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Comparing modelled to measured mortality reductions: applying the Lives Saved Tool to evaluation data from the Accelerated Child Survival Programme in West Africa

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Background The Lives Saved Tool (*LiST*) projects the magnitude of mortality reduction based on baseline coverage, demographic characteristics and coverage targets. As a validation exercise, we compared neonatal, post-neonatal, infant, child and under-5 mortality reductions as projected by *LiST* to changes in mortality measured through demographic surveys in Ghana and Mali as part of a recently completed, retrospective evaluation of a child survival programme.

Methods Using coverage and other information collected during the evaluation, we modelled the predicted mortality reduction, using logical assumptions to fill gaps if no data were available. We performed a sensitivity analysis on several indicators for which we used a proxy, using the results to examine model sensitivity and readdress our assumptions.

Results In Ghana, the modelled mortality reductions were within the 95% confidence boundaries of the measured reduction. In Mali *LiST* significantly underestimated the reduction. Several coverage indicators were found to influence the projection, specifically case management of serious neonatal illness in both countries and pneumonia treatment, vitamin A measles treatment and breastfeeding promotion in Mali.

Conclusions We consider *LiST* to be a useful tool given the limitations of the available data. Although the model was a good match in Ghana, we identified several limiting factors with the input data in the Mali projection. This exercise highlights the importance of continually improving the availability of sound demographic, epidemiological and intervention coverage data at district and national levels. More comparative studies are needed to fully assess the strengths and weaknesses of *LiST*.

Keywords Child health, lives saved tool, mortality, evaluation, Ghana, Mali, accelerated child survival and development

Introduction

The Lives Saved Tool (*LiST*) can use baseline coverage data, programme targets and a demographic projection to model the magnitude of mortality reduction expected from planned programme activities, as described earlier in this issue[1]. As a validation exercise, we modelled data from a recently completed, retrospective evaluation of a child survival programme in West Africa and compared the results with estimates of mortality measured through demographic surveys as part of the evaluation. Using this large-scale, 'real life' evaluation to validate *LiST* will help current and future users understand the strengths and limitations of mortality-modelling tools.

The United Nations Children's Fund (UNICEF) implemented the Accelerated Child Survival and Development (ACSD) programme in 11 countries from 2001 to 2005, supported by the Canadian International Development Agency (CIDA). UNICEF focused efforts on several 'high-impact' countries, including Benin, Ghana, Mali and Senegal, working closely with country governments and other partners to implement ACSD with the ultimate goal of reducing under-5 mortality. Focus districts within these countries implemented three intervention packages. The 'EPI+' package included vaccinations, vitamin A supplementation and distribution of insecticide-treated nets (ITN). The 'ANC+' package targeted pregnant women and included improved access to antenatal care and skilled delivery along with tetanus vaccination, intermittent preventive treatment of malaria (IPTp) and supplementation with iron/folate and postpartum vitamin A supplementation. The 'IMCI+' component included promotion of appropriate infant-feeding practices, iodized salt and improved sick-child care at facility and community levels, specifically treatment of diarrhoea, malaria and pneumonia.[2]

UNICEF commissioned the Institute for International Programs at the Johns Hopkins University (IIP-JHU) to carry out an external, retrospective evaluation of the ACSD programme in the four 'high-impact' countries of Benin, Ghana, Mali and Senegal. The evaluation design was a non-randomized, comparative study of changes in coverage, nutritional status and mortality in the focus districts and national comparison areas, defined as the entire country excluding the focus districts and the major metropolitan areas. The evaluation team, working with UNICEF and in-country partners, documented ACSD implementation in the focus districts and contextual factors in both the focus districts and nationally. Data on coverage of ACSD interventions, nutritional status and mortality were collected in both the ACSD focus districts and the national comparison areas through demographic surveys. The full methodology and results of the evaluation are available elsewhere.[3]

Methods

Data sources

We concentrate on the ACSD focus districts in Ghana and Mali for this exercise, as more robust information pertaining to intervention implementation and contextual factors was available for these districts. In Benin, we observed few significant changes in intervention coverage over time;[3] thus, Benin was excluded from this examination of *LiST*-projected mortality reductions based on scale-up of intervention coverage. The endline survey in Senegal did not yield mortality estimates of adequate quality and the results were not used to evaluate the ACSD programme.

We used baseline and endline coverage and mortality measured through Demographic Health Surveys (DHS) in both countries and a Multiple Indicator Survey (MICS) in Ghana. The baseline and endline survey coverage indicators were inputted into the *LiST* and the projected mortality rates were compared to the survey endline mortality rates. Table 1 identifies the ACSD focus districts and provides information on the timing of the household surveys and the pre- and post-ACSD mortality estimation periods and rates for Ghana and Mali. Pre-existing survey data were reanalysed for baseline (pre-ACSD) estimates of coverage. We worked with on-going DHS or MICS to develop supplemental surveys that over-sampled households in the ACSD focus districts to collect and analyse endline (post-ACSD) coverage and two period estimates (pre- and post-ACSD) of mortality. Periods for estimation of mortality were based on country-specific timelines of ACSD implementation, defined through documentation; the periods differed in each country. Both pre- and post-ACSD period mortality rates were retrospectively calculated from the endline surveys using direct methods from the full birth history. A detailed explanation of methods used in the ACSD evaluation is available elsewhere.[3]

Inputs and assumptions

We used version 3.44 of *LiST*.[4] Because the demographic projections and baseline data pre-loaded into *LiST* are national, we first adjusted the projection to represent the ACSD focus districts using available data from the 2000 census in Ghana and the 1998 census in Mali. National demographic data were used where no information was available for the focus districts. For Ghana, we adjusted the baseline sex and age population distribution and estimated migration to represent the Upper East region (UER) using 2000 census data. This assumes that the proportion of the population living in the UER relative to the rest of the country has remained stable. The total fertility rate was adjusted using regional estimates from the DHS 1988, 1993, 1998 and 2003. For Mali, we adjusted the baseline age and sex population distribution and migration to represent the focus

Table 1 Summary of the ACSD focus districts, the timing of the household surveys and mortality periods for Ghana and Mali

	Ghana	Mali
ACSD focus districts	Upper East region: consists of Bawku West, Bawku Municipality, Bolgatanga, Bongo, Builsa, Garu-Tempane, Kassena-Nankana and Talensi-Nabdam districts	Banamba and Kolokani in the Koulikoro region, Niono and Bla in the Segou region, and Koro and Djenné in the Mopti region
Baseline survey	1998 DHS (217 households in the focus districts)	2001 DHS (1581 households in the focus districts)
Midline survey	2003 DHS (280 households in the focus districts)	No midline survey available
Endline survey	2007 MICS supplemental; modified to include a full birth history and oversampled in the focus districts (3324 households)	2006–7 DHS supplemental; oversampled in the focus districts (3884 households).
Pre-ACSD mortality rate per 1000 live births (95% CI)		
Neonatal	38 (29–48)	65 (55–76)
Infant	59 (48–70)	130 (118–143)
Child	51 (37–64)	149 (130–167)
Under-five	107 (88–126)	260 (241–278)
Time Period	July 1998 to December 2001	July 1998 to December 2001
Post-ACSD: mortality rate per 1000 live births (95% CI)		
Neonatal	26 (18–35)	42 (34–50)
Infant	53 (41–65)	98 (85–111)
Child	35 (27–43)	110 (95–124)
Under-5	86 (72–100)	197 (178–217)
Time period	January 2004 to July 2007	July 2003 to December 2006

districts using projected data from the 1998 census and adjusting for the proportional population of these districts. District-level total fertility rates (TFR) were not available, so we used the national-level estimates, which were similar to the regional TFR (containing the focus districts) estimates reported in the 2006 Mali DHS.

The national under-5 cause-of-death profiles loaded into *LiST* are from 2000 to 2003 for Ghana and Mali based on data from the Child Health Epidemiology Reference Group (CHERG) estimates.[5] Cause-of-death data are not readily available sub-nationally for Mali, thus, we used the national profiles with the assumption that the cause-of-death patterns in the focus districts are similar to the national. In Ghana, we used the national cause-of-death profiles, which were similar to those reported from the Navrongo demographic surveillance site (DSS) located in the UER that conducts verbal autopsies to determine cause of death. The greatest causes of under-5 mortality for communicable diseases at the Navrongo DSS were malaria, followed by respiratory infections and diarrhoea.[6]

We entered baseline (pre-ACSD period) neonatal, infant and under-5 mortality rates, as measured retrospectively through the endline surveys, into the model for both countries (Table 1). Baseline, mid-line (for Ghana) and endline survey coverage estimates were also input into the model. Combined, Tables 2 and 3 present the intervention coverage indicators that are available for input in *LiST*. Table 2 shows the interventions for which we had available survey data, the indicator definition we used in the projection and the pre- and post-ACSD coverage values. Some coverage indicators were available in the surveys of both countries such as vaccination, antenatal care, oral rehydration salts solution for treatment of diarrhoea and others. Some indicators were only available in one of the country surveys. For instance, the Mali DHSs did not collect information on antibiotic treatment of suspected pneumonia so we used a proxy indicator, estimating that one-half of the children taken to a health facility would receive antibiotics. Other coverage indicators are not routinely collected in household surveys such as treatment of measles with vitamin A or case management of serious neonatal illnesses. In these instances, we used the survey data to estimate coverage of these interventions and the assumptions are shown on Table 2 as well. Table 3 shows the indicators that could be inputted in *LiST* for which no data were available from the surveys and we either excluded from the analysis or estimated using *LiST* formulas.

Sensitivity analysis

We conducted sensitivity analyses on the indicators listed in Table 2 for which we did not have the exact indicator from the survey and instead used a proxy. These include: complementary feeding—education only; complementary feeding—education and supplementation; full supportive care: case management of serious neonatal illness; vitamin A for measles treatment; breastfeeding promotion and case

Table 2 *LiST* Indicators used in the country projections: indicator definition and the baseline and endline values for the Ghana and Mali projections

Coverage intervention	Indicator used in model	Ghana		Mali	
		Pre-ACSD	Post-ACSD	Pre-ACSD	Post-ACSD
Antenatal care	Percentage of women received three or more antenatal care visits[a]	74%	89%	25%	52%
Pregnant women protected via IPT or sleeping under an ITN	Percentage of women received two or more doses of Fansidar[a]	0%[b]	67%	0%[b]	17%
Tetanus Toxoid	Percentage of women received two doses of tetanus toxoid[a]	63%	63%	22%	46%
Multiple micronutrient supplementation (maternal)	Percentage of women received ⩾90 days of iron supplementation[a]	N/A[b]	N/A[c]	6%	16%
Institutional delivery (clinic and hospital)	Percentage of deliveries occurring at a health facility[a]	17%	38%	29%	44%
Skilled birth attendance (SBA)	Percentage of deliveries occurring outside a health facility[a]	17%	40%	29%[d]	46%
Preventive postnatal care (healthy practices & illness detection)	Percentage of infants receiving postnatal care within 2 days of delivery[a]	N/A[c]	N/A[c]	25%	45%
Insecticide treated materials or indoor residual spraying	Percentage of under-five children slept under an insecticide treated mosquito net last night	0%[b]	58%	0%[b]	32%
Vitamin A for prevention	Percentage of children between the ages of 6–59 months received one dose of vitamin A in the previous 6 months	65%	90%	35%	77%
Measles vaccine	Percentage of children between the ages 12–23 months received measles vaccine before 12 months of age	60%	80%	29%	66%
Hib vaccine	Percentage of children between the ages 12–23 months received three doses of the haemophilus influenza type b vaccine before 12 months of age	0%	95%	N/A[e]	N/A[e]
DPT vaccination	Percentage of children between the ages 12–23 months received three doses of the diphtheria, pertussus and tetanus vaccine before 12 months of age	68%	95%	24%	73%
ORS	Percentage of children with diarrhoea in the previous 2 weeks received oral rehydration salts solution treatment	49%	41%	11%	13%
Anti-malarials	Percentage of children with fever in the previous 2 weeks received anti-malarial treatment	78%	53%	43%	36%
Use of improved water source within 30 min	Percentage of households report use of improved water source with 30 min	65%	51%	18%	28%
Use of water connection in the home	Percentage of households report use of water connection in the home.	14%	6%	3%	3%
Improved excreta disposal (latrine/toilet)	Percentage of households report use of improved sanitation facilities.	4%[f]	4%	41%	48%
Complementary feeding–education only Complementary feeding—supplementation and education	Estimated using the percentage of children 6–9 months of age received complementary feeding	N/A[g]	N/A[g]	27%	27%
Full supportive care: case management of serious neonatal illness	Estimated based on percentage of facility births[h]	9%	27%	21%	31%
Vitamin A for measles treatment	Estimated using one-half of the one dose vitamin A indicator	33%	45%	18%	39%
Breastfeeding promotion	Estimated using the prevalence of children up to 6 months of age that were exclusively breastfed	28%	55%	44%	28%
Case management of pneumonia (oral antibiotics)	Ghana: Percentage of children with suspected pneumonia in the previous 2 weeks received antibiotic treatment. Mali: Antibiotic treatment not available in the surveys. Estimated using one-half of the pneumonia care-seeking indicator	2%	51%	14%	16%

N/A, not available.
[a]For the most recent pregnancy in the previous twelve months that resulted in a live birth.
[b]Not available in baseline survey.
[c]Not available in the endline survey.
[d]The measured value through the survey is 26%, however, *LiST* will not allow the SBA indicator to be greater than the institutional delivery indicator, so we increased the inputted baseline value to equal institutional delivery.
[e]HiB vaccine not available in Mali during ACSD period.
[f]Not available in 1998 DHS, used 2003 DHS estimate.
[g]Sample sizes too small at baseline ($n < 20$) for precise estimate of coverage.
[h]If facility births are >95%, then for case management of NN illness, enter facility births*1.0. If facility births are 95–50%, then enter facility births*0.9. If facility births are 50–30%, then enter facility births*0.7. If facility births are <30%, then enter facility births*0.5 (J Lawn, personal communication).

Table 3 *LiST* indicators not available from the survey data and not used in the country projections: either estimated using *LiST* algorithms or not included in the model

Not available from survey data: estimated using *LiST* algorithms	**Not included in model**
Based on the *antenatal care* indicator:[a] • Case management during pregnancy • Syphilis detection and treatment Based on the *institutional delivery* indicator:[a] • Antenatal corticosteroids for preterm labour • Antibiotics for pPRoM • Essential care for all women and immediate essential newborn care • Basic emergency obstetric care (clinic) • Comprehensive emergency obstetric care • Neonatal resuscitation (institutional) Based on the *skilled birth attendant* indicator:[a] • Clean practices and immediate essential newborn care (home)	• Folic acid supplementation or fortification (periconceptual) • Abortion services • Calcium supplementation • Balanced Energy supplementation (maternal) • Case management of malaria during pregnancy (clinic or hospital) • Active management of the 3rd stage of labour • Kangaroo mother care • Zinc for prevention • Rotavirus vaccine • Pneumococcal vaccine • Oral antibiotics: case management of severe neonatal infection • Injectable antibiotics: case management of severe neonatal infection • Zinc for treatment • Therapeutic feeding • Neonatal resuscitation (home) • Antibiotics for dysentery[b] • Hygienic disposal of children's stools[b]

[a]Formulas available in Supplementary Table 1.
[b]These data were not collected at both baseline and endline surveys, therefore they were not included in the projection since the magnitude of scale-up is not known.

management of pneumonia (oral antibiotics). We did not perform a sensitivity analysis on indicators not routinely collected through household surveys (Table 3) such as emergency obstetric practices and abortion services, or for interventions that were not yet implemented in these two countries, e.g. zinc treatment and rotavirus vaccination.

Two scenarios were run for each indicator: a 'low' scenario in which coverage did not change from baseline to endline and a 'high' scenario in which coverage increased to 100%. For each scenario we changed only the indicator in question. We considered the model as being sensitive to a particular indicator if the range between the low and high scenario differed by five or more deaths per 1000 births relative to the original modelled under-5 mortality rate. If we found that the projection was sensitive to a particular indictor, we then examined why there was model sensitivity and critically assessed our assumptions.

Results

Table 4 shows the modelled results compared to the measured reduction in mortality rates. Because we measured period rather than yearly mortality rates in the ACSD evaluation, we used the 2005 *LiST*-projected mortality rates to compare to the midpoint from the post-ACSD endline periods. In Ghana *LiST* underestimates all mortality categories except post-neonatal. However, all *LiST* projections are within the 95% confidence interval of the measured mortality reduction and hence are not significantly different. In Mali, using the 95% confidence intervals, all mortality categories are significantly underestimated by *LiST*, except for post-neonatal mortality. However, the latter is not a significant difference when assessed against the 95% confidence interval.

Table 5 shows the results of the sensitivity analysis. For each indicator we show the difference in the number of deaths for the under-5 mortality rate from the original projection for both the 'low' and 'high' scenarios and the total range. In both Ghana and Mali, we found the projection to be sensitive to changes in case management of serious neonatal illnesses. According to the national cause-of-death profiles, sepsis pneumonia causes ~30% of neonatal deaths in both Ghana and Mali, and no data were available on coverage for correct management of these infections.

Case management of pneumonia in Mali is shown to be the most sensitive across all the indicators tested for Mali and Ghana. However, the 100% coverage used in the sensitivity for the 'high' scenario is far from what is reported by surveys—care-seeking of 28% (baseline) and 31% (endline) in Mali, with one-half of these values used for pneumonia treatment with antibiotics. To further test this assumption we increased the endline coverage from one-half to three-fourth of the pneumonia care-seeking indicator which resulted in two fewer under-5 deaths—a minor

Table 4 A comparison of the projection and the measured reduction for neonatal, post-neonatal, infant, child and under-5 mortality rates in Ghana and Mali

Rate (per 1000 live births)	Baseline	Endline		Difference				Significance
				Value (*R*)	Standard error (SE)	*R*-2SE	*R*+2SE	
Ghana								
Neonatal (NN)	38.4	Measured	26.3	12.1	6.7	−1.3	25.5	Inside 95% CI
		LiST	35	3.4				
Post-neonatal (PNN)	20.4	Measured	26.9	−6.4	5.7	−17.8	5.0	Inside 95% CI
		LiST	17	3.4				
Infant (1q0)	58.9	Measured	53.2	5.7	8.9	−12.0	23.4	Inside 95% CI
		LiST	55	3.9				
Child (4q1)	50.9	Measured	34.9	16.0	8.1	−0.2	32.2	Inside 95% CI
		LiST	42	8.9				
Under-5 (5q0)	106.7	Measured	86.2	20.6	12.5	−4.3	45.5	Inside 95% CI
		LiST	96	10.7				
Mali								
Neonatal (NN)	65.2	Measured	42.2	23.1	6.8	9.5	36.7	Outside 95% CI
		LiST	58	7.2				
Post-neonatal (PNN)	65.2	Measured	56.2	8.9	6.2	−3.4	21.2	Inside 95% CI
		LiST	62	3.2				
Infant (1q0)	130.4	Measured	98.4	32.0	9.0	14.0	50.1	Outside 95% CI
		LiST	121	9.4				
Child (4q1)	148.5	Measured	109.6	38.8	9.3	20.2	57.5	Outside 95% CI
		LiST	129	19.5				
Under-5 (5q0)	259.5	Measured	197.2	62.3	9.9	42.5	82.0	Outside 95% CI
		LiST	239	20.5				

Table 5 Sensitivity analysis on indicators estimated from survey data: the number of deaths different compared to the *LiST* projection for a 'low' scenario in which coverage did not change from baseline to endline and a 'high' scenario in which coverage increased to 100% by each indicator in Mali and Ghana

***LiST*-projected under-five mortality rate**	**Number of deaths different from the *LiST*-projected under-5 mortality rate**					
	Mali 239 U5MR (No. deaths different)			Ghana 96 U5MR (No. deaths different)		
Indicators	Low scenario	High scenario	Total	Low scenario	High scenario	Total
Complementary feeding–education only	N/A[a]	240 (−1)	1	N/A[b]	N/A[b]	N/A[b]
Complementary feeding–supplementation and education	N/A[a]	236 (−3)	3	N/A[b]	N/A[b]	N/A[b]
Full supportive care: case management of serious neonatal illnesses	240 (+1)	230 (−9)	10	97 (+1)	89 (−7)	8
Vitamin A for measles treatment	240 (+1)	235 (−4)	5	96 (0)	95 (−1)	1
Breastfeeding promotion	237 (−2)	232 (−7)	9	96 (0)	94 (−2)	2
Case management of pneumonia (oral antibiotics)	239 (0)	213 (−26)	26	N/A[c]	N/A[c]	N/A[c]

N/A, not available.
[a]No measured change in complementary feeding coverage.
[b]Sample size too small at baseline.
[c]Coverage data available from surveys; no assumptions required.

difference. Hence, the difference between the *LiST* estimate of under-5 mortality change (21 per 1000 live births) and the lower bound of the measured mortality confidence interval (43 per 1000 live births) appears too large to be explained only by pneumonia treatment impact. At the same time recent evidence suggests that antibiotics are widely available in the informal private sector of Mali,[7] so the impact of pneumonia treatment with antibiotics may be under-reported for Mali.

In Mali, we also found the projection to be sensitive to changes in coverage of vitamin A for measles treatment, breastfeeding promotion and case management of pneumonia (Table 5). Vitamin A for treatment of measles was also found to be marginally sensitive with the range between the 'low' and 'high' scenarios differing by five deaths per 1000 from the original projection. However, since the ACSD programme did not focus on treatment of measles with vitamin A supplementation, we do not have any additional information on this intervention in Mali.

Breastfeeding promotion was also found to be a sensitive component of the model in Mail, and we examined the prevalence of exclusive breastfeeding that was used as a proxy indicator. As part of the ACSD evaluation in Mali, we measured a statistically significant reduction of exclusive breastfeeding coverage from 44% in 2001 to 28% in 2007 ($P < 0.001$) in the HIDs.[3] This reduction in breastfeeding is counter-intuitive and may have resulted from an imprecise measurement at baseline. However, having no strong argument to remove the indicator, we left it in the model.

Discussion

LiST projections of mortality reduction based on changes in coverage for proven interventions were within the 95% confidence intervals of the measured mortality reduction in Ghana, and significantly underestimated mortality in Mali. Given the limitations of the available input data, we consider the Ghana projection to be an adequate match to the measured mortality reduction. This does not hold true for Mali and there are important limitations with the input indicators for the Mali projection.

Our assumptions for breastfeeding improvement, neonatal infection case management, treatment of measles with vitamin A and antibiotic treatment for pneumonia in Mali may be underestimating the actual coverage of these interventions. Pneumonia treatment had the largest influence on the model and there is supplemental evidence that antibiotics are likely more widely available and prescribed than indicated in the survey-reported care seeking for pneumonia in Mali. Our documentation in the two countries also indicates that there was a rapid expansion of first-level health facilities in the focus districts in Mali during this period, and no similar expansion in Ghana. Another explanation for this finding may therefore be that increased access to health facilities in Mali increased coverage of unmeasured indictors, relative to Ghana. In the future, *LiST* users should consider using health facility surveys along with household surveys to capture the full spectrum of child health data that impacts mortality.

We have highlighted the sensitivity of *LiST* mortality projections in the case of treatment of pneumonia and serious neonatal illness, but it also applies to other indicators, such as diarrhoea and malaria treatment and nutritional interventions. The primary reason is that these interventions target illnesses that represent a high proportion of deaths in Africa. There is also the issue of accuracy of measurement in household surveys used to input data into the model. Our results indicate that the *LiST* projections were highly sensitive to changes in coverage levels for several interventions for which coverage was not, and in some cases ***is*** not, measured well in the household surveys that serve as the major, and sometimes only source of coverage data in most African countries. For example, accurate reports of the treatment received by a child depends on the caretaker's recognition of the illness and correct reporting of the medicines provided at home or by a health care provider. The CHERG is currently working on improving the measurement of coverage for these and other proven child survival interventions.

A further dimension of accuracy is sample size. As can be seen from the baseline and midline household surveys for Ghana (Table 1), the sample sizes are small. Furthermore, the target group of children for which to assess treatment of some of the most sensitive *LiST* indicators, such as those on treatment of pneumonia and diarrhoea, is only a small proportion of all children. This is because the measurement of treatment can only be done on those children under-5 who had this illness in the last 2 weeks, a period required to reduce the impact of memory recall errors. Such situations require larger sample sizes in order to adequately assess changes in coverage between two points in time for such critical treatment indicators.

Our findings highlight the importance of continuing efforts to improve the availability of sound demographic, epidemiological and intervention coverage data at district and national levels. With respect to demographic data, *LiST* currently uses national-level projections. We have no reason to expect large differences between the ACSD focus districts and the country for fertility or migration patterns. Potentially more serious are differences in cause-of-death profiles for children <5 years of age between the focus districts and the country as a whole and changes in the profiles over time, especially with respect to levels of exposure to *Plasmodium falciparum* malaria. We attempted to assess the possible effect of using national estimates of the proportion of deaths due to malaria in the two countries by reducing the percentage of under-5 deaths due to malaria by half and examining the impact on the projected mortality reduction. We found negligible impact on the projected mortality (less than five deaths per 1000 live births different from the under-5 projected mortality rate). Given rapid changes in epidemiology in these and other countries in Africa due to the scale-up of malaria prevention,[8,9] it will be important to periodically update the cause-of-death profiles.

Given this and other validation exercises[10], *LiST* does appear to be a useful tool for projecting reductions in mortality based on changes in coverage. However, more comparison studies are needed to fully assess the strengths and weakness of the model. The quality of *LiST* projections is determined by the validity, quality and completeness of the input data—a limitation shared by all modelling tools. *LiST* users must examine and report on all assumptions made, and work together with countries and programmes to make informed decisions where high-quality data are not available.

As countries scale-up activities to reach Millennium Goal 4 to reduce under-5 mortality, indicators for tracking progress on high impact interventions need to be strengthened. Child mortality measures in many developing countries depend on household surveys, and these can only report on past mortality levels. More current data on high impact interventions can be obtained from the same surveys and these should greatly facilitate monitoring both changes in such interventions as well as likely changes in under-5 mortality using *LiST*.

Supplementary data

Supplementary data are available at *IJE* online.

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KEY MESSAGES

- *LiST* is a useful modelling tool, however, the limitations of available input data must be considered.
- Modelled mortality reduction is sensitive to certain indicators, such as management of pneumonia and neonatal sepsis.
- Continual improvements in demographic, epidemiological and intervention coverage data at national and district levels are necessary.

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