Quantifying risks and interventions that have reduced mortality due to diarrhea among children younger than 5 years old: An analysis of the Global Burden of Disease study 2017

GBD 2017 Diarrhea Collaborators

Abstract

Background. Many countries have shown marked declines in diarrhea disease mortality among children under-5, and much of this progress has been associated with programs addressing key environmental risks for diarrhea and scaling up interventions to prevent or effectively treat acute diarrhea. Yet no study to date has assessed the contribution of a range of risk factors and interventions on diarrheal disease mortality across a range of settings and over time. With this analysis, we provide updated results on diarrhea disease mortality among children under 5 from the Global Burden of Diseases, Injuries, and Risk Factors Study 2017 (GBD 2017), and leverage the study's comparative risk assessment to quantify trends and effects of risk factors, interventions, and broader sociodemographic development on mortality changes from 1990 to 2017.

Methods. There are three main components of this analysis for GBD 2017. Diarrhea mortality was modeled using vital registration and verbal autopsy data in a predictive, Bayesian, ensemble modeling tool; and the attribution of risk factors and interventions for diarrhea was modeled in a counterfactual framework that combines modeled population-level prevalence of the exposure to each risk or intervention with the relative risk of diarrhea given exposure to that factor. We assessed the relative and absolute change in diarrhea mortality rate between 1990 and 2017 and used the change in risk factor exposure and socio-demographic status to explain differences in the trends of diarrhea mortality among children younger than 5 years.

Findings. Diarrhea was responsible for an estimated 533,768 deaths (95% Uncertainty Interval [UI] 477,162 to 593,145) among children under-5 in 2017 globally, a rate of 78.4 per 100,000 (95% UI 70.1-87.1). The diarrhea mortality rate ranged between countries by over 685 per 100,000. Diarrhea mortality per 100,000 decreased by 69.6% between 1990 and 2017 globally (95% UI 63.1 to 74.6%). The largest relative decline in diarrhea mortality occurred in Saudi Arabia (98.1% decrease, 95% UI 95.9 to 99.1%) while the greatest absolute decline in diarrhea mortality occurred in Niger (1,344.2 fewer deaths per 100,000, 95% UI 969.9 to 1,735.1). Among the risk factors in this study, reductions in exposure to unsafe sanitation (13.3% decrease, 95% UI 11.2 to 15.5%), childhood wasting (9.9% decrease, 95% UI 9.6 to 10.2%), and low oral rehydration solution (ORS) coverage (6.9% decrease, 95% UI 4.8 to 8.4%) were responsible for the largest reductions in the diarrhea mortality rate.

Interpretation. Our findings show that there have been substantial declines in diarrhea mortality but with variation by country since 1990. Although improvements in socio-demographic indicators may explain some of these trends, changes in exposure to risk factors, particularly childhood growth failure, sanitation, and ORS, appear to be related to the relative and absolute rates of decline in diarrhea mortality. The most impactful interventions may vary

by country or region but emphasizing interventions to prevent and protect against diarrhea have reduced diarrhea mortality and scaling up these interventions could avert many thousands of deaths due to diarrhea.

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Research in Context

Evidence before this study

The Global Burden of Disease study (GBD) has produced a series of updates to estimates of health loss due to over 300 causes of death and disability, including diarrhea. The GBD study produces estimates for 195 countries and territories, both sexes, every age group, and over time. There are several other groups that also estimate diarrhea mortality, particularly among children younger than 5 years, including the World Health Organization/Maternal and Child Epidemiology Estimation partnership. Although the estimates vary slightly between GBD iterations and compared with other groups' estimates, one thing that is generally agreed upon is that diarrhea mortality among children younger than 5 is decreasing over time. Although there has been some effort to report the impact of a range of risk factors for diarrhea mortality in a cross-sectional way, to our knowledge, no other study has attempted to evaluate changes in mortality over time due to demographic changes and changes in risk factor exposure.

Added value of this study

Here we report findings from the GBD 2017 study which builds on previous iterations of the GBD with additional data and modeling improvements. We use estimates of 12 risk factors or interventions for diarrhea mortality, produced for the GBD study, to evaluate changes in diarrhea mortality among children younger than 5. A major component of the GBD study is producing internally consistent and externally comparable estimates for all locations and over time, which allows us to identify countries where the diarrhea mortality rate has changed the most and to evaluate the contributing risk factors or interventions that impact the mortality rate. We provide cross-sectional and longitudinal estimates of the reasons of why children are dying from diarrhea, how this varies, and where specific interventions may have the greatest impact.

Implications of all the available evidence

Diarrhea mortality among children younger than 5 years has declined in many parts of the world, particularly due to improvements in safe sanitation, childhood nutrition, and oral rehydration solution. However, there is variation by country, suggesting that there is no single silver bullet to reduce diarrhea mortality. Every country must consider their specific context to identify strategies to reduce diarrhea mortality. Our estimates can help provide evidence to do so.

Introduction

Diarrheal diseases (diarrhea) are the second leading infectious cause of mortality, after lower respiratory infections, among children younger than 5 years old globally and childhood mortality due to diarrhea has declined since the 1990s.[1–5] Accelerating and maintaining these declines is essential to meeting sustainable development goals for under-5 childhood mortality and ensuring that children everywhere have the opportunity at a full, healthy life.

Many countries have shown marked declines in diarrhea mortality among children younger than 5, and much of this progress has been associated with programs that address key environmental risks for diarrhea and scaling up interventions to prevent or treat acute diarrhea.[3] Several global initiatives have offered guidance on efficient and recommended interventions to avert illness and mortality, including the Global Action Plan for Pneumonia and Diarrhea.[6] These programs have typically categorized interventions into groups that are defined by where in the morbidity pathway they occur, including prevention of infection such as provision of safe water and sanitation, and treatment of disease, such as oral rehydration solution.[7] Yet no study to date has assessed the contribution of a range of risk factors and interventions on diarrhea mortality across settings and over time.

We have previously shown a strong relationship between the socio-demographic level and diarrhea mortality[2,8] but that does not necessarily translate to actionable evidence of interventions to prioritize to reduce health-loss associated with diarrhea. Understanding why some countries have seen more progress than others would provide such evidence and give a targeted roadmap for accelerating declines in diarrhea mortality. The Global Burden of Disease study 2017 (GBD) is a systematic, scientific effort to quantify morbidity and mortality, including for diarrhea and its risk factors.[1,9,10] With this analysis, we provide updated results of estimates of diarrhea mortality among children younger than 5 and leverage the study's comparative risk assessment to quantify trends and effects of risk factors, interventions, and broader sociodemographic development on mortality changes from 1990 to 2017. We use results from the GBD 2017 to assess which countries have performed best in reducing under-5 diarrhea mortality and compare countries on the basis of mortality rates, exposure to risk factors and interventions, and the contribution of changes in risk factor exposure on diarrhea mortality.

Methods

Detailed methods on the Global Burden of Disease study and on diarrhea estimation in GBD have been previously published.[1–3,9,10] We describe these methods briefly, focusing on a high-level description of modeling strategy. More information about diarrhea mortality modeling in GBD 2017 is provided in the **Appendix.** Uncertainty in the diarrhea estimates are maintained through the modelling process using 1000 draws and are reflected as 2·5th and 97·5th percentiles of the posterior distribution. In compliance with the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER),[11] data and code for the GBD 2017 cycle are publicly available (https://ghdx.healthdata.org/).

There are four main components of the analysis that we share here: 1) diarrhea mortality estimation; 2) diarrhea morbidity estimation; 3) diarrhea risk factor and intervention estimation;

and 4) the application of these results to evaluate changes in diarrhea mortality between 1990 and 2017.

Mortality. Most causes of death in the GBD 2017, including diarrhea, are modeled in the Cause of Death Ensemble model (CODEm).[1,12] This statistical tool is designed to create a wide variety of models using a covariate selection algorithm and then to weight these models based on their out-of-sample predictive validity. These models are combined into an ensemble that predicts diarrhea mortality by age, sex, year, and geography from 1980 to 2017. The model for diarrhea uses vital registration, demographic surveillance, and verbal autopsy data. Covariates include childhood undernutrition, safe water and sanitation, the Socio-demographic Index (SDI), and maternal education among others.[1] SDI is a composite measure of development that accounts for fertility, education, and income and we have previously shown that it is associated with many population health indicators, including diarrhea mortality.[2]

Risk factors. Risk factors in the GBD 2017 study are causally related to diarrhea incidence or mortality.[10] There are 12 risk factors or interventions for diarrhea reported in this manuscript and estimated in GBD 2017 (**Table 1**). In general, risk factors are part of a comparative risk assessment framework that involves a counterfactual approach to quantify the level of exposure to the risk factor in a population and the relative risk of diarrhea given exposure. Typically, the exposure in a population is modeled based on surveys and scientific literature and the risk of diarrhea is from published meta-analyses. More information on the modeling strategy for the risk factors can be found in the **Appendix (pages 7-45).** We also used existing aggregate risk factors for 1) childhood growth failure and 2) unsafe water, sanitation, and hygiene.[10]

Risk factors are counter-factual and estimated independently. For these reasons, the sum of risk factor attributable fractions is not equal to 100% in a given population and may be more or less, depending on the population-level exposure to each factor. In other words, in this counterfactual approach, there are multiple potential ways to avert an episode of diarrhea or prevent a diarrhea death. For example, a child who dies from diarrhea may have lacked adequate nutrition or safe water but access to either may have saved her life, even without access to the other.

Analysis of temporal trends. The last component is the application of these results to space and time patterns. The primary outcome of interest is the diarrhea mortality rate per 100,000 in 1990 and 2017. We calculated the absolute change in mortality rate as the difference between rates between 1990 and 2017. We calculated the relative percent change in mortality rate in 2017 compared to 1990. We fit a log-normal regression using SDI to predict the expected change in diarrheal mortality rate per unit increase in SDI. This rate was considered the baseline change in diarrheal mortality that is explained by changes in SDI.

To assess the effect of changes for each risk factor among children under 5, we took advantage of the counterfactual definition of risk factor burden such that the diarrhea mortality rate due to each risk factor was equivalent to the reduction expected given complete absence of the risk factor. We categorized risk factors for diarrhea mortality into two groups based on their biological mechanism of risk: prevention and protection. *Prevention* associated risks are those that increase the probability of becoming an incident episode of diarrhea and include lack of

rotavirus vaccine, no handwashing with soap, unsafe water, unsafe sanitation, and dietary zinc deficiency. *Protection* associated risks are those that increase the likelihood of mortality among children with diarrhea and include suboptimal breastfeeding, not receiving oral rehydration solution, low birth weight and short gestation, childhood stunting, childhood underweight, childhood wasting, and vitamin A deficiency (**Table 1**). We performed a decomposition of the effect of the change in exposure to each risk factor on the diarrhea mortality rate between 1990 and 2017, accounting for the independent effects of population growth, population ageing, and other drivers of diarrhea mortality. This process has been described in detail elsewhere.[8,10]

Results

In 2017, diarrhea was responsible for an estimated 533,768 deaths (95% UI 477,162 to 593,145) among children under-5, globally (**Table 2**), accounting for 9.9% of all deaths among children younger than 5 (95% UI 8.9 to 10.9%). Together, India (102,678 deaths, 95% UI 87,608 to 118,510) and Nigeria (104,267 deaths, 95% UI 75,975 to 139,594) accounted for more than a third of all diarrhea deaths (**Table 2**). The mortality rate among children younger than 5 was 78.4 per 100,000 (95% UI 70.1 to 87.1) globally and ranged from 0.09 (95% UI 0.07 to 0.13) in Singapore to 685.8 in the Central African Republic (95% UI 385.7 to 1083.0; **Figures 1 and 2A**). The regions with the highest diarrhea mortality rates were Western sub-Saharan Africa (269.3 per 100,000, 95% UI 219.1 to 328.9) and Central sub-Saharan Africa (176.1, 95% UI 130.6 to 233.9; **Table 2, Figure 2A**).

Diarrhea mortality per 100,000 decreased by 69.6% between 1990 and 2017 globally (95% UI 63.1 to 74.6%, **Table 2, Figure 1**). The greatest relative decline in diarrhea mortality occurred in Saudi Arabia (98.1% decrease, 95% UI 95.9 to 99.1%) from 77.1 per 100,000 (95% UI 47.1 to 122.1) to 1.46 per 100,000 (95% UI 0.79 to 2.58; **Table 2, Figure 1**). Diarrhea mortality increased in 25 countries (**Figure 2B**) but the absolute change in mortality rate in the locations where the mortality rate increased tended to be small during this time (**Table 2, Figures 1 and 2C**). The greatest absolute decline in diarrhea mortality occurred in Niger where mortality decreased 1,344.2 deaths per 100,000 (95% UI 969.9 to 1,735.1) between 1990 and 2017, from 1731.2 per 100,000 (95% UI 1223.8 to 2290.9) in 1990 to 387.8 per 100,000 (95% UI 253.9 to 555.9) in 2017 (**Table 2, Figures 1 and 2C**). At the global level, diarrhea incidence declined by 7.2% (95% UI 5.5 to 8.1%) between 1990-2017, from 1.75 episodes per child-year (95% UI 1.48 to 2.07) in 1990 to 1.63 episodes per child-year (1.36 to 1.96) in 2017 (**data not shown**, **incidence results available at GBD Compare**).

Nine countries had mortality rates above the global median rate in 1990 and below the global median rate in 2017 (Armenia, China, Iran, Jamaica, Kazakhstan, Macedonia, Saudi Arabia, Turkey, and Uzbekistan). These countries tended to experience dramatic increases in SDI levels during this time. Diarrhea mortality decreased by 98.1% (95% UI 95.9 to 99.1) in Saudi Arabia as reported above, by 98.0% (95% UI 85.5 to 96.5%) in Turkey (127.5 per 100,000 [95% UI 88.1 to 181.5] to 2.6 per 100,000 [95% UI 1.7 to 3.7])]), and by 95.5% (95% UI 94.6 to 96.4%) in China (from 65.0 per 100,000 [95% UI 56.3 to 75.9] to 2.9 per 100,000 [95% UI 2.5 to 3.4]). Some of these countries had diarrhea mortality rates much lower than expected based on SDI. For example, the ratio of observed to expected mortality rates in Armenia (0.17) and Macedonia (0.12) were among the three lowest globally suggesting the mortality rate in these countries is much lower

than expected based on SDI (**Figure 2D)**. In contrast, the ratio of observed to expected mortality in China (0.83) and Saudi Arabia (1.03) were closer to 1, suggesting a correlation in mortality and SDI in these locations. The observed mortality was much greater than expected based on SDI in some high-income locations (Canada [18.2] and Austria [12.4]) as well as low-income locations (Central African Republic [5.8] and Sudan [4.7]; **Figure 2D**).

The risk factors included in GBD 2017 for diarrhea among children under-5 accounted for 99.4% (95% UI 98.7 to 99.8) of diarrhea deaths in 2017 (**Table 2 and Figure 3)**. Full use of the rotavirus vaccine may prevent an estimated 22.0% of diarrhea deaths (95% UI 16.7 to 27.9%) and providing safe water, sanitation, and hygiene (WASH) could avert 94.8% of deaths (95% UI 81.3 to 98.9%; **Table 2 and Figure 3**) at the global level. Risk factors related to poor childhood nutrition including growth failure and micronutrient deficiencies were responsible for 89.6% (95% UI 77.6 to 94.7%) of diarrhea deaths in 2017 and full coverage of oral rehydration solution (ORS) could prevent 57.7% of diarrhea deaths in 2017 (95% UI 39.9 to 70.8%; **Table 2 and Figure 3A**). Poor childhood nutrition and unsafe WASH were attributed to a comparable fraction of deaths in most GBD super-regions with the exception of the High-income super-region where unsafe WASH was responsible for only 20.2% of deaths (95% UI 8.5 to 34.6%; **Table 2 and Figure 3A**).

A decomposition analysis of the percent change in diarrhea mortality between 1990 and 2017 due to changes in risk factor attribution is shown in **Figure 4**. Globally, unsafe sanitation (13.3% decrease, 95% UI 11.2 to 15.5%), childhood wasting (9.9% decrease, 95% UI 9.6 to 10.2%), and low ORS coverage (6.9% decrease, 95% UI 4.8 to 8.4%) were responsible for the greatest reductions in the diarrhea mortality rate (**Figure 4**).

Among the quintile of countries where the absolute decrease in diarrhea mortality rate was largest, improvements in risk factors associated with undernutrition were correlated with the largest declines in diarrhea mortality, including improvements in childhood wasting (19.0% decrease), childhood stunting (5.9% mean decrease), childhood underweight (5.5% decrease), vitamin A deficiency (9.4% mean decrease), and zinc deficiency (1.6% decreased attribution; **Figure 4E**). Expanded ORS coverage reduced diarrhea mortality by 7.1% on average in these countries (**Figure 4E**). The fastest improvements in childhood wasting were seen in Laos (55.2% decrease, 95% UI 50.2 to 52.4%) and Angola (53.9% decrease, 95% UI 45.5 to 59.1%; **Figure 4E**). Many countries in this quintile of diarrhea mortality decline, including Sierra Leone (24.5% decrease, 95% UI 16.9 to 29.8%), greatly reduced diarrhea mortality by expanding ORS coverage (**Figure 4E)**. Rotavirus vaccine reduced diarrhea mortality by substantial amounts among some countries that have introduced the vaccine such as 39.2% in Burkina Faso (95% UI 22.4 to 73.7%) and by 34.3% in Togo (95% UI 19.3 to 63.2%; **Figure 4E**). The countries with the greatest absolute decline in diarrhea mortality rate did not frequently have much of this reduction explained by water, sanitation, and hygiene with some exceptions in Equatorial Guinea and Egypt (**Figure 4E**).

Countries in the fourth quintile of the absolute change in diarrhea mortality rate tended to have more decline explained by WASH risks such as a 28.0% decrease (95% UI 25.7 to 29.7%) in diarrhea mortality due to sanitation in Indonesia and a 21.8% reduction in India (95% UI 18.9 to

23.8%); a 39.2% (95% UI 27.8 to 50.2%) decline due to unsafe water in Botswana, and a 10.7% (95% UI 4.8 to 16.2%) decline due to handwashing in Bhutan (**Figure 4D).** The mean change in diarrhea mortality in these countries was more evenly explained by childhood growth failure, micronutrition, and WASH risk factors than for countries in the third (**Figure 4C)** and second (**Figure 4B**) quintiles for reduction in diarrhea mortality. China and Saudi Arabia, two of three countries with the largest relative decline in diarrhea mortality rate, were in the third quintile in absolute decline. A substantial amount of the decline in China was driven by improvements in handwashing (6.8%, 95% UI 3.0 to 10.9%), unsafe sanitation (20.6%, 95% UI 19.4 to 21.0%), and unsafe water (22.4%, 95% UI 14.2 to 29.8%) (**Figure 4C)**. Countries in the first quintile with the smallest absolute change in diarrhea mortality tended to be countries in the high-income GBD super-region. The mortality rate increased due to greater prevalence of low birth weight and short gestational age in this quintile and by as much as 8.7% (95% UI 8.3 to 10.3%) in Singapore (**Figure 4A**). Although the Central African Republic and Zimbabwe reduced diarrhea mortality due to improvements in suboptimal breastfeeding, vitamin A deficiency, and low rotavirus vaccine coverage, the mortality rate increased in these two locations (6.1 per 100,000 increase in Zimbabwe and 241.4 per 100,000 increase in the Central African Republic; **Table 2 and Figure 4A**).

Discussion

Diarrhea mortality among children younger than 5 is largely preventable with existing interventions that reduce exposure to pathogens and reduce the risk of mortality. Our estimates from this and previous iterations of the GBD study have consistently shown that diarrhea is one of the leading causes of death in this age group.[2,3] There is reason to be optimistic about the observed decline in mortality. This trend should not lull public health officials, policy makers, and funding agencies into a sense that persistence of such declines is inevitable, but rather should press all actors into asking why the pace of decline has been unequal across countries. The analyses presented here attempt to answer some of those most important questions.

The SDI increased in every country between 1990 and 2017.[1] The greatest increase in SDI between 1990 and 2017 occurred in Equatorial Guinea, a country where diarrhea mortality decreased by more than 550 deaths per 100,000 during that time period. However, the two countries with the greatest absolute decline in diarrhea mortality rates, Niger and Liberia, had increases in SDI that were smaller than the global average.[1] We have previously shown that the SDI is a strong predictor of diarrhea mortality, but there are locations where difference between the mortality rate and the rate predicted on the basis of changes in SDI is large (**Figure 2D)**.[2] An important contrast becomes apparent as the countries with the greatest relative decline in diarrhea mortality, like China, Turkey, and Saudi Arabia appear to be correlated with increases in SDI while the countries with the greatest absolute decline in diarrhea mortality have exceeded declines predicted by SDI. Increasing development is related to greater ability for countries to build and maintain integrative surveillance and treatment programs. For example, starting in the early 1990s, China implemented a series of national programs to reduce under-5 mortality, including the Program for Control of Diarrheal Diseases that focused on surveillance, health education, training, and access to healthcare for all counties, cities, and provinces with emphasis on rural areas.[13]

Regardless of distinguishing between relative and absolute change, countries with the largest declines in diarrhea mortality rate tended to have large reductions in childhood underweight and stunting attribution. There have been substantial reductions in childhood growth failure from 1990 to 2017 but with stubborn subnational variation.[14] Improving nutritional status of children is the single most important intervention to prevent infectious disease mortality. To a smaller extent, micronutrient deficiencies like vitamin A and zinc have improved in countries with either the fastest relative or absolute change. Childhood growth failure, including stunting, underweight, and wasting, appear to have a nearly linear relationship with SDI.[10] The dietary zinc deficiency risk factor reported in this manuscript is distinct from zinc therapy which has been shown to substantially reduce diarrhea duration and possibly mortality among children.[15] We have previously shown that diarrheal episodes among children are associated with impaired growth and accounting for growth failure may increase the overall burden of diarrhea by 40%.[16,17] Given the range of additional health outcomes,[18] proven efficacy,[19] and cost effectiveness; nutritional interventions should not be overlooked when considering child vulnerability to diarrheal diseases.[20]

In recent years, researchers, policy makers, and clinicians have espoused the biologically plausible idea that reducing environmental contamination through WASH might be key to tackling the persistent challenge of childhood diarrhea and stunting. However, two large trials have reported no effect of drinking water, sanitation, and hygiene (WASH) interventions on linear child growth and showed only limited benefit for childhood diarrhea. Several studies investigating improvements in safe water and sanitation, found little improvement in diarrhea incidence or childhood growth.[19,21] While these studies focused on family or neighborhood level interventions, some evidence points to community-level contamination of water sources even when some members of the community are using safe water and sanitation. Provision of universal safe water and sanitation requires substantial infrastructural development which may not be feasible in some locations[22,23] It may be that in the absence of near universal coverage, community-level contamination persists even when some members are using safe water and sanitation.[19] A recent report concluded that many countries are not on pace to meet universal access to safe water and sanitation, markers introduced in the Sustainable Development Goals.[24] Poor access to safe water and sanitation persists particularly among rural and poor populations. This study, along with other previous studies, suggest that a more comprehensive, community-level approach to improving the environment might be necessary to influence child growth.[25] Sanitation had the greatest magnitude change in diarrhea mortality among all risk factors (13.3% decrease, 95% UI 11.2 to 15.5%), but this change appeared to be greatest in geographies at middle values of SDI (0.4 to 0.6).[10] Countries with the greatest relative change in diarrhea mortality, such as China, Turkey, and Saudi Arabia are examples of areas with dramatic reductions due to unsafe WASH. This was not typically true among countries with the fastest absolute reduction in diarrhea mortality, where the change in attribution for the WASH risks were frequently in the slowest two quintiles of change among all countries (**Figure 4E**).

Many countries are not near the range of SDI where water and sanitation are likely to improve rapidly. Countries at the lower range of SDI that experience the greatest declines in absolute mortality rates tended to succeed at reducing attribution to risks that act at the individual level.

Some of the countries with the largest absolute declines in diarrhea mortality rates, like Niger, Nigeria, Sierra Leone, and Somalia, had greater than a 15% reduction in diarrhea mortality due to increased ORS coverage. Treatment with ORS, or with recommended home fluids, is inexpensive and effective, perhaps explaining why ORS decreased mortality in locations with relatively limited change in SDI. Oral rehydration solution may prevent 93% of diarrhea deaths,[26] but appropriate use remains low in many locations, perhaps due to perceptions that it is a medication and must be prescribed by healthcare workers, due to adherence of treatment, and due to potential competing treatments, including antibiotics, that are viewed positively as Western medicine.[27]

Globally, 34.7% of under-5 diarrhea deaths were caused by rotavirus. Existing rotavirus vaccines prevented about 30,000 deaths in 2016.[28] Some of the poorest countries are eligible for Gavi support in funding rotavirus vaccine use but have not introduced the vaccine, such as the Democratic Republic of the Congo, Nigeria, Chad, and South Sudan.[29] These countries also had slower reductions in diarrhea mortality than neighboring countries that did introduce the vaccine, such as Rwanda, Niger, and Sudan. Countries in Latin America and the Caribbean tended to be early adopters of the rotavirus vaccine and several countries, like Brazil (11.1% decrease), Mexico (12.7% decrease), and Peru (14.5% decrease) have substantially reduced diarrhea mortality due to rotavirus. There remains some uncertainty about the future of the rotavirus vaccine in high-middle SDI countries that have or will soon transition from being Gavi-eligible. Introduction and coverage of the rotavirus vaccine, particularly among high-mortality countries, can avert a substantial amount of the 34.7% of diarrhea deaths attributable to rotavirus.

Limitations. There are a number of limitations in this study. Our estimates are dependent on data availability which tends to be scarce, particularly among countries with high expected mortality in sub-Saharan Africa. Detailed, reliable, and timely disease burden data are needed for countries to make informed decisions about health policy and interventions. Global burden estimates attempt to fill some of these gaps but exist with substantial uncertainty which we have attempted to report consistently and uncertainty is propagated through our modeling process. Many of the covariates used in the mortality modeling are also inputs into the risk factor attribution as estimates of population-level exposure to those risks. Although we have quantified ORS treatment for diarrhea, we do not explicitly account for healthcare seeking behaviors, primary healthcare availability, and other potential treatments like therapeutic zinc and antibiotic use. The comparative risk assessment framework used for risk factors in the GBD study estimates risk factors independently. While this is essential for understanding the counterfactual disease burden associated with a risk, it means that we are unable to assess the potential of combined intervention strategies, such as those that target reductions in childhood underweight through breastfeeding promotion, and such intervention packages are likely to be very effective at reducing disease burden.[30] We also know that there can be substantial overlap in exposure to risk factors such that an individual child may be both exposed to unsafe water and unvaccinated against rotavirus. While we do not account for covariance in all risk factors, our approach does allow for the intuitive, actionable interpretation that eliminating exposure to any attributable risk is sufficient to avert a diarrhea death.

Evaluating trends and disease burden on the national level can mask subnational variation that exists because of different risk factor exposure, access to healthcare, or other factors. We have shown that childhood growth failure,[14] diarrhea mortality,[5] and under-5 mortality[4] are all geographically heterogeneous between and within countries in Africa. This analysis is from a population level which may hide individual exposures and behaviors. Future work evaluating risks and trends at fine geographical or individual levels, and including correlations between risks at this level, could better inform targeting of resources for interventions.

This study provides a clear and actionable path for reducing diarrhea mortality among children younger than 5 but this path is likely to differ depending on location. Provision of ORS for diarrheal episodes and the rotavirus vaccine have contributed to declines in even the poorest locations while the provision of universal access to safe water and sanitation may require substantial infrastructural developments. While less beneficial than some other interventions, vitamin A and zinc supplementation should be considered an essential part of routine childhood healthcare. Continuing to reduce diarrhea mortality among children younger than 5 requires focused effort and intention. Assuming instead that these declines are inevitable, relying on the improvements expected with economic development is not enough, children are dying from diarrhea today.

Figures

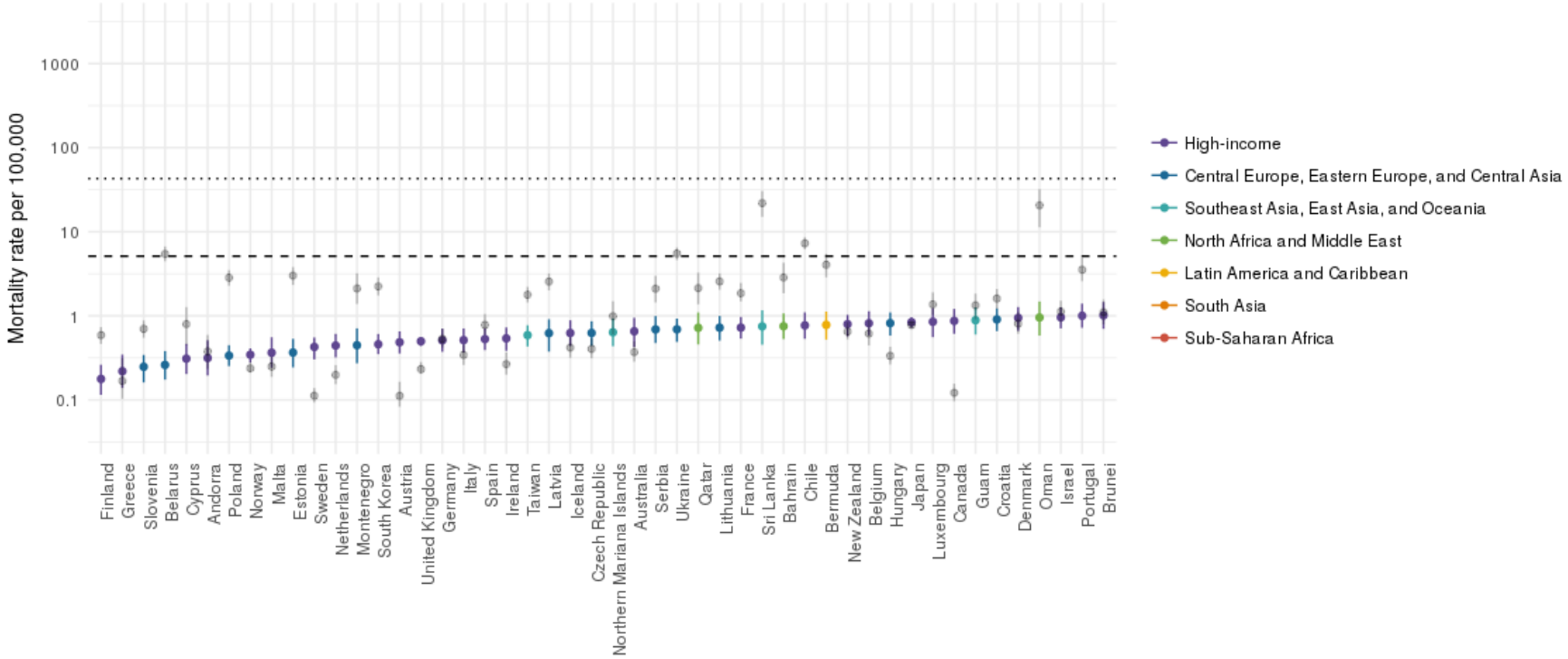
405

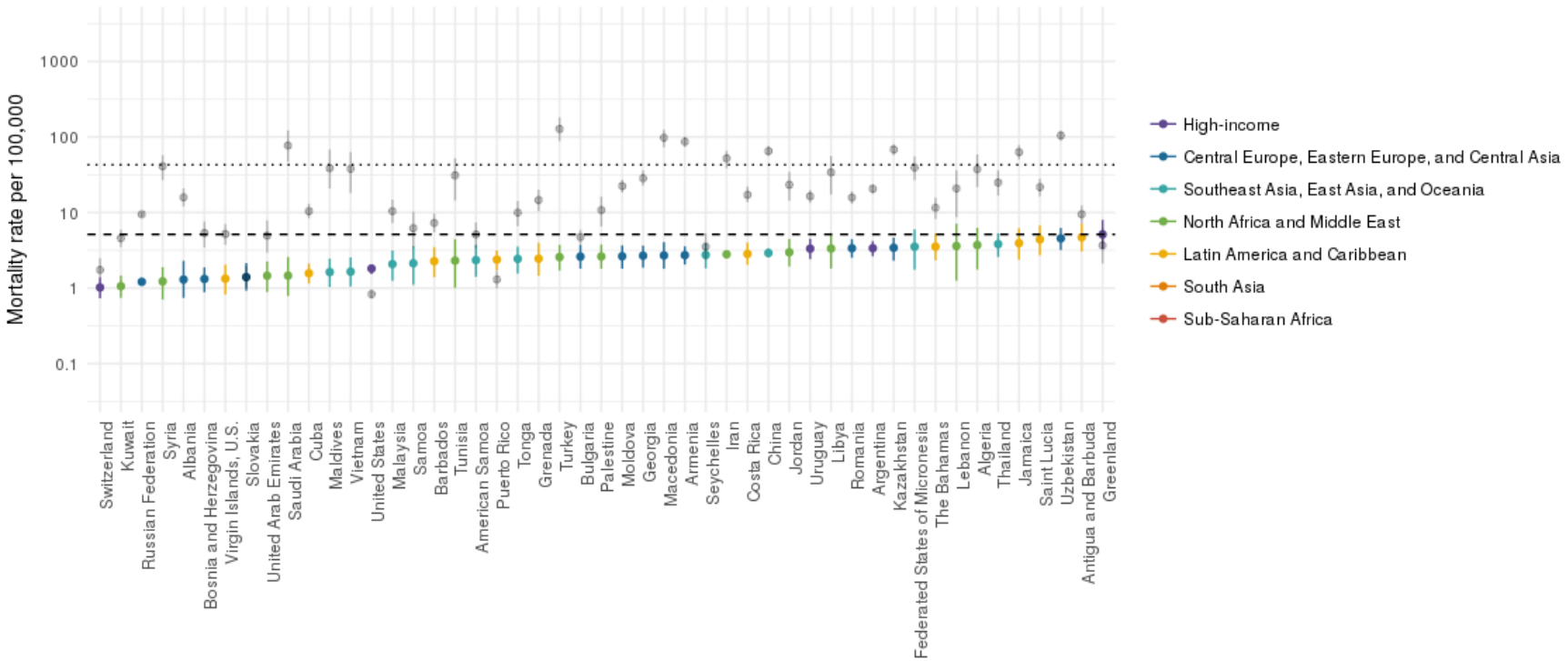
410

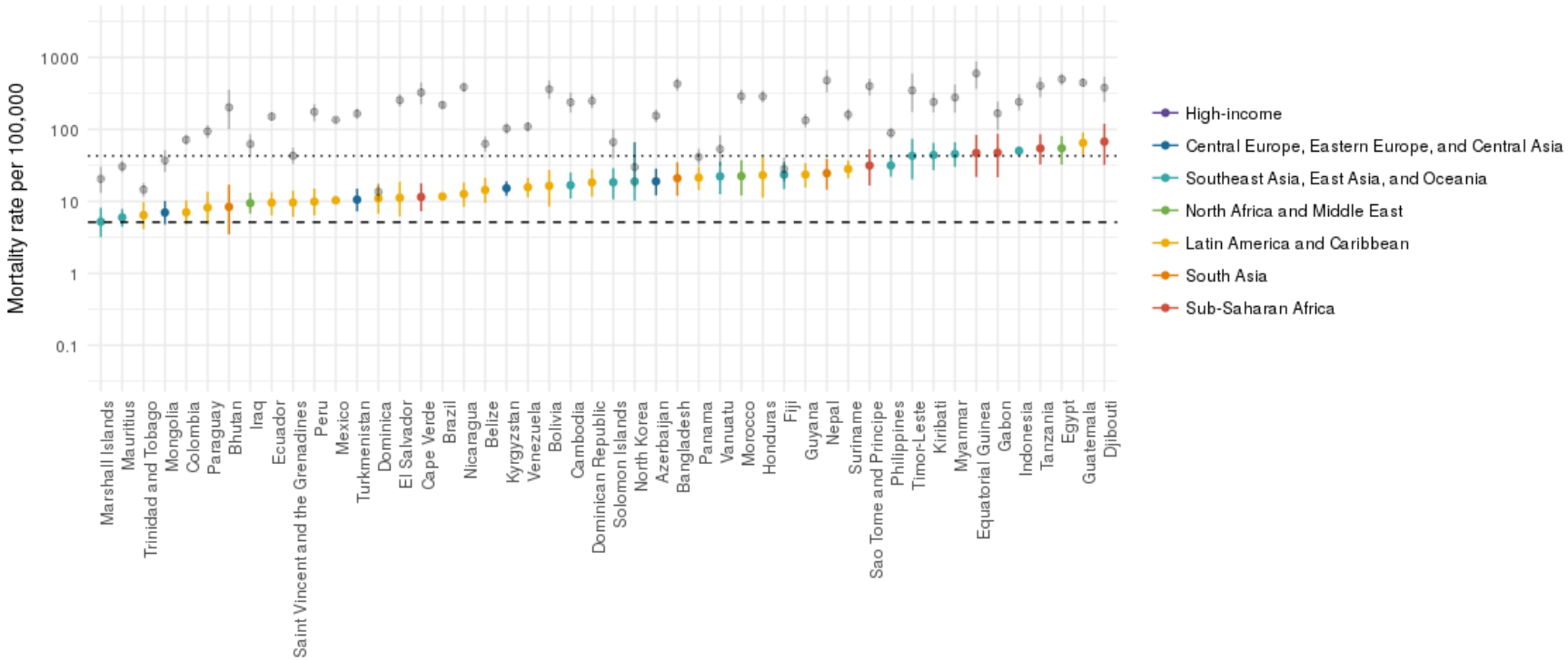
415

420

Figure 1. The diarrhea mortality rate among children younger than 5 by country. The colors indicate the GBD super region and the uncertainty around the mortality rate estimate in 2017 while the gray points and error bars mark the mortality rate in 1990. Countries are ordered from left to right in order of mortality rated in 2017. The horizontal dotted line indicates the median mortality rate in 1990 and the dashed horizontal line indicates the median mortality rate in 2017. The y-axis is plotted in log 10 transformation.




Mortality rate per 100,000
1000
100
10
1
0.1
Switzerland
Kuwait
Russian Federation
Syria
Albania
Bosnia and Herzegovina
Virgin Islands, U.S.
Slovakia
United Arab Emirates
Saudi Arabia
Cuba
Maldives
Vietnam
United States
Malaysia
Samoa
Barbados
Tunisia
American Samoa
Puerto Rico
Tonga
Grenada
Turkey
Bulgaria
Palestine
Moldova
Georgia
Macedonia
Armenia
Seychelles
Iran
Costa Rica
China
Jordan
Uruguay
Libya
Romania
Argentina
Kazakhstan
Federated States of Micronesia
The Bahamas
Lebanon
Algeria
Thailand
Jamaica
Saint Lucia
Uzbekistan
Antigua and Barbuda
Greenland
High-income
Central Europe, Eastern Europe, and Central Asia
Southeast Asia, East Asia, and Oceania
North Africa and Middle East
Latin America and Caribbean
South Asia
Sub-Saharan Africa


Mortality rate per 100,000
1000
100
10
1
0.1
Marshall Islands
Mauritius
Trinidad and Tobago
Mongolia
Colombia
Paraguay
Bhutan
Iraq
Ecuador
Saint Vincent and the Grenadines
Peru
Mexico
Turkmenistan
Dominica
El Salvador
Cape Verde
Brazil
Nicaragua
Belize
Kyrgyzstan
Venezuela
Bolivia
Cambodia
Dominican Republic
Solomon Islands
North Korea
Azerbaijan
Bangladesh
Panama
Vanuatu
Morocco
Honduras
Fiji
Guyana
Nepal
Suriname
Sao Tome and Principe
Philippines
Timor-Leste
Kiribati
Myanmar
Equatorial Guinea
Gabon
Indonesia
Tanzania
Egypt
Guatemala
Djibouti
High-income
Central Europe, Eastern Europe, and Central Asia
Southeast Asia, East Asia, and Oceania
North Africa and Middle East
Latin America and Caribbean
South Asia
Sub-Saharan Africa

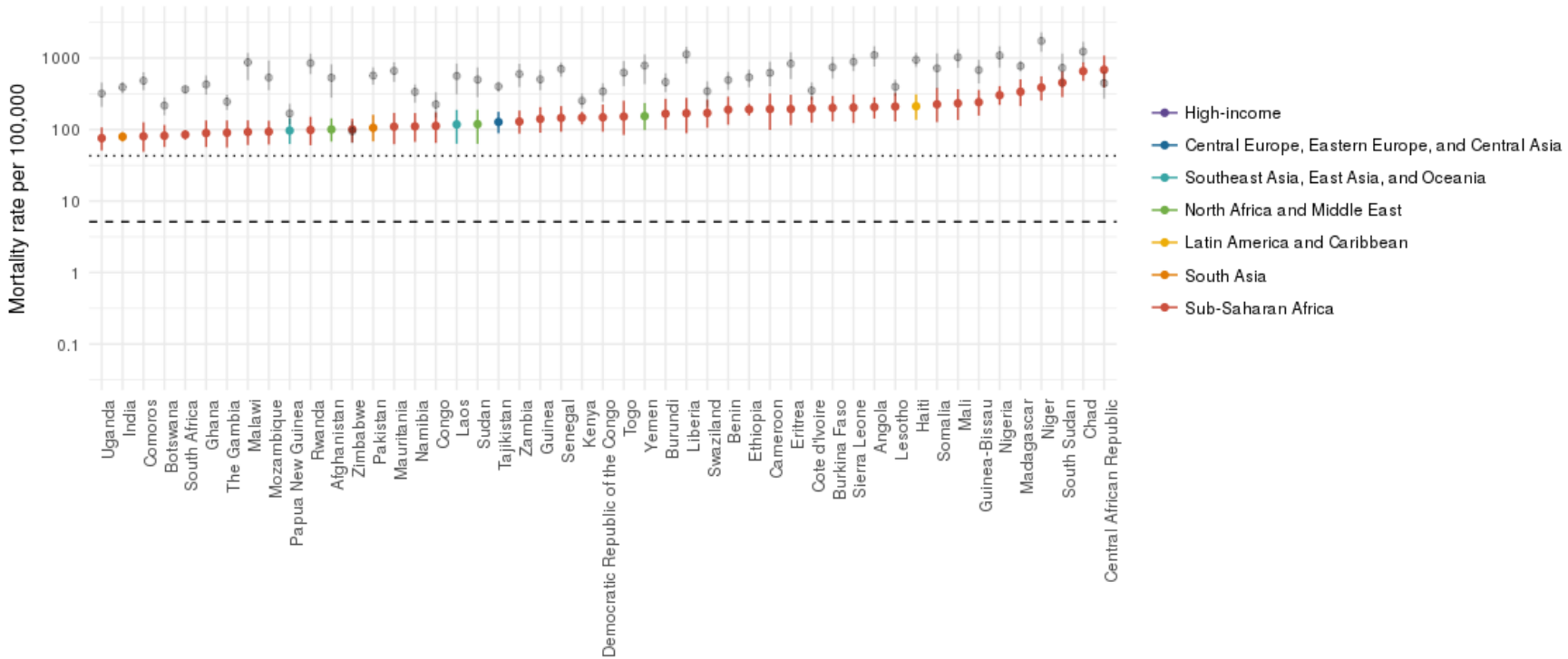
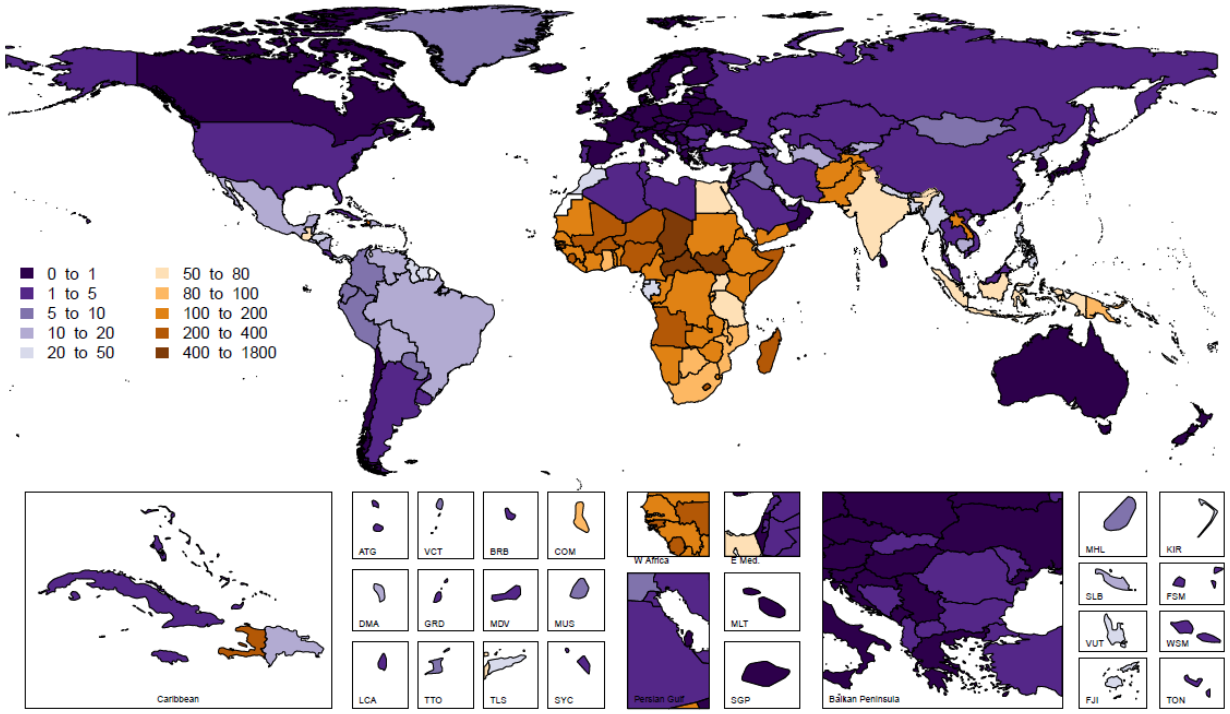
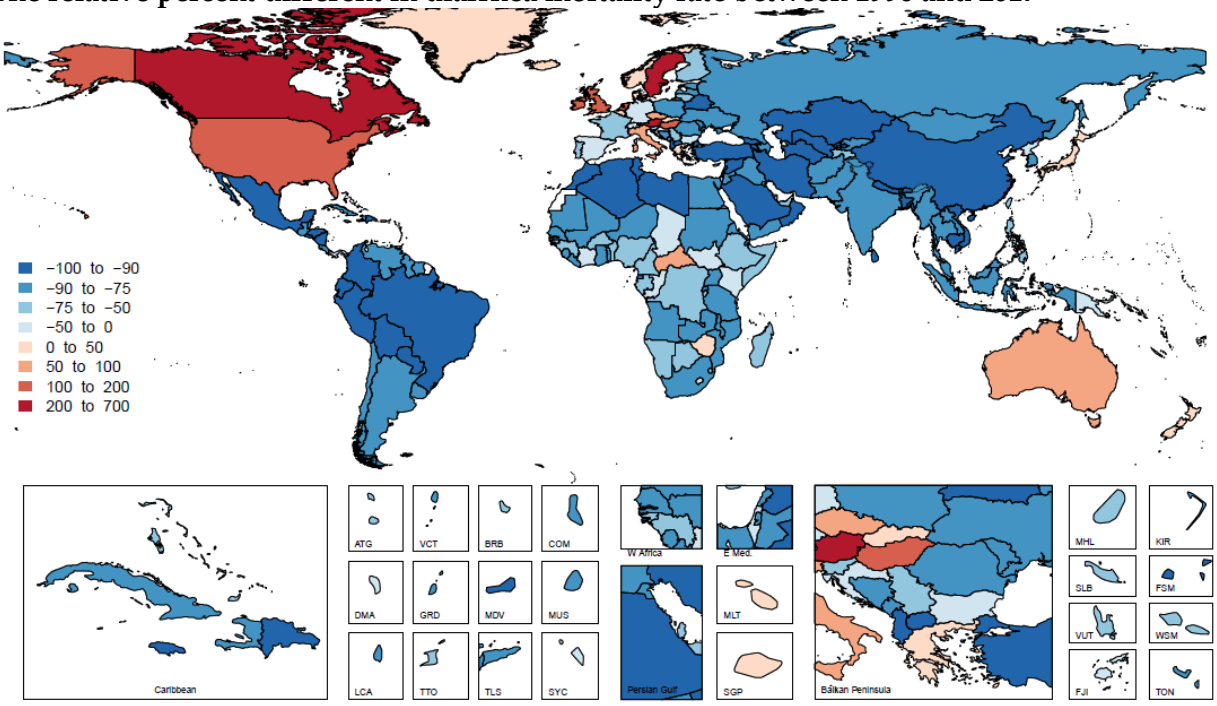

Mortality rate per 100,000
1000
100
10
1
0.1
Uganda
India
Comoros
Botswana
South Africa
Ghana
The Gambia
Malawi
Mozambique
Papua New Guinea
Rwanda
Afghanistan
Zimbabwe
Pakistan
Mauritania
Namibia
Congo
Laos
Sudan
Tajikistan
Zambia
Guinea
Senegal
Kenya
Democratic Republic of the Congo
Togo
Yemen
Burundi
Liberia
Swaziland
Benin
Ethiopia
Cameroon
Eritrea
Cote d'Ivoire
Burkina Faso
Sierra Leone
Angola
Lesotho
Haiti
Somalia
Mali
Guinea-Bissau
Nigeria
Madagascar
Niger
South Sudan
Chad
Central African Republic
High-income
Central Europe, Eastern Europe, and Central Asia
Southeast Asia, East Asia, and Oceania
North Africa and Middle East
Latin America and Caribbean
South Asia
Sub-Saharan Africa

Figure 2. Maps expressing the diarrhea mortality rate per 100,000 among children younger than 5 in 2017. A) Diarrhea mortality rate per 100,000 in 2017 among children under-5, B) The relative percent difference in diarrhea mortality rate between 2017 and 1990, C) Absolute difference between the diarrhea mortality rate per 100,000 in 2017 among children younger than 5 and D) The ratio between the observed and predicted diarrhea mortality rate per 100,000 based on the observed change in SDI between 1990 and 2017. Countries with values below 1 in panel D indicate that the estimated diarrhea mortality rate is lower than expected based on trends expected based on the relationship between the change in SDI and diarrhea mortality while values greater than 1 indicate that the estimated mortality rate is greater than expected based on the change in SDI.

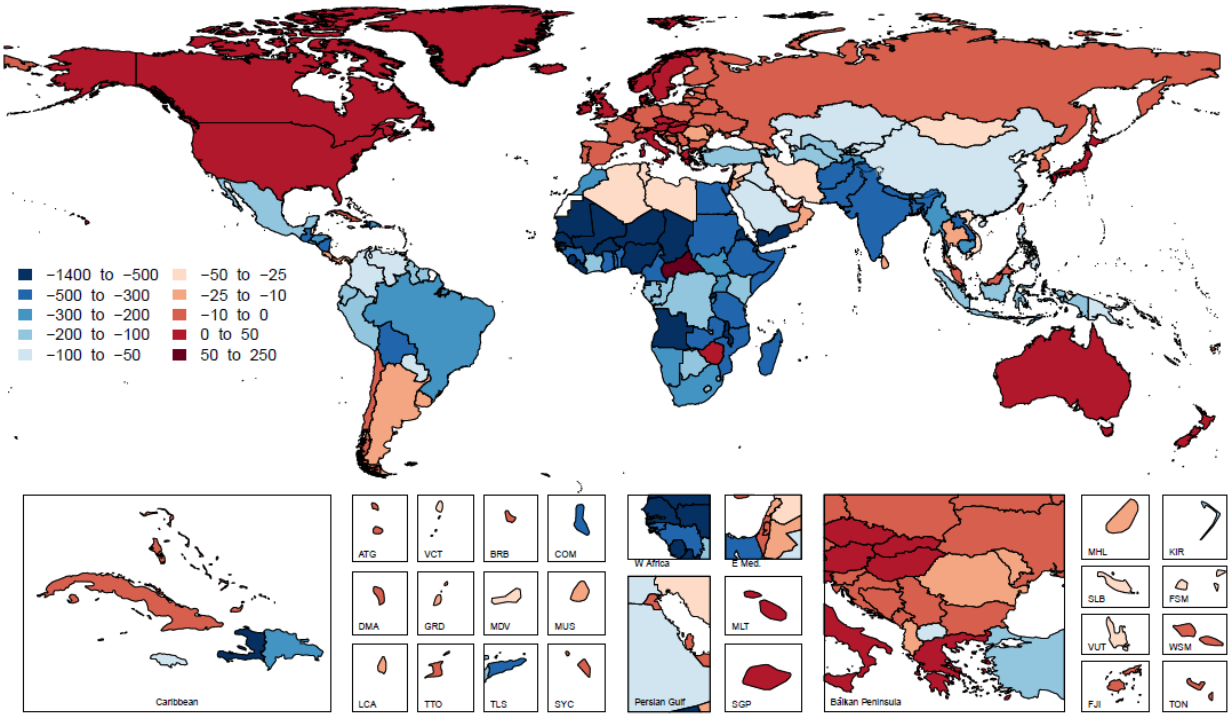
A) Diarrhea mortality rate per 100,000 in 2017.



B) **The relative percent different in diarrhea mortality rate between 1990 and 2017**



C) **The absolute difference between diarrhea mortality rate between 1990 and 2017 per 100,000.**



D) **Ratio of Observed to Expected mortality rate in 2017 based on the relationship between mortality and SDI.**

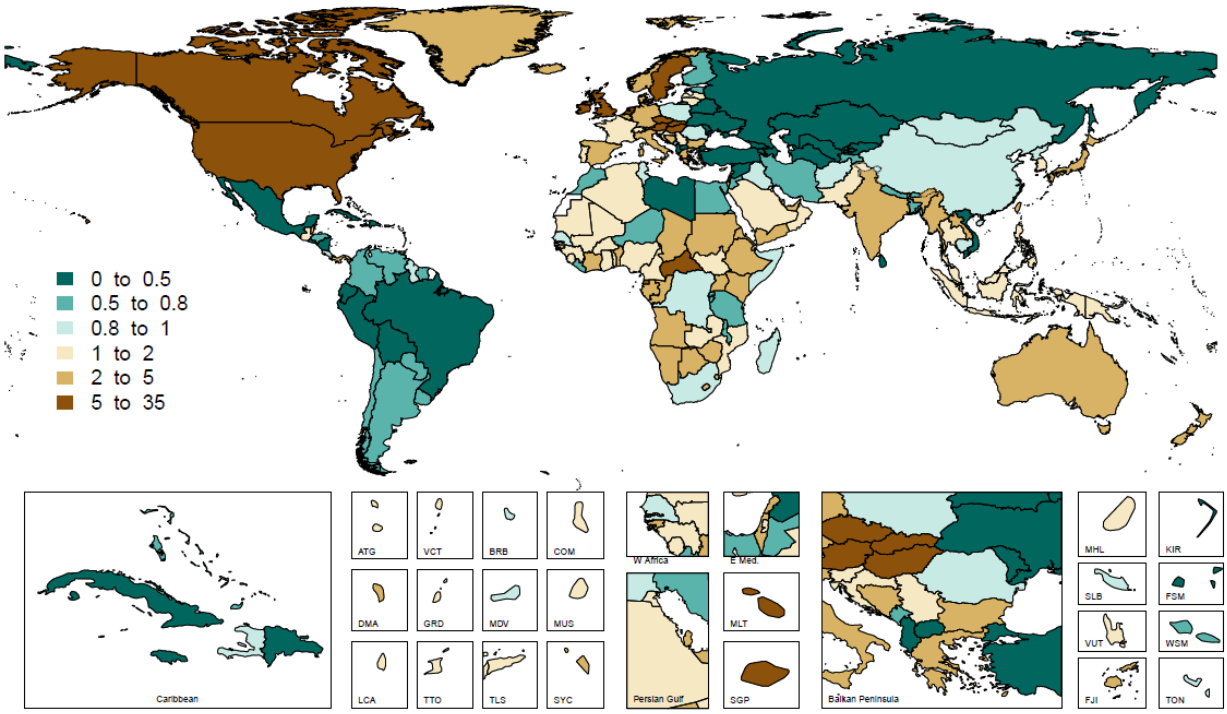


Figure 3. Bar charts for the aggregated attributable fractions for diarrheal risk factors among children younger than 5 years by GBD super region in 2017. In the comparative risk factors framework used in GBD 2017, risk factors are counterfactual and can overlap such that a single risk may be sufficient to cause a diarrhea death but is not necessary. Therefore, although the *Total* risk attribution cannot exceed 1, there could be overlap between rotavirus *Vaccine, ORS Treatment, Nutrition* or *WASH* associated risk factors at the population level such that eliminating exposure to one would avert a diarrhea death.

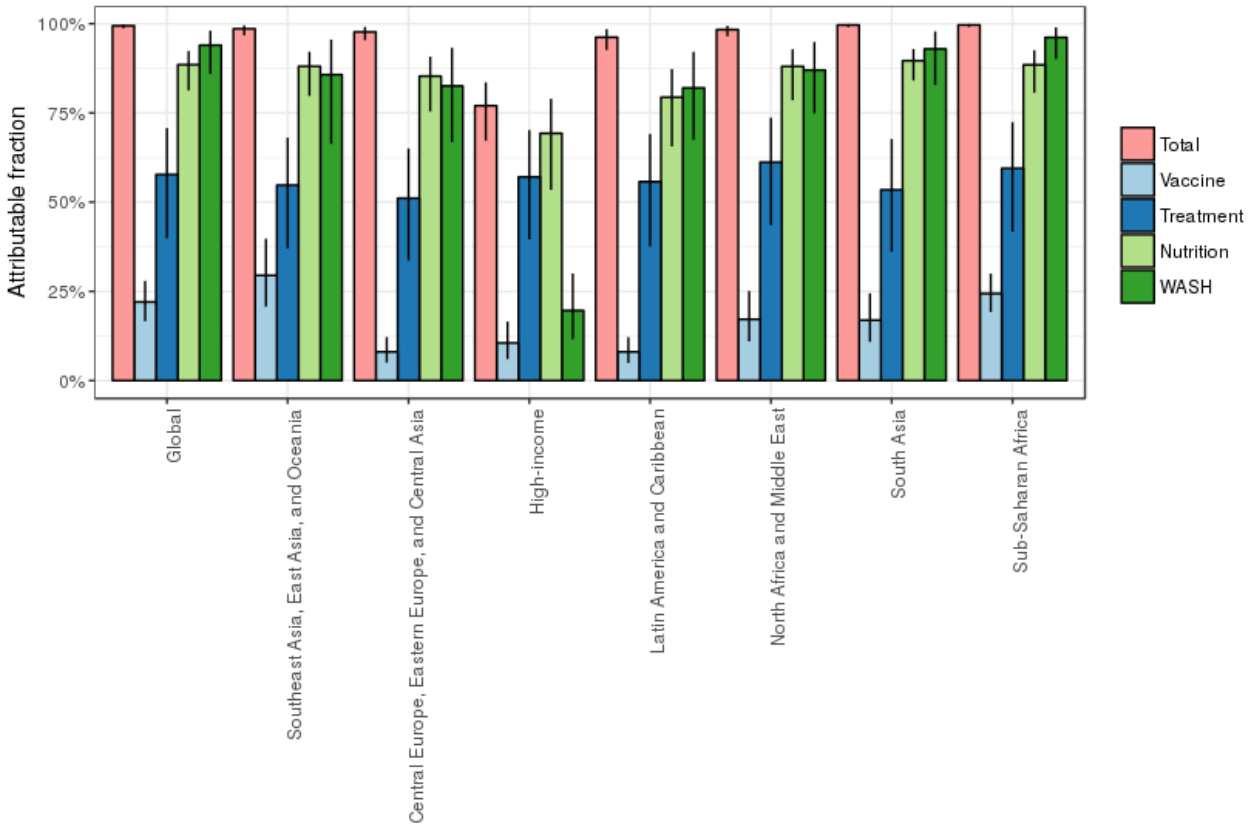
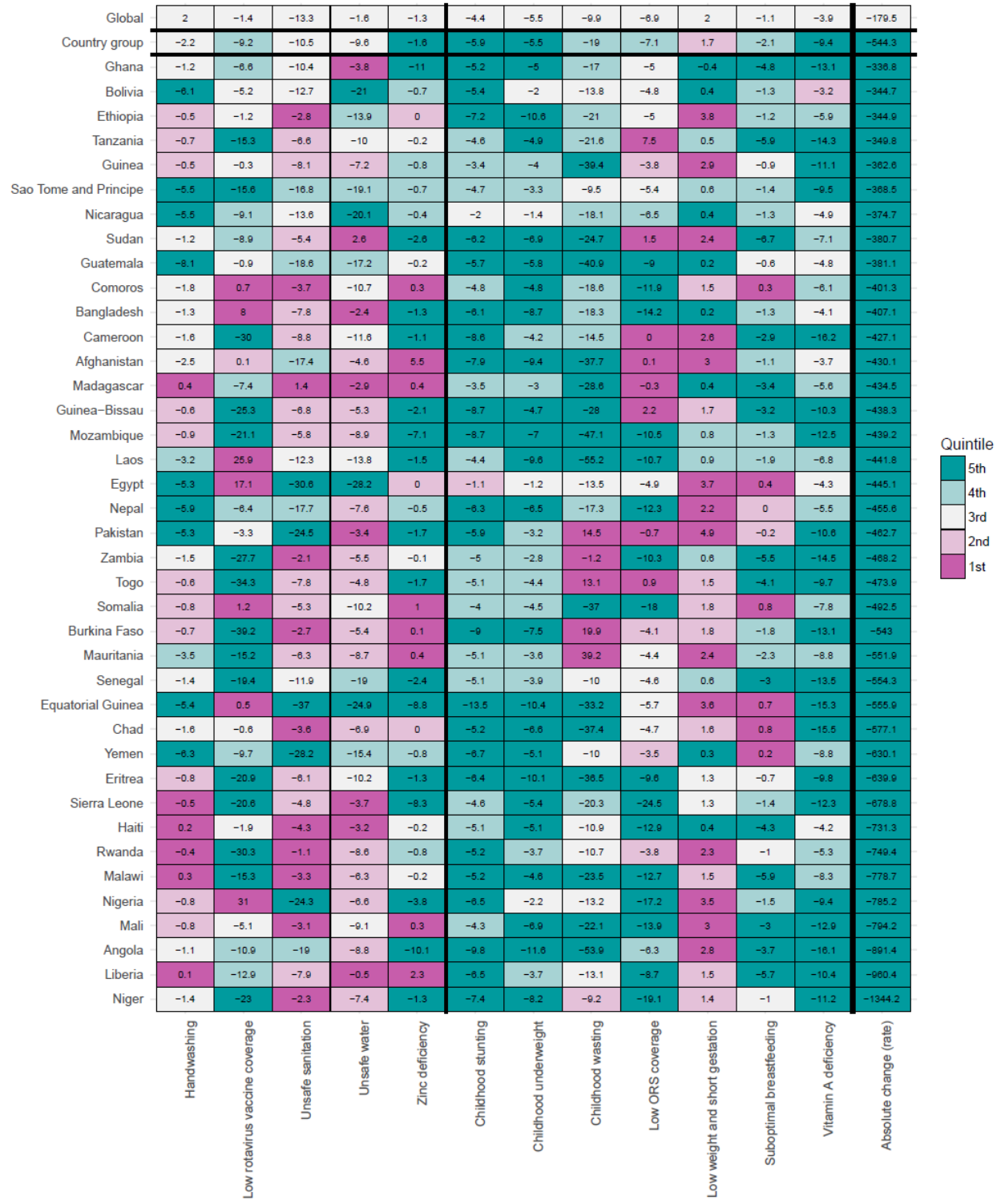
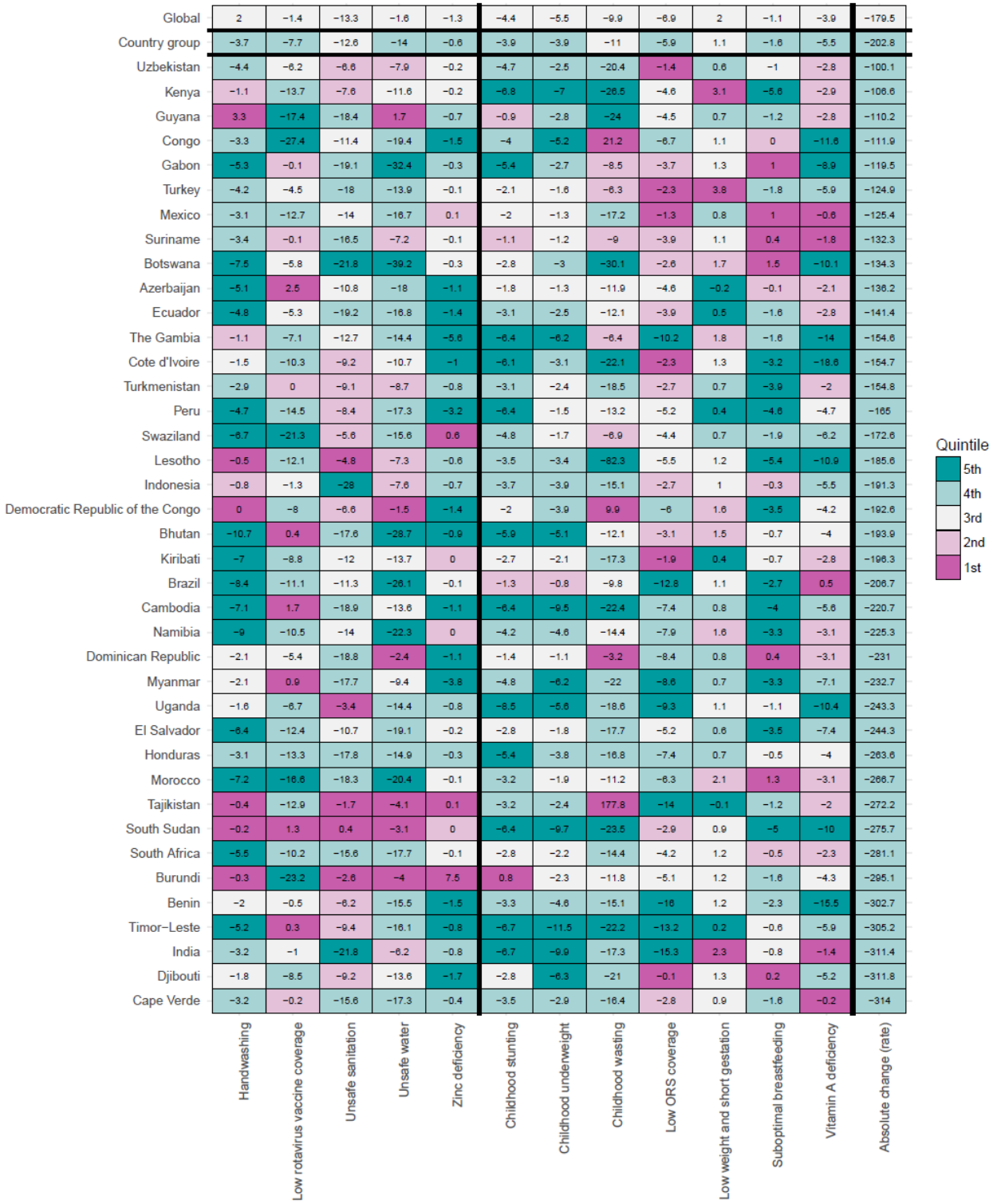


Figure 4. The percent change in the diarrhea mortality rate 1990 and 2017 attributable to changes in risk factor exposure by country, grouped in quintiles of the attributable change in mortality rate during the same time period. Values in the tiles represent the percent reduction in diarrhea mortality between 1990 and 2017 attributable to changes in risk factor exposure. The Global row represents the value among all countries and the Country grouping row represents the mean value among countries in each panel. Solid, thick vertical lines separate types of risks or interventions, grouped by nutritional, interventions, then WASH. The panels represent the ordered quintile of the absolute change in diarrhea mortality rate between 1990 and 2017 (difference in rates between 1990 and 2017) starting with the greatest relative decline (**A)** and ending with the smallest relative change (**E**). The colors of the tiles indicate the quintile for the attributable change in mortality due to each risk factor among all countries, ranging from teal blue (80-100th percentile of the change in risk attribution) to magenta red (0-20th percentile of change in risk attribution).

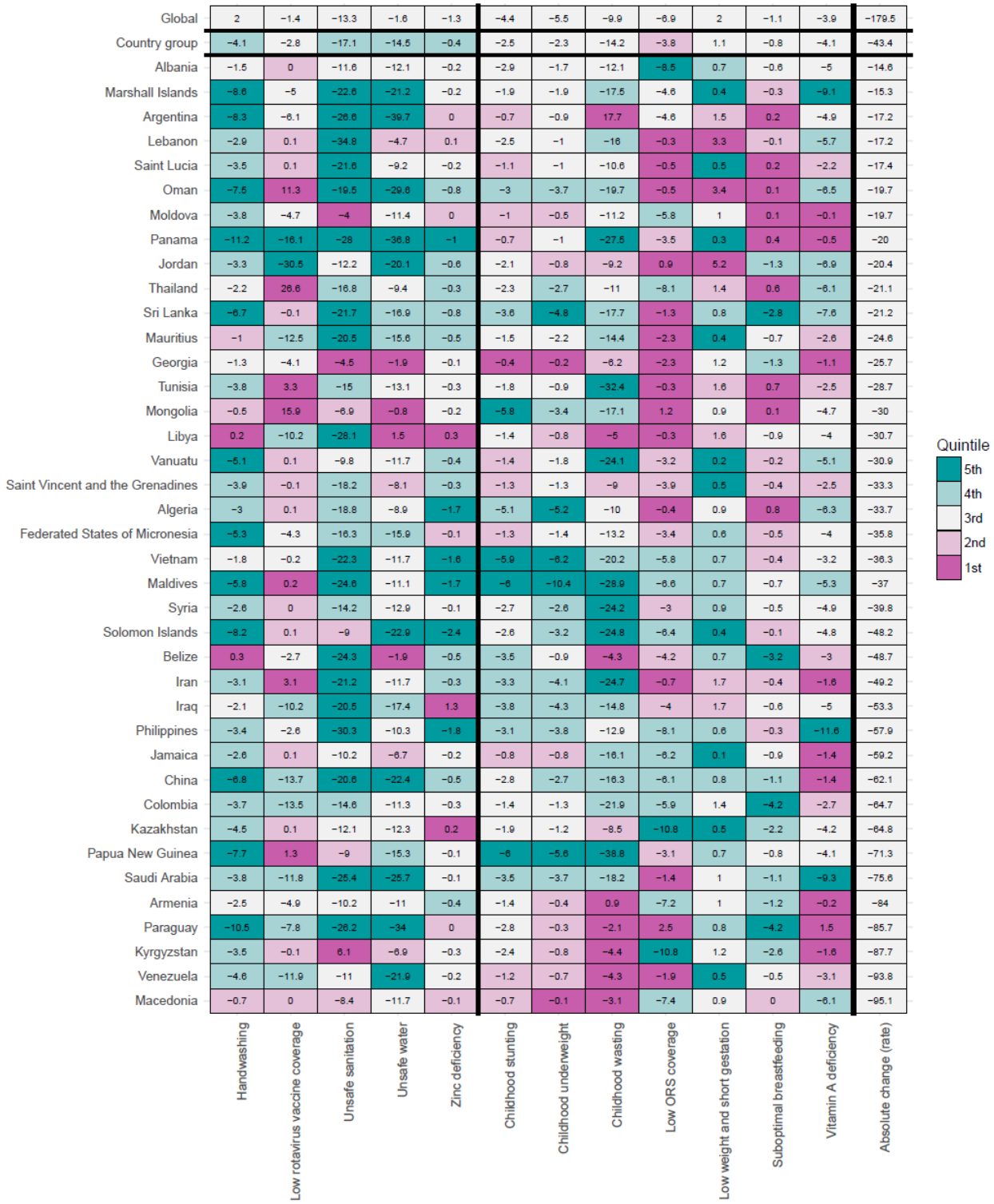
A)


Global 2 −1.4 −13.3 −1.6 −1.3 −4.4 −5.5 −9.9 −6.9 2 −1.1 −3.9 −179.5
Country group −2.2 −9.2 −10.5 −9.6 −1.6 −5.9 −5.5 −19 −7.1 1.7 −2.1 −9.4 −544.3
Ghana −1.2 −6.6 −10.4 −3.8 −11 −5.2 −5 −17 −5 −0.4 −4.8 −13.1 −336.8
Bolivia −6.1 −5.2 −12.7 −21 −0.7 −5.4 −2 −13.8 −4.8 0.4 −1.3 −3.2 −344.7
Ethiopia −0.5 −1.2 −2.8 −13.9 0 −7.2 −10.6 −21 −5 3.8 −1.2 −5.9 −344.9
Tanzania −0.7 −15.3 −6.6 −10 −0.2 −4.6 −4.9 −21.6 7.5 0.5 −5.9 −14.3 −349.8
Guinea −0.5 −0.3 −8.1 −7.2 −0.8 −3.4 −4 −39.4 −3.8 2.9 −0.9 −11.1 −362.6
Sao Tome and Principe −5.5 −15.6 −16.8 −19.1 −0.7 −4.7 −3.3 −9.5 −5.4 0.6 −1.4 −9.5 −368.5
Nicaragua −5.5 −9.1 −13.6 −20.1 −0.4 −2 −1.4 −18.1 −6.5 0.4 −1.3 −4.9 −374.7
Sudan −1.2 −8.9 −5.4 2.6 −2.6 −6.2 −6.9 −24.7 1.5 2.4 −6.7 −7.1 −380.7
Guatemala −8.1 −0.9 −18.6 −17.2 −0.2 −5.7 −5.8 −40.9 −9 0.2 −0.6 −4.8 −381.1
Comoros −1.8 0.7 −3.7 −10.7 0.3 −4.8 −4.8 −18.6 −11.9 1.5 0.3 −6.1 −401.3
Bangladesh −1.3 8 −7.8 −2.4 −1.3 −6.1 −8.7 −18.3 −14.2 0.2 −1.3 −4.1 −407.1
Cameroon −1.6 −30 −8.8 −11.6 −1.1 −8.6 −4.2 −14.5 0 2.6 −2.9 −16.2 −427.1
Afghanistan −2.5 0.1 −17.4 −4.6 5.5 −7.9 −9.4 −37.7 0.1 3 −1.1 −3.7 −430.1
Madagascar 0.4 −7.4 1.4 −2.9 0.4 −3.5 −3 −28.6 −0.3 0.4 −3.4 −5.6 −434.5
Guinea−Bissau −0.6 −25.3 −6.8 −5.3 −2.1 −8.7 −4.7 −28 2.2 1.7 −3.2 −10.3 −438.3
Mozambique −0.9 −21.1 −5.8 −8.9 −7.1 −8.7 −7 −47.1 −10.5 0.8 −1.3 −12.5 −439.2
Laos −3.2 25.9 −12.3 −13.8 −1.5 −4.4 −9.6 −55.2 −10.7 0.9 −1.9 −6.8 −441.8
Egypt −5.3 17.1 −30.6 −28.2 0 −1.1 −1.2 −13.5 −4.9 3.7 0.4 −4.3 −445.1
Nepal −5.9 −6.4 −17.7 −7.6 −0.5 −6.3 −6.5 −17.3 −12.3 2.2 0 −5.5 −455.6
Pakistan −5.3 −3.3 −24.5 −3.4 −1.7 −5.9 −3.2 14.5 −0.7 4.9 −0.2 −10.6 −462.7
Zambia −1.5 −27.7 −2.1 −5.5 −0.1 −5 −2.8 −1.2 −10.3 0.6 −5.5 −14.5 −468.2
Togo −0.6 −34.3 −7.8 −4.8 −1.7 −5.1 −4.4 13.1 0.9 1.5 −4.1 −9.7 −473.9
Somalia −0.8 1.2 −5.3 −10.2 1 −4 −4.5 −37 −18 1.8 0.8 −7.8 −492.5
Burkina Faso −0.7 −39.2 −2.7 −5.4 0.1 −9 −7.5 19.9 −4.1 1.8 −1.8 −13.1 −543
Mauritania −3.5 −15.2 −6.3 −8.7 0.4 −5.1 −3.6 39.2 −4.4 2.4 −2.3 −8.8 −551.9
Senegal −1.4 −19.4 −11.9 −19 −2.4 −5.1 −3.9 −10 −4.6 0.6 −3 −13.5 −554.3
Equatorial Guinea −5.4 0.5 −37 −24.9 −8.8 −13.5 −10.4 −33.2 −5.7 3.6 0.7 −15.3 −555.9
Chad −1.6 −0.6 −3.6 −6.9 0 −5.2 −6.6 −37.4 −4.7 1.6 0.8 −15.5 −577.1
Yemen −6.3 −9.7 −28.2 −15.4 −0.8 −6.7 −5.1 −10 −3.5 0.3 0.2 −8.8 −630.1
Eritrea −0.8 −20.9 −6.1 −10.2 −1.3 −8.4 −10.1 −36.5 −9.6 1.3 −0.7 −9.8 −639.9
Sierra Leone −0.5 −20.6 −4.8 −3.7 −8.3 −4.6 −5.4 −20.3 −24.5 1.3 −1.4 −12.3 −678.8
Haiti 0.2 −1.9 −4.3 −3.2 −0.2 −5.1 −5.1 −10.9 −12.9 0.4 −4.3 −4.2 −731.3
Rwanda −0.4 −30.3 −1.1 −8.6 −0.8 −5.2 −3.7 −10.7 −3.8 2.3 −1 −5.3 −749.4
Malawi 0.3 −15.3 −3.3 −6.3 −0.2 −5.2 −4.6 −23.5 −12.7 1.5 −5.9 −8.3 −778.7
Nigeria −0.8 31 −24.3 −6.6 −3.8 −8.5 −2.2 −13.2 −17.2 3.5 −1.5 −9.4 −785.2
Mali −0.8 −5.1 −3.1 −9.1 0.3 −4.3 −6.9 −22.1 −13.9 3 −3 −12.9 −794.2
Angola −1.1 −10.9 −19 −8.8 −10.1 −9.8 −11.6 −53.9 −6.3 2.8 −3.7 −16.1 −891.4
Liberia 0.1 −12.9 −7.9 −0.5 2.3 −8.5 −3.7 −13.1 −8.7 1.5 −5.7 −10.4 −960.4
Niger −1.4 −23 −2.3 −7.4 −1.3 −7.4 −8.2 −9.2 −19.1 1.4 −1 −11.2 −1344.2
Handwashing
Low rotavirus vaccine coverage
Unsafe sanitation
Unsafe water
Zinc deficiency
Childhood stunting
Childhood underweight
Childhood wasting
Low ORS coverage
Low weight and short gestation
Suboptimal breastfeeding
Vitamin A deficiency
Absolute change (rate)
Quintile
5th
4th
3rd
2nd
1st

B)


Global 2 −1.4 −13.3 −1.6 −1.3 −4.4 −5.5 −9.9 −6.9 2 −1.1 −3.9 −179.5
Country group −3.7 −7.7 −12.6 −14 −0.6 −3.9 −3.9 −11 −5.9 1.1 −1.6 −5.5 −202.8
Uzbekistan −4.4 −6.2 −6.6 −7.9 −0.2 −4.7 −2.5 −20.4 −1.4 0.6 −1 −2.8 −100.1
Kenya −1.1 −13.7 −7.6 −11.6 −0.2 −6.8 −7 −26.5 −4.6 3.1 −5.6 −2.9 −106.6
Guyana 3.3 −17.4 −18.4 1.7 −0.7 −0.9 −2.8 −24 −4.5 0.7 −1.2 −2.8 −110.2
Congo −3.3 −27.4 −11.4 −19.4 −1.5 −4 −5.2 21.2 −6.7 1.1 0 −11.6 −111.9
Gabon −5.3 −0.1 −19.1 −32.4 −0.3 −5.4 −2.7 −8.5 −3.7 1.3 1 −8.9 −119.5
Turkey −4.2 −4.5 −18 −13.9 −0.1 −2.1 −1.6 −6.3 −2.3 3.8 −1.8 −5.9 −124.9
Mexico −3.1 −12.7 −14 −16.7 0.1 −2 −1.3 −17.2 −1.3 0.8 1 −0.6 −125.4
Suriname −3.4 −0.1 −16.5 −7.2 −0.1 −1.1 −1.2 −9 −3.9 1.1 0.4 −1.8 −132.3
Botswana −7.5 −5.8 −21.8 −39.2 −0.3 −2.8 −3 −30.1 −2.6 1.7 1.5 −10.1 −134.3
Azerbaijan −5.1 2.5 −10.8 −18 −1.1 −1.8 −1.3 −11.9 −4.6 −0.2 −0.1 −2.1 −136.2
Ecuador −4.8 −5.3 −19.2 −16.8 −1.4 −3.1 −2.5 −12.1 −3.9 0.5 −1.6 −2.8 −141.4
The Gambia −1.1 −7.1 −12.7 −14.4 −5.6 −6.4 −6.2 −6.4 −10.2 1.8 −1.6 −14 −154.6
Cote d'Ivoire −1.5 −10.3 −9.2 −10.7 −1 −6.1 −3.1 −22.1 −2.3 1.3 −3.2 −18.6 −154.7
Turkmenistan −2.9 0 −9.1 −8.7 −0.8 −3.1 −2.4 −18.5 −2.7 0.7 −3.9 −2 −154.8
Peru −4.7 −14.5 −8.4 −17.3 −3.2 −6.4 −1.5 −13.2 −5.2 0.4 −4.6 −4.7 −165
Swaziland −6.7 −21.3 −5.6 −15.6 0.6 −4.8 −1.7 −6.9 −4.4 0.7 −1.9 −6.2 −172.6
Lesotho −0.5 −12.1 −4.8 −7.3 −0.6 −3.5 −3.4 −82.3 −5.5 1.2 −5.4 −10.9 −185.6
Indonesia −0.8 −1.3 −28 −7.6 −0.7 −3.7 −3.9 −15.1 −2.7 1 −0.3 −5.5 −191.3
Democratic Republic of the Congo 0 −8 −6.6 −1.5 −1.4 −2 −3.9 9.9 −6 1.6 −3.5 −4.2 −192.6
Bhutan −10.7 0.4 −17.6 −28.7 −0.9 −5.9 −5.1 −12.1 −3.1 1.5 −0.7 −4 −193.9
Kiribati −7 −8.8 −12 −13.7 0 −2.7 −2.1 −17.3 −1.9 0.4 −0.7 −2.8 −196.3
Brazil −8.4 −11.1 −11.3 −26.1 −0.1 −1.3 −0.8 −9.8 −12.8 1.1 −2.7 0.5 −206.7
Cambodia −7.1 1.7 −18.9 −13.6 −1.1 −6.4 −9.5 −22.4 −7.4 0.8 −4 −5.6 −220.7
Namibia −9 −10.5 −14 −22.3 0 −4.2 −4.6 −14.4 −7.9 1.6 −3.3 −3.1 −225.3
Dominican Republic −2.1 −5.4 −18.8 −2.4 −1.1 −1.4 −1.1 −3.2 −8.4 0.8 0.4 −3.1 −231
Myanmar −2.1 0.9 −17.7 −9.4 −3.8 −4.8 −6.2 −22 −8.6 0.7 −3.3 −7.1 −232.7
Uganda −1.6 −6.7 −3.4 −14.4 −0.8 −8.5 −5.6 −18.6 −9.3 1.1 −1.1 −10.4 −243.3
El Salvador −6.4 −12.4 −10.7 −19.1 −0.2 −2.8 −1.8 −17.7 −5.2 0.6 −3.5 −7.4 −244.3
Honduras −3.1 −13.3 −17.8 −14.9 −0.3 −5.4 −3.8 −16.8 −7.4 0.7 −0.5 −4 −263.6
Morocco −7.2 −16.6 −18.3 −20.4 −0.1 −3.2 −1.9 −11.2 −6.3 2.1 1.3 −3.1 −266.7
Tajikistan −0.4 −12.9 −1.7 −4.1 0.1 −3.2 −2.4 177.8 −14 −0.1 −1.2 −2 −272.2
South Sudan −0.2 1.3 0.4 −3.1 0 −6.4 −9.7 −23.5 −2.9 0.9 −5 −10 −275.7
South Africa −5.5 −10.2 −15.6 −17.7 −0.1 −2.8 −2.2 −14.4 −4.2 1.2 −0.5 −2.3 −281.1
Burundi −0.3 −23.2 −2.6 −4 7.5 0.8 −2.3 −11.8 −5.1 1.2 −1.6 −4.3 −295.1
Benin −2 −0.5 −6.2 −15.5 −1.5 −3.3 −4.6 −15.1 −16 1.2 −2.3 −15.5 −302.7
Timor−Leste −5.2 0.3 −9.4 −16.1 −0.8 −6.7 −11.5 −22.2 −13.2 0.2 −0.6 −5.9 −305.2
India −3.2 −1 −21.8 −6.2 −0.8 −6.7 −9.9 −17.3 −15.3 2.3 −0.8 −1.4 −311.4
Djibouti −1.8 −8.5 −9.2 −13.6 −1.7 −2.8 −6.3 −21 −0.1 1.3 0.2 −5.2 −311.8
Cape Verde −3.2 −0.2 −15.6 −17.3 −0.4 −3.5 −2.9 −16.4 −2.8 0.9 −1.6 −0.2 −314
Handwashing
Low rotavirus vaccine coverage
Unsafe sanitation
Unsafe water
Zinc deficiency
Childhood stunting
Childhood underweight
Childhood wasting
Low ORS coverage
Low weight and short gestation
Suboptimal breastfeeding
Vitamin A deficiency
Absolute change (rate)
Quintile
5th
4th
3rd
2nd
1st

C)


Global 2 −1.4 −13.3 −1.6 −1.3 −4.4 −5.5 −9.9 −6.9 2 −1.1 −3.9 −179.5
Country group −4.1 −2.8 −17.1 −14.5 −0.4 −2.5 −2.3 −14.2 −3.8 1.1 −0.8 −4.1 −43.4
Albania −1.5 0 −11.6 −12.1 −0.2 −2.9 −1.7 −12.1 −8.5 0.7 −0.6 −5 −14.6
Marshall Islands −8.6 −5 −22.6 −21.2 −0.2 −1.9 −1.9 −17.5 −4.6 0.4 −0.3 −9.1 −15.3
Argentina −8.3 −6.1 −26.6 −39.7 0 −0.7 −0.9 17.7 −4.6 1.5 0.2 −4.9 −17.2
Lebanon −2.9 0.1 −34.8 −4.7 0.1 −2.5 −1 −16 −0.3 3.3 −0.1 −5.7 −17.2
Saint Lucia −3.5 0.1 −21.6 −9.2 −0.2 −1.1 −1 −10.6 −0.5 0.5 0.2 −2.2 −17.4
Oman −7.5 11.3 −19.5 −29.6 −0.8 −3 −3.7 −19.7 −0.5 3.4 0.1 −6.5 −19.7
Moldova −3.8 −4.7 −4 −11.4 0 −1 −0.5 −11.2 −5.8 1 0.1 −0.1 −19.7
Panama −11.2 −16.1 −28 −36.8 −1 −0.7 −1 −27.5 −3.5 0.3 0.4 −0.5 −20
Jordan −3.3 −30.5 −12.2 −20.1 −0.6 −2.1 −0.8 −9.2 0.9 5.2 −1.3 −6.9 −20.4
Thailand −2.2 26.6 −16.8 −9.4 −0.3 −2.3 −2.7 −11 −8.1 1.4 0.6 −6.1 −21.1
Sri Lanka −6.7 −0.1 −21.7 −16.9 −0.8 −3.6 −4.8 −17.7 −1.3 0.8 −2.8 −7.6 −21.2
Mauritius −1 −12.5 −20.5 −15.6 −0.5 −1.5 −2.2 −14.4 −2.3 0.4 −0.7 −2.6 −24.6
Georgia −1.3 −4.1 −4.5 −1.9 −0.1 −0.4 −0.2 −6.2 −2.3 1.2 −1.3 −1.1 −25.7
Tunisia −3.8 3.3 −15 −13.1 −0.3 −1.8 −0.9 −32.4 −0.3 1.6 0.7 −2.5 −28.7
Mongolia −0.5 15.9 −6.9 −0.8 −0.2 −5.8 −3.4 −17.1 1.2 0.9 0.1 −4.7 −30
Libya 0.2 −10.2 −28.1 1.5 0.3 −1.4 −0.8 −5 −0.3 1.6 −0.9 −4 −30.7
Vanuatu −5.1 0.1 −9.8 −11.7 −0.4 −1.4 −1.8 −24.1 −3.2 0.2 −0.2 −5.1 −30.9
Saint Vincent and the Grenadines −3.9 −0.1 −18.2 −8.1 −0.3 −1.3 −1.3 −9 −3.9 0.5 −0.4 −2.5 −33.3
Algeria −3 0.1 −18.8 −8.9 −1.7 −5.1 −5.2 −10 −0.4 0.9 0.8 −6.3 −33.7
Federated States of Micronesia −5.3 −4.3 −16.3 −15.9 −0.1 −1.3 −1.4 −13.2 −3.4 0.6 −0.5 −4 −35.8
Vietnam −1.8 −0.2 −22.3 −11.7 −1.6 −5.9 −6.2 −20.2 −5.8 0.7 −0.4 −3.2 −36.3
Maldives −5.8 0.2 −24.6 −11.1 −1.7 −6 −10.4 −28.9 −6.6 0.7 −0.7 −5.3 −37
Syria −2.6 0 −14.2 −12.9 −0.1 −2.7 −2.6 −24.2 −3 0.9 −0.5 −4.9 −39.8
Solomon Islands −8.2 0.1 −9 −22.9 −2.4 −2.6 −3.2 −24.8 −6.4 0.4 −0.1 −4.8 −48.2
Belize 0.3 −2.7 −24.3 −1.9 −0.5 −3.5 −0.9 −4.3 −4.2 0.7 −3.2 −3 −48.7
Iran −3.1 3.1 −21.2 −11.7 −0.3 −3.3 −4.1 −24.7 −0.7 1.7 −0.4 −1.6 −49.2
Iraq −2.1 −10.2 −20.5 −17.4 1.3 −3.8 −4.3 −14.8 −4 1.7 −0.6 −5 −53.3
Philippines −3.4 −2.6 −30.3 −10.3 −1.8 −3.1 −3.8 −12.9 −8.1 0.6 −0.3 −11.6 −57.9
Jamaica −2.6 0.1 −10.2 −6.7 −0.2 −0.8 −0.8 −16.1 −6.2 0.1 −0.9 −1.4 −59.2
China −6.8 −13.7 −20.6 −22.4 −0.5 −2.8 −2.7 −16.3 −6.1 0.8 −1.1 −1.4 −62.1
Colombia −3.7 −13.5 −14.6 −11.3 −0.3 −1.4 −1.3 −21.9 −5.9 1.4 −4.2 −2.7 −64.7
Kazakhstan −4.5 0.1 −12.1 −12.3 0.2 −1.9 −1.2 −8.5 −10.8 0.5 −2.2 −4.2 −64.8
Papua New Guinea −7.7 1.3 −9 −15.3 −0.1 −6 −5.6 −38.8 −3.1 0.7 −0.8 −4.1 −71.3
Saudi Arabia −3.8 −11.8 −25.4 −25.7 −0.1 −3.5 −3.7 −18.2 −1.4 1 −1.1 −9.3 −75.6
Armenia −2.5 −4.9 −10.2 −11 −0.4 −1.4 −0.4 0.9 −7.2 1 −1.2 −0.2 −84
Paraguay −10.5 −7.8 −26.2 −34 0 −2.8 −0.3 −2.1 2.5 0.8 −4.2 1.5 −85.7
Kyrgyzstan −3.5 −0.1 6.1 −6.9 −0.3 −2.4 −0.8 −4.4 −10.8 1.2 −2.6 −1.6 −87.7
Venezuela −4.6 −11.9 −11 −21.9 −0.2 −1.2 −0.7 −4.3 −1.9 0.5 −0.5 −3.1 −93.8
Macedonia −0.7 0 −8.4 −11.7 −0.1 −0.7 −0.1 −3.1 −7.4 0.9 0 −6.1 −95.1
Handwashing
Low rotavirus vaccine coverage
Unsafe sanitation
Unsafe water
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Childhood stunting
Childhood underweight
Childhood wasting
Low ORS coverage
Low weight and short gestation
Suboptimal breastfeeding
Vitamin A deficiency
Absolute change (rate)
Quintile
5th
4th
3rd
2nd
1st

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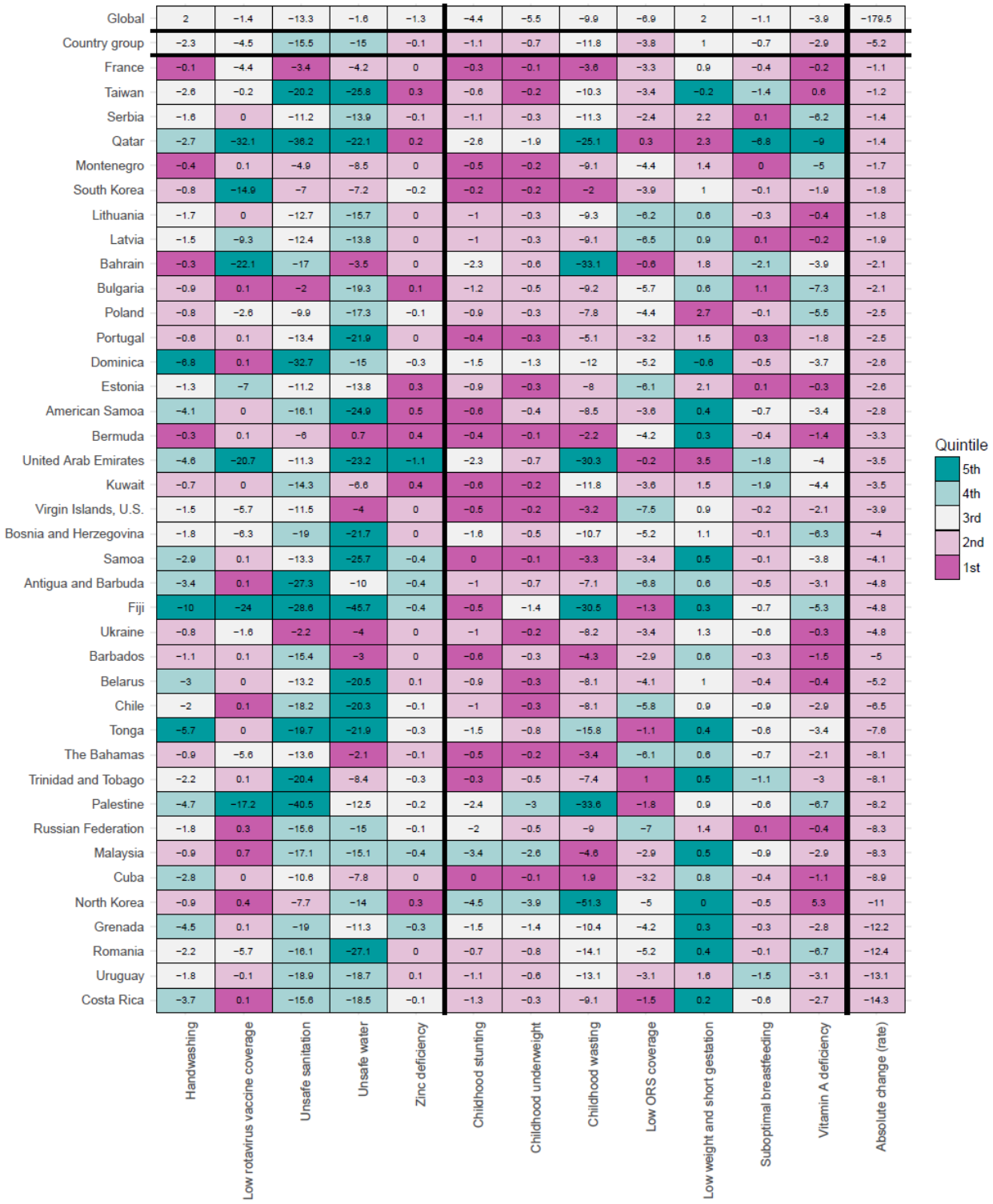
Global 2 −1.4 −13.3 −1.6 −1.3 −4.4 −5.5 −9.9 −6.9 2 −1.1 −3.9 −179.5
Country group −2.3 −4.5 −15.5 −15 −0.1 −1.1 −0.7 −11.8 −3.8 1 −0.7 −2.9 −5.2
France −0.1 −4.4 −3.4 −4.2 0 −0.3 −0.1 −3.6 −3.3 0.9 −0.4 −0.2 −1.1
Taiwan −2.6 −0.2 −20.2 −25.8 0.3 −0.6 −0.2 −10.3 −3.4 −0.2 −1.4 0.6 −1.2
Serbia −1.6 0 −11.2 −13.9 −0.1 −1.1 −0.3 −11.3 −2.4 2.2 0.1 −6.2 −1.4
Qatar −2.7 −32.1 −36.2 −22.1 0.2 −2.6 −1.9 −25.1 0.3 2.3 −6.8 −9 −1.4
Montenegro −0.4 0.1 −4.9 −8.5 0 −0.5 −0.2 −9.1 −4.4 1.4 0 −5 −1.7
South Korea −0.8 −14.9 −7 −7.2 −0.2 −0.2 −0.2 −2 −3.9 1 −0.1 −1.9 −1.8
Lithuania −1.7 0 −12.7 −15.7 0 −1 −0.3 −9.3 −6.2 0.6 −0.3 −0.4 −1.8
Latvia −1.5 −9.3 −12.4 −13.8 0 −1 −0.3 −9.1 −6.5 0.9 0.1 −0.2 −1.9
Bahrain −0.3 −22.1 −17 −3.5 0 −2.3 −0.6 −33.1 −0.6 1.8 −2.1 −3.9 −2.1
Bulgaria −0.9 0.1 −2 −19.3 0.1 −1.2 −0.5 −9.2 −5.7 0.6 1.1 −7.3 −2.1
Poland −0.8 −2.6 −9.9 −17.3 −0.1 −0.9 −0.3 −7.8 −4.4 2.7 −0.1 −5.5 −2.5
Portugal −0.6 0.1 −13.4 −21.9 0 −0.4 −0.3 −5.1 −3.2 1.5 0.3 −1.8 −2.5
Dominica −6.8 0.1 −32.7 −15 −0.3 −1.5 −1.3 −12 −5.2 −0.6 −0.5 −3.7 −2.6
Estonia −1.3 −7 −11.2 −13.8 0.3 −0.9 −0.3 −8 −6.1 2.1 0.1 −0.3 −2.6
American Samoa −4.1 0 −16.1 −24.9 0.5 −0.6 −0.4 −8.5 −3.6 0.4 −0.7 −3.4 −2.8
Bermuda −0.3 0.1 −6 0.7 0.4 −0.4 −0.1 −2.2 −4.2 0.3 −0.4 −1.4 −3.3
United Arab Emirates −4.6 −20.7 −11.3 −23.2 −1.1 −2.3 −0.7 −30.3 −0.2 3.5 −1.8 −4 −3.5
Kuwait −0.7 0 −14.3 −6.6 0.4 −0.6 −0.2 −11.8 −3.6 1.5 −1.9 −4.4 −3.5
Virgin Islands, U.S. −1.5 −5.7 −11.5 −4 0 −0.5 −0.2 −3.2 −7.5 0.9 −0.2 −2.1 −3.9
Bosnia and Herzegovina −1.8 −6.3 −19 −21.7 0 −1.6 −0.5 −10.7 −5.2 1.1 −0.1 −6.3 −4
Samoa −2.9 0.1 −13.3 −25.7 −0.4 0 −0.1 −3.3 −3.4 0.5 −0.1 −3.8 −4.1
Antigua and Barbuda −3.4 0.1 −27.3 −10 −0.4 −1 −0.7 −7.1 −6.8 0.6 −0.5 −3.1 −4.8
Fiji −10 −24 −28.6 −45.7 −0.4 −0.5 −1.4 −30.5 −1.3 0.3 −0.7 −5.3 −4.8
Ukraine −0.8 −1.6 −2.2 −4 0 −1 −0.2 −8.2 −3.4 1.3 −0.6 −0.3 −4.8
Barbados −1.1 0.1 −15.4 −3 0 −0.6 −0.3 −4.3 −2.9 0.6 −0.3 −1.5 −5
Belarus −3 0 −13.2 −20.5 0.1 −0.9 −0.3 −8.1 −4.1 1 −0.4 −0.4 −5.2
Chile −2 0.1 −18.2 −20.3 −0.1 −1 −0.3 −8.1 −5.8 0.9 −0.9 −2.9 −6.5
Tonga −5.7 0 −19.7 −21.9 −0.3 −1.5 −0.8 −15.8 −1.1 0.4 −0.6 −3.4 −7.6
The Bahamas −0.9 −5.6 −13.6 −2.1 −0.1 −0.5 −0.2 −3.4 −6.1 0.6 −0.7 −2.1 −8.1
Trinidad and Tobago −2.2 0.1 −20.4 −8.4 −0.3 −0.3 −0.5 −7.4 1 0.5 −1.1 −3 −8.1
Palestine −4.7 −17.2 −40.5 −12.5 −0.2 −2.4 −3 −33.6 −1.8 0.9 −0.6 −6.7 −8.2
Russian Federation −1.8 0.3 −15.6 −15 −0.1 −2 −0.5 −9 −7 1.4 0.1 −0.4 −8.3
Malaysia −0.9 0.7 −17.1 −15.1 −0.4 −3.4 −2.6 −4.6 −2.9 0.5 −0.9 −2.9 −8.3
Cuba −2.8 0 −10.6 −7.8 0 0 −0.1 1.9 −3.2 0.8 −0.4 −1.1 −8.9
North Korea −0.9 0.4 −7.7 −14 0.3 −4.5 −3.9 −51.3 −5 0 −0.5 5.3 −11
Grenada −4.5 0.1 −19 −11.3 −0.3 −1.5 −1.4 −10.4 −4.2 0.3 −0.3 −2.8 −12.2
Romania −2.2 −5.7 −16.1 −27.1 0 −0.7 −0.8 −14.1 −5.2 0.4 −0.1 −6.7 −12.4
Uruguay −1.8 −0.1 −18.9 −18.7 0.1 −1.1 −0.6 −13.1 −3.1 1.6 −1.5 −3.1 −13.1
Costa Rica −3.7 0.1 −15.6 −18.5 −0.1 −1.3 −0.3 −9.1 −1.5 0.2 −0.6 −2.7 −14.3
Handwashing
Low rotavirus vaccine coverage
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Vitamin A deficiency
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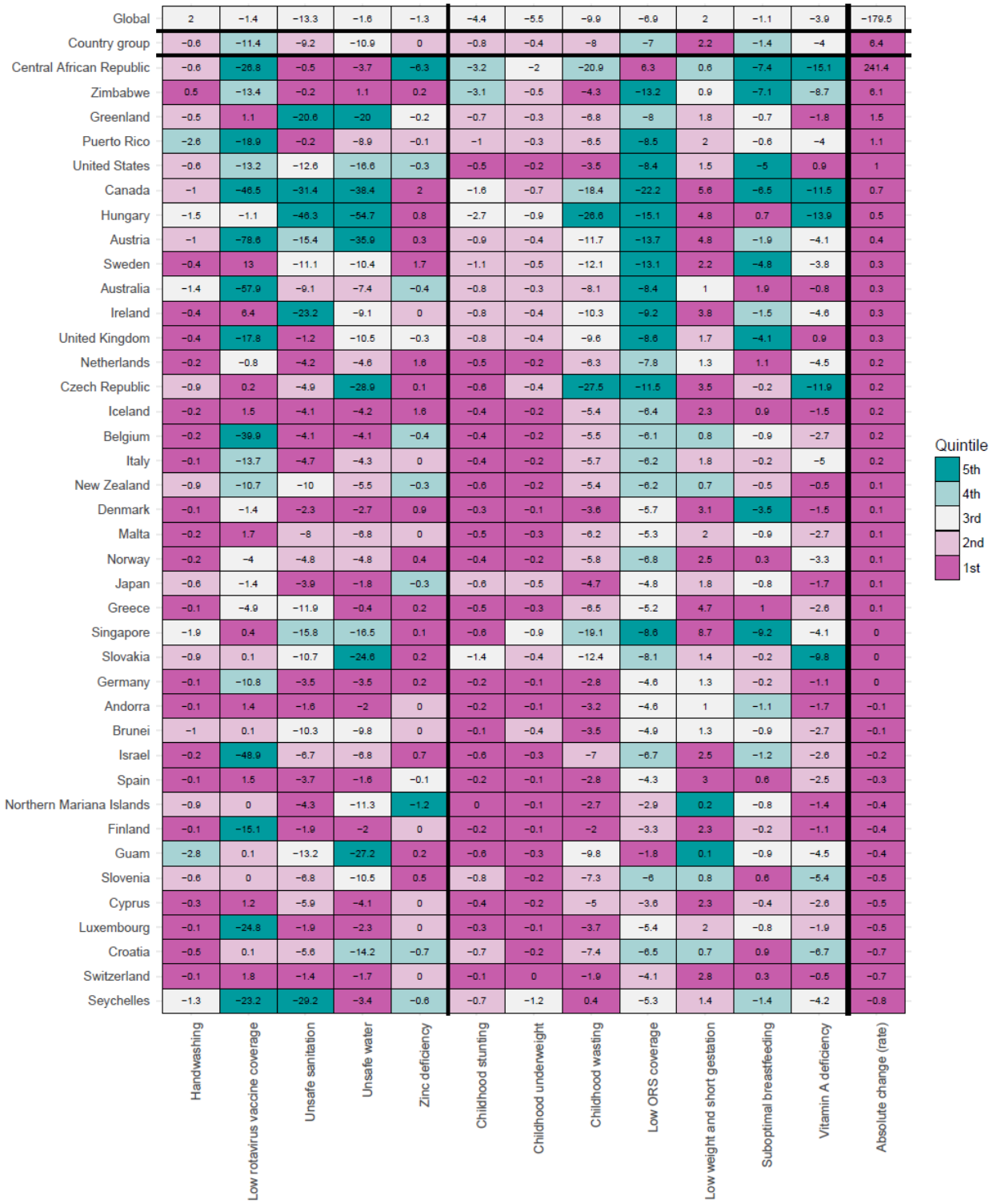
Global 2 −1.4 −13.3 −1.6 −1.3 −4.4 −5.5 −9.9 −6.9 2 −1.1 −3.9 −179.5
Country group −0.6 −11.4 −9.2 −10.9 0 −0.8 −0.4 −8 −7 2.2 −1.4 −4 6.4
Central African Republic −0.6 −26.8 −0.5 −3.7 −6.3 −3.2 −2 −20.9 6.3 0.6 −7.4 −15.1 241.4
Zimbabwe 0.5 −13.4 −0.2 1.1 0.2 −3.1 −0.5 −4.3 −13.2 0.9 −7.1 −8.7 6.1
Greenland −0.5 1.1 −20.6 −20 −0.2 −0.7 −0.3 −6.8 −8 1.8 −0.7 −1.8 1.5
Puerto Rico −2.6 −18.9 −0.2 −8.9 −0.1 −1 −0.3 −6.5 −8.5 2 −0.6 −4 1.1
United States −0.6 −13.2 −12.6 −16.6 −0.3 −0.5 −0.2 −3.5 −8.4 1.5 −5 0.9 1
Canada −1 −46.5 −31.4 −38.4 2 −1.6 −0.7 −18.4 −22.2 5.6 −6.5 −11.5 0.7
Hungary −1.5 −1.1 −46.3 −54.7 0.8 −2.7 −0.9 −26.6 −15.1 4.8 0.7 −13.9 0.5
Austria −1 −78.6 −15.4 −35.9 0.3 −0.9 −0.4 −11.7 −13.7 4.8 −1.9 −4.1 0.4
Sweden −0.4 13 −11.1 −10.4 1.7 −1.1 −0.5 −12.1 −13.1 2.2 −4.8 −3.8 0.3
Australia −1.4 −57.9 −9.1 −7.4 −0.4 −0.8 −0.3 −8.1 −8.4 1 1.9 −0.8 0.3
Ireland −0.4 6.4 −23.2 −9.1 0 −0.8 −0.4 −10.3 −9.2 3.8 −1.5 −4.6 0.3
United Kingdom −0.4 −17.8 −1.2 −10.5 −0.3 −0.8 −0.4 −9.6 −8.6 1.7 −4.1 0.9 0.3
Netherlands −0.2 −0.8 −4.2 −4.6 1.6 −0.5 −0.2 −6.3 −7.8 1.3 1.1 −4.5 0.2
Czech Republic −0.9 0.2 −4.9 −28.9 0.1 −0.6 −0.4 −27.5 −11.5 3.5 −0.2 −11.9 0.2
Iceland −0.2 1.5 −4.1 −4.2 1.6 −0.4 −0.2 −5.4 −6.4 2.3 0.9 −1.5 0.2
Belgium −0.2 −39.9 −4.1 −4.1 −0.4 −0.4 −0.2 −5.5 −6.1 0.8 −0.9 −2.7 0.2
Italy −0.1 −13.7 −4.7 −4.3 0 −0.4 −0.2 −5.7 −6.2 1.8 −0.2 −5 0.2
New Zealand −0.9 −10.7 −10 −5.5 −0.3 −0.6 −0.2 −5.4 −6.2 0.7 −0.5 −0.5 0.1
Denmark −0.1 −1.4 −2.3 −2.7 0.9 −0.3 −0.1 −3.6 −5.7 3.1 −3.5 −1.5 0.1
Malta −0.2 1.7 −8 −6.8 0 −0.5 −0.3 −6.2 −5.3 2 −0.9 −2.7 0.1
Norway −0.2 −4 −4.8 −4.8 0.4 −0.4 −0.2 −5.8 −6.8 2.5 0.3 −3.3 0.1
Japan −0.6 −1.4 −3.9 −1.8 −0.3 −0.6 −0.5 −4.7 −4.8 1.8 −0.8 −1.7 0.1
Greece −0.1 −4.9 −11.9 −0.4 0.2 −0.5 −0.3 −6.5 −5.2 4.7 1 −2.6 0.1
Singapore −1.9 0.4 −15.8 −16.5 0.1 −0.6 −0.9 −19.1 −8.6 8.7 −9.2 −4.1 0
Slovakia −0.9 0.1 −10.7 −24.6 0.2 −1.4 −0.4 −12.4 −8.1 1.4 −0.2 −9.8 0
Germany −0.1 −10.8 −3.5 −3.5 0.2 −0.2 −0.1 −2.8 −4.6 1.3 −0.2 −1.1 0
Andorra −0.1 1.4 −1.6 −2 0 −0.2 −0.1 −3.2 −4.6 1 −1.1 −1.7 −0.1
Brunei −1 0.1 −10.3 −9.8 0 −0.1 −0.4 −3.5 −4.9 1.3 −0.9 −2.7 −0.1
Israel −0.2 −48.9 −6.7 −6.8 0.7 −0.6 −0.3 −7 −6.7 2.5 −1.2 −2.6 −0.2
Spain −0.1 1.5 −3.7 −1.6 −0.1 −0.2 −0.1 −2.8 −4.3 3 0.6 −2.5 −0.3
Northern Mariana Islands −0.9 0 −4.3 −11.3 −1.2 0 −0.1 −2.7 −2.9 0.2 −0.8 −1.4 −0.4
Finland −0.1 −15.1 −1.9 −2 0 −0.2 −0.1 −2 −3.3 2.3 −0.2 −1.1 −0.4
Guam −2.8 0.1 −13.2 −27.2 0.2 −0.6 −0.3 −9.8 −1.8 0.1 −0.9 −4.5 −0.4
Slovenia −0.6 0 −6.8 −10.5 0.5 −0.8 −0.2 −7.3 −6 0.8 0.6 −5.4 −0.5
Cyprus −0.3 1.2 −5.9 −4.1 0 −0.4 −0.2 −5 −3.6 2.3 −0.4 −2.6 −0.5
Luxembourg −0.1 −24.8 −1.9 −2.3 0 −0.3 −0.1 −3.7 −5.4 2 −0.8 −1.9 −0.5
Croatia −0.5 0.1 −5.6 −14.2 −0.7 −0.7 −0.2 −7.4 −6.5 0.7 0.9 −6.7 −0.7
Switzerland −0.1 1.8 −1.4 −1.7 0 −0.1 0 −1.9 −4.1 2.8 0.3 −0.5 −0.7
Seychelles −1.3 −23.2 −29.2 −3.4 −0.6 −0.7 −1.2 0.4 −5.3 1.4 −1.4 −4.2 −0.8
Handwashing
Low rotavirus vaccine coverage
Unsafe sanitation
Unsafe water
Zinc deficiency
Childhood stunting
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Low weight and short gestation
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Vitamin A deficiency
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1st

Table 1. Definitions for risk factors and interventions used in this analysis. More information on each risk factor or intervention is provided in the Appendix, including input data and modeling strategy.

Type	Risk Factor	Definition	Modeled Values	Interpretation
Prevention	Handwashing	The proportion of the population that does not have access to a handwashing station with available soap and water.	The prevalence of the availability of a handwashing station with soap and water.	The provision of a handwashing station with soap reduces the exposure to fecal material.
Prevention	Low Rotavirus Vaccine Coverage	The proportion of children that are not vaccinated against rotavirus	The prevalence of children receiving a full course of rotavirus vaccine.	Not receiving the rotavirus vaccine puts children younger than 5 at an increased risk of dying from rotavirus diarrhea
Prevention	Unsafe sanitation	The proportion of the population that does not have access to a sanitation facility with a sewer connection.	The prevalence of unimproved sanitation use, the prevalence of improved sanitation facilities without a sewer connection or septic tank, the prevalence of toilet facilities with a sewer connection or septic tank.	Unsafe sanitation has three definitions based on the type of facilities in a population. Improved and unimproved facilities are based on the Joint Monitoring Programme definitions for sanitation.
Prevention	Unsafe water	The proportion of the population that does not use high quality piped water that has been boiled or filtered before drinking.	The prevalence of 1) unimproved water use without household water treatment (HWT), 2) unimproved water source with chlorine or solar purification, 3) unimproved water source with boiling or filtration, 4) Improved, non-piped water source without HWT, 5) Improved, non-piped water source with chlorine or solar purification, 6) Improved, non-piped water source with boiling or filtration, 7) Piped water source without HWT, 8) Piped water source with chlorine or solar purification, 9) Piped water source with boiling or filtration, 10) High quality piped water.	Unsafe water has several categorical definitions that have different relative risks for diarrhea. The definitions for improved and unimproved are from the Joint Monitoring Programme for water and sanitation. For example, unimproved and untreated water has the highest risk of diarrhea while improved, untreated water has a lower, but still existent, risk for diarrhea. The prevalence of each of these types of water are modeled for every population.
Prevention	Zinc deficiency	Consumption of less than 2.5 milligrams of dietary zinc per day	The prevalence of children who do not receive sufficient dietary zinc.	The low consumption of zinc puts children at elevated risks for mortality due to diarrhea.
Protection	Childhood stunting	Proportion of children younger than 5 years that are less than the WHO 2006 growth standard for height-for-age based on z-scores from that standard. The prevalence of mild (<-1 z score), moderate (-1 to -2 z scores), and severe	Prevalence of mild, moderate, and severe stunting.	Children who are short for their age, based on international growth standards, have a greater risk of dying from diarrhea than children who are not. Relative risks for diarrhea mortality by mild, moderate, and severe stunting are used in this analysis as

		(>-3 z-scores) were estimated for each population.		are modeled prevalence estimates for each of the stunting categories.
Protection	Childhood underweight	Proportion of children younger than 5 years that are less than the WHO 2006 growth standard for weight-for-age based on z-scores from that standard. The prevalence of mild (<-1 z score), moderate (-1 to -2 z scores), and severe (>-3 z-scores) were estimated for each population.	Prevalence of mild, moderate, and severe underweight.	Children who are low body weight for their age, based on international growth standards, have a greater risk of dying from diarrhea than children who are not. Relative risks for diarrhea mortality by mild, moderate, and severe underweight are used in this analysis as are modeled prevalence estimates for each of the underweight categories.
Protection	Childhood wasting	Proportion of children younger than 5 years that are less than the WHO 2006 growth standard for weight-for-height based on z-scores from that standard. The prevalence of mild (<-1 z score), moderate (-1 to -2 z scores), and severe (>-3 z-scores) were estimated for each population.	Prevalence of mild, moderate, and severe wasting.	Children who are low weight for their height, based on international growth standards, have a greater risk of dying from diarrhea than children who are not. Relative risks for diarrhea mortality by mild, moderate, and severe wasting are used in this analysis as are modeled prevalence estimates for each of the wasting categories.
Protection	Low birth weight and short gestation	A joint estimation of the prevalence of birth weight and gestational age below the minimum risk exposure level for birth weight and gestational age (<4000 grams and <38 weeks of gestation).	Jointly estimated prevalence of low weight and short gestational period, measured in a matrix of 500-gram birth weight and 2-week gestational periods.	The prevalence of low birth weight and short gestation period are modeled jointly. The prevalence for each category of birth weight, in 500 gram bins, and short gestation, in 2 week bins, represents the proportion of children in a population that were born prematurely.
Protection	Low Oral Rehydration Solution Coverage	The proportion of children with diarrhea that did not receive oral rehydration solution or recommended home fluids	The prevalence of children with diarrhea that were treated with oral rehydration solution or with recommended home fluids.	Not receiving oral rehydration solution or recommended home fluids puts children with diarrhea at an increased risk of death.
Protection	Suboptimal Breastfeeding	Suboptimal breastfeeding is either non-exclusive breastfeeding or discontinued breastfeeding. Non-exclusive breastfeeding is the proportion of children younger than 6 months that are not exclusively breastfed (predominant, partial, and none). Discontinued breastfeeding is the proportion of children 6 to 23 months who receive no breast milk.	Prevalence of predominant, partial, and no breastfeeding among children younger than 6 months, prevalence of children 6-23 months who receive no breastmilk.	Suboptimal breastfeeding is either non-exclusive breastfeeding for infants under 6 months or discontinued breastfeeding for children 6-23 months.

Protection	Vitamin A deficiency	Serum retinol less than 70 µmol/L	Prevalence of Vitamin A deficiency.	The prevalence of Vitamin A deficiency among children younger than 5 is a risk factor for diarrhea mortality.

Table 2. The number of deaths due to diarrhea among children younger than 5 years in 2017, the mortality rate per 100,000, the percent change in mortality rate between 1990-2017, the absolute difference in mortality rates between 1990-2017, and the attributable fraction for nutrition, vaccine, unsafe WASH, low ORS, and all risk factors by GBD super-region, region, and country.

Location Name	Deaths (95% UI)	Mortality per 100,000 (95% UI)	Percent change in mortality rate 1990-2017 (95% UI)	Absolute difference in mortality rate 1990-2017 (95% UI)	Nutrition-associated risks attributable fraction (95% UI)	Low rotavirus vaccine attributable fraction (95% UI)	Unsafe WASH attributable fraction (95% UI)	Low ORS coverage attributable fraction (95% UI)	Total risk attributable fraction (95% UI)
Global	**533,768 (477,162-593,145)**	**78.4 (70.1-87.1)**	**-69.6% (-74.6 to -63.1%)**	-179.5 (-149.2 to -207.1)	**88.5% (81.3 to 92.4%)**	**22.0% (16.7 to 27.9%)**	**94.0% (85.9 to 98.1%)**	**57.7% (39.9 to 70.8%)**	**99.4% (98.7 to 99.8%)**
Southeast Asia, East Asia, and Oceania	22,105 (19,881-24,679)	15.6 (14.0-17.4)	-83.1% (-85.5 to -79.9%)	-76.7 (-65.6 to -88.6)	88.1% (79.8 to 92.1%)	29.5% (20.7 to 39.8%)	85.7% (66.4 to 95.6%)	54.8% (37.1 to 68.1%)	98.6% (96.8 to 99.6%)
East Asia	2,645 (2,309-3,198)	3.1 (2.7-3.8)	-95.1% (-95.9 to -94.1%)	-60.5 (-52.3 to -70.9)	77.3% (61.4 to 86.2%)	9.9% (4.5 to 19.7%)	77.4% (58.2 to 91.2%)	55.5% (37.8 to 68.7%)	95.1% (89.8 to 98.2%)
China	2,343 (2,046-2,699)	2.9 (2.5-3.4)	-95.5% (-96.4 to -94.6%)	-62.1 (-53.7 to -72.6)	76.5% (60.4 to 85.5%)	7.8% (3.2 to 16.7%)	78.3% (59.0 to 91.8%)	55.5% (37.8 to 68.8%)	95.0% (89.6 to 98.2%)
North Korea	254 (137-887)	18.9 (10.2-66.1)	-36.9% (-66.7 to 15.2%)	-11.0 (-5.4 to -0.8)	86.2% (74.2 to 92.7%)	25.6% (16.2 to 36.4%)	70.1% (51.4 to 86.0%)	56.0% (37.6 to 70.7%)	96.3% (92.8 to 98.5%)
Taiwan	6 (4-8)	0.6 (0.4-0.8)	-66.9% (-77.5 to -53.4%)	-1.2 (-1.0 to -1.4)	69.4% (52.2 to 80.3%)	22.1% (13.9 to 31.6%)	37.0% (18.0 to 61.9%)	55.1% (36.3 to 68.9%)	83.5% (73.8 to 91.0%)
Southeast Asia	18,009 (15,924-20,389)	32.4 (28.6-36.7)	-79.3% (-83.3 to -73.7%)	-123.9 (-96.8 to -152.3)	89.5% (82.3 to 93.0%)	33.3% (23.8 to 44.5%)	86.2% (66.0 to 95.9%)	54.1% (36.4 to 67.5%)	99.0% (97.4 to 99.7%)
Cambodia	300 (195-451)	16.8 (10.9-25.2)	-92.9% (-95.9 to -87.7%)	-220.7 (-160.4 to -299.0)	85.4% (75.3 to 91.8%)	36.9% (31.8 to 41.6%)	89.7% (74.6 to 97.1%)	58.1% (40.0 to 71.8%)	99.0% (97.4 to 99.8%)
Indonesia	10,568 (9,121-12,150)	50.3 (43.4-57.9)	-79.2% (-83.9 to -71.9%)	-191.3 (-139.5 to -252.7)	90.8% (85.1 to 93.7%)	38.3% (24.6 to 53.6%)	84.6% (61.4 to 95.6%)	55.4% (37.8 to 68.6%)	99.2% (97.7 to 99.8%)
Laos	949 (510-1,513)	117.9 (63.3-187.9)	-78.9% (-87.8 to -65.4%)	-441.8 (-247.4 to -648.2)	86.3% (75.3 to 92.3%)	41.8% (35.6 to 47.9%)	93.4% (83.2 to 98.2%)	54.6% (35.8 to 68.9%)	99.3% (98.1 to 99.8%)
Malaysia	54 (32-82)	2.1 (1.2-3.1)	-80.0% (-88.9 to -64.5%)	-8.3 (-6.0 to -11.6)	85.7% (75.0 to 92.0%)	16.8% (10.8 to 24.4%)	55.4% (24.5 to 80.9%)	55.5% (36.7 to 69.9%)	95.8% (91.6 to 98.4%)
Maldives	1 (0-1)	1.6 (1.0-2.5)	-95.8% (-97.9 to -91.1%)	-37.0 (-19.8 to -66.1)	85.5% (73.4 to 92.2%)	30.6% (20.0 to 43.6%)	87.8% (70.6 to 96.4%)	49.9% (31.2 to 65.5%)	98.7% (96.7 to 99.7%)
Mauritius	4 (3-5)	6.0 (4.4-7.8)	-80.4% (-85.9 to -72.2%)	-24.6 (-21.0 to -28.5)	85.2% (74.1 to 90.9%)	10.5% (5.0 to 18.9%)	28.1% (13.8 to 48.1%)	55.7% (37.0 to 69.8%)	93.0% (87.0 to 96.0%)

Location Name	Deaths (95% UI)	Mortality per 100,000 (95% UI)	Percent change in mortality rate 1990-2017 (95% UI)	Absolute difference in mortality rate 1990-2017 (95% UI)	Nutrition-associated risks attributable fraction (95% UI)	Low rotavirus vaccine attributable fraction (95% UI)	Unsafe WASH attributable fraction (95% UI)	Low ORS coverage attributable fraction (95% UI)	Total risk attributable fraction (95% UI)
Myanmar	2,003 (1,330-2,921)	45.4 (30.2-66.3)	-83.7% (-90.7 to -71.2%)	-232.7 (-140.6 to -354.5)	86.3% (74.0 to 92.6%)	38.1% (32.9 to 43.2%)	93.0% (81.7 to 98.1%)	49.2% (31.2 to 64.1%)	99.2% (98.0 to 99.8%)
Philippines	3,763 (2,638-5,239)	31.5 (22.1-43.9)	-64.8% (-76.8 to -49.4%)	-57.9 (-53.5 to -60.9)	89.0% (78.4 to 94.1%)	16.6% (10.3 to 25.0%)	85.5% (64.6 to 95.6%)	53.0% (34.8 to 67.3%)	98.5% (96.2 to 99.6%)
Sri Lanka	12 (7-19)	0.7 (0.5-1.2)	-96.6% (-98.2 to -94.1%)	-21.2 (-14.6 to -29.3)	85.6% (75.0 to 92.0%)	19.3% (12.4 to 28.0%)	84.5% (64.0 to 95.1%)	59.2% (41.3 to 72.5%)	98.6% (96.5 to 99.6%)
Seychelles	0 (0-0)	2.7 (1.8-3.9)	-22.5% (-55.0 to 29.2%)	-0.8 (-0.5 to -1.4)	81.8% (66.7 to 89.8%)	7.6% (3.1 to 15.2%)	78.2% (52.1 to 93.0%)	55.8% (36.1 to 70.5%)	96.8% (92.3 to 99.1%)
Thailand	129 (87-179)	3.8 (2.6-5.3)	-84.6% (-90.4 to -75.0%)	-21.1 (-14.2 to -30.9)	84.3% (70.1 to 91.5%)	43.5% (35.6 to 51.8%)	83.7% (59.8 to 95.2%)	48.3% (30.6 to 63.7%)	98.0% (94.7 to 99.5%)
Timor-Leste	75 (35-129)	42.9 (20.2-74.0)	-87.7% (-93.6 to -77.9%)	-305.2 (-154.4 to -522.4)	93.5% (87.3 to 96.6%)	30.3% (19.6 to 43.5%)	92.7% (81.9 to 98.0%)	42.2% (24.6 to 58.4%)	99.7% (99.0 to 99.9%)
Vietnam	128 (81-197)	1.6 (1.0-2.6)	-95.6% (-97.8 to -89.1%)	-36.3 (-17.0 to -60.4)	83.7% (71.5 to 91.0%)	37.5% (30.2 to 46.2%)	86.3% (66.3 to 95.9%)	56.1% (38.8 to 70.2%)	98.4% (95.7 to 99.6%)
Oceania	1,450 (961-2,127)	81.5 (54.0-119.6)	-37.3% (-60.7 to 0.0%)	-48.5 (-41.3 to -52.2)	88.1% (80.5 to 93.0%)	21.5% (13.9 to 31.0%)	94.8% (86.7 to 98.6%)	61.7% (44.0 to 74.5%)	99.5% (98.8 to 99.9%)
American Samoa	0 (0-0)	2.3 (1.4-3.7)	-54.2% (-76.2 to -15.5%)	-2.8 (-2.0 to -3.7)	78.2% (59.8 to 87.8%)	26.1% (17.0 to 37.6%)	69.1% (39.3 to 88.5%)	61.0% (43.6 to 73.8%)	94.1% (87.4 to 98.1%)
Federated States of Micronesia	0 (0-1)	3.5 (1.8-6.0)	-91.0% (-95.7 to -84.3%)	-35.8 (-25.0 to -49.1)	83.7% (68.7 to 92.3%)	18.8% (11.5 to 28.6%)	83.1% (62.6 to 94.6%)	60.0% (42.2 to 72.8%)	97.6% (94.1 to 99.3%)
Fiji	22 (14-33)	23.4 (14.8-35.5)	-17.0% (-54.3 to 49.8%)	-4.8 (-4.0 to -5.2)	82.6% (66.1 to 90.7%)	8.4% (3.9 to 15.7%)	76.5% (51.9 to 91.8%)	59.1% (40.7 to 72.5%)	96.5% (92.0 to 98.9%)
Guam	0 (0-0)	0.9 (0.6-1.3)	-33.5% (-60.1 to 6.8%)	-0.4 (-0.3 to -0.6)	76.2% (57.9 to 86.6%)	26.6% (17.6 to 37.8%)	59.8% (27.1 to 83.7%)	59.7% (41.7 to 73.2%)	91.7% (83.0 to 97.0%)
Kiribati	7 (4-11)	44.1 (27.2-65.1)	-81.7% (-89.5 to -69.5%)	-196.3 (-145.2 to -257.6)	88.7% (78.2 to 94.1%)	14.5% (8.2 to 23.0%)	92.1% (80.4 to 97.8%)	59.0% (39.6 to 72.7%)	99.3% (98.1 to 99.8%)
Marshall Islands	0 (0-1)	5.2 (3.2-8.1)	-74.6% (-85.3 to -56.4%)	-15.3 (-9.9 to -22.1)	83.6% (68.7 to 91.3%)	18.9% (11.5 to 28.5%)	85.4% (65.8 to 95.4%)	61.9% (44.1 to 74.9%)	97.9% (94.9 to 99.4%)
Northern Mariana Islands	0 (0-0)	0.6 (0.4-0.9)	-35.5% (-62.2 to 13.6%)	-0.4 (-0.2 to -0.6)	74.6% (55.8 to 85.5%)	25.5% (17.0 to 36.9%)	62.9% (31.7 to 85.0%)	59.5% (41.0 to 72.8%)	92.1% (83.6 to 97.3%)
Papua New Guinea	1,312 (848-1,955)	96.8 (62.6-144.2)	-42.4% (-65.2 to -4.9%)	-71.3 (-56.0 to -84.8)	88.3% (80.9 to 93.2%)	21.7% (13.9 to 31.3%)	95.2% (87.4 to 98.8%)	61.8% (44.0 to 74.7%)	99.6% (98.9 to 99.9%)

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Samoa	1 (0-1)	2.1 (1.1-3.6)	-65.7% (-80.9 to -37.7%)	-4.1 (-2.3 to -6.7)	75.2% (55.4 to 86.5%)	26.1% (17.0 to 37.6%)	61.1% (31.6 to 83.6%)	59.3% (40.9 to 72.4%)	91.3% (82.5 to 96.8%)
Solomon Islands	17 (10-27)	18.4 (10.7-29.0)	-72.4% (-84.3 to -52.5%)	-48.2 (-28.7 to -71.8)	82.6% (67.2 to 91.1%)	25.5% (16.6 to 37.4%)	91.8% (80.6 to 97.5%)	60.0% (41.8 to 73.2%)	98.7% (96.7 to 99.6%)
Tonga	0 (0-0)	2.4 (1.6-3.5)	-75.6% (-85.6 to -59.2%)	-7.6 (-5.1 to -10.7)	81.7% (65.9 to 89.7%)	25.0% (16.6 to 36.3%)	78.1% (51.4 to 92.5%)	58.9% (40.7 to 72.2%)	96.5% (91.5 to 99.0%)
Vanuatu	9 (5-14)	22.3 (12.6-35.7)	-58.1% (-76.8 to -25.4%)	-30.9 (-18.5 to -46.7)	84.5% (71.4 to 91.9%)	25.7% (16.8 to 36.9%)	94.2% (85.4 to 98.4%)	61.5% (43.7 to 74.3%)	99.2% (97.9 to 99.8%)
Central Europe, Eastern Europe, and Central Asia	2,395 (1,907-3,032)	8.6 (6.8-10.8)	-78.6% (-83.2 to -72.8%)	-31.4 (-30.5 to -31.8)	85.3% (75.4 to 90.8%)	8.0% (5.0 to 12.2%)	82.5% (66.8 to 93.3%)	51.1% (33.7 to 65.0%)	97.7% (95.4 to 99.1%)
Central Asia	2,187 (1,703-2,812)	22.8 (17.8-29.3)	-82.2% (-86.4 to -76.8%)	-105.1 (-100.5 to -108.4)	86.2% (76.8 to 91.5%)	6.5% (4.0 to 10.3%)	85.0% (69.3 to 94.8%)	50.5% (33.1 to 64.6%)	98.3% (96.3 to 99.4%)
Armenia	6 (4-7)	2.7 (2.0-3.6)	-96.9% (-97.7 to -95.6%)	-84.0 (-71.3 to -97.9)	71.2% (54.0 to 82.0%)	2.0% (0.6 to 4.9%)	53.6% (39.8 to 71.0%)	52.1% (32.2 to 67.3%)	88.7% (81.2 to 94.0%)
Azerbaijan	161 (103-242)	19.0 (12.1-28.5)	-87.8% (-92.6 to -80.2%)	-136.2 (-113.5 to -160.7)	79.3% (64.4 to 88.1%)	10.2% (8.1 to 12.5%)	72.7% (54.0 to 88.6%)	61.8% (44.5 to 74.9%)	95.6% (91.5 to 98.3%)
Georgia	7 (5-9)	2.7 (1.9-3.6)	-90.6% (-93.7 to -86.6%)	-25.7 (-20.8 to -32.5)	73.7% (57.3 to 84.2%)	4.8% (2.2 to 8.8%)	71.3% (51.0 to 87.9%)	56.2% (37.0 to 70.4%)	93.6% (87.6 to 97.5%)
Kazakhstan	64 (43-88)	3.4 (2.3-4.6)	-95.0% (-96.7 to -92.9%)	-64.8 (-55.1 to -75.5)	75.5% (58.7 to 85.3%)	15.4% (9.2 to 23.2%)	72.9% (53.8 to 88.6%)	48.2% (29.3 to 64.2%)	94.1% (88.6 to 97.8%)
Kyrgyzstan	118 (92-147)	15.2 (11.9-19.0)	-85.2% (-89.2 to -80.3%)	-87.7 (-75.0 to -102.7)	71.3% (53.8 to 82.4%)	12.1% (7.1 to 18.3%)	84.9% (70.9 to 94.6%)	48.0% (29.6 to 63.5%)	96.0% (91.5 to 98.6%)
Mongolia	27 (18-39)	7.0 (4.8-10.1)	-81.1% (-89.2 to -67.6%)	-30.0 (-20.7 to -41.5)	68.4% (51.7 to 80.8%)	35.5% (30.1 to 40.5%)	90.0% (76.0 to 97.1%)	54.8% (36.7 to 69.0%)	97.5% (93.7 to 99.3%)
Tajikistan	1,590 (1,108-2,208)	127.5 (88.8-177.1)	-68.1% (-78.2 to -54.3%)	-272.2 (-245.8 to -292.0)	90.1% (83.1 to 94.4%)	4.1% (1.7 to 8.1%)	87.5% (71.9 to 96.1%)	48.5% (31.4 to 63.3%)	99.2% (98.0 to 99.8%)
Turkmenistan	58 (40-83)	10.6 (7.2-15.0)	-93.6% (-95.7 to -90.6%)	-154.8 (-133.3 to -178.0)	74.0% (56.8 to 84.0%)	13.0% (7.9 to 19.3%)	81.8% (62.8 to 93.5%)	54.7% (36.5 to 69.0%)	96.0% (91.2 to 98.7%)

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Uzbekistan	156 (110-215)	4.5 (3.2-6.3)	-95.7% (-97.0 to -93.8%)	-100.1 (-86.2 to -114.2)	78.3% (63.8 to 86.9%)	1.5% (0.4 to 4.0%)	80.2% (63.0 to 92.4%)	59.2% (41.2 to 72.5%)	96.7% (93.1 to 98.8%)
Central Europe	70 (61-82)	1.2 (1.1-1.4)	-83.4% (-86.4 to -79.4%)	-6.2 (-5.6 to -7.0)	79.1% (65.2 to 86.6%)	28.6% (18.8 to 40.0%)	47.0% (26.6 to 68.9%)	58.7% (40.9 to 71.9%)	90.4% (84.0 to 95.0%)
Albania	2 (1-4)	1.3 (0.7-2.3)	-91.8% (-95.8 to -84.8%)	-14.6 (-11.4 to -18.6)	86.3% (74.3 to 93.1%)	18.8% (11.4 to 27.4%)	69.8% (44.3 to 88.2%)	56.8% (38.6 to 71.5%)	97.0% (94.0 to 99.0%)
Bosnia and Herzegovina	2 (1-3)	1.3 (0.9-1.9)	-75.2% (-85.7 to -56.1%)	-4.0 (-2.6 to -5.7)	78.5% (63.0 to 89.0%)	25.0% (15.6 to 35.7%)	47.6% (24.0 to 72.3%)	59.1% (40.3 to 73.1%)	91.4% (85.7 to 95.9%)
Bulgaria	8 (6-12)	2.6 (1.8-3.7)	-44.7% (-65.1 to -14.9%)	-2.1 (-2.0 to -2.2)	79.9% (64.0 to 88.6%)	26.0% (16.6 to 37.3%)	38.1% (14.0 to 66.5%)	58.7% (40.3 to 73.2%)	88.8% (80.5 to 94.7%)
Croatia	2 (1-2)	0.9 (0.7-1.2)	-43.4% (-62.5 to -11.7%)	-0.7 (-0.6 to -0.9)	77.1% (60.1 to 86.7%)	25.7% (16.0 to 36.9%)	34.3% (13.9 to 60.4%)	58.3% (39.2 to 73.2%)	86.5% (77.3 to 92.7%)
Czech Republic	3 (2-5)	0.6 (0.4-0.9)	54.7% (-6.4 to 140.0%)	0.2 (0.1 to 0.3)	78.8% (62.7 to 87.9%)	25.9% (16.2 to 37.3%)	23.3% (8.2 to 47.6%)	58.6% (39.3 to 72.7%)	85.9% (76.7 to 91.5%)
Hungary	4 (3-5)	0.8 (0.6-1.1)	145.1% (59.6 to 252.9%)	0.5 (0.3 to 0.7)	76.2% (59.2 to 86.2%)	14.6% (9.1 to 21.3%)	33.5% (17.4 to 56.9%)	58.5% (40.5 to 73.3%)	86.5% (78.0 to 92.2%)
Macedonia	3 (2-5)	2.7 (1.8-4.1)	-97.2% (-98.3 to -95.5%)	-95.1 (-71.3 to -120.3)	78.1% (61.1 to 87.8%)	25.9% (16.2 to 37.7%)	44.4% (22.8 to 69.0%)	53.1% (33.3 to 68.6%)	89.3% (81.5 to 94.7%)
Montenegro	0 (0-0)	0.4 (0.3-0.7)	-78.9% (-89.6 to -58.7%)	-1.7 (-1.1 to -2.5)	79.8% (63.6 to 89.3%)	26.1% (16.3 to 37.5%)	56.1% (28.7 to 80.4%)	61.2% (42.9 to 74.6%)	92.7% (86.5 to 97.1%)
Poland	6 (5-8)	0.3 (0.3-0.4)	-88.2% (-92.1 to -82.8%)	-2.5 (-2.0 to -3.0)	72.6% (57.2 to 82.8%)	37.5% (23.9 to 53.7%)	31.8% (13.1 to 57.0%)	59.0% (39.6 to 73.4%)	85.6% (77.1 to 91.9%)
Romania	32 (24-42)	3.4 (2.5-4.4)	-78.7% (-84.9 to -69.9%)	-12.4 (-10.6 to -14.5)	80.6% (65.7 to 88.6%)	31.4% (21.1 to 44.6%)	59.1% (37.8 to 79.5%)	59.0% (39.5 to 73.6%)	93.3% (87.6 to 97.0%)
Serbia	3 (2-5)	0.7 (0.5-1.0)	-67.2% (-80.9 to -44.2%)	-1.4 (-1.0 to -2.0)	80.2% (64.9 to 89.1%)	25.8% (16.4 to 37.1%)	41.2% (16.6 to 67.6%)	62.0% (44.3 to 75.0%)	90.8% (83.6 to 95.4%)
Slovakia	4 (3-6)	1.4 (0.9-2.1)	0.2% (-38.8 to 74.2%)	0.0 (-0.1 to 0.2)	75.3% (57.3 to 85.9%)	25.6% (15.9 to 37.0%)	26.6% (10.3 to 51.1%)	58.6% (39.0 to 73.3%)	84.4% (74.9 to 91.0%)
Slovenia	0 (0-0)	0.2 (0.2-0.3)	-64.7% (-77.4 to -48.1%)	-0.5 (-0.4 to -0.5)	73.0% (55.5 to 83.7%)	25.5% (16.2 to 36.6%)	24.5% (10.5 to 46.0%)	58.6% (39.1 to 73.2%)	83.0% (73.7 to 89.5%)
Eastern Europe	138 (122-154)	1.1 (1.0-1.2)	-87.3% (-88.8 to -85.8%)	-7.4 (-7.0 to -7.9)	74.5% (60.7 to 81.8%)	31.4% (20.2 to 44.5%)	62.2% (43.7 to 79.4%)	56.3% (38.4 to 69.7%)	92.2% (86.3 to 96.2%)
Belarus	1 (1-2)	0.3 (0.2-0.4)	-95.2% (-96.9 to -92.7%)	-5.2 (-4.3 to -6.3)	71.2% (54.4 to 81.8%)	23.9% (15.1 to 34.2%)	53.5% (34.4 to 74.5%)	55.9% (36.7 to 70.7%)	88.4% (80.2 to 94.2%)

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Estonia	0 (0-0)	0.4 (0.2-0.5)	-87.8% (-92.4 to -81.3%)	-2.6 (-2.1 to -3.3)	70.3% (51.7 to 81.9%)	2.8% (1.1 to 5.7%)	41.3% (21.3 to 65.3%)	56.8% (37.4 to 72.3%)	85.1% (75.6 to 92.3%)
Latvia	1 (0-1)	0.6 (0.4-0.9)	-75.6% (-86.4 to -60.0%)	-1.9 (-1.6 to -2.3)	71.3% (52.5 to 82.2%)	6.6% (2.8 to 12.5%)	49.8% (28.3 to 73.1%)	56.6% (37.1 to 72.5%)	87.0% (77.8 to 93.7%)
Lithuania	1 (1-1)	0.7 (0.5-1.0)	-71.9% (-82.0 to -58.1%)	-1.8 (-1.5 to -2.2)	72.0% (53.0 to 82.6%)	23.5% (14.7 to 34.0%)	50.0% (28.4 to 73.4%)	57.0% (37.0 to 71.8%)	87.4% (78.6 to 93.9%)
Moldova	5 (3-7)	2.6 (1.8-3.7)	-88.2% (-92.1 to -83.1%)	-19.7 (-16.6 to -23.4)	71.5% (56.6 to 81.9%)	14.2% (8.1 to 22.1%)	85.5% (70.8 to 94.9%)	57.9% (39.8 to 72.4%)	96.7% (92.9 to 98.9%)
Russian Federation	113 (102-126)	1.2 (1.1-1.3)	-87.2% (-88.6 to -85.9%)	-8.3 (-7.7 to -8.8)	74.3% (60.7 to 81.6%)	33.6% (21.6 to 47.7%)	59.9% (41.1 to 78.1%)	57.2% (39.3 to 70.3%)	91.7% (85.5 to 96.0%)
Ukraine	16 (11-22)	0.7 (0.5-0.9)	-87.4% (-91.3 to -82.6%)	-4.8 (-4.1 to -5.6)	77.9% (61.7 to 86.9%)	25.8% (16.2 to 37.2%)	73.8% (53.9 to 89.1%)	49.5% (29.0 to 67.6%)	95.2% (90.3 to 98.2%)
High-income	706 (618-769)	1.2 (1.1-1.3)	-44.0% (-52.9 to -35.7%)	-1.0 (-0.9 to -1.1)	69.3% (53.4 to 79.0%)	10.6% (6.0 to 16.5%)	19.6% (11.6 to 30.0%)	57.1% (39.6 to 70.2%)	77.0% (67.2 to 83.6%)
High-income Asia Pacific	53 (45-61)	0.7 (0.6-0.8)	-43.5% (-56.0 to -28.5%)	-0.5 (-0.5 to -0.7)	72.0% (55.8 to 81.0%)	16.1% (10.3 to 23.2%)	21.7% (10.3 to 40.3%)	56.6% (38.5 to 69.8%)	81.1% (70.4 to 87.9%)
Brunei	0 (0-0)	1.0 (0.7-1.5)	-8.3% (-44.8 to 45.8%)	-0.1 (-0.1 to -0.1)	71.4% (54.7 to 82.0%)	19.5% (12.2 to 28.5%)	22.8% (10.3 to 42.3%)	56.9% (38.3 to 71.2%)	82.0% (72.2 to 88.8%)
Japan	42 (36-48)	0.8 (0.7-1.0)	8.0% (-11.3 to 29.8%)	0.1 (0.0 to 0.1)	73.7% (57.4 to 82.3%)	16.0% (10.1 to 23.3%)	21.8% (10.2 to 41.4%)	56.6% (38.6 to 69.7%)	82.1% (71.4 to 88.8%)
South Korea	10 (8-14)	0.5 (0.4-0.6)	-79.5% (-86.3 to -69.6%)	-1.8 (-1.4 to -2.3)	65.9% (46.4 to 78.4%)	15.9% (10.3 to 22.7%)	21.2% (10.0 to 39.9%)	56.7% (37.7 to 71.0%)	76.8% (65.6 to 84.6%)
Singapore	0 (0-0)	0.1 (0.1-0.1)	49.6% (-4.7 to 123.8%)	0.0 (0.0 to 0.0)	74.6% (61.2 to 83.8%)	26.7% (17.3 to 38.0%)	21.0% (9.9 to 39.2%)	56.7% (38.5 to 70.9%)	85.2% (76.8 to 90.8%)
Australasia	12 (8-17)	0.7 (0.5-0.9)	61.1% (-4.1 to 143.1%)	0.3 (0.1 to 0.4)	66.8% (47.3 to 78.6%)	4.1% (1.8 to 8.2%)	22.3% (10.3 to 40.8%)	56.9% (39.0 to 70.1%)	75.6% (63.8 to 83.8%)
Australia	10 (6-14)	0.7 (0.4-0.9)	76.9% (-0.2 to 179.4%)	0.3 (0.1 to 0.5)	67.2% (47.5 to 79.4%)	3.3% (1.2 to 7.7%)	20.9% (9.4 to 39.3%)	56.9% (38.9 to 70.5%)	75.5% (63.7 to 83.8%)
New Zealand	2 (2-3)	0.8 (0.6-1.0)	22.4% (-26.3 to 78.6%)	0.1 (0.0 to 0.2)	64.9% (45.1 to 77.5%)	7.3% (3.2 to 13.7%)	27.9% (13.1 to 49.3%)	56.9% (39.0 to 70.6%)	75.8% (63.4 to 85.0%)
Western Europe	129 (114-146)	0.6 (0.5-0.7)	-25.0% (-44.2 to -6.8%)	-0.2 (-0.2 to -0.3)	69.1% (52.5 to 79.1%)	18.5% (11.9 to 26.8%)	8.9% (5.1 to 15.0%)	56.7% (39.0 to 70.0%)	74.9% (63.5 to 81.6%)
Andorra	0 (0-0)	0.3 (0.2-0.5)	-16.6% (-53.0 to 52.0%)	-0.1 (0.0 to -0.1)	68.7% (45.9 to 82.8%)	27.5% (16.5 to 40.1%)	6.6% (3.5 to 11.3%)	56.7% (38.1 to 70.6%)	73.0% (60.4 to 81.1%)

Location Name	Deaths (95% UI)	Mortality per 100,000 (95% UI)	Percent change in mortality rate 1990-2017 (95% UI)	Absolute difference in mortality rate 1990-2017 (95% UI)	Nutrition-associated risks attributable fraction (95% UI)	Low rotavirus vaccine attributable fraction (95% UI)	Unsafe WASH attributable fraction (95% UI)	Low ORS coverage attributable fraction (95% UI)	Total risk attributable fraction (95% UI)
Austria	2 (2-3)	0.5 (0.4-0.7)	334.4% (169.9 to 585.4%)	0.4 (0.3 to 0.5)	69.3% (49.4 to 82.1%)	6.0% (2.2 to 12.5%)	11.3% (7.2 to 16.9%)	56.7% (38.2 to 71.0%)	76.4% (64.9 to 83.5%)
Belgium	5 (4-7)	0.8 (0.6-1.1)	32.6% (-21.5 to 107.5%)	0.2 (0.1 to 0.2)	69.5% (49.1 to 82.6%)	4.3% (1.7 to 9.1%)	7.4% (4.1 to 12.4%)	56.7% (38.8 to 70.4%)	73.6% (60.4 to 81.5%)
Cyprus	0 (0-0)	0.3 (0.2-0.5)	-61.2% (-79.9 to -18.5%)	-0.5 (-0.2 to -0.8)	70.5% (51.8 to 83.8%)	26.7% (16.3 to 38.5%)	9.6% (4.8 to 17.6%)	56.8% (38.0 to 70.6%)	79.7% (70.2 to 86.1%)
Denmark	3 (2-4)	0.9 (0.7-1.3)	17.2% (-27.4 to 79.8%)	0.1 (0.1 to 0.2)	68.7% (51.5 to 80.7%)	46.4% (30.1 to 64.4%)	6.5% (3.5 to 11.4%)	56.7% (38.1 to 71.2%)	74.9% (64.2 to 81.8%)
Finland	1 (0-1)	0.2 (0.1-0.3)	-69.9% (-81.7 to -51.8%)	-0.4 (-0.3 to -0.5)	68.7% (50.3 to 81.2%)	10.6% (4.5 to 20.6%)	6.7% (3.7 to 11.3%)	56.6% (37.9 to 70.8%)	75.7% (64.3 to 82.2%)
France	28 (20-37)	0.7 (0.5-1.0)	-61.0% (-74.2 to -42.4%)	-1.1 (-1.0 to -1.5)	64.8% (44.8 to 77.2%)	37.7% (25.2 to 52.9%)	9.8% (5.1 to 17.8%)	56.9% (37.9 to 70.9%)	70.7% (56.7 to 79.2%)
Germany	19 (14-26)	0.5 (0.4-0.7)	-3.9% (-37.3 to 42.4%)	0.0 (0.0 to 0.0)	64.3% (45.2 to 77.0%)	20.5% (12.1 to 31.2%)	7.8% (4.4 to 13.4%)	56.7% (38.8 to 70.7%)	71.1% (59.7 to 79.0%)
Greece	1 (1-2)	0.2 (0.1-0.3)	30.2% (-23.7 to 125.9%)	0.1 (0.0 to 0.0)	74.0% (56.6 to 85.8%)	13.3% (7.6 to 20.0%)	8.7% (5.2 to 13.4%)	56.8% (38.0 to 71.5%)	80.1% (70.6 to 86.1%)
Iceland	0 (0-0)	0.6 (0.4-0.9)	49.3% (-7.1 to 139.0%)	0.2 (0.1 to 0.3)	69.2% (48.9 to 82.2%)	21.2% (13.5 to 30.6%)	6.4% (3.4 to 11.2%)	56.7% (38.1 to 70.9%)	73.9% (61.5 to 81.5%)
Ireland	2 (1-2)	0.5 (0.4-0.7)	102.6% (23.4 to 213.1%)	0.3 (0.2 to 0.4)	71.2% (52.5 to 83.4%)	15.6% (9.6 to 22.6%)	9.2% (5.7 to 14.6%)	56.6% (37.8 to 70.8%)	76.7% (66.1 to 83.5%)
Israel	9 (6-11)	1.0 (0.7-1.3)	-14.7% (-41.8 to 22.1%)	-0.2 (-0.1 to -0.3)	71.4% (53.2 to 82.3%)	7.7% (3.2 to 15.6%)	10.0% (5.8 to 16.8%)	56.7% (37.9 to 70.4%)	77.2% (65.9 to 83.8%)
Italy	13 (9-18)	0.5 (0.4-0.7)	50.0% (1.3 to 120.5%)	0.2 (0.1 to 0.3)	77.6% (61.9 to 86.8%)	18.5% (12.3 to 26.1%)	10.9% (6.2 to 18.9%)	56.7% (38.5 to 70.8%)	81.9% (72.7 to 87.2%)
Luxembourg	0 (0-0)	0.9 (0.6-1.2)	-37.8% (-67.4 to 2.7%)	-0.5 (-0.5 to -0.7)	69.1% (49.8 to 82.0%)	3.4% (1.3 to 7.5%)	6.6% (3.6 to 11.7%)	56.6% (38.3 to 70.7%)	74.3% (62.5 to 81.9%)
Malta	0 (0-0)	0.4 (0.2-0.6)	46.0% (-11.2 to 140.3%)	0.1 (0.1 to 0.2)	71.0% (52.7 to 83.2%)	26.9% (16.3 to 38.8%)	9.0% (5.1 to 14.8%)	56.8% (37.5 to 70.9%)	77.2% (66.7 to 84.0%)
Netherlands	4 (3-5)	0.4 (0.3-0.6)	123.1% (41.0 to 242.7%)	0.2 (0.2 to 0.4)	71.1% (51.2 to 83.4%)	37.2% (23.6 to 53.4%)	6.3% (3.5 to 10.8%)	56.7% (38.2 to 70.4%)	75.4% (63.4 to 82.9%)
Norway	1 (1-1)	0.3 (0.3-0.4)	45.0% (4.4 to 87.2%)	0.1 (0.1 to 0.1)	68.3% (51.3 to 79.2%)	24.5% (15.4 to 35.3%)	6.4% (3.4 to 10.7%)	56.6% (39.1 to 69.6%)	73.8% (62.1 to 81.3%)

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Portugal	4 (3-6)	1.0 (0.7-1.4)	-71.7% (-82.0 to -56.6%)	-2.5 (-1.9 to -3.5)	74.0% (56.7 to 85.1%)	13.2% (8.5 to 19.1%)	22.1% (13.1 to 35.8%)	56.8% (38.2 to 70.9%)	82.7% (73.7 to 88.1%)
Spain	11 (8-15)	0.5 (0.4-0.7)	-32.1% (-55.6 to 2.4%)	-0.3 (-0.2 to -0.3)	70.3% (52.8 to 81.0%)	25.1% (17.2 to 34.8%)	8.0% (3.8 to 15.2%)	56.8% (38.7 to 70.7%)	76.7% (65.5 to 83.2%)
Sweden	3 (2-3)	0.4 (0.3-0.6)	280.4% (149.3 to 439.0%)	0.3 (0.2 to 0.4)	67.6% (48.0 to 79.9%)	31.9% (19.9 to 46.3%)	7.4% (4.0 to 12.5%)	56.6% (37.8 to 70.5%)	72.5% (60.1 to 80.2%)
Switzerland	4 (3-6)	1.0 (0.7-1.4)	-41.4% (-62.5 to -12.2%)	-0.7 (-0.6 to -1.1)	70.6% (56.7 to 81.3%)	27.8% (18.0 to 39.7%)	6.9% (4.0 to 11.7%)	56.6% (38.3 to 70.8%)	80.1% (72.2 to 85.0%)
United Kingdom	19 (17-21)	0.5 (0.4-0.5)	115.1% (65.7 to 159.6%)	0.3 (0.2 to 0.3)	70.1% (53.1 to 80.6%)	1.2% (0.4 to 2.8%)	6.3% (2.9 to 12.0%)	56.8% (38.9 to 69.9%)	74.5% (62.4 to 82.1%)
England	16 (14-17)	0.5 (0.4-0.5)	100.1% (54.1 to 140.1%)	0.2 (0.2 to 0.2)	69.3% (52.2 to 79.7%)	0.7% (0.2 to 1.6%)	6.1% (2.8 to 11.7%)	56.8% (39.2 to 69.8%)	73.8% (61.5 to 81.4%)
Northern Ireland	1 (1-1)	0.6 (0.4-1.0)	189.4% (67.2 to 360.3%)	0.4 (0.2 to 0.7)	73.1% (54.1 to 85.4%)	2.6% (0.6 to 7.8%)	6.6% (3.0 to 13.1%)	56.9% (39.1 to 70.4%)	77.4% (66.2 to 84.9%)
Scotland	2 (1-3)	0.6 (0.4-1.0)	214.1% (69.0 to 461.0%)	0.4 (0.2 to 0.7)	73.9% (54.7 to 86.1%)	3.1% (0.7 to 9.0%)	7.4% (3.3 to 14.9%)	56.9% (38.3 to 70.4%)	77.9% (66.5 to 84.9%)
Wales	1 (1-1)	0.6 (0.4-0.8)	246.7% (111.8 to 477.9%)	0.4 (0.3 to 0.6)	74.3% (55.6 to 86.4%)	3.5% (0.8 to 11.0%)	7.4% (3.3 to 15.1%)	56.9% (38.3 to 70.7%)	78.2% (66.8 to 85.4%)
Southern Latin America	141 (114-170)	2.8 (2.2-3.3)	-83.4% (-87.1 to -79.0%)	-13.9 (-12.6 to -15.3)	76.4% (61.2 to 85.2%)	10.1% (5.2 to 16.7%)	49.6% (26.5 to 74.4%)	57.8% (40.2 to 71.6%)	89.6% (82.3 to 95.2%)
Argentina	124 (97-154)	3.4 (2.6-4.2)	-83.6% (-87.8 to -78.4%)	-17.2 (-15.2 to -19.5)	77.3% (62.2 to 86.1%)	8.5% (4.1 to 14.8%)	51.0% (27.3 to 76.2%)	57.9% (40.0 to 71.8%)	90.4% (83.0 to 95.7%)
Chile	9 (6-13)	0.8 (0.5-1.1)	-89.4% (-93.0 to -84.4%)	-6.5 (-5.6 to -7.5)	67.5% (50.5 to 79.0%)	26.5% (17.2 to 37.8%)	39.8% (23.5 to 60.9%)	57.6% (39.1 to 71.6%)	82.7% (73.6 to 89.9%)
Uruguay	8 (6-11)	3.3 (2.4-4.5)	-79.7% (-85.8 to -71.2%)	-13.1 (-11.0 to -15.2)	72.3% (55.6 to 82.7%)	23.9% (15.3 to 34.6%)	40.1% (18.1 to 67.0%)	57.1% (38.1 to 71.3%)	86.2% (77.3 to 92.9%)
High-income North America	371 (314-410)	1.7 (1.5-1.9)	125.3% (76.4 to 164.1%)	1.0 (0.8 to 1.0)	66.9% (50.4 to 77.7%)	7.9% (3.8 to 13.6%)	11.6% (7.1 to 17.9%)	56.9% (39.1 to 70.2%)	72.4% (61.5 to 79.8%)
Canada	17 (12-24)	0.9 (0.6-1.2)	616.2% (355.5 to 993.9%)	0.7 (0.5 to 1.0)	72.1% (55.7 to 82.4%)	9.3% (5.3 to 14.3%)	9.6% (5.7 to 15.2%)	56.7% (37.5 to 70.3%)	78.2% (68.7 to 84.2%)
Greenland	0 (0-0)	5.1 (3.3-8.0)	40.1% (-30.3 to 189.4%)	1.5 (1.2 to 1.9)	70.0% (50.5 to 81.6%)	16.5% (9.7 to 24.1%)	19.8% (12.7 to 30.0%)	57.3% (38.0 to 71.1%)	77.2% (66.2 to 84.3%)

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United States	353 (298-392)	1.8 (1.5-2.0)	118.8% (69.5 to 157.8%)	1.0 (0.8 to 1.0)	66.6% (50.1 to 77.5%)	7.7% (3.7 to 13.6%)	11.7% (7.2 to 18.1%)	57.0% (39.1 to 70.2%)	72.1% (61.2 to 79.7%)
Latin America and Caribbean	9,904 (8,527-11,490)	19.5 (16.7-22.6)	-90.0% (-91.5 to -88.1%)	-175.6 (-165.7 to -185.4)	79.4% (65.6 to 87.3%)	8.0% (4.9 to 12.1%)	82.0% (67.5 to 92.1%)	55.7% (37.6 to 69.1%)	96.2% (92.6 to 98.5%)
Caribbean	3,513 (2,358-5,044)	89.8 (60.3-128.9)	-72.4% (-82.1 to -57.9%)	-236.1 (-212.3 to -262.3)	83.9% (70.9 to 91.2%)	6.9% (4.4 to 10.0%)	95.8% (88.9 to 98.9%)	53.7% (35.3 to 67.7%)	99.5% (98.6 to 99.9%)
Antigua and Barbuda	0 (0-0)	4.7 (3.1-7.1)	-50.5% (-70.4 to -16.6%)	-4.8 (-4.1 to -5.3)	71.0% (52.0 to 82.0%)	18.3% (11.5 to 26.8%)	83.9% (61.9 to 95.0%)	56.3% (38.7 to 70.7%)	95.9% (89.8 to 98.8%)
The Bahamas	1 (1-1)	3.5 (2.3-5.3)	-69.5% (-81.7 to -48.7%)	-8.1 (-5.9 to -10.4)	72.3% (53.1 to 82.9%)	11.3% (6.1 to 18.3%)	79.3% (54.9 to 93.2%)	56.7% (37.9 to 70.8%)	94.9% (87.7 to 98.4%)
Barbados	0 (0-1)	2.3 (1.4-3.5)	-68.8% (-82.7 to -48.1%)	-5.0 (-4.1 to -6.2)	73.4% (55.7 to 83.3%)	19.3% (12.1 to 28.2%)	75.4% (51.6 to 91.1%)	47.6% (29.3 to 63.4%)	94.5% (88.1 to 98.2%)
Belize	5 (4-8)	14.4 (9.5-21.2)	-77.2% (-86.0 to -63.8%)	-48.7 (-39.5 to -58.5)	77.7% (62.8 to 85.8%)	15.7% (9.5 to 23.3%)	91.5% (78.9 to 97.5%)	53.7% (35.2 to 68.2%)	98.4% (95.8 to 99.6%)
Bermuda	0 (0-0)	0.8 (0.5-1.1)	-80.7% (-88.4 to -68.5%)	-3.3 (-2.4 to -4.3)	69.1% (48.8 to 81.6%)	18.2% (11.2 to 26.8%)	77.3% (51.5 to 92.3%)	56.5% (38.0 to 70.3%)	93.6% (85.1 to 98.0%)
Cuba	9 (7-13)	1.6 (1.1-2.1)	-85.0% (-90.0 to -78.4%)	-8.9 (-7.3 to -11.0)	73.9% (56.0 to 83.6%)	24.4% (15.5 to 35.0%)	84.5% (64.2 to 95.2%)	51.1% (32.0 to 65.6%)	96.4% (91.3 to 99.0%)
Dominica	0 (0-1)	11.0 (6.7-16.9)	-19.2% (-51.7 to 36.6%)	-2.6 (-3.4 to -0.9)	74.1% (56.3 to 84.1%)	19.3% (11.9 to 28.1%)	86.2% (68.2 to 95.7%)	56.4% (37.4 to 70.2%)	96.9% (92.2 to 99.2%)
Dominican Republic	183 (116-279)	18.3 (11.7-28.0)	-92.7% (-95.6 to -88.2%)	-231.0 (-184.5 to -280.9)	78.7% (61.9 to 88.0%)	9.7% (5.2 to 16.4%)	91.6% (78.7 to 97.7%)	54.9% (35.5 to 69.2%)	98.4% (95.9 to 99.6%)
Grenada	0 (0-0)	2.5 (1.5-4.0)	-83.2% (-91.3 to -69.0%)	-12.2 (-8.9 to -16.1)	74.5% (56.2 to 84.9%)	19.1% (11.9 to 28.0%)	86.3% (68.4 to 95.6%)	56.4% (37.1 to 70.2%)	97.0% (92.7 to 99.1%)
Guyana	17 (11-25)	23.5 (15.6-34.0)	-82.4% (-89.1 to -72.7%)	-110.2 (-91.0 to -130.4)	84.3% (72.0 to 90.7%)	5.7% (2.1 to 12.7%)	91.8% (79.1 to 97.7%)	55.4% (36.8 to 69.5%)	99.0% (97.3 to 99.8%)
Haiti	3,138 (2,033-4,608)	211.7 (137.1-310.9)	-77.6% (-86.2 to -63.7%)	-731.3 (-611.0 to -870.0)	84.4% (71.7 to 91.5%)	6.5% (4.2 to 9.3%)	96.3% (90.0 to 99.1%)	53.6% (34.8 to 67.8%)	99.6% (98.9 to 99.9%)
Jamaica	7 (4-12)	3.9 (2.4-6.2)	-93.8% (-96.4 to -89.7%)	-59.2 (-48.1 to -71.9)	71.1% (52.2 to 82.6%)	18.9% (11.9 to 27.7%)	89.4% (75.3 to 96.8%)	53.9% (35.0 to 68.4%)	97.5% (94.0 to 99.3%)
Puerto Rico	4 (3-5)	2.4 (1.7-3.2)	83.2% (22.8 to 181.7%)	1.1 (0.7 to 1.5)	73.5% (56.8 to 83.3%)	4.5% (1.5 to 11.0%)	75.3% (46.4 to 91.7%)	56.4% (37.8 to 71.8%)	94.4% (87.0 to 98.3%)

Location Name	Deaths (95% UI)	Mortality per 100,000 (95% UI)	Percent change in mortality rate 1990-2017 (95% UI)	Absolute difference in mortality rate 1990-2017 (95% UI)	Nutrition-associated risks attributable fraction (95% UI)	Low rotavirus vaccine attributable fraction (95% UI)	Unsafe WASH attributable fraction (95% UI)	Low ORS coverage attributable fraction (95% UI)	Total risk attributable fraction (95% UI)
Saint Lucia	0 (0-1)	4.4 (2.7-6.7)	-79.8% (-87.9 to -67.4%)	-17.4 (-13.7 to -21.3)	75.2% (57.4 to 85.1%)	19.1% (12.0 to 27.9%)	84.6% (64.9 to 95.1%)	66.4% (49.3 to 78.1%)	96.9% (92.3 to 99.1%)
Saint Vincent and the Grenadines	1 (0-1)	9.6 (6.1-14.1)	-77.6% (-86.3 to -64.5%)	-33.3 (-27.0 to -41.6)	75.9% (59.6 to 85.7%)	19.4% (12.0 to 28.3%)	88.9% (73.5 to 96.7%)	56.5% (37.8 to 70.6%)	97.8% (94.6 to 99.4%)
Suriname	13 (10-18)	28.1 (21.0-36.8)	-82.5% (-87.6 to -76.0%)	-132.3 (-110.3 to -154.1)	80.4% (65.2 to 88.4%)	15.9% (9.8 to 23.2%)	86.6% (68.5 to 95.9%)	55.9% (38.3 to 70.1%)	97.9% (94.6 to 99.4%)
Trinidad and Tobago	6 (4-9)	6.4 (4.1-9.8)	-55.8% (-73.5 to -28.3%)	-8.1 (-7.5 to -8.2)	76.7% (59.4 to 86.5%)	19.2% (12.2 to 28.2%)	82.2% (60.7 to 94.1%)	56.7% (38.0 to 71.2%)	96.6% (91.4 to 99.0%)
Virgin Islands, U.S.	0 (0-0)	1.3 (0.8-2.0)	-74.3% (-85.3 to -55.7%)	-3.9 (-2.9 to -5.0)	70.4% (52.0 to 81.7%)	9.0% (3.9 to 16.2%)	78.2% (51.4 to 93.0%)	56.7% (37.8 to 70.6%)	94.5% (87.1 to 98.4%)
Andean Latin America	754 (560-1,003)	11.2 (8.4-15.0)	-94.5% (-96.0 to -92.4%)	-193.7 (-163.8 to -227.1)	70.4% (53.3 to 81.4%)	5.1% (2.7 to 8.7%)	77.0% (54.8 to 91.3%)	60.3% (42.0 to 73.0%)	93.5% (86.7 to 97.7%)
Bolivia	238 (123-397)	16.4 (8.5-27.3)	-95.4% (-97.7 to -92.1%)	-344.7 (-257.6 to -453.3)	70.6% (51.9 to 82.7%)	6.8% (2.7 to 13.3%)	75.0% (50.1 to 90.8%)	59.3% (41.5 to 72.4%)	93.0% (85.3 to 97.6%)
Ecuador	149 (100-210)	9.6 (6.4-13.5)	-93.6% (-95.9 to -90.7%)	-141.4 (-125.4 to -159.6)	74.8% (57.4 to 85.6%)	6.0% (2.6 to 11.2%)	71.5% (45.2 to 88.8%)	59.5% (40.2 to 72.8%)	93.2% (86.0 to 97.7%)
Peru	366 (236-558)	9.9 (6.4-15.1)	-94.3% (-96.5 to -90.8%)	-165.0 (-123.3 to -208.2)	68.3% (50.7 to 80.0%)	1.8% (0.9 to 3.2%)	80.5% (60.4 to 93.0%)	61.3% (43.5 to 73.9%)	94.0% (87.6 to 97.9%)
Central Latin America	3,781 (3,269-4,428)	15.6 (13.5-18.3)	-89.9% (-91.4 to -88.0%)	-138.4 (-132.7 to -143.5)	76.3% (62.5 to 84.9%)	10.5% (6.3 to 16.3%)	74.4% (55.8 to 88.3%)	58.7% (41.1 to 71.5%)	94.6% (89.7 to 97.8%)
Colombia	298 (203-437)	7.0 (4.8-10.3)	-90.2% (-93.3 to -85.7%)	-64.7 (-56.5 to -73.5)	69.7% (51.6 to 81.1%)	6.7% (2.7 to 14.1%)	70.5% (44.4 to 88.7%)	53.2% (35.8 to 66.9%)	91.6% (83.0 to 96.9%)
Costa Rica	10 (7-14)	2.8 (2.0-4.0)	-83.5% (-88.7 to -76.1%)	-14.3 (-11.6 to -18.1)	70.0% (50.2 to 81.7%)	25.0% (16.2 to 36.4%)	49.3% (26.5 to 73.6%)	59.3% (41.3 to 72.1%)	85.5% (75.1 to 92.9%)
El Salvador	61 (34-102)	11.2 (6.2-18.7)	-95.6% (-97.7 to -92.3%)	-244.3 (-200.1 to -291.6)	77.0% (59.2 to 86.7%)	5.8% (2.1 to 13.0%)	83.6% (66.8 to 94.3%)	53.0% (35.3 to 66.8%)	96.5% (92.2 to 98.9%)

Location Name	Deaths (95% UI)	Mortality per 100,000 (95% UI)	Percent change in mortality rate 1990-2017 (95% UI)	Absolute difference in mortality rate 1990-2017 (95% UI)	Nutrition-associated risks attributable fraction (95% UI)	Low rotavirus vaccine attributable fraction (95% UI)	Unsafe WASH attributable fraction (95% UI)	Low ORS coverage attributable fraction (95% UI)	Total risk attributable fraction (95% UI)
Guatemala	1,288 (890-1,797)	64.8 (44.8-90.4)	-85.5% (-90.2 to -79.6%)	-381.1 (-347.2 to -413.0)	72.2% (58.9 to 82.0%)	17.3% (10.3 to 26.5%)	89.5% (75.3 to 96.7%)	56.4% (38.1 to 69.5%)	97.2% (93.2 to 99.2%)
Honduras	271 (132-484)	23.1 (11.3-41.2)	-91.9% (-95.9 to -85.6%)	-263.6 (-224.9 to -305.0)	74.1% (57.7 to 84.6%)	4.9% (1.7 to 11.0%)	82.1% (65.0 to 93.7%)	50.5% (33.0 to 64.5%)	95.9% (91.3 to 98.7%)
Mexico	1,247 (1,123-1,406)	10.3 (9.3-11.7)	-92.4% (-93.3 to -91.2%)	-125.4 (-116.9 to -133.7)	79.7% (65.6 to 87.6%)	6.7% (3.1 to 12.2%)	59.7% (40.3 to 78.1%)	65.9% (48.7 to 77.5%)	92.0% (86.1 to 96.1%)
Nicaragua	86 (57-125)	12.7 (8.4-18.3)	-96.7% (-97.9 to -95.0%)	-374.7 (-321.0 to -429.5)	71.3% (53.8 to 82.3%)	0.1% (0.0 to 0.4%)	86.9% (72.0 to 95.8%)	50.8% (33.3 to 64.7%)	96.5% (92.1 to 98.9%)
Panama	77 (52-110)	21.4 (14.3-30.4)	-48.3% (-65.6 to -24.0%)	-20.0 (-17.4 to -23.5)	69.6% (51.2 to 81.0%)	8.0% (3.5 to 15.8%)	75.8% (55.1 to 90.9%)	52.4% (34.0 to 66.0%)	92.9% (85.6 to 97.5%)
Venezuela	443 (321-597)	15.7 (11.4-21.2)	-85.6% (-90.0 to -79.9%)	-93.8 (-82.6 to -104.5)	84.8% (70.4 to 91.2%)	14.9% (8.0 to 25.0%)	66.8% (40.3 to 86.5%)	57.0% (38.9 to 70.2%)	95.4% (90.0 to 98.4%)
Tropical Latin America	1,856 (1,647-2,087)	11.5 (10.2-13.0)	-94.6% (-95.4 to -93.6%)	-202.7 (-178.9 to -225.0)	79.8% (64.7 to 88.2%)	2.2% (0.8 to 4.9%)	73.6% (56.7 to 87.7%)	51.7% (33.6 to 66.5%)	94.5% (89.9 to 97.6%)
Brazil	1,795 (1,586-2,025)	11.7 (10.3-13.2)	-94.6% (-95.4 to -93.6%)	-206.7 (-181.8 to -229.6)	79.8% (64.7 to 88.2%)	2.2% (0.8 to 5.0%)	73.5% (56.6 to 87.6%)	51.3% (33.0 to 66.4%)	94.5% (89.9 to 97.6%)
Paraguay	61 (36-101)	8.2 (4.8-13.5)	-91.3% (-95.0 to -85.2%)	-85.7 (-70.8 to -100.9)	78.9% (61.6 to 88.2%)	1.1% (0.4 to 3.0%)	76.0% (54.8 to 91.3%)	64.2% (43.0 to 77.5%)	95.1% (89.9 to 98.4%)
North Africa and Middle East	28,962 (23,106-35,611)	45.0 (35.9-55.3)	-80.7% (-84.8 to -75.3%)	-188.5 (-149.5 to -227.8)	88.0% (78.6 to 92.8%)	17.2% (11.0 to 25.1%)	87.0% (74.9 to 94.9%)	61.2% (43.6 to 73.6%)	98.3% (96.5 to 99.4%)
Afghanistan	5,911 (3,994-8,431)	100.4 (67.8-143.2)	-81.1% (-89.8 to -62.3%)	-430.1 (-211.1 to -674.5)	87.4% (77.5 to 93.1%)	27.1% (17.1 to 39.4%)	96.1% (89.7 to 99.0%)	61.1% (43.2 to 73.7%)	99.6% (99.0 to 99.9%)
Algeria	166 (79-280)	3.7 (1.8-6.3)	-90.1% (-94.7 to -82.0%)	-33.7 (-19.9 to -52.3)	82.9% (69.2 to 90.6%)	26.5% (16.6 to 38.1%)	63.1% (39.3 to 83.6%)	59.3% (41.7 to 72.1%)	94.7% (89.7 to 97.9%)
Bahrain	1 (1-1)	0.8 (0.5-1.1)	-73.7% (-85.0 to -55.5%)	-2.1 (-1.3 to -3.2)	77.8% (59.1 to 87.2%)	1.3% (0.3 to 4.1%)	63.2% (38.7 to 83.6%)	59.0% (41.3 to 72.0%)	92.3% (84.4 to 97.0%)

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Egypt	6,457 (3,827-9,531)	54.7 (32.4-80.8)	-89.1% (-93.4 to -82.8%)	-445.1 (-378.8 to -514.7)	79.2% (63.4 to 88.1%)	23.8% (16.6 to 32.4%)	66.4% (48.0 to 83.7%)	58.5% (41.0 to 71.4%)	94.7% (90.0 to 97.7%)
Iran	191 (168-212)	2.8 (2.5-3.1)	-94.6% (-96.0 to -92.5%)	-49.2 (-36.1 to -62.9)	78.8% (63.8 to 86.1%)	48.8% (31.9 to 67.7%)	67.8% (43.6 to 86.3%)	59.1% (41.3 to 71.8%)	94.4% (88.9 to 97.8%)
Iraq	561 (401-780)	9.5 (6.8-13.1)	-84.9% (-90.6 to -75.2%)	-53.3 (-37.0 to -72.7)	86.8% (75.2 to 92.7%)	16.2% (9.1 to 25.5%)	75.9% (54.4 to 91.0%)	58.4% (40.3 to 71.4%)	97.7% (94.9 to 99.2%)
Jordan	35 (23-52)	3.0 (1.9-4.5)	-87.3% (-92.8 to -76.3%)	-20.4 (-12.4 to -30.0)	77.4% (60.9 to 87.2%)	3.5% (1.3 to 7.8%)	56.8% (32.8 to 78.8%)	62.1% (44.7 to 74.5%)	91.6% (84.7 to 96.3%)
Kuwait	3 (2-4)	1.1 (0.7-1.5)	-76.9% (-84.7 to -64.3%)	-3.5 (-2.7 to -4.4)	73.4% (55.7 to 84.0%)	26.8% (17.1 to 38.7%)	52.8% (28.5 to 76.7%)	60.7% (43.1 to 73.4%)	89.6% (81.4 to 95.3%)
Lebanon	32 (11-64)	3.6 (1.3-7.1)	-82.7% (-92.1 to -66.6%)	-17.2 (-7.5 to -29.3)	78.3% (59.7 to 88.1%)	26.9% (16.9 to 38.9%)	73.0% (45.5 to 90.4%)	56.6% (38.9 to 69.9%)	95.0% (88.9 to 98.4%)
Libya	21 (12-34)	3.3 (1.8-5.3)	-90.2% (-94.6 to -82.1%)	-30.7 (-15.5 to -50.6)	79.8% (61.4 to 89.3%)	6.5% (2.5 to 13.2%)	71.5% (49.0 to 88.1%)	59.1% (41.1 to 71.9%)	95.0% (89.6 to 98.2%)
Morocco	687 (372-1,144)	22.4 (12.1-37.3)	-92.2% (-96.0 to -86.5%)	-266.7 (-214.8 to -321.0)	81.2% (65.9 to 89.8%)	4.1% (1.3 to 10.5%)	79.6% (57.7 to 93.3%)	60.4% (42.7 to 72.9%)	96.7% (92.5 to 99.0%)
Palestine	17 (12-25)	2.6 (1.8-3.8)	-75.7% (-86.4 to -55.0%)	-8.2 (-4.7 to -12.5)	78.3% (61.6 to 87.8%)	7.5% (2.9 to 15.1%)	81.7% (59.0 to 94.3%)	59.9% (42.2 to 72.7%)	96.7% (92.3 to 99.1%)
Oman	4 (2-6)	1.0 (0.6-1.5)	-95.4% (-97.8 to -88.5%)	-19.7 (-10.7 to -30.7)	82.7% (70.0 to 90.1%)	46.2% (30.2 to 65.1%)	65.1% (37.9 to 85.5%)	59.1% (41.3 to 72.1%)	96.3% (92.1 to 98.6%)
Qatar	1 (1-2)	0.7 (0.5-1.1)	-66.3% (-80.6 to -40.0%)	-1.4 (-0.9 to -2.2)	77.2% (58.6 to 87.1%)	4.0% (1.4 to 9.3%)	55.9% (31.1 to 79.8%)	59.0% (41.3 to 71.8%)	90.9% (83.0 to 96.4%)
Saudi Arabia	36 (20-64)	1.5 (0.8-2.6)	-98.1% (-99.1 to -95.9%)	-75.6 (-46.3 to -119.5)	73.5% (53.0 to 84.7%)	3.7% (1.3 to 8.7%)	54.6% (29.5 to 78.2%)	59.2% (41.4 to 72.1%)	88.8% (79.7 to 95.3%)
Sudan	7,215 (3,821-11,469)	118.9 (63.0-189.1)	-76.2% (-86.2 to -58.2%)	-380.7 (-220.5 to -548.6)	90.6% (82.4 to 95.2%)	7.2% (4.0 to 11.6%)	95.7% (89.2 to 98.9%)	62.8% (45.1 to 75.1%)	99.7% (99.3 to 99.9%)
Syria	18 (10-27)	1.2 (0.7-1.9)	-97.0% (-98.5 to -94.5%)	-39.8 (-26.1 to -55.3)	85.9% (73.4 to 92.8%)	26.9% (17.3 to 38.6%)	66.2% (42.3 to 85.9%)	64.1% (46.6 to 76.1%)	96.7% (93.0 to 98.8%)
Tunisia	21 (9-40)	2.3 (1.0-4.4)	-92.6% (-96.5 to -85.5%)	-28.7 (-13.5 to -47.7)	73.1% (53.6 to 85.2%)	19.0% (14.0 to 24.9%)	74.7% (52.3 to 90.4%)	48.7% (31.2 to 62.5%)	94.2% (88.3 to 98.0%)
Turkey	151 (100-220)	2.6 (1.7-3.7)	-98.0% (-98.8 to -96.5%)	-124.9 (-86.4 to -177.7)	74.0% (55.6 to 85.1%)	16.9% (13.1 to 21.4%)	73.5% (48.8 to 90.1%)	63.7% (46.2 to 75.8%)	93.3% (86.4 to 97.7%)

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United Arab Emirates	6 (4-9)	1.5 (0.9-2.3)	-70.6% (-84.5 to -40.0%)	-3.5 (-2.1 to -5.6)	79.9% (65.2 to 89.0%)	5.7% (2.2 to 12.0%)	55.8% (29.1 to 79.5%)	59.0% (41.1 to 72.0%)	95.0% (90.2 to 98.1%)
Yemen	7,400 (4,726-11,260)	154.0 (98.4-234.4)	-80.4% (-87.6 to -66.7%)	-630.1 (-334.1 to -887.5)	94.3% (89.3 to 97.0%)	16.7% (9.6 to 26.3%)	92.7% (82.3 to 98.0%)	62.5% (45.0 to 74.7%)	99.8% (99.4 to 99.9%)
South Asia	135,390 (115,688-156,734)	77.6 (66.3-89.9)	-81.4% (-85.8 to -76.1%)	-339.4 (-282.5 to -397.7)	89.6% (84.1 to 92.9%)	16.9% (10.9 to 24.5%)	92.9% (82.9 to 97.9%)	53.5% (36.1 to 67.7%)	99.6% (99.1 to 99.9%)
Bangladesh	3,062 (1,743-5,087)	21.0 (11.9-34.9)	-95.1% (-97.4 to -91.4%)	-407.1 (-329.1 to -479.9)	85.8% (74.8 to 92.4%)	32.4% (27.8 to 37.0%)	96.0% (89.9 to 98.9%)	34.6% (19.7 to 49.2%)	99.7% (99.2 to 99.9%)
Bhutan	7 (3-15)	8.4 (3.5-17.0)	-95.9% (-98.1 to -91.7%)	-193.9 (-97.1 to -339.1)	77.9% (62.5 to 87.8%)	18.9% (12.1 to 27.4%)	83.1% (66.9 to 94.2%)	45.7% (24.8 to 65.1%)	97.1% (93.8 to 99.1%)
India	102,678 (87,608-118,510)	79.4 (67.7-91.6)	-79.7% (-84.4 to -73.3%)	-311.4 (-249.2 to -370.1)	89.9% (84.9 to 93.1%)	19.7% (12.4 to 28.4%)	92.8% (82.5 to 97.8%)	53.3% (35.9 to 68.1%)	99.7% (99.2 to 99.9%)
Nepal	753 (445-1,191)	24.6 (14.5-38.9)	-94.9% (-97.3 to -89.6%)	-455.6 (-311.6 to -633.6)	76.9% (60.6 to 87.0%)	9.8% (7.3 to 13.0%)	93.5% (83.8 to 98.1%)	50.6% (32.2 to 67.1%)	99.0% (97.3 to 99.7%)
Pakistan	28,890 (18,641-43,911)	105.7 (68.2-160.7)	-81.4% (-89.2 to -68.5%)	-462.7 (-355.5 to -578.4)	89.4% (81.0 to 94.3%)	5.8% (4.2 to 7.7%)	93.2% (83.0 to 98.1%)	56.1% (35.9 to 70.3%)	99.6% (98.8 to 99.9%)
Sub-Saharan Africa	334,306 (285,351-388,790)	204.6 (174.7-238.0)	-68.4% (-74.2 to -60.3%)	-443.0 (-352.9 to -523.8)	88.5% (80.6 to 92.6%)	24.4% (19.2 to 30.0%)	96.2% (90.1 to 99.0%)	59.5% (41.7 to 72.4%)	99.7% (99.1 to 99.9%)
Central Sub-Saharan Africa	34,800 (25,798-46,206)	176.1 (130.6-233.9)	-63.5% (-73.9 to -49.3%)	-306.9 (-246.9 to -364.9)	88.6% (79.2 to 93.4%)	39.8% (32.0 to 47.2%)	96.5% (91.2 to 99.1%)	60.5% (42.2 to 73.4%)	99.7% (99.2 to 99.9%)
Angola	10,236 (7,080-14,044)	206.3 (142.7-283.0)	-81.2% (-87.8 to -70.6%)	-891.4 (-616.5 to -1,176.0)	86.8% (76.5 to 92.4%)	21.7% (15.5 to 29.5%)	96.0% (89.6 to 99.0%)	58.1% (39.8 to 72.1%)	99.6% (98.8 to 99.9%)
Central African Republic	4,156 (2,338-6,558)	685.8 (385.7-1,082.0)	54.3% (-12.7 to 167.5%)	241.4 (114.6 to 430.5)	89.3% (81.0 to 94.1%)	31.1% (24.7 to 37.6%)	97.2% (92.5 to 99.3%)	65.2% (47.7 to 77.1%)	99.8% (99.4 to 99.9%)

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Congo	710 (410-1,098)	112.5 (64.9-174.0)	-49.9% (-71.3 to -17.8%)	-111.9 (-81.8 to -157.8)	89.9% (80.2 to 94.6%)	23.3% (17.0 to 30.1%)	95.6% (89.2 to 98.8%)	60.6% (42.2 to 73.8%)	99.7% (99.1 to 99.9%)
Democratic Republic of the Congo	19,514 (12,250-29,439)	148.2 (93.0-223.5)	-56.5% (-73.6 to -29.1%)	-192.6 (-153.7 to -221.3)	89.4% (80.0 to 94.7%)	53.4% (46.2 to 60.2%)	96.7% (91.6 to 99.1%)	60.8% (42.2 to 73.6%)	99.7% (99.3 to 99.9%)
Equatorial Guinea	89 (41-159)	47.0 (21.9-83.8)	-92.2% (-96.5 to -84.5%)	-555.9 (-343.7 to -793.6)	81.8% (67.6 to 90.0%)	42.4% (28.1 to 60.1%)	92.3% (81.6 to 97.8%)	59.9% (41.2 to 73.0%)	98.8% (97.1 to 99.7%)
Gabon	95 (43-173)	47.5 (21.8-86.8)	-71.6% (-85.0 to -49.9%)	-119.5 (-76.4 to -156.6)	79.1% (62.9 to 88.7%)	40.4% (26.9 to 56.8%)	91.3% (81.3 to 97.3%)	59.5% (41.9 to 72.7%)	98.5% (96.6 to 99.6%)
Eastern Sub-Saharan Africa	98,175 (84,620-114,013)	155.1 (133.7-180.1)	-70.3% (-76.4 to -62.3%)	-367.1 (-287.5 to -446.7)	86.7% (78.5 to 91.2%)	13.4% (8.7 to 19.0%)	96.7% (91.2 to 99.2%)	58.9% (41.1 to 71.5%)	99.7% (99.1 to 99.9%)
Burundi	3,045 (1,829-4,944)	166.3 (99.9-270.0)	-64.0% (-78.5 to -40.3%)	-295.1 (-232.7 to -344.0)	88.1% (79.0 to 93.5%)	3.6% (1.1 to 9.0%)	97.1% (92.3 to 99.3%)	59.9% (41.2 to 74.0%)	99.8% (99.3 to 99.9%)
Comoros	69 (42-108)	80.5 (49.0-126.4)	-83.3% (-90.2 to -72.5%)	-401.3 (-306.5 to -505.7)	88.4% (78.5 to 94.0%)	27.8% (17.9 to 39.1%)	95.8% (89.4 to 98.9%)	51.9% (32.7 to 68.1%)	99.7% (99.2 to 99.9%)
Djibouti	102 (48-182)	67.6 (32.0-120.4)	-82.2% (-90.5 to -69.5%)	-311.8 (-208.7 to -419.4)	89.7% (81.6 to 94.8%)	17.2% (10.0 to 26.1%)	95.8% (89.4 to 98.8%)	61.1% (42.1 to 74.8%)	99.8% (99.4 to 99.9%)
Eritrea	1,585 (945-2,508)	193.4 (115.3-306.1)	-76.8% (-87.1 to -56.4%)	-639.9 (-394.2 to -900.1)	88.8% (79.7 to 94.1%)	0.3% (0.1 to 0.8%)	96.5% (90.9 to 99.1%)	56.3% (36.4 to 71.9%)	99.7% (99.3 to 99.9%)
Ethiopia	31,805 (26,081-38,114)	191.3 (156.9-229.2)	-64.3% (-74.1 to -49.7%)	-344.9 (-234.5 to -457.2)	89.3% (82.1 to 93.1%)	17.8% (11.0 to 25.9%)	96.7% (91.8 to 99.2%)	63.8% (45.8 to 76.0%)	99.7% (99.3 to 99.9%)
Kenya	9,552 (7,681-11,489)	146.7 (118.0-176.5)	-42.1% (-58.2 to -25.0%)	-106.6 (-80.0 to -143.7)	83.0% (74.0 to 88.4%)	8.0% (4.1 to 13.6%)	96.0% (89.8 to 99.0%)	57.9% (40.2 to 71.0%)	99.5% (98.7 to 99.9%)
Madagascar	14,675 (9,248-21,904)	337.3 (212.5-503.4)	-56.3% (-73.2 to -33.4%)	-434.5 (-439.0 to -401.5)	87.2% (78.2 to 92.5%)	6.3% (2.9 to 11.0%)	97.0% (91.8 to 99.3%)	64.0% (46.4 to 76.7%)	99.7% (99.3 to 99.9%)

Location Name	Deaths (95% UI)	Mortality per 100,000 (95% UI)	Percent change in mortality rate 1990-2017 (95% UI)	Absolute difference in mortality rate 1990-2017 (95% UI)	Nutrition-associated risks attributable fraction (95% UI)	Low rotavirus vaccine attributable fraction (95% UI)	Unsafe WASH attributable fraction (95% UI)	Low ORS coverage attributable fraction (95% UI)	Total risk attributable fraction (95% UI)
Malawi	2,538 (1,664-3,688)	92.6 (60.7-134.6)	-89.4% (-93.8 to -78.7%)	-778.7 (-429.6 to -1,040.3)	79.6% (66.0 to 87.9%)	8.0% (3.5 to 15.0%)	96.7% (91.4 to 99.1%)	43.9% (26.9 to 61.1%)	99.5% (98.6 to 99.9%)
Mozambique	4,393 (2,905-6,257)	93.4 (61.8-133.1)	-82.5% (-90.3 to -70.3%)	-439.2 (-294.4 to -789.7)	83.1% (69.9 to 90.9%)	6.5% (3.4 to 11.0%)	96.7% (91.4 to 99.2%)	50.9% (32.1 to 66.9%)	99.5% (98.8 to 99.9%)
Rwanda	1,887 (1,156-2,890)	98.6 (60.4-151.0)	-88.4% (-93.9 to -79.4%)	-749.4 (-537.2 to -1,000.8)	77.5% (63.5 to 86.9%)	3.0% (1.1 to 7.4%)	96.1% (90.1 to 99.0%)	60.5% (42.8 to 74.0%)	99.3% (98.0 to 99.8%)
Somalia	6,681 (3,765-11,254)	225.2 (126.9-379.4)	-68.6% (-81.5 to -38.3%)	-492.5 (-245.7 to -778.9)	91.3% (83.5 to 95.7%)	27.5% (17.7 to 38.8%)	96.8% (91.5 to 99.2%)	55.2% (35.9 to 70.7%)	99.8% (99.5 to 100.0%)
South Sudan	7,912 (4,971-11,405)	452.8 (284.5-652.7)	-37.8% (-59.7 to 4.5%)	-275.7 (-100.4 to -504.7)	90.8% (83.8 to 95.0%)	27.5% (17.7 to 38.7%)	97.3% (92.7 to 99.4%)	54.6% (35.1 to 69.6%)	99.9% (99.6 to 100.0%)
Tanzania	4,902 (2,939-7,719)	54.4 (32.6-85.7)	-86.5% (-92.3 to -76.1%)	-349.8 (-246.5 to -443.8)	80.8% (67.7 to 88.6%)	3.7% (1.6 to 7.4%)	96.0% (89.5 to 99.0%)	55.0% (36.1 to 70.0%)	99.4% (98.4 to 99.9%)
Uganda	5,261 (3,545-7,453)	75.8 (51.0-107.3)	-76.3% (-85.6 to -59.6%)	-243.3 (-157.2 to -346.5)	77.7% (63.1 to 86.7%)	27.4% (23.5 to 31.2%)	96.2% (90.0 to 99.0%)	54.6% (34.0 to 70.5%)	99.3% (98.2 to 99.8%)
Zambia	3,708 (2,510-5,277)	129.3 (87.5-184.0)	-78.4% (-86.9 to -62.9%)	-468.2 (-306.3 to -647.3)	84.6% (74.2 to 90.9%)	0.8% (0.4 to 1.5%)	95.8% (89.0 to 98.9%)	45.2% (25.9 to 63.1%)	99.5% (98.7 to 99.9%)
Southern Sub-Saharan Africa	8,070 (6,972-9,314)	94.5 (81.7-109.1)	-67.9% (-73.3 to -61.4%)	-200.1 (-173.6 to -223.6)	81.5% (68.3 to 88.6%)	7.1% (4.1 to 11.1%)	89.0% (78.3 to 96.0%)	53.2% (35.2 to 66.7%)	98.3% (96.2 to 99.4%)
Botswana	196 (137-278)	82.0 (57.0-116.1)	-62.1% (-75.1 to -42.9%)	-134.3 (-101.5 to -166.3)	85.0% (72.7 to 91.5%)	16.1% (9.9 to 23.3%)	90.7% (79.9 to 97.1%)	51.2% (33.1 to 65.9%)	98.8% (97.2 to 99.7%)
Lesotho	474 (293-738)	209.5 (129.6-326.1)	-47.0% (-67.8 to -14.4%)	-185.6 (-166.8 to -171.9)	80.0% (67.2 to 88.3%)	7.7% (3.3 to 14.7%)	96.7% (91.6 to 99.2%)	49.4% (31.3 to 64.3%)	99.4% (98.5 to 99.9%)
Namibia	321 (194-492)	110.8 (67.2-170.0)	-67.0% (-80.0 to -50.8%)	-225.3 (-170.3 to -256.2)	86.1% (73.4 to 92.2%)	4.0% (1.6 to 8.0%)	92.5% (82.4 to 97.7%)	43.1% (25.8 to 57.5%)	99.1% (97.9 to 99.8%)

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South Africa	4,616 (3,941-5,353)	84.9 (72.5-98.5)	-76.8% (-81.0 to -72.2%)	-281.1 (-243.2 to -317.7)	82.9% (70.2 to 89.6%)	5.1% (2.2 to 9.5%)	84.5% (70.9 to 94.0%)	53.3% (35.7 to 67.0%)	97.6% (95.0 to 99.2%)
Swaziland	247 (154-379)	170.3 (106.2-261.2)	-50.3% (-67.7 to -27.0%)	-172.6 (-101.6 to -210.4)	75.7% (61.1 to 85.1%)	11.9% (6.1 to 19.9%)	94.8% (87.3 to 98.6%)	41.3% (24.6 to 56.6%)	98.8% (97.0 to 99.7%)
Zimbabwe	2,216 (1,457-3,112)	100.6 (66.2-141.3)	6.4% (-34.7 to 76.6%)	6.1 (1.8 to 11.1)	78.7% (64.1 to 87.7%)	10.5% (6.2 to 16.1%)	95.5% (88.5 to 98.8%)	56.7% (38.7 to 70.2%)	99.1% (97.8 to 99.8%)
Western Sub-Saharan Africa	193,260 (157,286-236,075)	269.3 (219.1-328.9)	-70.1% (-76.9 to -60.2%)	-630.4 (-480.1 to -785.7)	89.8% (82.2 to 93.6%)	29.2% (23.7 to 35.0%)	96.1% (89.9 to 99.0%)	59.9% (41.0 to 72.9%)	99.7% (99.2 to 99.9%)
Benin	3,614 (2,232-5,495)	189.4 (116.9-287.9)	-61.5% (-77.8 to -35.8%)	-302.7 (-241.3 to -355.6)	89.1% (79.8 to 94.0%)	31.2% (20.2 to 44.3%)	96.5% (91.1 to 99.1%)	55.4% (35.8 to 70.6%)	99.7% (99.3 to 99.9%)
Burkina Faso	7,517 (4,875-11,033)	201.4 (130.6-295.5)	-73.0% (-83.8 to -55.3%)	-543.0 (-386.3 to -749.5)	91.4% (84.3 to 95.4%)	11.3% (5.6 to 19.7%)	97.1% (92.5 to 99.3%)	63.7% (45.4 to 76.5%)	99.8% (99.6 to 100.0%)
Cameroon	7,944 (4,065-13,144)	193.1 (98.8-319.5)	-68.9% (-81.8 to -51.6%)	-427.1 (-304.3 to -566.3)	84.1% (71.9 to 90.9%)	11.4% (5.7 to 19.4%)	96.1% (90.1 to 99.0%)	64.3% (46.4 to 76.9%)	99.5% (98.7 to 99.9%)
Cape Verde	6 (4-9)	11.5 (7.3-17.8)	-96.5% (-98.0 to -93.9%)	-314.0 (-217.0 to -430.9)	70.9% (51.5 to 82.2%)	31.4% (20.3 to 44.2%)	92.6% (83.0 to 97.8%)	58.8% (39.8 to 73.5%)	98.2% (95.6 to 99.5%)
Chad	20,057 (14,653-26,592)	654.3 (478.0-867.5)	-46.9% (-62.5 to -22.7%)	-577.1 (-381.3 to -812.6)	92.5% (86.5 to 95.8%)	30.9% (20.1 to 44.7%)	97.2% (92.4 to 99.3%)	62.2% (43.3 to 75.3%)	99.9% (99.6 to 100.0%)
Cote d'Ivoire	7,608 (4,839-11,201)	196.5 (125.0-289.4)	-44.0% (-64.5 to -15.4%)	-154.7 (-135.0 to -165.2)	85.8% (73.5 to 92.4%)	19.6% (11.4 to 29.6%)	95.8% (89.6 to 98.8%)	63.3% (46.5 to 76.4%)	99.5% (98.7 to 99.9%)
The Gambia	288 (178-428)	90.3 (56.0-134.2)	-63.1% (-77.1 to -44.0%)	-154.6 (-132.4 to -173.2)	88.8% (78.4 to 94.0%)	2.8% (1.3 to 5.1%)	95.9% (89.8 to 98.9%)	54.5% (35.8 to 69.6%)	99.7% (99.1 to 99.9%)
Ghana	3,628 (2,306-5,447)	89.4 (56.8-134.2)	-79.0% (-87.7 to -63.5%)	-336.8 (-250.1 to -434.5)	85.0% (72.4 to 91.9%)	7.7% (3.7 to 13.0%)	96.3% (90.5 to 99.0%)	58.0% (40.0 to 71.0%)	99.6% (98.9 to 99.9%)

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Guinea	2,763 (1,775-4,048)	140.5 (90.3-205.9)	-72.1% (-83.2 to -53.8%)	-362.6 (-265.3 to -471.9)	87.0% (76.3 to 92.9%)	31.1% (20.2 to 44.4%)	96.8% (91.5 to 99.2%)	58.4% (39.0 to 72.6%)	99.7% (99.2 to 99.9%)
Guinea-Bissau	738 (479-1,097)	241.2 (156.5-358.3)	-64.5% (-78.2 to -39.2%)	-438.3 (-285.2 to -582.9)	85.5% (73.3 to 91.8%)	17.6% (9.0 to 29.7%)	96.8% (91.6 to 99.2%)	62.6% (44.9 to 75.6%)	99.6% (99.0 to 99.9%)
Liberia	1,195 (628-1,959)	169.0 (88.7-277.0)	-85.0% (-92.5 to -72.5%)	-960.4 (-750.5 to -1,158.5)	84.8% (71.8 to 91.9%)	18.7% (10.2 to 30.1%)	96.9% (91.8 to 99.2%)	49.4% (30.7 to 66.1%)	99.6% (98.9 to 99.9%)
Mali	8,704 (5,093-13,707)	233.0 (136.4-367.0)	-77.3% (-86.8 to -62.6%)	-794.2 (-593.7 to -961.6)	88.5% (79.1 to 93.7%)	6.6% (4.3 to 9.2%)	96.8% (91.6 to 99.2%)	60.0% (42.2 to 73.9%)	99.8% (99.4 to 100.0%)
Mauritania	628 (357-978)	109.7 (62.4-171.0)	-83.4% (-90.2 to -73.0%)	-551.9 (-401.8 to -699.0)	92.0% (86.3 to 95.8%)	13.3% (6.1 to 22.7%)	95.8% (89.6 to 98.9%)	62.7% (45.5 to 75.8%)	99.9% (99.7 to 100.0%)
Niger	16,939 (11,091-24,281)	387.8 (253.9-555.9)	-77.6% (-86.6 to -64.3%)	-1,344.2 (-969.9 to -1,735.1)	93.5% (88.0 to 96.5%)	16.0% (11.4 to 21.2%)	97.1% (92.2 to 99.3%)	57.8% (40.5 to 72.3%)	99.9% (99.7 to 100.0%)
Nigeria	104,267 (75,975-139,594)	302.7 (220.6-405.3)	-72.2% (-81.6 to -56.2%)	-785.2 (-517.5 to -1,053.9)	89.8% (81.9 to 93.9%)	40.4% (35.3 to 45.1%)	95.7% (88.8 to 98.9%)	59.5% (40.8 to 73.1%)	99.7% (99.1 to 99.9%)
Sao Tome and Principe	8 (4-13)	31.5 (16.6-53.4)	-92.1% (-96.0 to -85.1%)	-368.5 (-278.1 to -454.5)	84.3% (70.5 to 91.6%)	6.6% (2.7 to 13.3%)	92.7% (82.9 to 97.9%)	55.3% (35.9 to 70.6%)	99.1% (97.9 to 99.8%)
Senegal	3,300 (2,109-4,807)	145.6 (93.0-212.1)	-79.2% (-87.2 to -68.3%)	-554.3 (-454.3 to -645.8)	87.0% (75.2 to 92.7%)	6.4% (2.7 to 13.0%)	94.4% (86.5 to 98.4%)	63.4% (45.5 to 76.1%)	99.4% (98.5 to 99.9%)
Sierra Leone	2,430 (1,467-3,705)	203.4 (122.8-310.0)	-76.9% (-86.6 to -62.3%)	-678.8 (-534.4 to -824.0)	88.9% (78.9 to 94.3%)	9.2% (3.8 to 17.7%)	96.9% (91.7 to 99.2%)	39.9% (21.7 to 57.3%)	99.7% (99.3 to 99.9%)
Togo	1,625 (899-2,698)	151.9 (84.0-252.3)	-75.7% (-84.9 to -62.1%)	-473.9 (-321.0 to -654.4)	87.0% (76.3 to 92.9%)	12.6% (7.3 to 20.6%)	96.6% (91.2 to 99.1%)	65.0% (47.0 to 77.1%)	99.7% (99.2 to 99.9%)

References

1 GBD 2017 Causes of Death Collaborators. Global, regional, and national age-sex-specific mortality for 282 causes of death, 1980-2017: a systematic analysis for the Global Burden of Disease Study 2017. *The Lancet* 20118; : Accepted.

2 GBD Diarrhoeal Diseases Collaborators. Estimates of global, regional, and national morbidity, mortality, and aetiologies of diarrhoeal diseases: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet Infect Dis* 2017; **17**: 909–48.

3 GBD 2016 Diarrhoeal Disease Collaborators. Estimates of the global, regional, and national morbidity, mortality, and aetiologies of diarrhoea in 195 countries: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet Infect Dis* 2018.

4 Golding N, Burstein R, Longbottom J, *et al.* Mapping under-5 and neonatal mortality in Africa, 2000-15: a baseline analysis for the Sustainable Development Goals. *Lancet Lond Engl* 2017; **390**: 2171–82.

5 Reiner RC, Graetz N, Casey DC, *et al.* Variation in Childhood Diarrheal Morbidity and Mortality in Africa, 2000–2015. *N Engl J Med* 2018; **379**: 1128–38.

6 World Health Organization/The United Nations Children's Fund (UNICEF). End preventable deaths: Global Action Plan for Prevention and Control of Pneumonia and Diarrhoea. 2013.

7 Bhutta ZA, Das JK, Walker N, *et al.* Interventions to address deaths from childhood pneumonia and diarrhoea equitably: what works and at what cost? *Lancet Lond Engl* 2013; **381**: 1417–29.

8 Troeger C, Blacker BF, Khalil IA, *et al.* Estimates of the global, regional, and national morbidity, mortality, and aetiologies of diarrhoea in 195 countries: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet Infect Dis* 2018; **0**. DOI:10.1016/S1473-3099(18)30362-1.

9 GBD 2017 Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. *The Lancet* 2018; : Submitted.

10 GBD 2017 Risk Factor Collaborators. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. *The Lancet* 2018; : Submitted.

11 Stevens GA, Alkema L, Black RE, *et al.* Guidelines for Accurate and Transparent Health Estimates Reporting: the GATHER statement. *The Lancet* 2016; **388**: e19–23.

12 Foreman KJ, Lozano R, Lopez AD, Murray CJ. Modeling causes of death: an integrated approach using CODEm. *Popul Health Metr* 2012; **10**: 1.

13 Guo Y, Bai J, Na H. The history of China's maternal and child health care development. *Semin Fetal Neonatal Med* 2015; **20**: 309–14.

14 Osgood-Zimmerman A, Millear AI, Stubbs RW, *et al.* Mapping child growth failure in Africa between 2000 and 2015. *Nature* 2018; **555**: 41–7.

15 Lamberti LM, Walker CLF, Chan KY, Jian W-Y, Black RE. Oral zinc supplementation for the treatment of acute diarrhea in children: a systematic review and meta-analysis. *Nutrients* 2013; **5**: 4715–40.

16 Troeger C, Colombara DV, Rao PC, *et al.* Global disability-adjusted life-year estimates of long-term health burden and undernutrition attributable to diarrhoeal diseases in children younger than 5 years. *Lancet Glob Health* 2018; **6**: e255–69.

17 Khalil IA, Troeger C, Rao PC, *et al.* Morbidity, mortality, and long-term consequences associated with diarrhoea from Cryptosporidium infection in children younger than 5 years: a meta-analyses study. *Lancet Glob Health* 2018; **6**: e758–68.

18 Olofin I, McDonald CM, Ezzati M, *et al.* Associations of suboptimal growth with all-cause and cause-specific mortality in children under five years: a pooled analysis of ten prospective studies. *PloS One* 2013; **8**: e64636.

19 Luby SP, Rahman M, Arnold BF, *et al.* Effects of water quality, sanitation, handwashing, and nutritional interventions on diarrhoea and child growth in rural Bangladesh: a cluster randomised controlled trial. *Lancet Glob Health* 2018; **6**: e302–15.

20 Mosley WH, Chen LC. An analytical framework for the study of child survival in developing countries. 1984. *Bull World Health Organ* 2003; **81**: 140–5.

21 Null C, Stewart CP, Pickering AJ, *et al.* Effects of water quality, sanitation, handwashing, and nutritional interventions on diarrhoea and child growth in rural Kenya: a cluster-randomised controlled trial. *Lancet Glob Health* 2018; **6**: e316–29.

22 Hutton G, Haller L. Evaluation of the costs and benefits of water and sanitation improvements at the global level. 2004. http://www.who.int/water_sanitation_health/publications/wash-improvements-costs-benefits/en/ (accessed Sept 28, 2018).

23 Hutton G, Chase C. The Knowledge Base for Achieving the Sustainable Development Goal Targets on Water Supply, Sanitation and Hygiene. *Int J Environ Res Public Health* 2016; **13**. DOI:10.3390/ijerph13060536.

24 The World Health Organization and United Nations Children's Fund. Progress on drinking water, sanitation and hygiene: Joint Monitoring Programme 2017 update and SDG baselines. 2018. http://www.who.int/water_sanitation_health/publications/jmp-2017/en/ (accessed Sept 28, 2018).

25 Schmidt W-P, Cairncross S. Household water treatment in poor populations: is there enough evidence for scaling up now? *Environ Sci Technol* 2009; **43**: 986–92.

26 Munos MK, Walker CLF, Black RE. The effect of oral rehydration solution and recommended home fluids on diarrhoea mortality. *Int J Epidemiol* 2010; **39 Suppl 1**: i75-87.

27 Blum LS, Oria PA, Olson CK, Breiman RF, Ram PK. Examining the Use of Oral Rehydration Salts and Other Oral Rehydration Therapy for Childhood Diarrhea in Kenya. *Am J Trop Med Hyg* 2011; **85**: 1126–33.

28 Troeger C, Khalil IA, Rao PC, *et al.* Rotavirus Vaccination and the Global Burden of Rotavirus Diarrhea Among Children Younger Than 5 Years. *JAMA Pediatr* 2018; published online Aug 13. DOI:10.1001/jamapediatrics.2018.1960.

29 Vaccine Introduction. Rota Counc. http://rotacouncil.org/vaccine-introduction/global-introduction-status.

30 Pneumonia and diarrhea progress report 2018. International Vaccine Access Center, Johns Hopkins Bloomberg School of Public Health. 2018.