Patterns in coverage of maternal, newborn, and child health interventions: projections of neonatal and under-5 mortality to 2035

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Summary

Background Urgent calls have been made for improved understanding of changes in coverage of maternal, newborn, and child health interventions, and their country-level determinants. We examined historical trends in coverage of interventions with proven effectiveness, and used them to project rates of child and neonatal mortality in 2035 in 74 Countdown to 2015 priority countries.

Methods We investigated coverage of all interventions for which evidence was available to suggest effective reductions in maternal and child mortality, for which indicators have been defined, and data have been obtained through household surveys. We reanalysed coverage data from 312 nationally-representative household surveys done between 1990 and 2011 in 69 countries, including 58 Countdown countries. We developed logistic Loess regression models for patterns of coverage change for each intervention, and used *k*-means cluster analysis to divide interventions into three groups with different historical patterns of coverage change. Within each intervention group, we examined performance of each country in achieving coverage gains. We constructed models that included baseline coverage, region, gross domestic product, conflict, and governance to examine country-specific annual percentage coverage change for each group of indicators. We used the Lives Saved Tool (LiST) to predict mortality rates of children younger than 5 years (henceforth, under 5) and in the neonatal period in 2035 for Countdown countries if trends in coverage continue unchanged (historical trends scenario) and if each country accelerates intervention coverage to the highest level achieved by a Countdown country with similar baseline coverage level (best performer scenario).

Results Odds of coverage of three interventions (antimalarial treatment, skilled attendant at birth, and use of improved sanitation facilities) have decreased since 1990, with a mean annual decrease of 5·5% (SD 2·7%). Odds of coverage of four interventions—all related to the prevention of malaria—have increased rapidly, with a mean annual increase of 27·9% (7·3%). Odds of coverage of other interventions have slowly increased, with a mean annual increase of 5·3% (3·5%). Rates of coverage change varied widely across countries; we could not explain the differences by measures of gross domestic product, conflict, or governance. On the basis of LiST projections, we predicted that the number of Countdown countries with an under-5 mortality rate of fewer than 20 deaths per 1000 livebirths per year would increase from four (5%) of the 74 in 2010, to nine (12%) by 2035 under the historical trends scenario, and to 15 (20%) under the best performer scenario. The number of countries with neonatal mortality rates of fewer than 11 per 1000 livebirths per year would increase from three (4%) in 2010, to ten (14%) by 2035 under the historical trends scenario, and 67 (91%) under the best performer scenario. The number of under-5 deaths per year would decrease from an estimated 7·6 million in 2010, to 5·4 million (28% decrease) if historical trends continue, and to 2·3 million (71% decrease) under the best performer scenario.

Interpretation Substantial reductions in child deaths are possible, but only if intensified efforts to achieve intervention coverage are implemented successfully within each of the Countdown countries.

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Introduction

In June, 2012, at a global meeting convened by UNICEF and the governments of Ethiopia, India, and the USA, a target was proposed of 20 or fewer deaths of children younger than 5 years (henceforth, under 5) per 1000 livebirths by 2035 in all countries.[1] There are increasingly urgent calls for improved understanding of changes in coverage of maternal, newborn, and child health (MNCH) interventions, and their country-level determinants.[2] Some have claimed that changes in intervention coverage across countries have no discernible patterns, and have recommended that country case studies are the only useful way forward.[3] Others, including Countdown to 2015 for Maternal, Newborn and Child Survival (henceforth, Countdown), are working to combine cross-country analyses of patterns with in-depth country case studies to generate the information needed to inform programme planning and support the difficult choices about alternative programmatic strategies that must be made.

Here, we use available evidence to examine the extent to which the 2035 under-5 mortality goal is achievable. We focused on 74 countries that together account for

more than 95% of maternal and child deaths worldwide and are priority countries for both Countdown[4] and for follow-up by the Commission on Information and Accountability for Women's and Children's Health.[5] We address three broad areas. First, we describe differences in historical coverage change since 1990 for proven MNCH interventions and investigate potential explanatory variables, such as baseline coverage and country characteristics, as drivers of coverage change. Second, we use the results of these analyses to develop country-specific and intervention-specific models to predict future coverage of these interventions. Finally, with these predicted coverage levels and the Lives Saved Tool (LiST), we project under-5 and neonatal mortality in 2035 under two scenarios: one based on the continuation of historical trends and one using best performer assumptions.

See Online for appendix

For more on the **Demographic and Health Survey programme** see http://www.measuredhs.com

For more on the **Multiple Indicator Cluster Survey programme** see http://www.childinfo.org

Methods

Data sources

We included all low-income and middle-income countries with adequate data in initial descriptive analyses of patterns of coverage change (69 countries, of which 58 were Countdown countries). We grouped countries into geographical regions as defined by UNICEF and Countdown to explore possible patterns. Country estimates of gross domestic product (GDP) were taken from the World Bank;[6] we used the average country-specific estimate for 2000–09. Scores for conflict were taken from the Uppsala Conflict Data Program[7] and reflect the presence of conflict in 1991–2000, and 2001–10. We used a combined measure of good governance that measures perceptions of political stability and absence of violence as reported by the Worldwide Governance Indicators Project,[8] additional information about which is available elsewhere.[9]

We investigated coverage of all interventions for which evidence was available to suggest effective reductions in maternal and child mortality, for which indicators (standard variables that can be measured reliably over time and across contexts) have been defined, and data have been obtained through household surveys in which indicators are as defined in the 2012 Countdown cycle[4] and used by LiST. Some indicators reflect health service contacts (eg, antenatal care, postnatal care, and skilled attendant at delivery) rather than true intervention coverage. The appendix contains a list of the 29 indicators and the definitions and recall periods used in the analysis. These indicators are used in LiST to estimate present and projected coverage of 50 interventions that effectively reduce under-5 mortality (appendix).

We used data from 312 nationally-representative household surveys done under the Demographic and Health Survey programme between 1990 and 2011, including Malaria Indicator Surveys, AIDS Indicator Surveys, and those done under the UNICEF-supported Multiple Indicator Cluster Survey programme (appendix). To ensure the definitions of the indicators for the water and sanitation interventions were consistent with time, we used recalculations of survey data done by the Joint Monitoring Program for Water and Sanitation[10] rather than raw survey data for indicators of improved water, improved sanitation, and a household water connection.

We did not use estimates of intervention coverage and associated standard errors from the published survey reports. Instead, to ensure consistent methods in computing coverage, the survey datasets were used to recalculate the coverage estimates. For some of the surveys, this recalculation had already been done by the Countdown Equity Technical Working group.[11] For the other surveys and indicators, we obtained the survey data files and recalculated the coverage indicators using the same methods as used by Countdown. Raw data files were unavailable for 1192 specific point estimates of coverage (27·6%) used in the analysis; for surveys for which we could confirm that the standard indicator

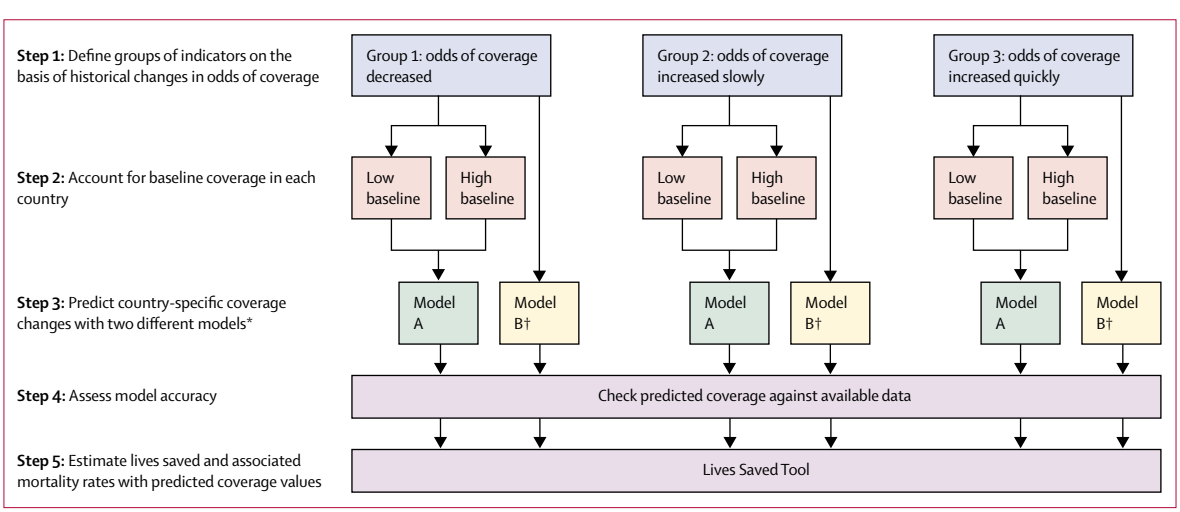

Figure 1: **Five-step strategy to develop prediction models for change in coverage of maternal, newborn, and child health interventions**
*The choice of model depended on how many coverage estimates were available for the country. †Coverage at baseline (high or low) was not used as a predictor.

definition had been used, we abstracted the sample sizes and coverage levels from the survey report (appendix). Coverage for interventions targeting malaria was investigated only for countries where malaria is a major cause of death for children under 5 and for which needed data were available (32 countries in sub-Saharan Africa).

Statistical analyses

We calculated the percentage change in odds of coverage of each intervention per year as our key outcome variable, which was defined as:

$$[\exp(\beta_1) - 1] \times 100\%$$

where β_1 is the estimated change in log odds of coverage per year for the specific indicator aggregating data across all countries (appendix).

We then used a five-step strategy to develop the prediction models (figure 1, appendix). In step 1, we plotted all point estimates for coverage for each indicator by calendar year and used locally weighted (Loess) regression to estimate a smooth, best-fitting trend line and to describe the average trajectory for each indicator.[12] We then used *k*-means cluster analysis on the estimated slopes to group indicators with similar patterns of coverage change.[13] This method allowed us to partition the data into three similar groups used in final analysis (figure 1). To validate that the three groups were different, we compared indicator-specific slopes with one-way ANOVA. The estimated annual percentage change in odds of coverage by country for each of the three groups of indicators was plotted against the estimated baseline.

We postulated that the existing level of coverage would be an important determinant of coverage change, because interventions that already had high population coverage would have little scope for further improvement. Therefore, in step 2, we used *k*-means cluster analysis to classify countries as having high or low baseline coverage (defined as the earliest available coverage measurement after 1990; figure 1), using the intercept and the slope from country-specific logistic regression models for each indicator group.

In step 3, we developed and tested models to predict country-specific coverage for each group of indicators for individual country by year. We used generalised linear mixed effects models with logit link and binomial distributions to model coverage, to estimate coverage change with time as the slope for the time variable in the model, and to predict future coverage.[14] Predictions were based on solutions for the random effects—ie, the estimated best linear unbiased predictors.[15] Two types of models were developed (figure 1). Model A had three levels with random intercepts for country and indicator to account for the hierarchical structure of the data: country, indicator nested within country, and coverage nested within indicator. We assumed that the random intercepts were independent and normally distributed with respective variances. The model also included a random slope at the indicator level to allow for heterogeneity of coverage trajectories over calendar time across indicators. Five predictors were included in model A: a linear function of calendar time represented as the number of years since baseline, region modelled as six indicator variables, GDP per capita modelled as a continuous variable, coverage at baseline (high or low), and an interaction between baseline coverage and calendar time. Model B was almost identical to model A, but did not include the random slope at the indicator level and the predictors were limited to calendar time

	Number of Countdown countries with at least two measurements since 1990	Estimated change in odds of coverage per year (%)*
Group 1: decreases in odds of coverage		
Antimalarial treatment†	32	–8·6%
Skilled attendant at birth	67	–4·7%
Use of improved sanitation facilities	70	–3·3%
Group 2: slow increases in odds of coverage		
Use of improved drinking water sources	67	0·6%
Institutional delivery	45	1·8%
Careseeking for pneumonia	62	2·0%
Hygienic disposal of children's stools	37	2·0%
Exclusive breastfeeding (1–5 months)	30	2·3%
Oral rehydration salts	61	2·4%
Antenatal care (at least four visits)	44	2·4%
Exclusive breastfeeding (<6 months)	31	2·5%
Neonatal tetanus protection	47	3·5%
Exclusive breastfeeding (0–1 month)	31	3·6%
Contraceptive prevalence‡	63	4·6%
Early initiation of breastfeeding	49	5·3%
Antenatal care (at least one visit)	56	5·4%
Measles immunisation	63	5·5%
Need for family planning satisfied	48	5·9%
Three doses of combined diphtheria–pertussis–tetanus vaccine immunisation	55	6·8%
Vitamin A supplementation	32	7·9%
Use of water connection in the home	66	8·4%
Caesarean section	43	8·7%
Three doses of *Haemophilus influenzae* serotype b immunisation	10	10·4%
Postnatal care for mothers	25	10·5%
Artemisinin-combination treatment for malaria case management†	17	13·9%
Group 3: fast increases in odds of coverage		
Household ownership of insecticide-treated nets†	21	18·5%
Use of insecticide-treated nets by pregnant women†	11	25·9%
Use of insecticide-treated nets†	28	32·3%
Intermittent preventive treatment for malaria during pregnancy†	22	35·0%

*Estimated percentage change in odds of coverage per year is defined as $[\exp(\beta_1) - 1] \times 100\%$, where β_1 is the estimated change in log odds of coverage per year for the specific indicator, aggregating data across all countries. †Only countries where malaria is a major cause of deaths in children younger than 5 years, all of which are in sub-Saharan Africa. ‡Definition in appendix.

Table 1: **Predicted change in odds of coverage by intervention**

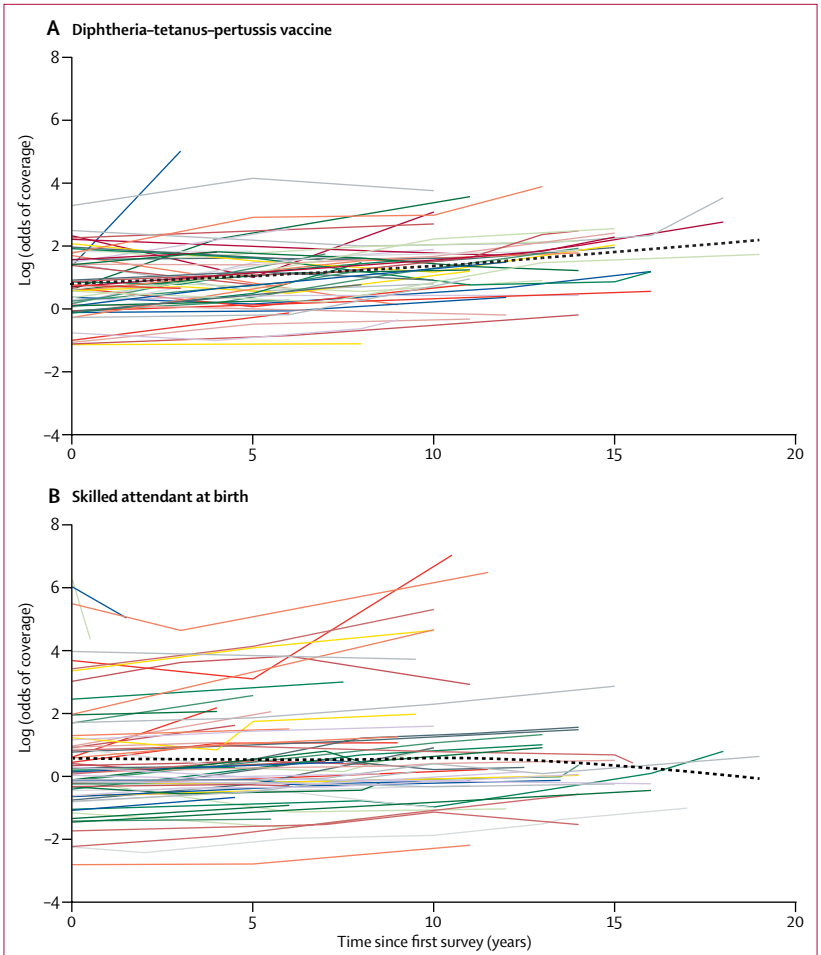

Figure 2: **Coverage change by intervention for countries with at least two surveys since 1990**
(A) Coverage of diphtheria–tetanus–pertussis vaccine in 55 countries. (B) Presence of a skilled attendant at birth in 67 countries. Each coloured line represents one country. The dashed black lines represent lines of best fit (estimated with Loess regression). The y-axis is shown as log (odds of coverage) to match the estimated slope from the logistic regression model. A value of 6 translates to coverage of 99·8%, a value of 5 to 99·3%, 4 to 98·2%, 3 to 95·3%, 2 to 88·1%, 1 to 73·1%, 0 to 50·0%, and −1 to 26·9%. Plots for other interventions shown in the appendix.

represented as the number of years since baseline, region modelled as six indicator variables, and region by calendar time interaction. We used model A to make predictions for all countries with at least two measured point estimates of coverage since 1990; we used model B when only one coverage estimate was available for the period.

In step 4, we checked model predictions against the available data for the countries that were used in model development using the cross-validated *C* statistic, which for binary outcomes is identical to the area under the receiver operating curve.[16] The *C* statistic assesses the ability of the model to distinguish between people with and without coverage (ie, classification); it varies between 0·5 and 1, with higher values indicating better model performance. Cross-validation is an internal validation technique, by which the model prediction is applied to data that were not used in the estimation of model parameters to assess the out-of-sample model performance.

In step 5, we used the final models to project coverage change for the 74 Countdown countries. These projected coverage changes were then used in the LiST model to estimate mortality rates until 2035 for the Countdown countries. Baseline data were not sufficient to do a separate projection for South Sudan. LiST estimates the effect of scaling up of interventions on child mortality, both in the neonatal period and for children aged 1–59 months. The basic structure of the model is that a country is described in a baseline year by various factors, such as death rates, proportional death by cause for the neonatal and 1–59-month periods, background characteristics in a country (eg, income, exposure to *Plasmodium falciparum*, and frequency of stunting), and coverage of interventions. Each of the interventions has an associated set of effectiveness values reflecting estimated effect on one or more causes of mortality or levels of risk factors (eg, stunting). In LiST, we made the assumption that mortality rates are only altered by changes in coverage of interventions, assuming that relations between more distal variables, such as poverty or mothers' education, operate through increasing coverage of interventions. A general, descriptive characterisation of the modelling approach used in LiST is in the appendix and in Garnett and colleagues' report.[17]

In this analysis, we created a set of starting assumptions for 2010 for each country within Spectrum software (version 4.49 beta 3), including information about family planning, HIV prevalence, and for MNCH interventions included in LiST. Point estimates of intervention coverage used were the most recent available, usually drawn from the Demographic and Health Survey and Multiple Indicator Cluster Survey. Estimates of vaccine coverage (diphtheria, tetanus, and pertussis; *Haemophilus influenzae* serotype b; measles; and tetanus toxoid) were taken from the WHO/UNICEF consensus estimates of coverage.[18]

We used these starting assumptions in LiST to generate projected mortality rates in 2035 in two scenarios. With the historical trend scenario, we used the predicted country-specific health intervention coverage values to 2035 from the models. Region-specific compound annual growth rates were applied to countries and interventions for which two measured values were not available. For newer vaccines (rotavirus, *H influenzae* serotype b, and pneumococcal), we used predictions of roll-outs of childhood vaccines for all countries to 2035, provided by the GAVI Alliance.[19] Additionally, we calculated the country-specific compound annual growth rate (or regional if not included in the trend analysis) and applied it to the WHO/UNICEF tetanus toxoid value for all countries. For predictions of HIV incidence, prevention of mother-to-child transmission, antiretroviral therapy for children and adults, and treatment with co-trimoxazole, we used extensions of the AIDS 2031 model directly.[20] For family planning, we calculated predictions of the contraceptive

prevalence rate with the coverage prediction model. These predictions were entered into Spectrum to estimate the projected total fertility rate. The total fertility rate was capped at a minimum of 2·1 children per woman, except in the four cases for which the present total fertility rate was already less than 2·1 children per woman. The changes in the total fertility rate caused by increases in the contraceptive prevalence rate alter the default projected population growth for the country, which come from the UN Population Division.

For the second scenario—best performer—we replaced the projected coverage values derived from historical trends with the best rate of change achieved by any country with a similar level of coverage at baseline (low or high) for each of the three groups of interventions (appendix). The coverage scale-up rates for contraceptive use, vaccines, and HIV/AIDS were identical to those used in the historical trend scenario; for vaccines and HIV/AIDS interventions, coverage was already more than 90% by 2035 with the more conservative assumptions.

Role of the funding source

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

Results

The analyses produced three groups of interventions on the basis of percentage change in odds of coverage per year. Odds of coverage of three interventions had decreased and so were included in group 1 (table 1). The mean annual decrease in odds of coverage of these interventions was 5·5% (SD 2·7%) across all countries with at least two measurements since 1990. Odds of coverage of 22 interventions had increased slowly and so were included in group 2 (table 1). The mean annual increase in odds of coverage was 5·3% (SD 3·5%) across all countries with at least two measurements. Odds of coverage of four interventions—all related to malaria prevention—had increased quickly and so were included in group 3. The mean annual increase in odds of coverage was 27·9% (7·3%) across all countries with at least two measurements. These trends in coverage reflect substantial heterogeneity in odds of coverage across countries for individual interventions (figure 2).

The range of baseline coverage values defined as high was lower in group 3 than in group 2 (figure 3). Group 1 had the highest range of high baseline coverage (figure 3). The ranges for low baseline coverage across the indicator groups had a similar pattern (figure 3). The results of these exploratory analyses seem to confirm the notion that coverage change is capped. We explored them further in the prediction models by allowing the slope for calendar time to vary by the level of baseline coverage (ie, interaction of time and baseline coverage, model A).

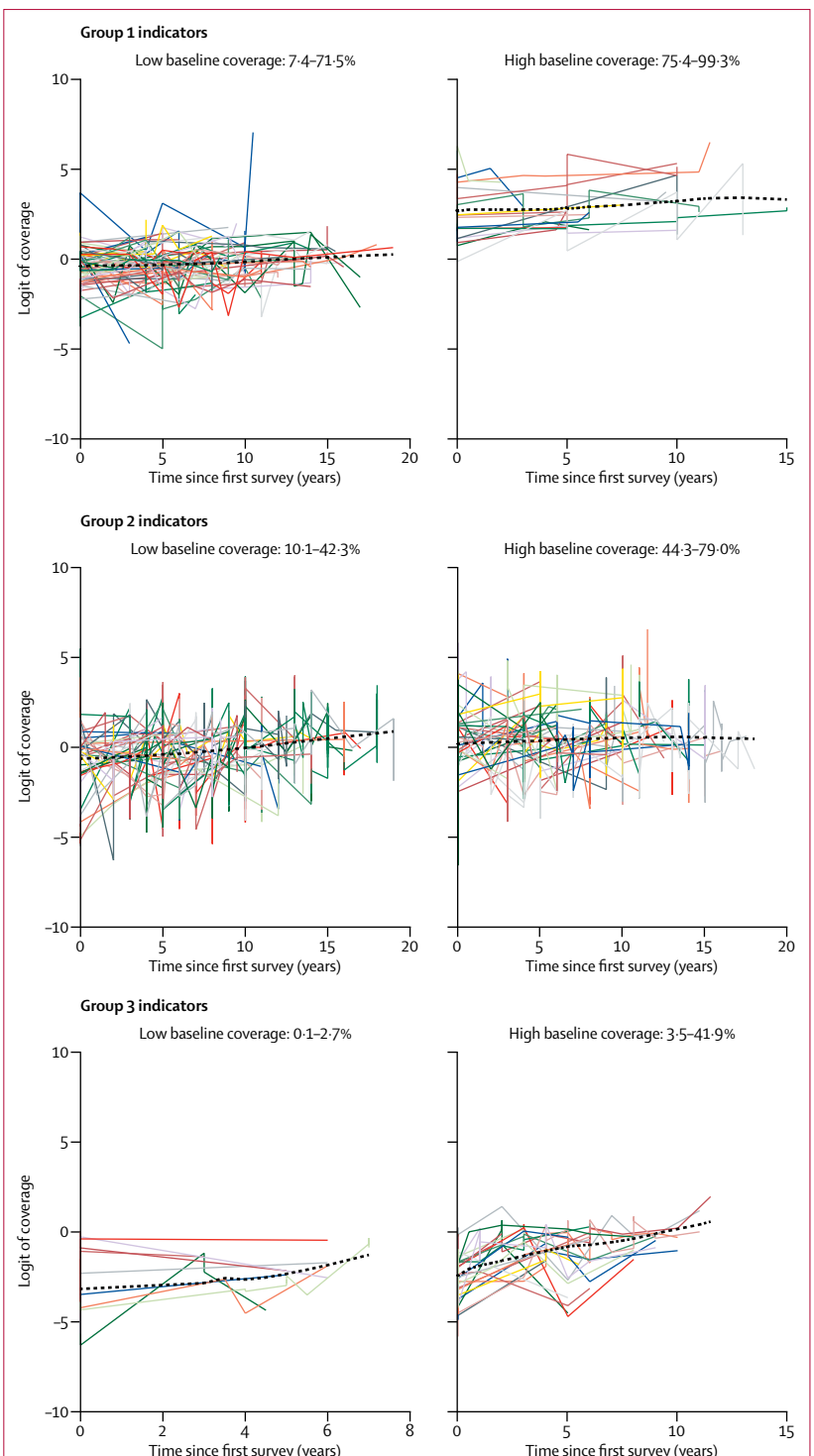

Figure 3: **Change in odds of coverage since time of first survey for countries with low and high baseline coverage, by intervention group**

More than half the countries had percentage changes in odds of coverage of group 3 interventions that were greater than the countries with the greatest changes in

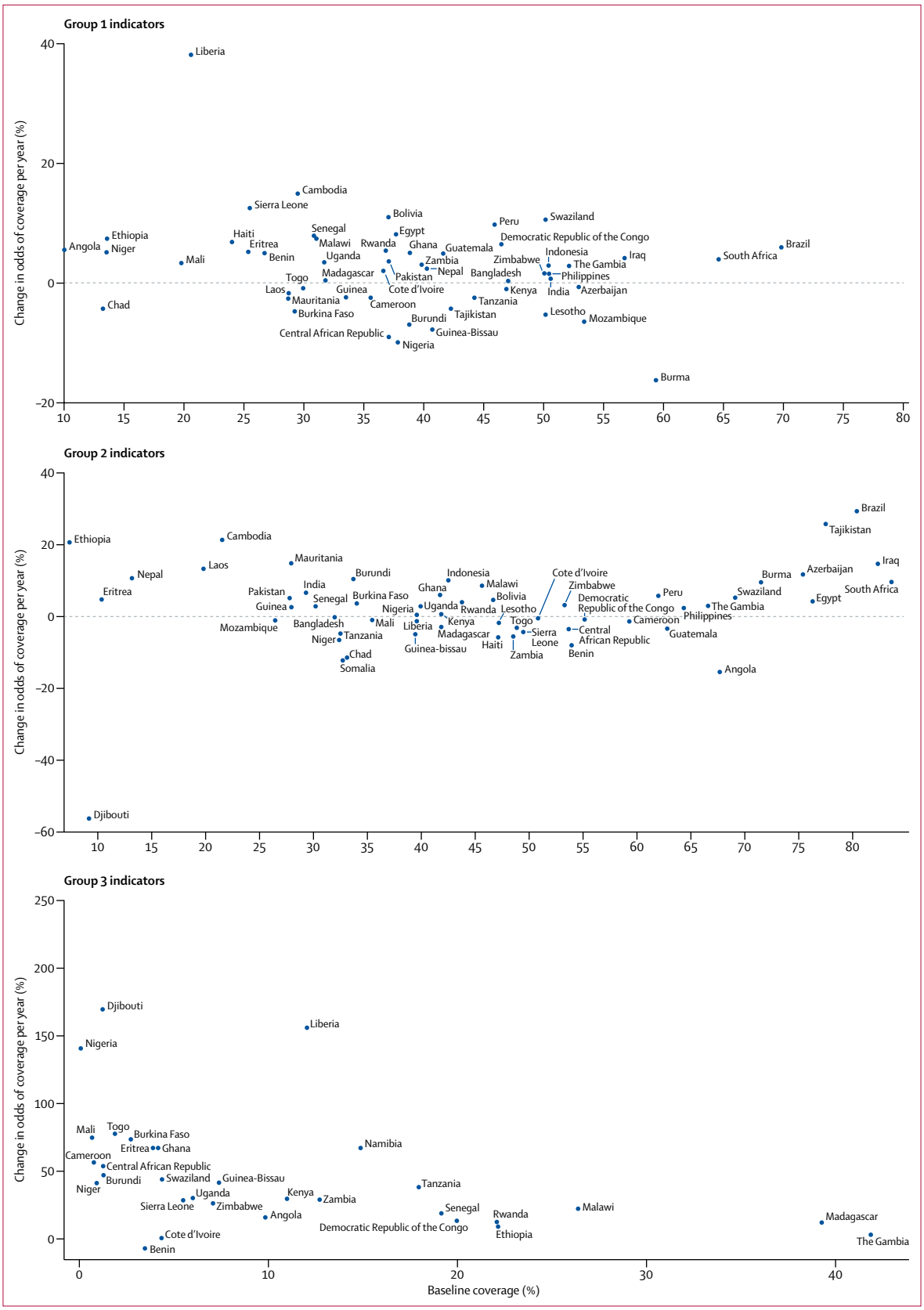

Figure 4: **Change in odds of coverage by baseline odds of coverage for countries with at least two measurements of coverage since 1990**
Baseline coverage is from different years in different countries, depending on when surveys were done. Therefore, comparison of differences between countries on the basis of baseline coverage is not possible. Group 3 indicators had to be plotted on a completely different scale for the percent change, because of the fast increases in coverage.

odds of coverage of group 1 or 2 interventions (data not shown). We also recorded differences between countries within intervention groups. Countries in Africa consistently did the least well, with the lowest baselines and least progress across all three intervention groups (figure 4). For group 1 interventions, Liberia was an outlier, with fairly low baseline coverage (21%) but an annual increase in odds of coverage of nearly 40% (figure 4). For group 2 interventions, Mauritania, Ethiopia, and Cambodia had low baseline coverage and fairly rapid increases (figure 4). South Africa, Swaziland, and The Gambia had mean baseline coverage of group 2 interventions of 60% or more but still had coverage gains (figure 4). The results for the fast-increasing malaria-related indicators showed that most countries had baseline coverage of less than 10%, but achieved rapid increases in coverage (figure 4).

Results of analyses produced three categories of countries reflecting the extent of coverage change across the interventions within each group (data not shown). The results did not help to differentiate between countries, because only three countries were in the lowest performing category for group 1 indicators, and only four countries were in the highest performing category for group 2 indicators.

The fitted linear model of the estimated change in log odds of coverage as a function of country-level predictors could explain only about 10–13% of the variance in slopes in group 1 and group 2 indicators, and about 29% of the variance in slopes for group 3 indicators. No predictor variables were significant, with the exception of the model for group 3 indicators, in which increased baseline coverage was associated with decreased change in log odds of coverage per year after adjustment for region, GDP, conflict, and governance (p=0·037). When we included only baseline coverage in the model, the proportion of variation in the speed of coverage change that was explained by the baseline was 18% for group 3 indicators and about 1% for group 1 and 2 indicators (data not shown). Overall, although there are clearly country differences in the pace of coverage change, we could not define a good set of variables to explain these differences.

To check how well model A fitted with measured trends in coverage, we used each prediction and applied it to datapoints that were not used in the estimation of model parameters. We could not do the same comparison for model B because no trend data were available for these countries. The out-of-sample area under the receiver operator curve (*C* statistic) was 0·7–0·8 for prediction model A across the three indicator groups, suggesting good accuracy of classification. We then used these two models to predict coverage change to 2035 for 74 Countdown countries.

Most interventions were predicted to have high coverage by 2035 (table 2). However, we predicted coverage of less than 30% for maternal interventions delivered during postnatal care by 2035 (table 2), perhaps because postnatal care for mothers is a new indicator with few available datapoints to support the development of reliable historical trends in the scale-up of coverage. Use of oral rehydration salt solution for treatment of diarrhoea and careseeking for pneumonia—both of which are cheap and can be delivered by community health workers—were both predicted to be at fairly low levels of coverage in 2035 (table 2). These predictions, unlike postnatal care for mothers, are based on detailed historical data for coverage change of the interventions and a consistently low rate of change in almost all countries.

Although we did predict almost full coverage for a few indicators (eg, use of insecticide-treated nets by pregnant women, intermittent preventive treatment of malaria for pregnant women, and at least one antenatal care visit), predicted coverage for most of the

	2020	2025	2035
Group 1: decreases in odds of coverage			
Antimalarial treatment*	42%	44%	46%
Skilled attendant at birth	78%	83%	89%
Use of improved sanitation facilities	72%	77%	85%
Group 2: slow increases in odds of coverage			
Use of improved drinking water sources	84%	86%	90%
Institutional delivery	80%	86%	93%
Careseeking for pneumonia	65%	70%	77%
Hygienic disposal of children's stools	61%	66%	76%
Exclusive breastfeeding (1–5 months)	39%	46%	61%
Oral rehydration salts	45%	48%	53%
Antenatal care (at least four visits)	75%	81%	89%
Neonatal tetanus protection	87%	90%	95%
Exclusive breastfeeding (0–1 month)	74%	81%	90%
Contraceptive prevalence†	51%	56%	69%
Early initiation of breastfeeding	72%	79%	88%
Antenatal care (at least one visit)	98%	99%	99%
Measles immunisation	81%	84%	92%
Need for family planning satisfied	75%	79%	86%
Three doses of combined diphtheria–pertussis–tetanus vaccine immunisation	85%	89%	95%
Vitamin A supplementation	65%	71%	80%
Use of water connection in the home	25%	28%	35%
Caesarean section	14%	19%	33%
Three doses of *Haemophilus influenzae* serotype b immunisation	90%	90%	90%
Postnatal care for mothers	23%	25%	28%
Artemisinin-combination treatment for malaria case management*	93%	99%	99%
Group 3: fast increases in odds of coverage			
Household ownership of insecticide-treated nets*	84%	97%	99%
Use of insecticide-treated nets by pregnant women*	99%	99%	99%
Use of insecticide-treated nets*	98%	99%	99%
Intermittent preventive treatment for malaria during pregnancy*	97%	99%	99%

Data are median predicted coverage. *Only countries where malaria is a major cause of deaths in children younger than 5 years, all of which are in sub-Saharan Africa. †Definition in appendix.

Table 2: **Predicted change in coverage of interventions in 74 Countdown countries by 2020, 2025, and 2035**

	Number of countries in 2010	LiST projections of number of countries in 2035	
		Historical trends scenario	Best performer scenario
Under-5 mortality			
≤20 per 1000 livebirths	4 (5%)	9 (12%)	15 (20%)
21–30 per 1000 livebirths	4 (5%)	6 (8%)	17 (23%)
31–40 per 1000 livebirths	6 (8%)	7 (9%)	21 (28%)
41–50 per 1000 livebirths	3 (4%)	15 (20%)	9 (12%)
51–100 per 1000 livebirths	32 (43%)	29 (39%)	12 (16%)
>100 per 1000 livebirths	25 (34%)	8 (11%)	0
Neonatal mortality			
<11 per 1000 livebirths	3 (4%)	10 (14%)	67 (91%)
11–20 per 1000 livebirths	15 (20%)	44 (59%)	7 (9%)
21–30 per 1000 livebirths	24 (32%)	16 (22%)	0
>30 per 1000 livebirths	32 (43%)	4 (5%)	0

Data are n (%). Percentages calculated with the total number of Countdown countries (n=74). LiST=Lives Saved Tool.

Table 3: **Number of Countdown countries achieving different under-5 and neonatal mortality rates in 2010 and projected for 2035**

interventions was less than 90% in 2035 (table 2), suggesting that special attention will be needed to ensure that interventions reach the most marginalised populations unless historical rates of change are accelerated to achieve universal coverage.

We then used LiST to estimate future under-5 and neonatal mortality (appendix). If historical trends in coverage continue unchanged, we estimated that the number of countries with an under-5 mortality rate of fewer than 20 per 1000 livebirths would increase from four (5%) of the 74 Countdown countries in 2010, to nine (12%) in 2035. 52 countries (70%) would still have under-5 mortality rates greater than 40 per 1000 livebirths, and eight (11%) would still have rates of more than 100 per 1000 livebirths (table 3). The results for neonatal mortality are similar: the number of countries with a neonatal mortality rate of fewer than 11 per 1000 livebirths would increase from three (4%) in 2010, to ten (14%) in 2035, and 20 countries (27%) would still have rates of more than 20 per 1000 livebirths (table 3).

Under the best performer scenario, 15 countries (20%) would achieve the target of an under-5 mortality rate of fewer than 20 per 1000 livebirths by 2035, and 53 (72%) would have rates of 40 per 1000 livebirths or fewer (table 3). All countries would have rates of neonatal mortality of 20 per 1000 livebirths or fewer (table 3).

In absolute terms, the number of under-5 deaths in the 74 Countdown countries would decrease from 7·6 million in 2010, to 5·4 million in 2035 under the historical trend scenario—a decrease of 28%—and to 2·3 million in 2035 under the best performer scenario—a decrease of 71%. The drop in the absolute number of child deaths is driven not only by coverage, but also by projected drops in fertility.

Discussion

We have identified important differences in historical trends of coverage of specific subsets of MNCH interventions. High baseline coverage can restrict continued coverage gains, and must be taken into account when judgments about progress are made on the basis of changes in coverage. We could not identify consistent explanations for variations in coverage across countries attributable to different GDP, conflict, or governance, which is consistent with previous research.[3]

Of interventions for which coverage is measured with household surveys, we have shown that coverage has risen most quickly for those related to malaria prevention. Interventions related to HIV have also been scaled up rapidly, but were not included in this analysis because their coverage is not measured through household surveys (panel 1) and because consistent time series data since 2000 are not available. Both malaria and HIV interventions were introduced in the late 1990s, and benefited from high financial investment and political commitment. They are examples of what is possible, and of what needs to be done for other highly effective MNCH interventions. Our results suggest that coverage gains may occur in bursts rather than linearly, increasing rapidly once financing and health system requirements are in place, although we could not describe these gains statistically because of data limitations.

If historical patterns of country-specific and intervention-specific coverage continue without change, we predict that the child mortality rate will continue to decrease, but by less than 28% by the year 2035 relative to 2010. These projections suggest that continuing past trends in coverage change will not be sufficient for most countries to reach the target of an under-5 mortality rate of 20 per 1000 livebirths per year (panel 2).[1] However, the best performer scenario offers a potentially achievable basis for the setting of global and national targets, especially because we selected the best performing country on the basis of gains in coverage for several indicators rather than only one. If each country can accelerate coverage at the same rate as the best performing country with similar baseline levels for that intervention, the total number of deaths in 2035 is projected to be more than 70% lower than in 2010. However, even under this optimistic scenario, only 15 countries are projected to reach this target.

Clearly, our results and projections should be interpreted with caution, primarily because of data limitations. Data for coverage of interventions were scarce for some countries and no coverage data are available for some interventions for any country. Some interventions do not have true indicators, and other interventions are difficult to measure successfully with household surveys.[25] Even for interventions for which measures of coverage are available, we can say little about the quality of the intervention and how it might change with time. Additionally, some new interventions will be rolled out between now and 2035—eg, improved vaccines for pneumococcal pneumonia and

Panel 1: Change in coverage of HIV/AIDS interventions for children

Two primary interventions reduce the effect of HIV/AIDS on child mortality: drug regimens to reduce the transmission of HIV from mothers to their children and paediatric formulations of antiretroviral drugs for children who are infected with HIV. Data for coverage of these interventions are not obtained in household surveys; instead, estimates of coverage are based on reported number of children or mothers provided services divided by the estimates of mothers and children in need. The most recent estimates of coverage[21] for 44 countries in sub-Saharan Africa show that mean coverage of regimens to prevent mother-to-child transmission in 2011 was 49% (median 52%) and of paediatric formulations was 22% (median 19%). Although the UN does not have official estimates of coverage in 2000, the values used in the most recent UN country estimates[21] suggested that coverage of these two interventions was less than 1% in 2000. The rate of coverage increase for these two interventions is similar to our estimated rates for interventions to prevent malaria, with rapid growth to high levels of coverage even in poor countries in sub-Saharan Africa. These results beg the question of why countries have been so successful with introduction of these complex interventions, achieving high coverage, while coverage of other, often much simpler interventions for maternal, neonatal, and child health have shown little or low growth during the same period.

Panel 2: Research in context

Systematic review

The efficacy and, in some cases, the effectiveness of most but not all the interventions tracked by the Countdown to 2015 collaboration and used in the Lives Saved Tool have been the subject of previous systematic reviews.[22–24] The challenges of accurate measurements of coverage are the subject of a recent set of reviews and validations studies.[25] A new systematic review of coverage change metrics has been done for three intervention areas within maternal, newborn, and child health.[26] We used the results of this review to guide our choice of methods and metrics.

Interpretation

We have shown that, without any changes in the delivery of proven interventions to women and children in 74 Countdown countries—where more than 95% of child deaths occur—the global target of an under-5 mortality rate of less than 20 per 1000 livebirths per year by 2035 will not be reached. Our findings also show that coverage of some interventions, especially those for malaria, has grown at much faster rates than others. If all countries match levels of coverage in the best performing countries, the number of child deaths would decrease by 71% by 2035, although only 15 countries (20%) will reach the target. Governments—both of the Countdown countries and of nations providing development assistance—must redouble their efforts to deliver known and proven interventions at high and sustained levels, and search for new interventions that will save the lives of more children.

malaria—that could have a rapid positive effect on child deaths. Finally, although LiST is based on the best available evidence and has done well in validation exercises, any projection extending 20 years into the future should be interpreted with caution in view of the many unknowns.

The challenge to the global public health community is clear: ways to reach more women and children with the full range of effective interventions need to be identified. There will not be one overall formula for success, but the necessary actions are known. Strategies need to be locally defined and address the major causes of death. Lessons from malaria and HIV must be applied to the interventions that will save the most lives, notably nutrition interventions and correct treatment of pneumonia and diarrhoea. Frequent monitoring of coverage should be recognised as an essential component of good programme management, and the results used to develop effective strategies to reach every woman and every child. Effective and efficient solutions to accelerate coverage change, including ehealth applications and innovative approaches to delivery, could and should bend the curve of coverage gains relative to historic trends, which would make our projections overly conservative.

Globally, the lessons learned about the importance of focus and financing from the successes of the malaria prevention and HIV communities should now be applied to the scale-up of effective interventions for childhood pneumonia and diarrhoea, and for prevention of neonatal deaths. Sustaining and expansion of the gains achieved in child survival is an essential focus of the global agenda for the future. Our results suggest that further dramatic gains are achievable within this generation.

Contributors

All authors developed the study, planned the analysis, revised the report, and approved the final version. GY did the statistical analyses. NW and IKF used LiST. JB wrote the first draft of the report.

Conflicts of interest

We declare that we have no conflicts of interest.

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What works in saving children: the essentials

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"Getting on with what works" was not merely a slogan in the 2006 *Lancet* Maternal Survival Series,[1] but defined the approach of the global reproductive, maternal, newborn, and child health (RMNCH) community to prioritise a few highly cost-effective, evidence-based interventions. Strategic global initiatives to reduce child deaths,[2] stillbirths,[3] and newborn deaths[4] have followed this approach. Broad interagency consortia have defined the so-called essential interventions for RMNCH, accompanied by commodities and guidelines,[5] and introduced the Lives Saved Tool (LiST),[6] which provides guidance for how many lives interventions can save and at what cost. The unified message has been that what works is known, so action should be taken.

Since 1990, the numbers of maternal and child deaths have nearly halved.[7] Despite this progress, the bold Millennium Development Goal to reduce maternal deaths by three-quarters and child deaths by two-thirds by 2015 will not be met.[7] Were the essential interventions insufficient for the task?

In *The Lancet,* Neff Walker and colleagues suggest that, for child survival, more of the same could be the best way forward.[8] They gathered survey data from between 1990 and 2011 to investigate patterns of change in coverage of interventions in 69 countries. They then used LiST to estimate potential reductions in the numbers of deaths of newborns and children aged younger than 5 years in the 74 Countdown to

2015 priority countries should trends in coverage continue unchanged or accelerate. The researchers report that uptake of most interventions has been slow, particularly in Africa.[8] If trends in coverage continue unchanged until 2035—the new deadline set by UNICEF and partners[9]—only nine (12%) of the 74 countries will have under-5 mortality rates of fewer than 20 per 1000 livebirths, and ten (14%) will have neonatal mortality rates of fewer than 11 per 1000 livebirths per year. Therefore, Walker and colleagues study the best performing countries to see what could be achieved in the best-case scenario. If each country accelerates intervention coverage to the highest level achieved by a similar Countdown country, 15 countries (20%) will achieve an under-5 mortality rate of fewer than 20 per 1000 livebirths and 67 (91%) will achieve a neonatal mortality rate of fewer than 11 per 1000 livebirths per year. At best, the number of under-5 deaths per year could decrease to 2·3 million (a 71% decrease from 2010) with essential interventions.

Should it be believed that all countries will perform at top of their class? Realistically, no. However, survey data alone obscure how fast coverage can increase. As Walker and colleagues note,[8] increases in coverage rarely follow a linear course over time, but when policies, infrastructure, and funding all align in a moment of opportunity, coverage can increase substantially. The mean pace of change in coverage over 20 years will systematically underestimate how fast countries improve during periods when they actually strive to increase coverage. Additionally, inequities matter: individuals with the highest burden are often the last to be granted care. Thus, more lives could be saved if interventions finally reached the poorest individuals.

Malaria, AIDS, and vaccines have received extraordinary attention—including financing—and the correspondingly rapid increase in intervention coverage shows that coverage of effective essential interventions can be increased independent of a fully developed health-care system. Preventive interventions for nutrition and family planning, and life-saving interventions for childhood diarrhoea and pneumonia have all been lagging behind despite being core issues for child survival.[7] But a global action plan for pneumonia and diarrhoea is now in place,[10] and, in the wake of the 2012 London Family Planning Summit,[11] advocacy and commitment now seem to be on the right track for accelerated child survival initiatives. Therefore, more countries should be able to achieve what was apparently only possible for a few in the past two decades.

Stephanie Rabemiafara/Art in All of Us/Corbis

Yet for countries to be able to prioritise, monitor, and improve quality of interventions efficiently, improved data for coverage are essential. The standard surveys' crude data for care service encounters—eg, skilled care at birth and antenatal care—are poor indicators of quality of both the process and outcomes of interventions. Indicators of many essential interventions have not been examined at all. Quality of care in RMNCH means consistent, safe, and cost-effective provision of evidence-based essential interventions without inequities and in a timely and patient-centred way. Thus, this provision is what needs to be monitored. However, gathering of more and better data is little more than a costly burden if these data are to be buried in databases or, at best, aggregated into an annual report and exported to global health reports. Development of the capacity of public health surveillance and response for RMNCH is not an essential intervention—it is simply essential.

Better data are on the way. Among others, the harmonised Reproductive Health Registries initiative[12] provides process and outcome indicators for WHO of all essential interventions in RMNCH with ready-made electronic and mobile solutions for routine data collection integrated in clinical health-management systems. With improved instruments to plan and

monitor increased coverage of essential interventions, the RMNCH community will hopefully prove Walker and colleagues too conservative in their predictions.

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