp occurred in adults and children older than 5 years.
The reduction in DALYs due to diarrhoea is largely attributable to reductions in mortality and can probably be traced to improvements in treatment and prevention, such as reductions in childhood undernutrition prevalence and expanded access to safe water and sanitation.24,29 Our results suggest that large strides in reducing childhood undernutrition, especially in tropical Latin America and some countries in sub-Saharan Africa, as well as increasing access to safe water and sanitation such as in south and southeast Asia, have contributed to substantial reductions in diarrhoeal DALYs. Reducing exposure to these risk factors was a key focus of the Millennium Development Goals and is included in the SDGs (figures 6–8).

Figure 7: Risk factor and cause decomposition of changes in attributable DALYs among all ages in north Africa and the Middle East and sub-Saharan Africa, 2005–15

Changes from 2005 to 2015 are shown for (A) north Africa and the Middle East and (B) sub-Saharan Africa. Black dots represent the overall rate of change in DALYs attributable to each risk or cause. Colours represent the population and cause–rate contribution to the rate of change. Bars to the left of zero show a reduction in attribution and bars to the right show an increase. Red bars show the change in risk factor or cause attribution after accounting for the other factors.

DALYs=disability-adjusted life-years.
by the Joint Monitoring Programme.\textsuperscript{30} Despite large improvements in safe sanitation, our results suggest that use of safe water has increased only slightly.\textsuperscript{20} Interventions that focus on provision of improved water sources without regard for the transport and treatment of the water are less effective than are infrastructural improvements in water provision, such as piped and chlorinated systems.\textsuperscript{20}

Childhood undernutrition is a risk factor for infectious diseases other than diarrhoea, including lower respiratory infections and measles.\textsuperscript{31} The reduction in childhood undernutrition is therefore crucial to decreasing under-5 mortality, and direct interventions, such as improved agriculture and supplementary nutritional programmes, and indirect interventions, such as encouraging lower fertility rates and expanded maternal education, are rightly emphasised in SDG 2.\textsuperscript{32,33}

Although diarrhoea-associated mortality decreased substantially between 2005 and 2015, the morbidity

Figure 8: Risk factor and cause decomposition of changes in attributable DALYs among all ages in Latin America and Caribbean and high-income countries, 2005–15
Changes from 2005 to 2015 are shown for (A) Latin America and Caribbean and (B) high-income countries. Black dots represent the overall rate of change in DALYs attributable to each risk or cause. Colours represent the population and cause–rate contribution to the rate of change. Bars to the left of zero show a reduction in attribution and bars to the right show an increase. Red bars show the change in risk factor or cause attribution after accounting for the other factors.
DALYs = disability-adjusted life-years.
associated with diarrhoea has not decreased nearly as fast, suggesting that much of this reduction might be attributable to appropriate case management including access to health care and the use of oral rehydration solution. The effectiveness of oral rehydration solution in the prevention of severe dehydration and death further emphasises the fact that diarrhoea-attributable mortality is largely preventable, even in low-resource settings, with appropriate treatment.

The GBD 2015 estimates of diarrhoea mortality in children younger than 5 years in 2015 (498 900, 95% UI 447 500–557 600) are slightly lower than those produced by the WHO Department of Evidence, Information and Research and the Maternal and Child Epidemiology Estimation (MCEE) group (526 000; appendix p 35). The total envelope for under-5 mortality was nearly 1·5 million fewer deaths in GBD 2015 compared with the MCEE group estimates. A comparison of aetiologies for diarrhoea-attributable mortality among children younger than 5 years between the Child Health Epidemiology Research Group (CHERG), from which the MCEE developed, and GBD 2015 estimates for the year 2010, is shown in the appendix (p 34).

There are several reasons to use counterfactual analyses for the attribution of diarrhoea aetiologies. First, multiple pathogens can be present in a single case of diarrhoea, and these pathogens might interact with each other, making it difficult to attribute each case of diarrhoea to one pathogen. Second, the presence of a given pathogen might not be directly related to diarrhoea. For example, the same pathogens might exist in stool from a healthy individual and from someone with diarrhoea, so simply measuring the presence of a given pathogen might not accurately describe diarrhoea burden. By engaging in scientific debate and learning from the categorical attribution approach used in previous iterations of GBD (2010), we decided to use a counterfactual approach in future work. Unlike categorical attribution that assigns one outcome to one aetiology, counterfactual analyses allow for multicausality of diarrhoea episodes.

Comparison with GBD 2013

The GBD 2015 estimates of diarrhoea burden differ from those of previous GBD iterations, including cause attribution. Global under-5 deaths due to diarrhoea in 2010, the most recent shared estimation year, are generally lower in GBD 2015 compared with GBD 2013 estimates. These differences can be traced to three high-population and high-burden countries: Pakistan, Nigeria, and India (appendix). GBD estimates in India are now made at the subnational level, which has added data and geographic resolution to this country. This modelling change in India has also reduced the non-fatal diarrhoea estimates in the country (appendix).

Diagnostics

For GBD 2015, we have updated our case definitions for the diarrhoeal aetiologies to reflect detection using molecular methods. This advancement of molecular diagnostic tools enables identification of pathogens that may have previously gone undetected and can more accurately determine the prevalence of pathogens. These diagnostics are more sensitive in pathogen detection than traditional laboratory methods, particularly for bacterial organisms, and could allow for improvements in case management, epidemiological tracking, and assessing the effectiveness of interventions, such as vaccines. To adopt a molecular diagnostic case definition for our diarrhoeal aetiologies, we introduced a source of uncertainty in our estimates because of the necessity of adjusting our estimates of the proportion of diarrhoea episodes that test positive for each aetiology, according to the non-molecular diagnostic methods, for misclassification of exposure.

Data limitations

Our estimates of diarrhoea mortality, morbidity, and cause attribution are limited by data availability, especially the sparsity of data in sub-Saharan Africa, the region of the world with the highest diarrhoea burden. It is difficult to assess a systematic bias in morbidity or mortality estimates caused by data gaps because it is not clear that missing data in some countries means that deaths due to diarrhoea are disproportionately higher or lower compared with other preventable causes. We account for confounding effects of diarrhoea and other causes by making use of regional information to inform the fraction of all-cause mortality attributable to diarrhoea. Data sparsity is also reflected in the uncertainty interval for the particular geography (table 1). A list of all GBD 2015 data sources is available for each country online. The MAL-ED study will be a great resource in elucidating the burden of community diarrhoea and its aetiologies, especially in Africa and Latin America. There is also a general dearth of data on diarrhoea in populations older than 5 years, and although we model diarrhoeal aetiologies in these age groups, the OR from the oldest age group in GEMS, which is still younger than 5 years (2–5 years), are assumed to be representative in older ages. Moreover, our statistical models have a limitation in predicting cases based on very small numbers or when data are absent.

ETEC estimates in GBD 2015 represent the combined burden of the ST and LT genotypes, of which ST is recognised as more frequently associated with diarrhoea. Although the OR of diarrhoea given detection would be higher for ST if the genotypes were to be differentiated, there would be a tradeoff in the proportion of diarrhoea episodes that test positive for ST-ETEC. The modelling strategy for cholera attribution is limited by case reporting to WHO. Although cholera is a notifiable disease to WHO, many countries underreport or fail to report at all for various social and economic reasons.
Next steps
Malnutrition or regular illness during the first few years of life has negative effects on future cognitive development, education, and productivity. Despite being the fourth most common cause of DALYs in children younger than 5 years globally, the full burden of non-fatal diarrhoea might remain unknown.44,45 Results from many studies have implicated diarrhoea as a risk factor for malnutrition and impaired physical growth, while others have suggested that diarrhoea, possibly mediated by malnutrition, might also impair cognitive development.46–48 Capturing these sequelae will increase the quantified burden of diarrhoea to more completely measure its effects on child health and potential. Future iterations of GBD will incorporate geospatial data on diarrhoeal burden to map the spatiotemporal distribution of diarrhoea and its aetiologies on a 5 km by 5 km geographic scale, as has been done for malaria.49 This work will provide important insight into higher spatial resolution space-time trends in diarrhoea.

Conclusion
Despite substantial reductions in diarrhoea mortality in many countries, the burden of this preventable disease remains concentrated in the poorest children. Understanding the contribution of each cause to the burden of diarrhoea and how this varies geographically will enable interventions to be targeted. Vaccine use and a continued focus on improving access to WaSH indicators, reducing childhood undernutrition, and providing appropriate treatment and care management will accelerate reductions in diarrhoea disease burden.

Contributors
CT, PCR, IK prepared the first draft. CT, MF, and AB constructed the figures and tables. MF, CJLM, AM, RCR, and SIH provided overall guidance. PCR managed the project. CT, PCR, and IK finalised the manuscript on the basis of comments from other authors and reviewer feedback. CT and PCR managed the appendix. All other authors provided data or developed models for indicators, reviewed results, initiated modeling infrastructure, or reviewed and contributed to the report.

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Declaration of interests
We declare no competing interests.

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