Malawi and Millennium Development Goal 4: a Countdown to 2015 country case study

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Summary

Background Several years in advance of the 2015 endpoint for the Millennium Development Goals (MDGs), Malawi was already thought to be one of the few countries in sub-Saharan Africa likely to meet the MDG 4 target of reducing under-5 mortality by two-thirds between 1990 and 2015. Countdown to 2015 therefore selected the Malawi National Statistical Office to lead an in-depth country case study, aimed mainly at explaining the country's success in improving child survival.

Methods We estimated child and neonatal mortality for the years 2000–14 using five district-representative household surveys. The study included recalculation of coverage indicators for that period, and used the Lives Saved Tool (LiST) to attribute the child lives saved in the years from 2000 to 2013 to various interventions. We documented the adoption and implementation of policies and programmes affecting the health of women and children, and developed estimates of financing.

Findings The estimated mortality rate in children younger than 5 years declined substantially in the study period, from 247 deaths (90% CI 234–262) per 1000 livebirths in 1990 to 71 deaths (58–83) in 2013, with an annual rate of decline of 5·4%. The most rapid mortality decline occurred in the 1–59 months age group; neonatal mortality declined more slowly (from 50 to 23 deaths per 1000 livebirths), representing an annual rate of decline of 3·3%. Nearly half of the coverage indicators have increased by more than 20 percentage points between 2000 and 2014. Results from the LiST analysis show that about 280 000 children's lives were saved between 2000 and 2013, attributable to interventions including treatment for diarrhoea, pneumonia, and malaria (23%), insecticide-treated bednets (20%), vaccines (17%), reductions in wasting (11%) and stunting (9%), facility birth care (7%), and prevention and treatment of HIV (7%). The amount of funding allocated to the health sector has increased substantially, particularly to child health and HIV and from external sources, but remains below internationally agreed targets. Key policies to address the major causes of child mortality and deliver high-impact interventions at scale throughout Malawi began in the late 1990s and intensified in the latter half of the 2000s and into the 2010s, backed by health-sector-wide policies to improve women's and children's health.

Interpretation This case study confirmed that Malawi had achieved MDG 4 for child survival by 2013. Our findings suggest that this was achieved mainly through the scale-up of interventions that are effective against the major causes of child deaths (malaria, pneumonia, and diarrhoea), programmes to reduce child undernutrition and mother-to-child transmission of HIV, and some improvements in the quality of care provided around birth. The Government of Malawi was among the first in sub-Saharan Africa to adopt evidence-based policies and implement programmes at scale to prevent unnecessary child deaths. Much remains to be done, building on this success and extending it to higher proportions of the population and targeting continued high neonatal mortality rates.

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Introduction

The world is at the finish line for the Millennium Development Goals (MDGs), madly counting and publicising how many countries have met their goals and how many have not.[1] But the important questions are not how many, but why, how, and to what extent some countries have achieved the goals and others have not. Answering these questions needs in-depth, historical analysis of the decisions made by governments, partners, and families over the course of

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Research in context

Evidence before this study

This is the first in-depth multidisciplinary analysis of how Malawi has achieved MDG 4. We searched PubMed with no language restrictions with the search terms ("Child"[Mesh] OR ("child"[MeSH Terms] OR "child"[All Fields] OR "children"[All Fields]) OR ("pediatrics"[MeSH Terms] OR "pediatrics"[All Fields] OR "paediatric"[All Fields]) OR ("pediatrics"[MeSH Terms] OR "pediatrics"[All Fields] OR "pediatric"[All Fields])) AND ("Malawi"[MeSH Terms] OR "Malawi"[All Fields]) AND ("mortality"[MeSH Terms] OR "mortality"[All fields] OR "death"[MeSH Terms] OR "death"[All fields]) AND ("Malawi"[MeSH Terms] OR "Malawi"[All Fields]) between Sept 1, 2000 and Jan 4, 2016 (the date of the last search). We found 435 studies, none of which had investigated Malawi's achievement of MDG 4 in as much depth as our study.

Added value of this study

This study is the first to pool nationally representative household survey datasets to produce trends in under-5 and neonatal mortality by district, region, and the whole of Malawi. We also examined trends in coverage of key interventions, equity of intervention coverage and mortality, and present a thorough analysis estimating the lives saved by each of the main interventions between 2000 and 2013 using the Lives Saved Tool. This analysis explains 80% of the observed reduction in under-5 mortality. This is also the first study to synthesise publicly available information, relevant published articles, policy documents, and information gained from interviewing key programme and finance staff at district and national levels to investigate Malawi's success in child survival.

Implications of all the available evidence

This study should inform further efforts to reduce under-5 (especially newborn) mortality as well as maternal mortality in Malawi, and contribute to planning for achievement of the Sustainable Development Goal targets of ending preventable mortality by 2030. Other countries in sub-Saharan Africa should also learn from Malawi's relative success via this in-depth case study.

25 years, drawing on imperfect data from widely varying sources and analytical approaches from many disciplines that rely on plausibility rather than probability inferences.[2] The need for answers is urgent, because the MDG finish line is also the starting point for the next set of global and country goals—goals that build on the strengths of the MDGs, but take into account the new understanding regarding the inter-relatedness of health and development, of contextual constraints, and of the challenges of producing timely measurements of progress that can guide mid-course corrections in policies and programmes.[3,4]

For the **UN Millennium Development Goals** see http://www.un.org/millenniumgoals/

Countdown to 2015 for Maternal, Newborn and Child Survival (Countdown) is a suprainstitutional movement established in 2003 to set and maintain standards for accountability for improving the health of women and children.[5] Countdown tracks progress and equity in population coverage of health interventions (ie, the proportion of individuals who need an intervention who actually receive it) and the health system and financial determinants related to population coverage in the 75 countries with the highest burdens of maternal and child mortality worldwide.[4] Frustrated with the failure to explain country progress in achieving high and equitable coverage levels through the use of statistical approaches comparing progress across countries,[6] Countdown established a programme of in-depth country case studies led by country institutions, bringing together multidisciplinary teams to explore how and why individual countries were able to make progress towards the achievement of MDG 4 and MDG 5, addressing child and maternal survival, respectively. Case studies have been completed in Bangladesh,[7] Niger,[8] Peru (Huicho L, et al, Universidad Peruana Cayetano Heredia, Universidad Nacional Mayor de San Marcos, and Instituto Nacional de Salud del Niño, Lima, Peru, personal communication), and Tanzania,[9] and this report presents the results for Malawi. Work is continuing in Afghanistan, China, Ethiopia, Kenya, and Pakistan. This case study was led by the Malawi National Statistical Office, with contributions from the Malawian Government, non-governmental organisations, WHO, other UN agencies, and a range of academic institutions both within and outside the country.

The global community has been watching Malawi in recent years, despite its small population of about 16·7 million people (as of 2014).[10] At the start of the monitoring period for the MDGs in 1990, Malawi's under-5 mortality rate was 247 (90% CI 234–262) per 1000 livebirths (at the national level, we have used estimates from the UN Interagency Group on Mortality Estimation [IGME], because these are the official estimates of the UN agencies).[11] By 2013, Malawi was on a trajectory towards success in child survival. The under-5 mortality rate had declined at an average annual rate of 5·4%, to 71 (90% CI 58–83) per 1000 livebirths. In this study, we used a recently completed national survey to determine whether Malawi achieved MDG 4.

Malawi's progress was notable in part because it ran counter to expectations based on the usual predictors of rapid advances in development. It is a landlocked country with few natural resources, and in 2013 ranked 174th of 187 countries on the Human Development Index.[12] Based on purchasing-power-parity (PPP) estimates and international US dollars, the gross

domestic product per person was $350 in 1990 and had doubled to $780 in 2013.[13] 72·2% of the population was estimated to live in severe poverty in 2010.[14] 85% of the population resides in rural areas, with subsistence farming as the primary source of income. The country has high rates of child undernutrition, exacerbated by food shortages in 2001 and 2002 and by severe foreign exchange and fuel crises during 2009–12.

Countdown invited Malawi to do a case study to understand factors contributing to its progress in achieving MDG 4. The case study objectives were to explain how Malawi achieved MDG 4 at the national level; examine the roles of other programmes (such as immunisation, Integrated Management of Childhood Illness [IMCI], nutrition, reproductive, maternal, and newborn health, and prevention and control of malaria and HIV), equity, and contextual factors in this achievement; describe variations in district progress; and share lessons learned to guide future policies and programmes in Malawi and similar countries.

Methods

Study design and implementation

Our conceptual framework for the case study adapted the impact model used widely in maternal, newborn, and child health research and Countdown, moving from programme processes through immediate outputs and intermediate outcomes to impacts on child health and nutrition.[15] Additionally, however, we incorporated a systems approach, exploring the mechanisms through which national policies and strategies were operationalised and implemented, and the potential effects of a broad range of contextual factors. We examined trends in equity as an integral part of the case study, including geographical equity as shown by differences in districts as well as differentials in coverage and impact according to household wealth and mothers' education.

Figure 1 summarises the organisation of the case study work relative to the conceptual framework. We defined 1990–2014 as the temporal scope of our analysis, and combined national-level analyses with more focused attention to subsets of districts when data permitted. The entire Case Study Working Group met for the first time in November, 2013, reconvened in March and November, 2014, and met for the final time at a highly publicised launch chaired by the Ministry of Health in July, 2015. Each of the six primary teams (responsible for documentation, financing, coverage, the Lives Saved Tool [LiST] analyses, mortality, and nutrition), as well as crosscutting teams focusing on contextual factors and equity, worked together in the interim periods, coordinating with other teams as needed.

Data sources and analysis

Figure 1 also summarises the sources of data and analytical approaches used by each team (appendix

See Online for appendix

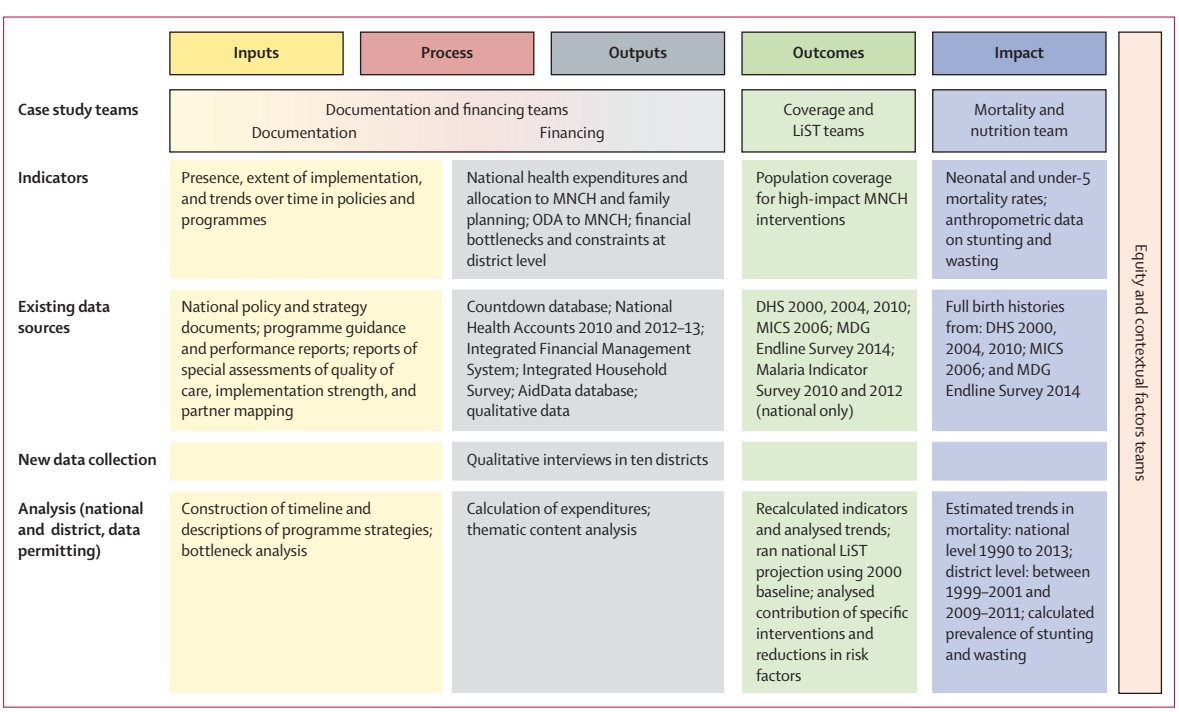

***Figure 1*: Conceptual model for the case study and overview of methods**

DHS=Demographic and Health Surveys. LiST=Lives Saved Tool. MDG=Millennium Development Goal. MICS=Multiple Indicator Cluster Surveys. MNCH=maternal, newborn, and child health. ODA=official development assistance.

pp 2–8). We analysed mortality trends at the national level using the methods developed by the UN IGME to fit trends of neonatal and under-5 mortality to all the nationally representative survey data for Malawi.[11] We produced estimates of child mortality indicators (specifically, the neonatal mortality rate, the mortality rate between the ages of 1 month and 59 months, and the under-5 mortality rate) for each of the 26 districts in the analysis. We pooled data from the five nationally representative full birth history surveys done since 2000[16–20] (figure 1), created consistent coding of districts (as in the 2006 Multiple Indicator Cluster Surveys [MICS]; appendix p 2), and calculated child mortality indicators with standard errors (SEs) for each district for the years 1999–2001 and 2009–11. We estimated SEs using the Jack-knife repeated replications method.[21] We incorporated the results from the 2014 MDG Endline Survey[20] for three 5-year periods before the 2014 MDG Endline Survey took place into a provisional revision of IGME's estimates of trends in the under-5 mortality rate since 1990. We also assessed trends in biodemographic factors related to risk of death in children younger than 5 years. These factors include the proportions of first births or births of order five or higher, births to women younger than 18 years and 35 years or older, and births with a preceding birth interval of less than 18 months. We assessed trends by comparing these indicators between 1999–2001 and 2009–11 using pooled full birth history datasets from the Demographic and Health Surveys (DHS),[16–18] MICS,[19] and MDG Endline Survey.[20] We used estimates of the distribution of deaths in children younger than 5 years by cause developed by the Child Health Epidemiology Reference Group (CHERG) for the year 2000 in Malawi as baselines in our LiST applications, and also report the most recent available CHERG estimates of time trends in the causes of death from 2000 to 2013.[22]

We examined trends in moderate and severe stunting (inadequate length and height for age) and wasting (inadequate weight for height) by recalculating data from the nationally representative household surveys (figure 1). We use stunting and wasting as proxy measures for coverage of nutrition interventions because data for coverage of these interventions is scarce, with the exception of trends in breastfeeding.

We reanalysed trends in coverage at the national level and for each district for all interventions tracked by Countdown and used in LiST[23] for which data were available, using the original datasets from the five national household surveys (figure 1). We used the standard Countdown indicator definitions supplemented by the definitions used for additional proven interventions included in LiST (appendix pp 9–10).

We applied LiST to help attribute reductions in mortality to specific reproductive maternal, newborn, and child health (RMNCH) interventions, changes in stunting and wasting rates, and behaviours. LiST is a widely used software that estimates the impact of scaling up one or several interventions on overall and cause-specific mortality in children (appendix pp 11–17).[6,24,25] We created a national projection for Malawi using the year 2000 as the baseline, with the most recent estimates of mortality rates and cause of death structure,[22] and then applied changes in intervention coverage and nutritional status over time to determine lives saved up until 2013 (appendix pp 18–21).[11,22,26] For LiST analyses in Machinga and Salima districts, we used the same basic approach but with some adjustments (appendix pp 18–21).

We documented the presence, extent of implementation, and trends over time for relevant programmes and policies by collating information from documents and interviews. We organised the information by health system area (eg, availability of medicines, skills building, skills reinforcement and supervision, and levels of service delivery) and year. The resulting timeline and description of programme strategies were developed and reviewed with the Ministry of Health and major development partners who had supported implementation during this period. We considered a policy as implemented only when it had moved beyond the pilot phase and the Ministry of Health believed that interventions were being provided to most women and children who needed them in most districts in the country. We also did a bottleneck analysis, based on the WHO health system building blocks framework.[27] Further details on documentation methods are available in the appendix, pp 22–27.

We analysed financial data at both national and district levels. At the national level, we used data from the Malawi National Health Accounts to analyse health expenditure and its allocation to maternal, newborn, and child health and family planning. Data were extracted from two National Health Accounts reports,[28,29] covering annual expenditure data for 2006–11. We analysed data by source of expenditure: government, donors, and out-of-pocket expenditures. We estimated government

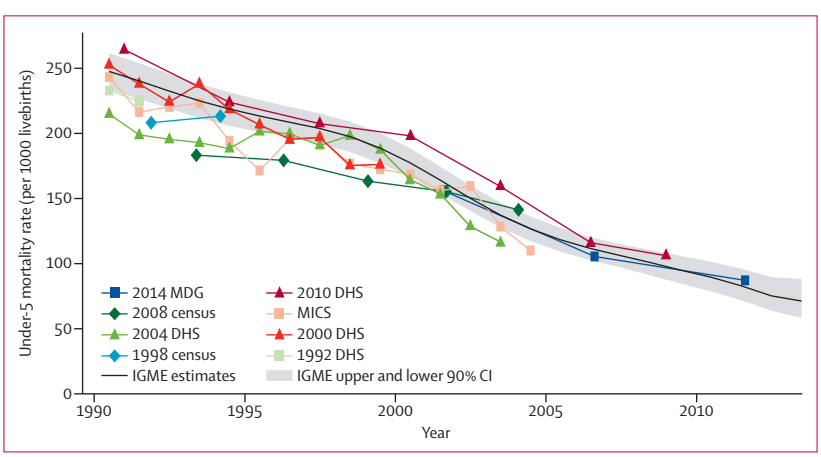

Figure 2: **National trends in under-5 mortality rate in Malawi from 1990 to 2013, as estimated in 2014**
DHS=Demographic and Health Surveys. IGME=Interagency Group on Mortality Estimation. MDG=Millennium Development Goal Endline Survey. MICS=Multiple Indicator Cluster Surveys.

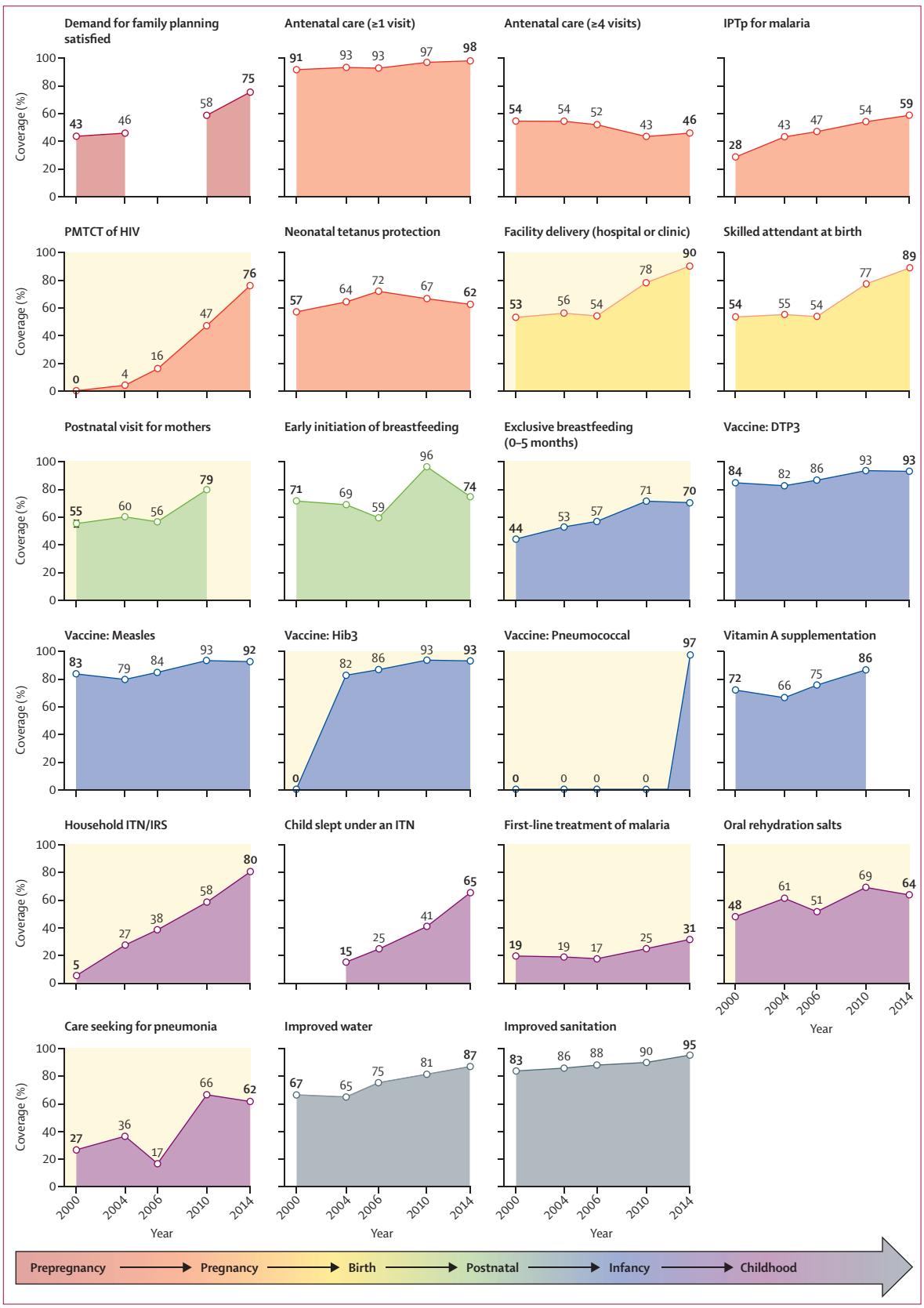

Figure 3: **National trends in coverage (%) for priority indicators along the continuum of care, 2000–14**
The ten interventions with the greatest impact on under-5 mortality in Malawi, as estimated by the Lives Saved Tool, are highlighted in yellow boxes. 95% CIs for baseline (2000) and endline (2014) estimates are available in the appendix, p 36. DTP3=diphtheria-tetanus-pertussis. IPTp=intermittent preventive treatment in pregnancy. IRS=indoor residual spraying. ITN=insecticide-treated bednets. PMTCT=prevention of mother-to-child transmission. Hib3=*Haemophilus influenzae* type B, third dose.

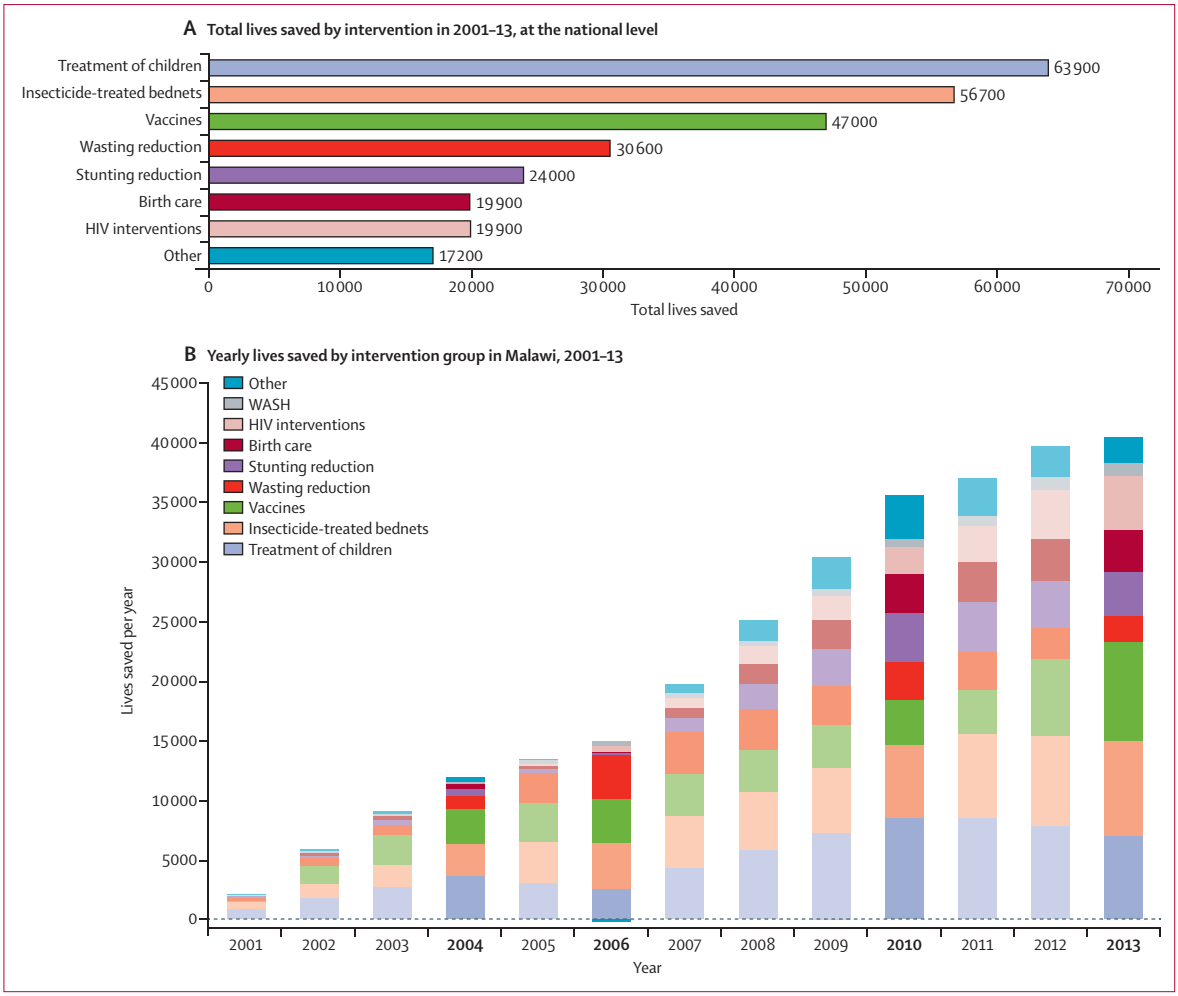

Figure 4: **Lives saved according to intervention group during 2001–13 as estimated by the Lives Saved Tool**
(A) Total lives saved according to intervention group between 2001 and 2013 at the national level in Malawi, as estimated by the Lives Saved Tool. (B) Yearly lives saved according to intervention group in Malawi between 2001 and 2013, as estimated by the Lives Saved Tool. The darker bars indicate the years in which intervention coverage was measured (2004, 2006, 2010, and 2013). In 2006 the "other" lives saved per year was actually a negative value (denoted by the blue bar just protruding below the x-axis) and represents missed opportunities to save lives. WASH=water, sanitation, and hygiene.

expenditure on health as a share of total government expenditure compared with the Abuja target of 15%. Official development assistance to maternal, newborn, and child health was obtained from the Countdown database for the period 2003–12. Health expenditure data were converted to Malawian kwacha (when in US dollars) and inflated to 2013 prices.

We also considered contextual variables that we believed could have affected trends in under-5 mortality. All quantitative data for contextual factors were taken from open access sources.

We analysed inequities by drawing on variables available in the DHS, MICS, and MDG Endline Survey. We examined differentials in under-5 mortality by place of residence (urban *vs* rural) and mother's education for 1999–2001 and 2009–11, using pooled DHS, MICS, and MDG Endline Survey full birth history datasets. We also assessed changes in the distribution of births by mother's education level, and differentials in intervention coverage by household wealth, using standard methods.[30]

The findings reported here are syntheses of the entire Working Group. We focus on national-level findings and present limited district-level results relevant to equity analyses.

Role of the funding source

The funders 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

We present the results based on the conceptual framework (figure 1) moving from right to left, closing with the results on equity and contextual factors. Figure 2 shows

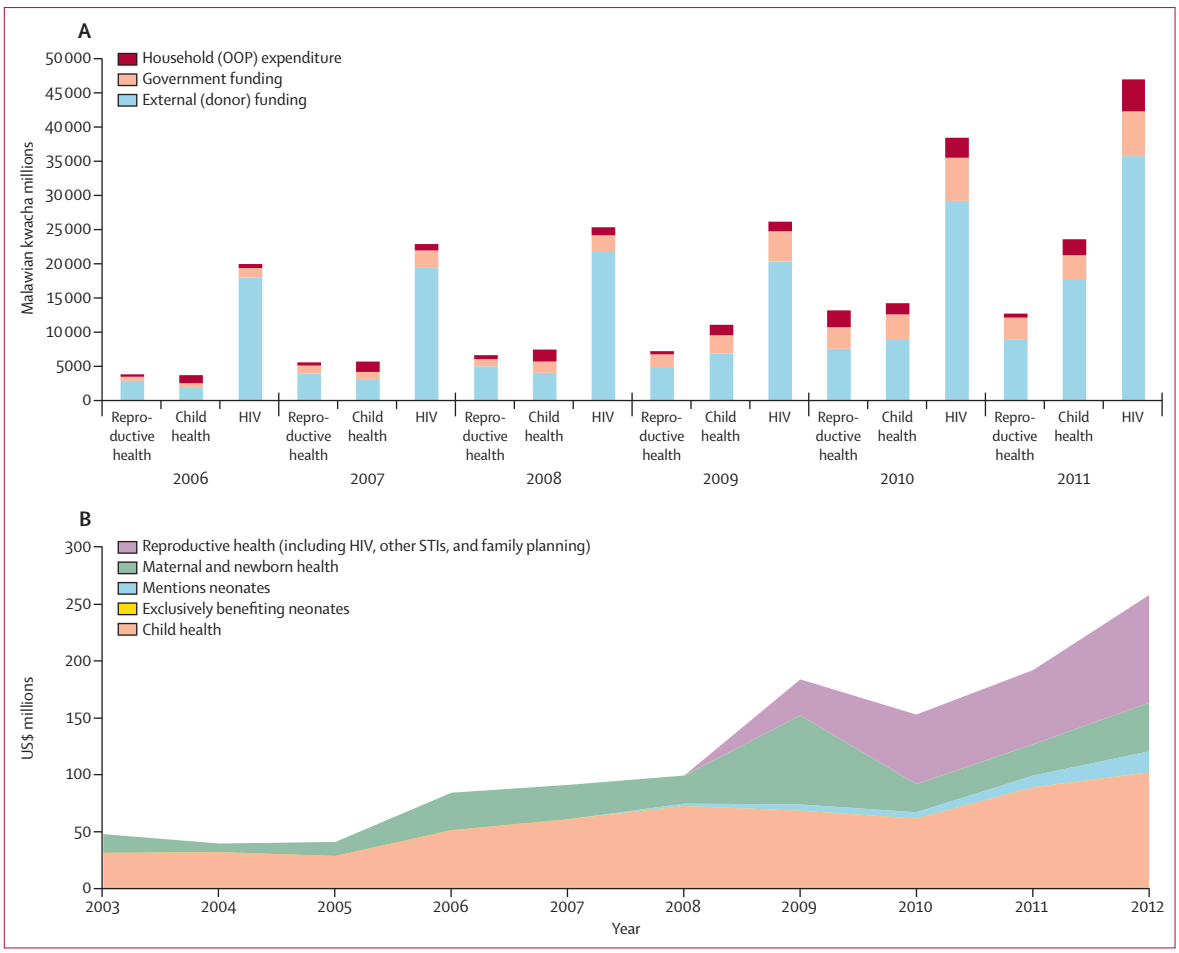

Figure 5: **Assessment of health financing trends in Malawi**
(A) Health subsector expenditure (in 2013 Malawian kwacha millions) between 2006 and 2011 (data are from Malawian National Health Accounts[28,29]). (B) Trends in official development assistance for reproductive, maternal, newborn, and child health between 2003 and 2012 (data are from the Countdown official development assistance database). Financing that exclusively benefits neonates is so low that it is not visible on this figure. STIs=sexually transmitted infections. OOP=out-of-pocket.

the results of incorporating the 2014 MDG Endline Survey data into a revision of IGME estimates of trends in under-5 mortality since 1990. The 2014 MDG Endline Survey results fit closely with estimates from earlier periods, confirming that the data are of similar quality to those from earlier surveys. We estimate that under-5 mortality in Malawi declined at an annual rate of 5·4% from 1990 to 2013, and that Malawi had already achieved the 2015 MDG 4 goal reduction by 2013. In absolute terms, the decline is also remarkable—the under-5 mortality rate per 1000 livebirths fell from 247 (90% CI 234–262) in 1990 to 71 (58–83) in 2013. The most rapid mortality decline occurred in the 1–59 months age group. Neonatal mortality declined more slowly (from 50 to 23 deaths per 1000 livebirths, representing an annual rate of decline of 3·3%), although this result is still impressive compared with those of neighbouring countries.[31,32]

District-level estimates of neonatal and under-5 mortality rates for 1999–2001 and 2009–11, proportionate declines in the neonatal and 1–59-month mortality rate, and sampling errors are available in the appendix, pp 28–35. All districts show declines in the under-5 mortality rate of 20% or more, but vary substantially. Five districts show a decline of 30% or more in neonatal mortality, and five different districts—with no overlap—show a decline of 60% or more in mortality in children aged 1–59 months. Median district declines also show starkly different rates of progress between 2000 and 2010, with neonatal mortality declining by 12% and mortality in children aged 1–59 months declining by 54%. The district results should be interpreted with caution because of the large sampling errors, although the strong patterns across districts are still informative.

The major causes of child deaths in Malawi changed between 2000 and 2013.[22] In 2000, malaria was the single greatest threat to child survival, accounting for about 20% of all deaths in children younger than 5 years in that year, followed by pneumonia (14%), diarrhoea (13%), and AIDS (13%); 23% of deaths occurred in the neonatal period. By 2013, the latest year for which estimates are

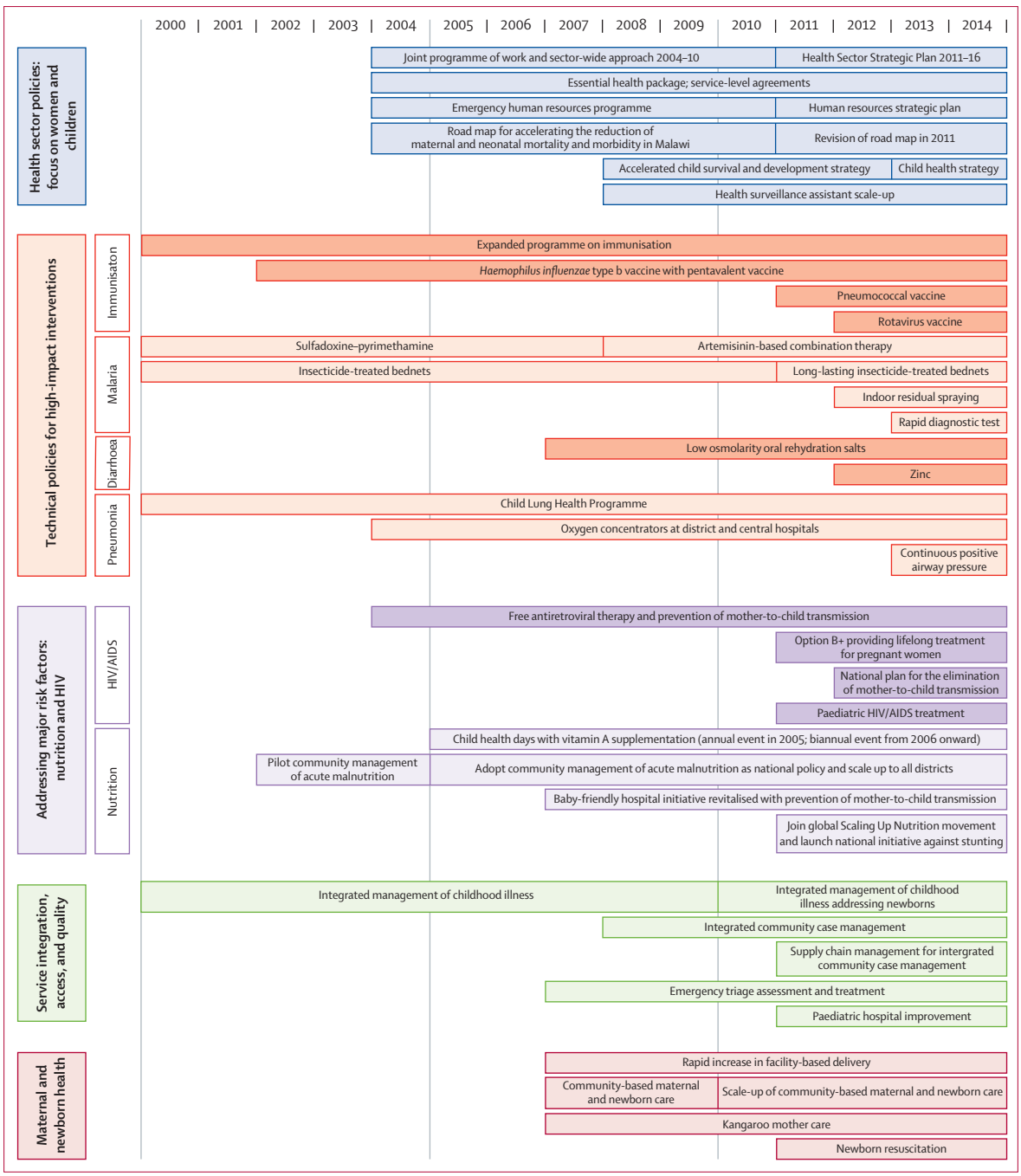

***Figure 6*: Timelines for Malawi's policy and programme initiatives for Millennium Development Goal 4**

available, many fewer deaths and a lower proportion of the total were attributable to malaria (14%) and diarrhoea (7%), fewer deaths but similar proportions were attributable to pneumonia (13%) and AIDS (12%), and 34% of deaths occurred in the neonatal period.[22]

Most high-impact interventions along the maternal, newborn, and child health continuum of care had gains in coverage, with the exception of a decrease of 8 percentage points in the proportion of women who report four or more antenatal care visits (figure 3). Coverage for nearly half of the interventions increased by more than 20 percentage points during this period. Some interventions—particularly those such as vaccination that could be planned and delivered in a scheduled manner—were introduced and scaled up to high population coverage rapidly. Rapid increases also occurred in coverage of prevention of mother-to-child transmission of HIV and skilled care at birth. Coverage of prevention of

mother-to-child transmission of HIV increased steadily over 12 years, and by 2014 had achieved population coverage of 76%. The proportion of women who reported giving birth in a health facility increased rapidly from 53–56% in 2000–06 to 90% in 2014. Of the remaining interventions, we see slow growth for care seeking and treatment of childhood illnesses (pneumonia, malaria, diarrhoea), with 36–69% of children still not receiving the interventions in 2014. Full results for all indicators at national level including 95% CIs are available in the appendix, p 36. Important differences were noted in patterns of coverage change for high-impact child survival interventions by district (appendix pp 37–45).

To determine whether it was appropriate to use LiST to attribute changes in mortality to specific interventions or behaviours, we compared the under-5 mortality rate generated by LiST for the period 2000–13 to the under-5 mortality rate estimated using the IGME methods for the same period. The IGME under-5 mortality rate fell from 174 (90% CI 167–189) per 1000 livebirths in 2000 to 71 (58–83) in 2013. The rate projected by LiST fell from 174 to 92 per 1000 livebirths in 2013, representing 80% of the reduction reported by IGME. Similar to the Countdown case study in Niger,[8] this level of concordance is high, strengthening the case for using LiST as a method to attribute changes in mortality to changes in intervention coverage, stunting and wasting status, and behaviour.

Figure 4A shows the cumulative numbers of lives saved by intervention or intervention group during the years 2001–13. We use the term intervention group as shorthand for changes in intervention coverage, changes in stunting and wasting rates, and behaviour. Of the roughly 280 000 lives saved during this period, increases in treatment for diarrhoea, pneumonia, and malaria accounted for 23%, insecticide-treated bednets accounted for roughly 20%, and vaccines (mainly *Haemophilus influenzae* type b [Hib] and pneumococcal vaccines, but also the measles and diphtheria, pertussis, and tetanus vaccines) for 17%. The numbers of lives saved due to reductions in the prevalence of stunting (8·6%) and wasting (11·0%) are assumed by the LiST model to be a result of the measured change in age-specific stunting and wasting rates rather than changes in intervention coverage, for which data were not available (appendix p 18). The lives saved attributed to HIV interventions (7·1%) are as a result of the increased coverage of prevention of mother-to-child transmission of HIV (including a shift to more efficacious regimens), but also treatment with antiretrovirals and co-trimoxazole. Lives saved attributed to birth care (7·1%) are as a result of increases in the number of births in facilities and the resulting access to additional facility interventions including emergency obstetric care.

The cumulative lives saved depend on the efficacy of the interventions and the timecourse of the scale-up. Some interventions, such as insecticide-treated bednets and Hib vaccines, were scaled up early in Malawi, with coverage increasing slowly over time. Other interventions, such as pneumococcal vaccine, were not rolled out until late 2011, so the cumulative impact was less. To show this effect, figure 4B shows the estimated lives saved in each year by intervention groups.

From 2000 until 2006, the lives saved were mainly due to increased coverage of insecticide-treated bednets, vaccines (almost entirely due to roll-out of Hib vaccine in 2002), and coverage of treatment for childhood illness (figure 4B). A reduction in wasting rates in children also occurred during this period, and has been shown in multicountry analyses to result in lower mortality.[33] In 2006, we see the first substantial impact of HIV/AIDS interventions on lives saved.

In 2006–10, the lives saved due to insecticide-treated bednets and treatment for diarrhoea, pneumonia, and malaria continued to increase and we noted an increasing impact of HIV/AIDS interventions and the positive effects of large increases in births in health facilities rather than at home. Stunting rates in children younger than 5 years also dropped substantially between 2006 and 2010 (appendix p 46). Between 2010 and 2013, we noted a dramatic increase in lives saved as a result of vaccination, reflecting the roll-out of pneumococcal vaccine from late 2011, and, to a lesser extent, rotavirus vaccine from late 2012. Coverage of HIV/AIDS interventions and insecticide-treated bednets continued to increase in this period, resulting in an increasing number of lives saved.

Financial inputs to maternal, newborn, and child health in Malawi are summarised in figure 5 and the appendix, p 47. The share of the total government budget allocated to health increased from 4·6% in 2006 to 7·2% in 2011 (appendix p 47), so the Abuja target of allocating 15% of total government expenditure to the health sector[34] was not achieved.

The increase in funding to the health sector was largely driven by increased donor funding, which represents 66–70% of total health expenditure (figure 5A). The share of out-of-pocket payments remained fairly constant over time, at around 10%. When considering funds to maternal, newborn, and child health specifically, funding to child health increased substantially over the period of study, but funds to maternal and newborn health and family planning increased much less (figure 5B).

The increase in donor funding was also evident through the Countdown database,[35] which provides annual estimates of RMNCH expenditures, including expenditures on nutrition, which are a subset of child health expenditures (figure 5B). Donor funding for child health was much higher than for maternal and newborn health, starting from $31·2 million in 2003, with funding increasing between 2005 and 2008, and again from 2010 to $102·2 million in 2012. By contrast, funding for MNH started at $16·5 million in 2003, peaked in 2009, after which it decreased before increasing again to $42·6 million in 2012. Newborn health has remained the

	2000	2004	2006	2010	2013
GNI per person, PPP (current international $)[40]	$490	$520	$550	$710	$750
Poverty gap at $1·25 a day (PPP)[41]	..	33%	..	34%	..
Annual inflation, consumer prices[42]	30%	11%	14%	7%	27%
HIV prevalence in adults[43]	18%	16%	15%	12%	10%
Northern region*	..	8%[17]	..	7%[18]	..
Central region*	..	7%[17]	..	8%[18]	..
Southern region*	..	18%[17]	..	15%[18]	..
HIV prevalence in women aged 15–24 years[44]	10%	8%	7%	5%	4%
Female literacy†	57%[16]	62%[17]	67%[19]	68%[18]	72%[20]
Northern region	63%[16]	78%[17]	75%[19]	80%[18]	86%[20]
Central region	49%[16]	61%[17]	66%[19]	65%[18]	70%[20]
Southern region	46%[16]	59%[17]	66%[19]	68%[18]	72%[20]
Total fertility rate (births per woman)	6·3[16,45]	6·0[45]	5·9[45]	5·6[45]	5·0[20]
Proportion of births after short interval (<18 months)‡	3·6%	3·4%	3·7%	3·4%	2·8%
Proportion of first births‡	23·3%	22·3%	22·0%	19·9%	22·3%
Proportion of births to mothers aged <18 years‡	4·2%	3·3%	4·4%	3·5%	3·9%
Prevalence of contraceptive use in women aged 15–49 years§[46]	30·6%	32·5%	41·0%	46·1%	..
Urban households[47]	14·6%	15·0%	15·1%	15·5%	15·9%
Extent of food deficit (kcal/day per person)[48]	217	186	189	153	149

GNI=gross national income. PPP=purchasing power parity. *These data might differ from The World Bank data for the whole country. †Defined as attendance at secondary school or higher and ability to read at least part of a sentence; all estimates are about 8 percentage points lower when women who can only read part of a sentence are excluded. ‡Based on births in the 2 years preceding the survey and calculated from pooled Demographic and Health Surveys, Multiple Indicator Cluster Surveys, and MDG Endline Survey full birth history datasets.[16–20] §Including lactational amenorrhea and folk methods of contraception.

***Table*: Trends in selected contextual factors that might be related to trends in child survival in Malawi**

smallest priority, with funds specifically targeting neonates not visible on figure 5B; although funding has increased for projects mentioning neonates, from $48 000 in 2007 to $18·1 million in 2012.

Figure 6 provides timelines for the implementation of key policies and programme strategies that the Government of Malawi used to increase coverage of life-saving interventions between 2000 and 2014. Figure 6 is organised in five sections: major health sector policies affecting women and children; technical policies and programmes for high-impact interventions; policies and programmes addressing major risk factors; policies for integration, access, and quality of high-impact interventions; and specific maternal and newborn health policies. Further descriptions of these initiatives, including priority interventions and packages of interventions targeting reductions in child mortality, can be found in the appendix, pp 48–51.

Large and important differences have occurred in programme implementation across districts in Malawi. We show these differences through a LiST analysis in two districts (appendix pp 52–55). A full analysis of all districts in the country has been completed, but will be reported elsewhere. The results of our bottleneck analysis in ten districts show that four types of health systems barriers are limiting the extent and quality of implementation of child survival, nutrition, and other RMNCH programmes at district level. The first is the health workforce: despite increases during the emergency human resources plan of 2004–10,[36] a substantial proportion of positions in the established plan remained vacant (unpublished data). WHO's current projections for Malawi suggest that massive investment in training and retention of skilled health personnel (doctors, nurses, and midwives) is needed. For example, to reach the minimum recommended density of 22·8 skilled health personnel per 10 000 population by 2030, the number of skilled health personnel will need to increase to 59 188 at an annual rate of about 12·4%, and to achieve the universal health access ratio of 41·1 skilled health personnel per 10 000 population, the number of skilled health personnel will need to increase to 106 694 by 2030 at an average annual rate of 15·6% (Siyam A, WHO, personal communication). Additionally, available evidence suggested that the performance of trained personnel might not meet required standards.[37,38] The second health systems barrier is medicines and supplies. Available data show frequent stock-outs of essential life-saving commodities in health facilities and village health clinics.[38,39] The third barrier is mentorship and skills improvement. Supervision of health workers is infrequent, and often does not include observation of case management by the supervisor with immediate feedback to the health worker.[38,39] The final barrier is governance: our findings suggest that there is limited predictability of health sector funding at district level, and that budget allocations are insufficient relative to basic needs.[28,29]

The role of contextual factors—both positive and negative—have to be taken into account to understand Malawi's achievement of MDG 4 (table). Socioeconomic factors have generally improved, such as gross national income per person, and these factors might have had a positive impact on child mortality. The total fertility rate in Malawi has declined by more than one child in the past decade, and contraceptive prevalence significantly increased between 2000 and 2010. Despite declining total fertility, essentially no change occurred in biodemographic risk factors such as the proportion of births after a short birth interval (of <18 months), the proportion of first births, and the proportion of births to mothers younger than 18 years. The only biodemographic change likely to have an effect on under-5 mortality was the decline in HIV prevalence in women aged 15–24 years, from 10% in 2000 to 4% in 2013 (table). Regional differences in these contextual factors have to be taken into account in future district-level analyses. For example, biodemographic and sociodemographic indicators, including HIV prevalence and female literacy (table), are generally better in the northern region of Malawi than the southern region, with the central region falling in between. The northern region is also less densely

populated and has a higher density of health facilities and better indicators of household wealth than the other two regions.[20,49] These differences probably explain the regional gradient in mortality noted during both the 1999–2001 and 2009–11 evaluation periods (appendix p 28).

The effect of other important contextual factors is less clear. Malawi has serious problems with corruption and governance, but less so than other low-income countries.[50] Levels of perceived corruption have gone down and up twice in the last 25 years in Malawi, but no clear evidence links such changes to changes in health outcomes.[50] Although only 47% of neonates lived within 5 km of delivery services in 2004, distance to such facilities was not linked to early neonatal mortality in a study of Malawian Demographic and Health Survey data.[51] We could not find sufficient data to support analyses of trends in referral system functioning or in availability and access of essential drugs.[49,52]

Our equity analyses of under-5 mortality show that mortality differentials are relatively small by international standards. Children in rural areas had a risk of dying that was 21% higher than those in urban areas, and did not change between 2000 and 2010 (appendix p 33). Children of mothers with no education had an excess mortality risk of only 14% relative to children of women with secondary or higher education in 2010, much lower than their excess risk of 67% in 2000 (appendix p 34). The distribution of births by mothers' education shifted towards those with higher levels of education, but the mortality advantage of being born to an educated mother declined, so the net effect was small (appendix).

Gaps in intervention coverage between the bottom and top wealth quintiles have narrowed for ten key interventions between 2000 and 2014 (appendix p 56).

***Panel*: Key findings and future directions**

- Malawi achieved MDG 4 by increasing equitable national coverage for high-impact interventions addressing the major causes of child deaths, including treatment of childhood pneumonia, diarrhoea, and malaria, prevention of these diseases through the timely introduction of vaccines and insecticide-treated bednets, and reduction of child undernutrition
- Contributors to national success include early adoption of evidence-based policies, government leadership, and partner coordination for rapid scale-up of new initiatives such as integrated community case management and Scaling Up Nutrition, attention to health system strengthening and innovation, and active use of periodic survey and independent assessment data to improve programmes
- Further reductions in under-5 mortality can be realised by addressing remaining system constraints, identifying women and children who are not being served, and developing effective strategies for reaching them and promoting service use, and increased harmonisation of implementation strategies across communities, at the first-level and at referral facilities
- Newborn mortality has decreased more slowly than under-5 mortality, and should be prioritised in future actions; improving quality of care around the time of birth and providing adequate care for small and sick babies should be prioritised, while unmet need for family planning should be minimised
- Available evidence suggests wide disparities in achievement across districts; continuing work should seek to explain the determinants of district success

Discussion

This in-depth case study provides plausible evidence that policy, programme, and financial inputs to child survival in Malawi from 2000 to 2014 led to increases in population coverage for high-impact interventions, and contributed in important ways to Malawi's achievement of MDG 4 by 2013, and improvements in child nutrition. The key findings are summarised in the panel.

Inputs to child survival included strong commitments by the Government of Malawi to survival-enhancing policies and programme strategies for children. Malawi was an early adopter of many policies supporting increased access to and coverage of essential, life-saving interventions. For example, Malawi was among only 12 of 49 African countries that adopted community treatment of pneumonia with antibiotics before 2008, and was among the 25 of these 49 countries that adopted low osmolarity oral rehydration solution and zinc for management of diarrhoea before 2008.[4,53–55]

This policy support, combined with the expansion of human resources for health and the rapid scale-up in IMCI, made quality child health services more accessible to the population, and seems likely to be responsible for the dramatic increase in care seeking for childhood illness that occurred between 2006 and 2010. Malawi achieved MDG 4 despite assessment results showing gaps in the quality of child health services,[49,56,57] suggesting that all-or-nothing approaches to monitoring of progress might be unduly pessimistic. Reductions in stunting occurred during the assessment period, and were probably attributable to a combination of the scale-up of direct nutrition interventions (appendix p 46), declines in childhood illness, and other environmental factors such as economic growth.

Despite Malawi's success in achieving MDG 4, important work remains to be done. The slower decline in newborn mortality relative to under-5 mortality calls for a redoubling of efforts, including care for small and sick babies. At 18%, Malawi has the highest recorded rate of babies born prematurely in the world.[58] Prematurity is related to infections such as malaria, physical and psychological stress, and poor nutrition, during pregnancy.[58,59] The launch of the national Every Newborn Action Plan in July, 2015, has provided additional momentum for an

accelerated scale-up of effective neonatal interventions, including improvements in the quality of care around the time of childbirth for mother and baby.

Additionally, the agenda for children aged 1–59 months is unfinished. Treatment interventions for childhood pneumonia, diarrhoea, and malaria accounted for 23% of the lives saved in this analysis, and yet coverage remains relatively low with only around 60% of children with pneumonia or diarrhoea being taken to a trained provider for care or given oral rehydration solution, respectively, and only 30% of children with fever or malaria received the first-line antimalarial. These coverage levels must be maintained, and further gains must be made. The Ministry of Health and partners should continue to refine their delivery strategies for the management of child illness at both facility and community levels, building a better understanding of why some women and children are not accessing services even when the services are geographically accessible.

Similarly, current efforts to improve infant and young child feeding and to tackle child malnutrition at an early stage in the community must be sustained and expanded. Care around labour and delivery also needs to be strengthened, to ensure that the rapid increases in facility delivery result in their full life-saving potential for mothers and babies in Malawi. Quality of health services across the continuum of care for women, newborn babies, children, and adolescents needs deliberate and massive attention to ensure every service contact is used to provide high-impact interventions. Supply chains for essential drugs and commodities need to be reliable and human resources for health need to be further strengthened through quality improvement processes in health facilities, better retention of personnel, fewer transfers of personnel (including managerial staff), and increased production of competent nurses and midwives with adequate supports for health worker performance.

Despite increases in spending in health in general and child health specifically at the national level, overall health sector funding in Malawi is still insufficient, and below internationally agreed thresholds such as the Abuja target. The health sector is increasingly dependent on external funds, which is of concern given recent evidence of a plateauing of development assistance for health[60] and decreases of funding through the Government of Malawi as a result of concerns with public financial management practices. This dependency on external funds not only decreases the Malawian Government's ability to plan, but also concentrates decision-making power on the donors, who have continued to disburse funding in the form of vertical projects, in which the government has little involvement. Furthermore, out-of-pocket expenditures were around 10% of total health expenditure, despite health services being free at the point of care in Malawi. The Malawian health sector would benefit from increased funding, particularly from the government and targeted to newborn health, but better data are also needed to undertake more in-depth subsector financing analyses. External partners should find a way to ensure predictable long-term funding, given the dependence on external funds and the impact that out-of-pocket payments can have on households.

Our finding of important differences in the choices made at district level about how, and how strongly, to implement evidence-based programmes also merits further attention. The major health system bottlenecks we identified at district level will not be easy to address. Massive investment will be needed in the health workforce to reach the minimum recommended density and standards. Stock-outs of essential life-saving commodities in health facilities and village health clinics must be addressed. Mentorship and skills improvement strategies will need to be implemented more widely, and revised to include observation of case management by the supervisor with immediate feedback to the health worker. Health sector funding at district level must be both increased and made more predictable.

Our study has a number of strengths. Our methods draw on many disciplines (demography, epidemiology, health economics, social science, policy analysis) and permit in-depth analysis. Regular, high-quality household surveys with samples at district level provided the data needed to undertake mortality, coverage, and LiST analyses. Involving key stakeholders across the health system and government in the review of the preliminary results strengthened the interpretation of our findings, and will provide a strong foundation for dissemination and subsequent action.

Our study also has limitations. Most importantly, insufficient data were available to support attribution of declines in stunting to specific interventions, or to quantify the impact of changes in contextual factors on the delivery of health interventions or on under-5 mortality. The fact that we found no overlap in the sets of districts that did best in reducing neonatal mortality and those that did best in reducing post-neonatal mortality suggests that considerable sampling error might have occurred. A large decline (by statistical chance perhaps) in the neonatal mortality rate makes a large decline in mortality in children aged 1–59 months less likely, since the 1–59-month mortality rate is calculated in infants who have survived to 1 month of age; however, we observe no association between the two declines across districts. Additionally, although the LiST estimates of mortality reduction based on increases in intervention coverage, changes in stunting and wasting rates, and behaviour change match well with the measured mortality reduction, questions about some of the LiST inputs remain. Specifically, in the LiST analyses we were forced to use trends in skilled birth attendance and facility deliveries to estimate access to interventions for childbirth, including clean delivery, access to emergency care, and active

management of the third stage of labour, because the national programme does not have coverage estimates of these interventions. This is a crucial weakness in the monitoring of maternal and child health programmes in almost all low-income countries and makes the attribution of mortality reduction to improved birth care less robust than other interventions such as insecticide-treated bednets and vaccination, for which the national programme does have good measures of coverage trends. A final limitation is that attempting to tell the full story of Malawi's achievement of MDG 4 in one report required a series of hard choices about which results and supporting documentation to present, and which to present in the appendix or to hold for future reports. The in-depth country case studies are urgently needed, but are challenging to present in a traditional scientific format.

This is the most detailed study of child survival in Malawi that we are aware of. It contributes to global efforts to understand why some countries have achieved MDG 4 while others have yet to make sufficient progress.[61] Further detailed analyses of district-level progress are underway, and will inform continuing efforts to make further gains in reducing child mortality in Malawi.

Contributors

JBr and MK conceived the study, which was developed by all authors. The five teams who collected or collated the relevant data, analysed the data, and wrote the corresponding sections of the report including panels, tables, figures, and appendix were as follows: mortality, KH, AA, JN, and MM; coverage, TM, EH, RH, and LP; Lives Saved Tool, LC and NW; documentation, JD, RF, LM, BN, HN, BD, and TC; financing, MMÁ, SM, and JBo. JBr wrote the first draft of the report from the contributions of all authors. All authors contributed intellectual content during and between the collaborative analysis and writing workshops, contributed to revising drafts, and read and approved the final version of the report, which was collated and finalised by TC. MK, JBr, and TC are the guarantors of the work.

Declaration of interests

KH and TC report personal fees from the World Health Organization. All other authors declare no competing interests.

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Supplementary appendix

This appendix formed part of the original submission and has been peer reviewed. We post it as supplied by the authors.

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ONLINE APPENDIX FOR:

MALAWI IN-DEPTH COUNTRY CASE STUDY
MALAWI AND MDG-4: EARLY ADOPTER; EARLY ACHIEVER

Appendix Part 1: Data Sources

Box A1: Geographic scope – details of Districts

District-level results exclude the island district of Likoma (because of its small population size) and combined two sets of districts that were not sampled separately in the earlier surveys (Mwanza and Neno districts, and Mzimba North and Mzimba South). In total, we completed quantitative analyses for 26 district units.

For household surveys in which separate samples were drawn for the four major cities in Malawi, the urban and rural households were combined at district level (i.e., Blantyre city was grouped with Blantyre district; Lilongwe city was grouped with Lilongwe district; Mzuzu city was grouped with Mzimba district; and Zomba city was grouped with Zomba district).

Table A1: Reviewed documents

Policy area	Author and Year of Publication	Title	Type of document
Macro-health governance	Malawi Government	Vision 2020	Policy document
	Malawi Government, Finance and development planning	Malawi Growth and Development Strategy 2, 2011-2016	Policy document
	Malawi Government, Finance and development planning	Malawi Growth and Development Strategy 1: From poverty to prosperity 2006-2011	Policy document
	Government of Malawi, Ministry of Development Planning and Cooperation, 2010	2010 Malawi Millennium Development Goals Report	Report
	Mark Pearson, DFID, 2010	Impact evaluation of the sector wide approach, SWAp, Malawi	Evaluation report
	Dr. Hatib Njie and Dr. Ken Maleta, 2007	Malawi Health SWAp Midterm Review, Essential Health Package Report	Midterm review Report
	Government of Malawi, 2002	Malawi Poverty Reduction Strategy Paper	Strategic plan
	Ministry of Health, Reproductive Health Unit, Lilongwe, August 2009	National Sexual and Reproductive Health and Rights (SRHR) Policy	Policy document

Policy area	Author and Year of Publication	Title	Type of document
	Sally Lake, EHP working group and JIP Sub-committee, MOHP/UNICEF June 2001	An Essential Health Package for Malawi: Background, Methods, Progress, and Issues	Report
	Ministry of Health, April 2004	Handbook and guide for health providers on the EHP in Malawi: understanding the EHP	
	Ministry of Health, 2011	Malawi Health Sector Strategic Plan 2011 – 2016: Moving towards equity and quality	National strategic plan
	Ministry of Health, department of Planning, Lilongwe, December 2004	A Joint Programme of Work for A Health Wide Approach (SWAp), 2004 – 2010	Strategic plan document
	Ministry of Health, May 1999	To The Year 2020: A Vision for the Health Sector in Malawi	National strategic plan
	Ministry of Health, May 1999	Malawi National Health Plan, 1999 – 2004	National strategic plan
	Ministry of Health, 1986	Malawi national health plan 1986-1995	National strategic plan
	Ministry of Health, 1995	Health policy framework	National strategic plan
Reproductive health	Ministry of Health, Reproductive Health USAID, JHPIEGO, June 2006; Lilongwe	National Reproductive Health Strategy 2006 - 2010	Strategic plan document
	Office of President and Cabinet, 2011	The presidential Initiative on Safe Motherhood strategic plan 2011-2016	Strategic pan
	UNFPA, Lilongwe	Best Practices and Lessons Learned; The Adolescent and Reproductive Health Project (FARH)	Project document
	Ministry of Health, 2011	National Reproductive Health strategy 2011-2016	Strategic plan
	Ministry of Health, 2004	National Reproductive Health strategy 2004-2010	Strategic plan
	Ministry of Health, 1999	National Reproductive Health strategy 1999-2004	Strategic plan

Policy area	Author and Year of Publication	Title	Type of document
	Ministry of Health, RHD,USAID, CHIP, January 2012	National Sexual and Reproductive Health and Rights Strategy, 2011 - 1016	Policy document
	Ministry of Health, 2002	Sexual and Reproductive Health policy 2002	Policy document
	Ministry of Health , UNFPA, Reproductive Health Unit, Lilongwe may 2007	Guidelines for Community Initiatives for Reproductive Health	Standard operating procedures/guidelines
Maternal and neonatal healthy	Ministry of Health, UNICEF, UNFPA, WHO and AMDD, February 2011 Reproductive Health Unit, Lilongwe	Malawi 2010 EmONC Needs Assessment Final Report	An evaluation report
	Ministry of Health, UNICEF, UNFPA, WHO and AMDD, February 2005 Reproductive Health Unit, Lilongwe	Malawi 2005 EmONC Needs Assessment Final Report	An evaluation report
	Ministry of Health, October 2012 Reproduction Health Unit, Lilongwe	Road Map for Accelerating the reduction of Maternal and Neonatal Morbidity and Mortality in Malawi	Policy document
	Ministry of Health, October 2007 Reproduction Health Unit, Lilongwe	Road Map for Accelerating the reduction of Maternal and Neonatal Morbidity and Mortality in Malawi	Policy document
	Ministry of Health, October 2005 Reproduction Health Unit, Lilongwe	Road Map for Accelerating the reduction of Maternal and Neonatal Morbidity and Mortality in Malawi	Policy document
	Ministry of Health, USAID, CHIP and Save the Children, 2012	Thirteen years of KMC Practice in Malawi; Scaling up to a Continuum of facility-based and Community KMC	An evaluation report
Child health	Ministry of Health, 2014	Child health strategy: For Survival and Health Development of Under-five Children in Malawi 2014-2010	Strategic plan

Policy area	Author and Year of Publication	Title	Type of document
	UNICEF and Ministry of Health, IMCI Unit, Lilongwe December 2008	IMCI Approach for Accelerated Child Survival and Development; Extension workers' Training Manual- Scaling up of High impact interventions in the context of Essential Health Package at Community Level	A training manual
	Ministry of Health, 2007 Community Health Sciences Unit, National IMCI Secretariat, Lilongwe	Five Year National Strategic Plan for Accelerated Child Survival and Development in Malawi; Scaling high impact interventions in the context of Essential Health Package, 2008 -2012	A strategic plan document
	Ministry of Health and UNICEF, 2007 Community Health Sciences Unit, National IMCI Secretariat, Lilongwe	Five Year National Strategic Plan for Accelerated Child Survival and Development in Malawi; Scaling high impact interventions in the context of Essential Health Package, 2007 -2011	A strategic plan document
	Ministry of Health and WHO	Report on Community Based Primary Health Care Review: Volume II	Ministry of Health, Lilongwe
	UNICEF, WHO and Ministry of Health, December 2000	Household Baseline Survey on Key Community Child Care Practices in Selected Districts of Malawi	A survey report
	Ministry of Health, Community Health Sciences Unit, Lilongwe November 2006	IMCI Approach Policy for Accelerated Child Survival and Development in Malawi; Scaling up of high interventions in the context of Essential Health Package	Policy document
	Ministry of Health, 2002 Ministry of Health and Population, Lilongwe	Report of Integrated Management of Childhood Illness (IMCI); Abridged Cham Training 9 – 14 December 2002	Training manual
	Ministry of Health, 2003 Ministry of Health, IMCI, Lilongwe	Integrated Management of Childhood Illness; Abridged Case Management for Kamuzu College of Nursing (KCN) lectures, 13 – 20 September 2003	Training manual (pre-service)
	Ministry of health, IMCI, Lilongwe October 2010,	A Report on Review meeting with the HSAs Running the Village Clinics	Minutes
	Ministry of Health, IMCI unit, Lilongwe 2003	Integrated Management of Childhood Illness; Case Management Training Report for Balaka and Mangochi Districts, 16 – 29 November 2003	Training report

Policy area	Author and Year of Publication	Title	Type of document
	Ministry of Health, IMCI unit, Lilongwe 2010	Report on Community Logistics Orientation for Health Facility in-charges and HSAs in Mzimba at Chenda hotel Mzuzu, 21 – 26 June 2010	Training manual
	UNICEF, WHO, ministry of Health, IMCI unit, Lilongwe	Infant and Young Child Nutrition Policy	Policy document
	Ministry of health, 2011	Report on IMCI (CCM) Mentorship Training, 19 – 25 June 2011	Ministry of Health,
	Ministry of Health, IMCI unit, Lilongwe September 2010	Report on Orientation of Nurses and Clinicians on Management of Diarrhoea in under-five Children Using Low Osmolality ORS and ZINC in Ntcheu District, conducted on 26 – 27 August 2010	Training manual
	Ministry of Health, MCI unit, Lilongwe , 2010	Accelerated child Survival and Development Job Aid Orientation for extension Workers in Chikwawa District, 23 -25 November 2010	Training manual
	Ministry of Health, , IMCI, Lilongwe, UNICEF, September 2011	Integrated Management of Childhood Illness report on community sensitization on village clinics, from 11 – 23 July 2011	IEC activity report
	WHO, AFRO, Pretoria, South Africa 1999	Integrated Management Childhood Illness; First review meeting on IMCI pre-service training in the African region	Minutes
	Ministry of Health, IMCI Unit, Lilongwe 2010	Report on Community Case Management Training: Dedza District Health Office, 29 March – 3 April 2010	Training report
	Ministry of Health, IMCI Unit, Lilongwe, 2009	Report on Village Clinic Review Meeting with Health Surveillance Assistance, 12 – 19 December 2009	Activity report
	Ministry of health, IMCI Unit, Lilongwe, 2011	Report on SC4CCM Interventions Piloting Monitoring tools: Nkhotakota and Nkhatabay	Activity report
	Ministry of Health, IMCI Unit, Lilongwe, 2010	Report on IMCI (CCM) Mentorship Training, 25 – 27 November 2010	Activity report

Policy area	Author and Year of Publication	Title	Type of document
	Ministry of Health, IMCI Unit, Lilongwe, 2010	Report on Community Case Management Training for HSAs, 24 – 29 May 2010	Training manual
	Ministry of Health, IMCI, Lilongwe, 2010	Training of Trainers for Community Case Management of sick Young Infants (age 0 to 2 months), 6 – 10 December 2010	Training manual
	Ministry of Health, UNICEF	A Programme for Child Survival and Development: Plan of Operations and Plans of Action 1988 – 1992	Ministry of Health, Lilongwe
	Ministry of Health	The National Health Plan of Malawi, 1986 – 1995	National strategic plan
	Ministry of Health, IMCI Unit, Lilongwe, 2011	Activity Report for an Orientation of Health Workers in Management of Diarrhoea using ORS and ZINC and in New Referral System Conducted in Dedza District	Activity report
	Ministry of Health, IMCI Unit, Lilongwe December 2005	Evaluation Report for the Integrated Project on Decreasing Childhood Mortality in Malawi	Evaluation report
	Ministry of Health, IMCI Unit, Lilongwe, 2002	Consensus Meeting on Pre-service IMCI Training in Malawi, 10 – 14 June 2002	Minutes
	Ministry of Health, IMCI Unit, Lilongwe, 2003	Integrated Management of Childhood Illnesses (IMCI): Machinga District Third IMCI Training , 19 January – 1 February	Training manual
	Ministry of Health, 2002	First Case Management Training Course in Machinga, 29 July – 10 August 2002	Ministry of Health, IMCI Unit, Lilongwe
PMTCT	Ministry of Health, 2012	Malawi National Plan for the Elimination of Mother to Child Transmission	National strategic plan
Nutrition	Government of Malawi, Office of the President and Cabinet, department of Nutrition, HIV and AIDS, Lilongwe	National Nutrition Education and Communication Strategy for Preventing Child Stunting in Malawi	Strategic plan
	Department of Nutrition HIV and AIDS	National Nutrition Policy and Strategic Plan	Policy document
	Wim Klaassen, Shelagh Layland, June 2001	Review of EC Interventions in the Health Sector in Malawi	Report

Policy area	Author and Year of Publication	Title	Type of document
EPI	Ministry of Health, 2012	Republic of Malawi Ministry of Health and Population Expanded Programme on Immunization Malawi Field Operation Manual 2012	Operational manual
	Ministry of Health 1994	EPI field Manual 1994-2001	Operational manual
Human resource	Ministry of Health, 2012	Human Resource for Health strategic plan 2012-2016	Strategic plan
		Evaluation of EHRP, 2010	Evaluation report
	Ministry of Health, 2004	HR strategy in Malawi 2004-2010	Strategic plan

Appendix Part 2: Indicator Defintions

*Note: any deviations from the standard Countdown definitions are indicators in **BOLD** font*	
Indicator	Definition
Antenatal care (1+)	Numerator: Number of women ages 15–49 who were attended at least once during pregnancy in the 2 years preceding the survey by skilled health personnel (**doctor, nurse, midwife, or ward attendant**); Denominator: Total number of women ages 15–49 with a live birth in the 2 years preceding the survey
Antenatal care (4+)	Numerator: Number of women ages 15–49 who were attended at least four times during pregnancy in the 2 years preceding the survey; Denominator: Total number of women ages 15–49 with a live birth in the 2 years preceding the survey
Any breastfeeding (12-23m infant age)	Numerator: Number of children 12-23 months receiving any breastmilk; Denominator: Total number of children 12-23 months
Any breastfeeding (6-11m infant age)	Numerator: Number of children 6-11 months receiving any breastmilk; Denominator: Total number of children 6-11 months
Careseeking for pneumonia	Numerator: Number of children ages 0–59 months with symptoms of pneumonia **(cough + rapid breathing)** in the two weeks prior to the survey who were taken to an appropriate health provider; Denominator: Total number of children ages 0–59 months with symptoms of pneumonia **(cough + rapid breathing - no question on "problem in the chest" in the 2000 DHS)** in the two weeks prior to the survey
Child slept under an ITN	Numerator: Number of children ages 0–59 months sleeping under an insecticide-treated mosquito net **(LLITN or treated in the previous 12m)** the night before the survey; Denominator: Total number of children ages 0–59 months surveyed. **2000 DHS used "colored net" proxy for treated net. Excluded children who didn't spend the last night in the HH.**
Contraceptive prevalence rate	Numerator: Number of women 15-49 at risk of getting pregnant that are using **modern** form of contraception; Denominator: Total number of women 15-49 at risk of getting pregnant
C-section	Numerator: Number of women ages 15-49 with a live birth in the 2 years preceding the survey delivered by caesarean section; Denominator: Total number of women ages 15-49 with a live birth in the 2 years preceding the survey.
Demand for FP satisfied	Numerator:Women who are married or in union and currently using **a modern** method of contraception; Denominator: Women who are married or in union and who are currently using any method of contraception or who are fecund, not using any method of contraception but report wanting to space their next birth or stop childbearing altogether
DPT3/Penta3 immunization	Numerator: Number of children ages 12–23 months receiving three doses of diphtheria/ pertussis/tetanus vaccine; Denominator: Total number of children ages 12–23 months surveyed. **LIST uses UNICEF annual estimates**
Early initiation of breastfeeding	Numerator: Number of women with a live birth in the 2 years prior to the survey who put the newborn infant to the breast within 1 hour of birth; Denominator: Total number of women with a live birth in the 2 years prior to the surveyed
Exclusive breastfeeding (<1m infant age)	Numerator: Number of children 0-1 months receiving only breastmilk for food (plus medication, vaccines, and vitamins).; Denominator: Total number of children 0-1 months
Exclusive breastfeeding (0-5m infant age)	Numerator: Number of infants ages 0–5 months who are exclusively breastfed; Denominator: Total number of infants ages 0–5 months surveyed
Exclusive breastfeeding (1-5m infant age)	Numerator: Number of children 1-5 months receiving only breastmilk for food (plus medication, vaccines, and vitamins).; Denominator: Total number of children 1-5 months
Facility delivery (clinic and hospital)	Numerator: Number of children born in an institution **in the previous 2 years**; Denominator: Total number of births **in the previous 2 years**
Hib immunization (3 doses)	Numerator: Number of children ages 12–23 months receiving three doses of Haemophilus influenzae type B vaccines; Denominator: Total number of children ages 12–23 months surveyed
Household ITN/IRS	Numerator: Number of households owning at least 1 ITN or protected by IRS; Denominator: Total number of households. **[Notes: IRS begins in 2010, previous estimates are ITN only (LLITN or net treated in the previous 12 months; in 2000, they did not specifically ask about treatment. Instead use of "colored net" is assumed as ITN**].
Hygienic disposal of children's stools	Numerator: Number of children's stools that are disposed of safely and contained (use toilet, stools discarded into toilet or buried); Denominator: Total number of children age 0-2 years
Improved sanitation (can be shared)	Numerator: Number of household members using improved sanitation facilities (flush toliet, any pitlatrine, VIP); Denominator: Total number of household members.
Improved sanitation (cannot be shared)	Numerator: Number of households using improved sanitation facilities **(flush toliet, any pitlatrine, VIP - all must be not shared)**; Denominator: Total number of households.
Improved water source	Numerator: Number of household members using improved drinking water sources **[piped water, covered well, borehole, all springs (2000 DHS does not specify protected or unprotected), rainwater]**; Denominator: Total number of household members
Intermittent preventative treatment in pregnancy (for malaria)	Numerator: Number of women ages 15–49 at risk for malaria who received two or more doses of a sulfadoxine-pyrimethamine (Fansidar™) to prevent malaria during their last pregnancy that led to a live birth in the previous 2 years; Denominator: Total number of women ages 15–49 with a live birth in the 2 years preceding the survey.

Indicator	Definition
Iron folate supplementation	**Numerator: Number of women taking an iron-folate supplement daily, for at least 90 days during the most recent pregnancy that resulted in a live birth; Denominator: Total number of women with a live birth in the previous two years**
Malaria treatment - Artemesinin compounds	Numerator: Number of children ages 0–59 months who had a fever in the two weeks prior to the survey who received **ACT in 48 hours of symptom onset**; Denominator: Total number of children ages 0–59 months who had a fever in the two weeks
Malaria treatment (Antimalarials within 48 hours)	Numerator: Number of children ages 0–59 months who had a fever in the two weeks prior to the survey who received **any antimalarial in 48 hours of symptom onset**; Denominator: Total number of children ages 0–59 months who had a fever in the two weeks
Malaria treatment (first line)	Numerator: Number of children ages 0–59 months who had a fever in the two weeks prior to the survey who received first line treatment according to national policy; Denominator: Total number of children ages 0–59 months who had a fever in the two weeks who recieved any antimalarial. **Note: 2000, 2004 and 2006 = SP; 2010 and 2013 = ACT - (http://apps.who.int/medicinedocs/documents/s18367en/s18367en.pdf) it was in December 2007 that the policy for ACTs was launched, but it notes that supervisory visits to assist implementation occurred in March 2008.**
Measles immunization	Numerator: Number of children ages 12–23 months who are immunized against measles; Denominator: Total number of children ages 12–23 months surveyed. **LIST uses UNICEF annual estimates**
Neonatal mortality rate	Number of neonates dying before reaching 28 days per 1000 live births in a given time period.
Neonatal tetanus protection	Numerator: Number of mothers who received **two doses of tetanus toxoid vaccine during the most recent pregancy**; Denominator: Total number of women ages 15-49 with a live birth in the 2 years prior to the survey
ORS - oral rehydration solution	Numerator: Number of children ages 0–59 months with diarrhoea in the two weeks prior to the survey receiving oral rehydration therapy (oral rehydration salts packet, or increased fluids) and continued feeding; Denominator: Total number of children ages 0–59 months with diarrhoea in the two weeks prior to the survey. **Note: removed "reccommended home fluids" since not all surveys ask about that**
ORS + continued feeding	Numerator: Number of children ages 0–59 months with diarrhoea in the two weeks prior to the survey receiving oral rehydration salts; Denominator: Total number of children ages 0–59 months with diarrhoea in the two weeks prior to the survey
Partial breastfeeding (<1m infant age)	Numerator: number of children (0-1m) receiving breastmilk plus complementary foods and/or milk-based liquids (plus medication, vaccines, and vitamins); Denominator: Total children 0-1m of age
Partial breastfeeding (1-5m infant age)	Numerator: number of children (1-5m) receiving breastmilk plus complementary foods and/or milk-based liquids (plus medication, vaccines, and vitamins); Denominator: Total children 1-5m of age
Postnatal care for infant	Numerator: Number of children born to women in previous (2) years who received postnatal check within two days of childbirth **OR child was born in health facility**; Denominator: Total number of births in the previous 2 years
Postnatal care for mothers	Numerator: Number of women ages 15–49 who received postnatal care within two days of childbirth **(if delivered outside facility) OR all women who delivered in facility**; Denominator: Total number of women ages 15–49 with a last live birth in the **2** years prior to the survey
Predominant breastfeeding (<1m infant age)	Numerator: number of children (0-1m) fed breastmilk plus water and/or other non-milk liquids such as juices (plus medication, vaccines, and vitamins), Denominator: Total children 0-1 months of age
Predominant breastfeeding (1-5m infant age)	Numerator: Number of children (1-5m) fed breastmilk plus water and/or other non-milk liquids such as juices (plus medication, vaccines, and vitamins), Denominator: Total children 1-5 months of age
Skilled birth attendance (SBA)	Numerator: Number of women ages 15–49 with a live birth in the 2 years prior to the survey who were attended during delivery by skilled health personnel (**doctor, nurse, midwife or ward attendant**); Denominator: Total number of women ages 15–49 with a live birth in the 2 years preceding the survey **(2006 MICS does not ask about ward attendant)**
Stunting (<5y)	% of children under 5 who are moderately or severely stunted
Under five mortality rate	Number of children dying before reaching 60 months per 100 live births in a given time period.
Underweight (<5y)	% of children under 5 who are moderately or severely underweight
Vitamin A supplementation (DHS/MICS)	Numerator: **Number of children ages 6–59 months who received at least one dose of vitamin A in the previous 6 months**; Denominator: Total number of children ages 6-59 months. **Note: LIST projection uses UNICEF annual estimates**
Wasting (<5y)	% of children under 5 who are moderately or severely wasted
Water connection in the home	Numerator: Number of households with a household connection, including water piped into the home or yard; Denominator: Total number of households.

Appendix Part 3: Lives Saved Tool (LiST) Methods

In this section of the appendix we present two pieces related to the LiST analyses presented in the paper. The first section provides a brief overview and background of the Lives Saved Tool. The second section then presents explicit details of the methods used in the analyses and also provides a link to the country-specific and two district models that were used in the analyses. These models which include all of the country-specific information can be downloaded and run to reproduce the analyses presented in the main text.

Section 1: General Overview of the Lives Saved Tool (*LiST*)[i]

Background and history

The ***Lives Saved Tool (LiST***) has been developed over the past 10 years. The initial version of the software was developed as part of the work for the Child Survival Series in Lancet in 2003[1]. The purpose of the program was to estimate the impact that scaling up community-based interventions would have on under-five mortality[2], but the program had a very limited demographic capability. Starting from this initial point the software was expanded first to handle a new set of interventions that focused more on facility-based care with the primary impact being on neonatal mortality.[3,4] The model was then improved to handle populations and cohorts and to include wasting and stunting as risk factors as part of the work for the Lancet Nutrition Series[5]. At about the same time, the Bill & Melinda Gates foundation provided on-going support to the further development and maintenance of the software as part of the work of the Child Health and Epidemiology Reference Group (CHERG). At that point, the software was shifted into the free

[i] This overview document is based on: Walker N, Tam Y, Friberg IK. Overview of the Lives Saved Tool (LiST). *BMC Public Health* 2013; **13 Suppl 3**: S1

and publicly available Spectrum software package, to take advantage of the demographic capabilities in that software and to provide links to the AIM module that had been developed to estimate the impact of HIV/AIDs[6]. Since that time *LiST* has expanded its scope to look at the impact of interventions on birth outcomes and stillbirths[7], maternal mortality, and incidence of pneumonia and diarrhea[8] as well as neonatal and child mortality.

Theoretical approach and basic modelling structure of LiST

The Lives Saved tool has been characterized as a linear, mathematical model that is deterministic.[9] It describes fixed relationships between inputs and outputs that will produce the same outputs each time one runs the model. In *LiST* the primary inputs are coverage of interventions and the outputs are changes in population level of risk factors (such as wasting or stunting rates, birth outcomes such a prematurity or size at birth) and cause-specific mortality (neonatal, 1-59 months, and child mortality, maternal mortality and stillbirths). The relationship between an input (change in intervention coverage) with one or more outputs is specified in terms of the effectiveness of the intervention in reducing the probability of that outcome. The outcome can be cause-specific mortality or a risk factor. The overarching assumption in *LiST* is that mortality rates and cause of death structure will not change except in response to changes in coverage of interventions. The model assumes that changes in distal variables such as increase in per capita income or mothers' education will affect mortality by increasing coverage of interventions or reducing risk factors.

Currently there are around 70 separate interventions within *LiST*. These interventions have an impact on stillbirths, neonatal mortality, mortality in children 1-59 months, maternal mortality or risk factors within the model. Interventions can be linked to multiple outcomes, with some interventions linked to multiple causes of death and risk factors. A key feature of *LiST* is that it

allows one to look at the impact of scaling up coverage of multiple interventions simultaneously, instead of a single intervention and one cause as is done in many natural history models.

There are several structural features about the model that must be considered in order to estimate the impact of scaling up coverage of multiple interventions and changes in risk factors on mortality. First, the effectiveness or efficacy of an intervention must be described in terms of reduction in cause-specific mortality rather than in overall mortality. With cause-specific estimates of efficacy we can then compute the combined impact of interventions. Within *LiST,* efficacy of an intervention is defined in terms of the reduction of a cause of death or risk factor. When there is a single intervention the calculation of impact is simple as one has change in coverage times the efficacy of the intervention and this is applied to the cause specific mortality. For example if we have 10,000 diarrhea deaths in children aged 1-59 months and we introduce a new vaccine that would be 50% effective in reducing diarrhea mortality. If we have coverage of 50% we would then reduce diarrhea mortality to 7,500 (10000 – (10,000 *.5 * .5)). When there is a second or a third intervention, the same approach is followed except that the second diarrhea intervention would be applied to the residual diarrhea deaths. So if the second new diarrhea intervention is also 50% effective and coverage reaches 50% we would then reduce diarrhea mortality to 5,626. By using cause-specific efficacy and applying each intervention to the residual deaths after the previous intervention we ensure that we are not double counting impact of interventions.

Age structure within LiST

LiST has a fairly simple age structure within the model that serves as a pseudo cohort. The age periods in *LiST* include pregnancy, 0-1 month, 1-5, 6-11, 12-23 and 24-59 months. Within the model impact at one age period has a cascading effect of what happens at the next. For example,

if we scale up interventions that have an impact of neonatal mortality, more children will survive that period and then be exposed to the risk of death in the 1-59 month period. So the number of deaths in this period will increase, but the rate of mortality will remain the same. These time periods are also linked to the impact of sub-optimal breastfeeding on mortality.

For pregnancy, neonatal and 1-59 months there is a fixed cause of death structure in the base year (during pregnancy it is stillbirths). There is also a mortality rate that is applied to the age period. Within the 1-59 month period it is adjusted to reflect the higher mortality at earlier ages. Interventions within *LiST* can have an impact on one or more age periods.

Links to other modules in Spectrum

The Lives Saved Tool is a linked module within the Spectrum program. Currently *LiST* is linked directly to three other modules in Spectrum. A required linkage in Spectrum is between *LiST* and the demographic module, *DemProj*. *DemProj* is a fully functioning demographic package that allows users to define populations via inputs on age-specific fertility, migration, population structure by age and sex, and other factors. The software contains the most recent population projections from the United Nations Population Division for 192 countries. When using *LiST*, users select a country, base year and end year and then *LiST* automatically loads in the population projection for that time period. Users can then use this as the population projection or they can use *DemProj* to update or alter as they deem appropriate.

FamPlan is a second module within Spectrum that is linked to *LiST*. FamPlan was developed to estimate the impact of scaling up family planning on fertility. As with the other modules, when one selects a country the most recent information on family planning, contraceptive prevalence, unmet need for contraception and contraceptive method mix is loaded. The user can then create

scenarios where one reduces unmet need, increase contraceptive use and changes the contraceptive method mix. By changing these parameters in *FamPlan* several outputs change when it feeds into *LiST* as inputs. First, if one changes contraceptive prevalence then there is an impact on fertility. When a user specifies changes in *FamPlan*, this overrides the predicted fertility assumptions and alters assumptions about abortion from *DemProj* and passes this new information to *LiST*. For example, if one scales up contraceptive prevalence to very high rates in a country with low contraceptive use, then the number of births will decrease and therefore the number of under-five and maternal deaths predicted by *LiST* will decrease.

A third linked package is the AIDS Impact Module, *AIM*, which is used to estimate the impact of HIV/AIDS on mortality. This module has been developed under the auspices of UNAIDS and the UNAIDS reference group on modeling and estimates[10]. This module describes the epidemic curve in terms of incidence for each country. The module also has coverage of interventions (e.g., treatment, prevention of mother-to-child transmission) and uses the information to estimate prevalence and mortality by age and sex. Estimating the impact of interventions to reduce AIDS mortality in children in not done in *LiST*, rather the calculations are done in *AIM* and then passed to *LiST*. Within Spectrum, when one selects a country it will automatically load in the most recent country-specific *AIM* module developed by UNAIDS and the national AIDS program[11]. As with other modules in Spectrum, the user can override the standard *AIM* inputs and can scale up interventions and change the epidemic curve to develop new scenarios for the future.

Source of assumptions and process of updating LiST

The development of the Lives Saved Tool has been under the guidance of the Child Health Epidemiology Reference Group (CHERG) of WHO and UNICEF. CHERG, along with its institutional sponsors, has developed rules of evidence to decide what interventions should be

included in the model as well as how to develop the estimates of efficacy and effectiveness used in the model.[12] While the assumptions used within *LiST* are drawn from various sources, most of the assumptions about efficacy and effectiveness of interventions come from a series of journal supplements. Previously three supplements containing over 70 articles have been published[13,14],[15]. The set of assumptions and their sources can be found at the *LiST* website (www.livessavedtool.org).

The CHERG also supports efforts to compare the estimates that come from *LiST* to measured changes in intervention coverage and mortality. There have been several studies that have compared measured changes in mortality to *LiST* estimates of mortality change looking at different sets of interventions in different countries. For example, one study compared *LiST* estimates to measured reduction in neonatal mortality in community trials in South Asia.[16] Another study looked at community trials that focus on the scale up of use of insecticide treated nets (ITNs) in sub-Saharan Africa.[17] A third compared measured and estimated mortality for a community trial in Mozambique.[18] In all of these studies there was close agreement between the estimates of mortality from *LiST* based on coverage changes and the measured reductions in mortality. Additional studies doing comparisons of *LiST* have been published in the *LiST* journal supplements.[17-19]

Creating a projection scenario in LiST

The basic process to create a projection scenario is fairly simple. First, one must select a baseline year for a country (or region, district or any other area one choses). In that baseline year the country must be described in terms of a five broad sets of variables: mortality, exposure, risk factors, intervention coverage and demography. For mortality one must specific the neonatal, 1-59 month, stillbirth rates and maternal mortality rates, as well as the proportional causes of

mortality (or stillbirths). Exposure variables include such factors as exposure to falciparum, level of deficiency of vitamin A and zinc, and percent of the population living in poverty. Risk factors include stunting and wasting rates by age, birth outcomes, breastfeeding patterns and diarrhea and pneumonia incidence. Coverage of interventions must be provided for all intervention in *LiST* in the baseline year. Finally, for *LiST* to operate basic demographic information must be provided including population structure by age and sex as well as age-specific fertility. Fortunately *LiST* allows readers to automatically load in this information for 90 low- and middle-income countries for any year from 2000 to 2011, where the information are typically compiled from large surveys such as DHS or MICS. Once one selects the country and base year, the information is automatically loaded into the program but the user can change any values if they have better data or if they would like to modify the population to reflect a region in a country.

Once a baseline year is set for a country, the user can then create a projection scenario by scaling up coverage of a single or multiple interventions over a time period. For example, one could look at the impact of scaling up vitamin A supplementation from its current level of coverage of 50% in 2013 to 95% coverage in 2015. Or one could develop a treatment scenario where one scales up coverage of treatment for diarrhea with ORS, antibiotics for pneumonia and treatment for malaria with ACT from current levels of coverage to 90% by 2018.

Once one has created a scale up scenario, *LiST* then re-computes all of the inputs used in the base year based on the impact of the interventions in the scale up scenario. The levels of mortality, cause of deaths structure and levels of risk factors will be recomputed and applied to the new population structure that reflects not only the changes in *DemProj* but also any changes in intervention coverage from the *LiST* model and changes made in the *FamPlan* and *AIM* modules.

Section 2: Methods and Assumptions of the LiST Analyses for the Malawi Countdown Case study

National model. For the national model we developed a baseline for the year 2000. In that year we set mortality and cause of death to the national estimates from the UN (www.childmortality.org). For coverage and age-specific rates of stunting and wasting we used the estimates derived from the 2000 Malawi DHS survey. All other assumptions including intervention efficacy and exposure levels we used the national estimate defaults contained in *LiST*.

For these analyses we set the configuration of the model to use direct entry of stunting and wasting rates. As we have reliable estimates of age-specific stunting and wasting rates for each national survey, and we do not have reliable coverage data on nutrition interventions we felt this was a better way to estimate the impact of intervention coverage and changes in stunting in wasting on mortality.

Once we had the baseline year of 2000 set, we then entered intervention coverage and stunting and wasting rates for each year in which we had a national survey. These were the years 2000, 2004, 2006, 2010 and 2013. For the years between two surveys we used linear interpolation to estimate coverage. The one exception to this was for coverage of vaccines, where we used the joint UN estimates of vaccine coverage as these would more accurately capture the coverage of newly introduced vaccines which occurred in non-survey years.

With the trends in coverage and stunting and wasting we were then able to compute the new mortality rates (and causes) based on the changes in these variables. As with all *LiST* analyses

were then able to estimate mortality reduction (neonatal, 1-59 months, under-five, maternal and stillbirths) as well as attribute the change in mortality to changes in intervention coverage or changes in stunting and wasting. The final models we run using Spectrum (LiST) version 5.31.

District LiST models. For the district models we followed the same basic procedure as used in the national model with four exceptions. First, the start year for district models depended on when district-level data were available on coverage. For 11 districts the first year (base year) was 2000, for another 15 districts the base year was 2006 and for one district the base year was 2010.

For estimates of neonatal, infant and under-five mortality in the baseline year we used the district-level estimates generated as part of the countdown case study. For maternal mortality and stillbirth rates we used the national estimates. For cause of death estimates for neonatal and 1-59 month periods we used a procedure described elsewhere[19] . In short, with this approach one takes the national-level model and then adjusts it so that coverage and levels of stunting and wasting are those in the district. Then based on these changes in coverage *LiST* re-estimates the cause of death structure.

Finally, for each district we had to re-estimate age-specific stunting and wasting rates for each district. Although the surveys did have representative data at the district levels, with the narrow age bands (1-5 month, 6-11, 12-23 and 24-59) the number of children were not sufficient to produce a reliable estimate of the proportions of children in each age group into the four categories of height for age and weight for height. Instead we created a ratio of stunting at the national level of all children less than five years of age to the district stunting of all children less

than five years of age and then used this ratio to estimate the district age-specific estimates of stunting and wasting.

With these four adjustments we were then able to estimate the impact of scaling up interventions and changes in stunting and wasting rates for each district.

We did not have data on coverage of PMTCT, pediatric ARV and prophylactic cotrimoxazole for HIV-exposed children at district level; instead we used the same estimates of HIV prevalence and coverage of interventions as in the national model.

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Appendix Part 4: Documentation methods

The objectives for the documentation team were to:

- To document contextual factors, transversal health sector policies, sspecific technical health policies, and health system characteristics that are relevant for maternal, neonatal and child health
- To assess health system characteristics and the strength of policy implementation at national and district levels, and detect potential associations with changes in coverage and/or mortality indicators and in equity

To achieve these objectives, we reviewed policies and documents relevant to child survival; carried out Key Informant (KI) interviews both at national and district level, and tracked programme output indicators for a selected number of districts.

Review of policies and other relevant documents

Once Malawi was selected for a Countdown in-depth case study, there was an initial stakeholder's planning meeting in Lilongwe in November 2013. Again in March 2014, there was a technical planning meeting in Zomba. At both of these meetings, participants mapped possible sources of data and came up with a list of possible key documents to be interviewed and national level key informants to be interviewed.

Following the Zomba meeting, in order to document policies, programmes and interventions for Maternal Newborn and Child Health (MNCH) as well as health policy and system changes, we reviewed a range of various programme areas of maternal, neonatal, child health, nutrition and HIV/AIDS. More documents were identified during national level KI interviews. Web Annex 1 gives a detailed list of all the documents that were reviewed between March and November 2014.

The purpose was three fold;

- To document contextual factors, those that might have influenced the country's performance in achieving MDGs 4 and 5
- To develop a timeline of policies and programmes (including interventions)
- To trace health policy and system indicators, which reflect national adaptation of internationally agreed policies and health system changes.

To capture the information, we used the standardized Countdown to 2015 health policy and systems documentation tool. The Countdown to 2015 WHO tools aimed to standardize policy, systems and programmes documentation across countries. These included three tools:

- Tool 1 documents policies, systems and programmes on a timeline.
- Tool 2 tracks the key Countdown tracer indicators over time.

- Tool 3 is a detailed analysis tool to assess programme implementation. This was modified by the Malawi documentation team during a workshop in Kenya

Key informants interviews – national level

Alongside the review of documents, to understand the programmes and factors that may have contributed to the improvements in child survival in Malawi, we conducted national level interviews with Ministry of Health (MoH) departments and government partners for the health sector. 25 national level KIs were interviewed from February to November 2014. The documentation team developed a template for stakeholder interviews, which aimed to collect information about interventions, or programmes that have contributed to child survival and progress in maternal and neonatal health (stakeholder's theories of change). The tool was based on the WHO health system building blocks and is reproduced as Box A2. Table A2 gives details of key informants who were interviewed between March and November 2014.

Box A2: Master national [and district level] interview guide

Themes of programme implementation	Categories of information	Possible questions
Adaptation for local use	Beginning/inception	When did the program start [in this district]?
	Scale-up and integration	Was the programme started in all health facilities at once or it was scaled up with time? Which other services has it been integrated with? How easy is it to implement that service in its current arrangement
Institutional arrangements		Who does the district responsible person report to at national level? What sort of support does the district person get from MoH? What challenges are there in relation to this arrangement?
Financing of implementation		How is the service funded for its implementation? What other resources are used to implement the service and where do they come from? What challenges are there in financing this service?
Cadres of health workforce utilized to implement the programme		Which cadre of service providers implements the service?
Training	Pre-service	How much training did you get in training school on this programme?
	In-service	When did you have in-service training for this programme? How about a refresher course? How helpful was the training?
Essential infrastructure and health facilities	Level of programme implementation	At what level of the facility is this service implemented (district/health center)?
	Capacity of level to implement programme	Do you think health facilities have capacity to implement this programme? i.e. adequate numbers of trained staff, space, equipment, utilities (water, electricity), means of transport, means of communication
	Referral systems in place	What sort of procedures or systems are in place to ensure effective referral system from HC to district?

Themes of programme implementation	Categories of information	Possible questions
Commodities	Medicines, supplies and equipment	Does the facility have a pharmacy or space for medical equipment and pharmaceuticals? Who manages pharmaceuticals? What is the normal process of ordering and procuring medical supplies and drugs and equipment? Does the medical equipment in your working area function at all times? If not why? Are you able to use any equipment that is available in your work area? If not why?
	Supplies	Are medical supplies and drugs available all the time? If not why?
	Equipment	Do you have functioning equipment all the time? If not, why? Are you able to use all the equipment in your area of work? If not why?
Standards on quality of care	Standard clinical procedures	How do you ensure that health providers follow the standard clinical procedures?
	Criteria for referral	What is the criteria and procedure for referring patients
	Other	Why are patients not referred as appropriately
Supportive supervision for all health workers in the delivery of quality care	Supervisory checklists	Who is responsible for supervising implementation of this service? How frequent are you supervised? Why do you think you are not supervised frequently as expected? How helpful is that supervision to you? How can it be improved?
Community participation	Role of village committees	What is the role of the village committees?
	Existing community structures	How do you work with the community? What are the challenges of working with village committees?
	Role of community stakeholders	How do you work with other NGOs who provide similar services in this district?
	Existence of other community health workers	Who are other services providers from other sectors, agriculture, education,
Community mobilization and health education	Mass campaigns Pamphlet distribution Health education at facility level	What activities do you do to mobilize the community to support the service? What sort of activities and how frequent do you to for communities to aware of the service availability? How frequent do you do mass campaigns? What are the challenges?
Health management information system		Who is responsible for managing health information? How is data transferred from service area to IT officer? What challenges do you face that limit you to be able to report routine data to the central office as expected? What factors do you experience that affect completeness of data that gets to be reported to the central office?

Table A2: list of national level KIs

Programme area	Key informant	Institution/position
Health system changes	Trish Araru	MoH, Planning
	Gilian Nkalamba	MoH, HR
	Simeon Yosefe	MoH, HMIS
	Earnest Kaludzu	MoH, IMCI M and E
	Dr. Annie Phoya	SWAp, Former director
	Dr. Martius Joshua	Director, Zomba C. Hospital
	Thoko Lipato	Nurses and Midwives Council
RMNH	Diana Khonje Fannie Kachali	RHD- Deputy Director RHD-Director
	Dr. Chisale Mhango	RHD-Former director
	Leslie Mgalula	WHO
	Harriet Chanza	WHO
	Evelyn Zimba	USAID
	Grace Mlava	UNICEF
	Jean Mwandira	UNFPA
	Tambudzai Rashi	JHPIEGO
	Lonnie Nchozana	FPAM
	Emmanuel Chimbalanga	Save the children
	Michael Eliya	PMTCT
Child health	Mr Nsona.	MOH, ICI Unit
	Norman Lufesi	ARI
	Earnest Kaludzu	IMCI M & E officer
	Mr Dedza	Logistics officer _IMCI
EPI	Mr Chirwa	MoH, Preventive health
Nutrition	Felix Phiri	DNH

KI interviews- district level

In addition, between July and September 2014 we conducted district field visits. The aim was to understand policy and programme implementation at district level and identify supply and demand side bottlenecks, using the interview tool reproduced as Box A2. Ten districts were selected for field visits, based on performance in reducing under-five mortality within each of the three regions (Table A3).

Table A3: Selection of districts and selection criteria

Region	District	Reason for selection	Districts
North	1	Well performing	Chitipa
	2	Least performing	Mzimba
Central	1	Well performing	Mchinji
	2	In between	Dedza
	3	Least performing	Salima
South	1	Well performing	Machinga
	2	Well performing (2013)	Mwanza
	3	In between	Mangochi
	4	Least performing	Mulanje
	5	Least performing	Chikwawa

An Excel template with all the district profile variables was used to capture data for the district profile variables. Three people (including JD) pulled out data from existing surveys, programme evaluations and reports and filled in the template for each of the selected districts. Since sources of data were different, we used color-coding to track sources of data used for developing the district profiles.

For district level KI interviews, we also used the WHO health system building blocks to develop themes, categories of information and guiding questions for structured interviews with district KI. The district level KI were purposively selected on the basis of position and role in Reproductive Maternal Newborn and Child Health, Nutrition and HIV/AIDS (RMNCHN+H/A). Table A4, lists district level key informants who were interviewed and reasons for their selection.

Two teams of three interviewers carried out district level interviews for all the 10 selected districts over a period of three weeks. Immediately after the fieldwork, the same interviewers transcribed the recorded interviews over a period of one month, from 5th August to 5th September 2014.

Tracking of output indicators

To track output indicators for each of the selected districts over time from 1990 to 2014 we entered data on an excel sheet with a few selected programme output indicators. Sources of data included, surveys (DHS, MICS), evaluation reports (EmONC evaluation report 2005 and 2010; health facility survey for IMCI). It was, however, difficult to find district level data for programme output indicators.

Table A4: district level KI who were interviewed per district and their role/position in relation to RMNCHN+H/A

Information to be collected	Key informant	Role (reason for selection)
Leadership/governance, financing, partnerships, institutionalization and scale-up of interventions	DHO	Manages all district level services
Institutionalization and scale up of interventions,	District Health Environmental officer	In-charge of outreach services
IMCI, iCCM, nutrition	IMCI coordinator	Responsible for IMCI activities
FP, FANC, immunization, nutrition, malaria prevention	MCH coordinator /nurse in-charge PMTCT coordinator	Responsible for FP, ANC, PMTCT, U5 clinic, Out-Patient Therapeutic nutritional programmes
EPI	EPI coordinator	Responsible for EPI at the district
Labour, delivery (BEmONC and CEmONC services), PMTCT	In-charge of labor ward	Oversees and provides BEmONC, CEmONC services and immediate postnatal care and essential newborn care services
Postnatal care, PNC FP, PMTCT, vaccines (BCG and Polio)	In-charge of postnatal ward	Oversees postnatal care
Neonatal care	In-charge of postnatal ward In-charge of Nursery In-charge of KMC	Oversee neonatal care during postnatal period
Management of childhood illnesses and malnutrition (facility based)	In-charge of paediatric ward	Oversees facility in-patient based management of sick children
Pharmaceuticals and equipment	Pharmacy technician	Responsible for management of pharmaceuticals and equipment at district level
Information	HMIS officer	Responsible for management of information at district level
Challenges	2 HSA's, 1 MCH and 1 iCCM	Responsible for direct provision of outreach services

Abbreviations: ANC: Antenatal Care; BEmONC: Basic Emergency Obstetric Care; CEmONC: Comprehensive Emergency Obstetric Care; DHO: District Health Officer; EPI: Extended Programme on Immunisation; FP: Family Planning; IMCI: Integrated Management of Childhood Illness; iCCM: Integrated Community Case Management; KMC: Kangaroo Mother Care; MCH: Maternal and Child Health; PMTCT: Prevention of Mother to Child Transmission [of HIV]

Appendix Part 5: Mortality results by district, region and mother education, and urban and rural

Figure A1 shows the U5MRs by district for periods around 2000 (1999-2001) and around 2010 (2009-2011). Stand-out districts in terms of NMR decline (a 30% decline or more) are Dowa, Lilongwe, Dedza, Zomba and Thyolo; stand-out districts in terms of decline in 59q1 (a 60% decline or more) are Chitipa, Rumphi, Mzimba, Ntchisi, Chiradzulu and Phalombe (Table A5). There is no overlap between the two lists of stand-out districts. Although calculated by pooling data from all available surveys, these estimates have large sampling errors (Table A5). The relative magnitude of sampling errors can be expressed as the coefficient of variation (C of V), the standard error divided by the estimate. For district-level U5MR, the C of V's tend to be greater than 0·10, indeed all for 2009-11 are greater than 0·10 (a floor level for safe interpretation of a statistic[1]). We must therefore not be overly confident of any one estimate, although strong patterns across districts are still informative.

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Figure A1: Under-five mortality rates around 2000 and around 2010 for districts in the North, Central and South regions of Malawi

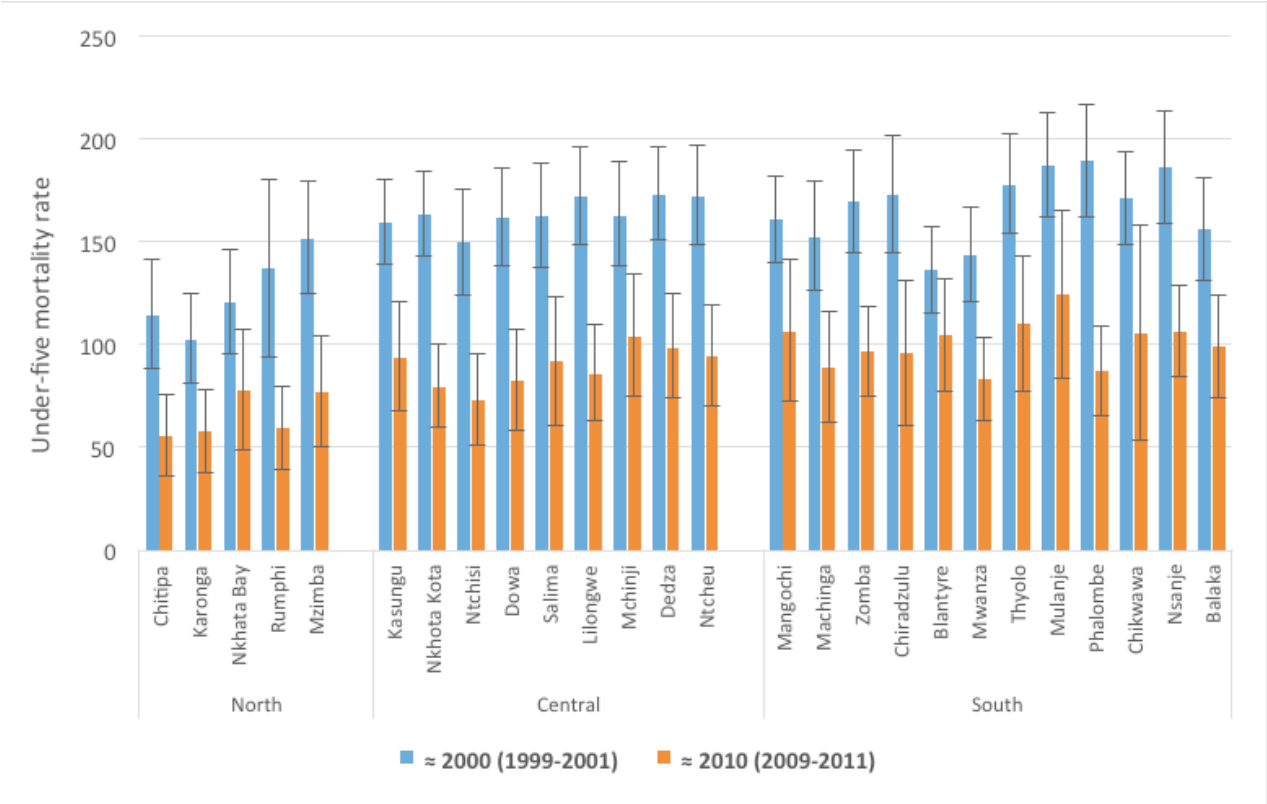


Table A5: District Estimates of Mortality

District	Period		Probabilities of Dying from Pooled Data Sets					
			NNMR	PNMR	IMR	4q1	U5MR	59q1
Northern Region								
Chitipa	1999-01	Mortality	0.031215	0.033307	0.064521	0.053365	0.114443	0.08591
		Std Error	0.006023	0.007364	0.009507	0.009733	0.013239	
	2005-07	Mortality	0.028263	0.013116	0.041378	0.015409	0.056149	0.028698
		Std Error	0.005742	0.00432	0.007331	0.003552	0.007692	
	2009-11	Mortality	0.027456	0.023266	0.050722	0.005232	0.055689	0.02903
		Std Error	0.007277	0.006939	0.008989	0.002366	0.009835	

District	Period		Probabilities of Dying from Pooled Data Sets					
			NNMR	PNMR	IMR	4q1	U5MR	59q1
Karonga	1999-01	Mortality	0.030137	0.033279	0.063416	0.041867	0.102628	0.074743
		Std Error	0.006023	0.006461	0.008949	0.006489	0.010759	
	2005-07	Mortality	0.020458	0.011257	0.031714	0.021123	0.052167	0.032372
		Std Error	0.004887	0.002911	0.005617	0.004805	0.007231	
	2009-11	Mortality	0.027667	0.019919	0.047586	0.010595	0.057677	0.030864
		Std Error	0.006962	0.005577	0.009986	0.003871	0.009962	
Nkhata Bay	1999-01	Mortality	0.02842	0.055677	0.084097	0.040145	0.120866	0.09515
		Std Error	0.009744	0.00824	0.011514	0.008455	0.012631	
	2005-07	Mortality	0.03058	0.039404	0.069984	0.019422	0.088047	0.05928
		Std Error	0.006694	0.006847	0.009286	0.004567	0.01042	
	2009-11	Mortality	0.035521	0.02322	0.058741	0.020167	0.077724	0.043757
		Std Error	0.009491	0.006056	0.011993	0.005415	0.014548	
Rumphi	1999-01	Mortality	0.024696	0.072492	0.097188	0.044189	0.137083	0.115232
		Std Error	0.007277	0.031805	0.027623	0.009195	0.021547	
	2005-07	Mortality	0.03114	0.01496	0.0461	0.018281	0.063538	0.03344
		Std Error	0.00651	0.003248	0.006593	0.003845	0.00715	
	2009-11	Mortality	0.029726	0.016376	0.046103	0.013772	0.05924	0.030418
		Std Error	0.007643	0.00485	0.008814	0.004921	0.010001	
Mzimba and Mzuzu	1999-01	Mortality	0.058319	0.041048	0.099367	0.05799	0.151595	0.099052
		Std Error	0.009551	0.005594	0.011162	0.00747	0.013569	
	2005-07	Mortality	0.052772	0.02703	0.079802	0.033663	0.110778	0.061238
		Std Error	0.009764	0.006242	0.010952	0.005682	0.013441	
	2009-11	Mortality	0.043294	0.019065	0.062359	0.01576	0.077136	0.035374
		Std Error	0.009263	0.006886	0.012101	0.005093	0.013433	
Central Region								
Kasungu	1999-01	Mortality	0.045134	0.052259	0.097392	0.068753	0.159449	0.119719
		Std Error	0.00636	0.005644	0.00817	0.006527	0.010314	
	2005-07	Mortality	0.039848	0.019398	0.059246	0.036367	0.093459	0.055836
		Std Error	0.00878	0.00381	0.009866	0.00484	0.010335	
	2009-11	Mortality	0.039512	0.025253	0.064766	0.031233	0.093976	0.056704
		Std Error	0.009778	0.005821	0.009972	0.006106	0.013151	
Nkhota Kota	1999-01	Mortality	0.03489	0.065423	0.100314	0.070375	0.163629	0.133392
		Std Error	0.005856	0.007003	0.009329	0.007631	0.010197	
	2005-07	Mortality	0.026142	0.019782	0.045924	0.031056	0.075553	0.050738
		Std Error	0.006314	0.003923	0.007224	0.004775	0.007928	
	2009-11	Mortality	0.024563	0.030763	0.055325	0.025324	0.079249	0.056063
		Std Error	0.006941	0.007319	0.00921	0.0056	0.010042	
Ntchisi	1999-01	Mortality	0.029102	0.051164	0.080266	0.075365	0.149582	0.124091
		Std Error	0.006531	0.00836	0.010255	0.008496	0.012851	
	2005-07	Mortality	0.029082	0.025402	0.054484	0.027897	0.080861	0.05333
		Std Error	0.006438	0.005067	0.008722	0.005175	0.010109	
	2009-11	Mortality	0.027961	0.022193	0.050154	0.024054	0.073002	0.046336
		Std Error	0.007545	0.006369	0.008893	0.005356	0.01096	
Dowa	1999-01	Mortality	0.038774	0.042464	0.081238	0.087636	0.161754	0.127941
		Std Error	0.006163	0.005986	0.008086	0.00867	0.011776	
	2005-07	Mortality	0.025181	0.02387	0.049052	0.03596	0.083248	0.059567

District	Period		Probabilities of Dying from Pooled Data Sets					
			NNMR	PNMR	IMR	4q1	U5MR	59q1
Dowa	2005-07	Std Error	0.00622	0.004673	0.007485	0.005893	0.009109	
	2009-11	Mortality	0.024067	0.028227	0.052295	0.031615	0.082256	0.059624
		Std Error	0.007659	0.009834	0.011691	0.007388	0.01225	
Salima	1999-01	Mortality	0.03987	0.053814	0.093684	0.075969	0.162536	0.12776
		Std Error	0.006271	0.006732	0.009918	0.008393	0.012661	
	2005-07	Mortality	0.030485	0.034937	0.065422	0.048195	0.110464	0.082494
		Std Error	0.00675	0.007185	0.010145	0.007654	0.013642	
	2009-11	Mortality	0.039362	0.025265	0.064627	0.02894	0.091697	0.054479
		Std Error	0.012532	0.005976	0.014045	0.005645	0.015671	
Lilongwe + City	1999-01	Mortality	0.041961	0.05387	0.095831	0.084645	0.172365	0.136115
		Std Error	0.007934	0.005966	0.009204	0.008555	0.011869	
	2005-07	Mortality	0.032817	0.024444	0.057261	0.04114	0.096045	0.065373
		Std Error	0.006441	0.005009	0.008443	0.005794	0.009032	
	2009-11	Mortality	0.024214	0.034977	0.059191	0.028224	0.085744	0.063057
		Std Error	0.006953	0.007247	0.009519	0.006029	0.011592	
Mchinji	1999-01	Mortality	0.027745	0.049013	0.076758	0.093469	0.163052	0.139169
		Std Error	0.006597	0.007043	0.009023	0.008925	0.01261	
	2005-07	Mortality	0.018943	0.022879	0.041822	0.034308	0.074695	0.056829
		Std Error	0.004976	0.005073	0.007003	0.005175	0.008055	
	2009-11	Mortality	0.034584	0.029536	0.06412	0.042837	0.104211	0.072121
		Std Error	0.009564	0.00605	0.012147	0.008331	0.014761	
Dedza	1999-01	Mortality	0.042573	0.03861	0.081183	0.100271	0.173314	0.136555
		Std Error	0.006104	0.005407	0.007907	0.009195	0.011221	
	2005-07	Mortality	0.02985	0.037841	0.067691	0.038825	0.103887	0.076315
		Std Error	0.006393	0.006093	0.008542	0.006266	0.009221	
	2009-11	Mortality	0.029021	0.025258	0.054279	0.046822	0.098559	0.071617
		Std Error	0.008561	0.006286	0.010335	0.008591	0.0127	
Ntcheu	1999-01	Mortality	0.044037	0.067008	0.111045	0.068909	0.172301	0.134173
		Std Error	0.00655	0.008744	0.010126	0.008234	0.012021	
	2005-07	Mortality	0.022106	0.035132	0.057237	0.034068	0.089356	0.06877
		Std Error	0.005574	0.005871	0.007299	0.00497	0.007974	
	2009-11	Mortality	0.031993	0.02194	0.053932	0.042631	0.094265	0.06433
		Std Error	0.008479	0.007134	0.010933	0.007043	0.012204	
South Region								
Mangochi	1999-01	Mortality	0.038938	0.068334	0.107273	0.060199	0.161014	0.127022
		Std Error	0.005819	0.007498	0.008801	0.007353	0.010413	
	2005-07	Mortality	0.022778	0.038695	0.061473	0.035742	0.095018	0.073924
		Std Error	0.005003	0.007454	0.008305	0.005136	0.010002	
	2009-11	Mortality	0.053509	0.019737	0.073246	0.036036	0.106642	0.056137
		Std Error	0.011891	0.005191	0.014446	0.006629	0.017181	
Machinga	1999-01	Mortality	0.049893	0.052553	0.102445	0.055972	0.152683	0.108188
		Std Error	0.008543	0.006321	0.011315	0.007403	0.013135	
	2005-07	Mortality	0.02534	0.02984	0.05518	0.027028	0.080716	0.056816
		Std Error	0.006107	0.00576	0.007755	0.004517	0.009206	
	2009-11	Mortality	0.03626	0.028869	0.065129	0.025356	0.088834	0.054552
		Std Error	0.009374	0.006104	0.011681	0.005343	0.013359	

District	Period		Probabilities of Dying from Pooled Data Sets					
			NNMR	PNMR	IMR	4q1	U5MR	59q1
Zomba + City	1999-01	Mortality	0.044665	0.066876	0.111541	0.065415	0.16966	0.130839
		Std Error	0.00861	0.006684	0.010754	0.006595	0.012417	
	2005-07	Mortality	0.033439	0.03719	0.070629	0.034318	0.102523	0.071475
		Std Error	0.008386	0.00683	0.008934	0.006141	0.009845	
	2009-11	Mortality	0.025577	0.037351	0.062928	0.036064	0.096723	0.073013
		Std Error	0.006822	0.008599	0.010677	0.006441	0.010724	
Chiradzulu	1999-01	Mortality	0.041027	0.062339	0.103366	0.077428	0.17279	0.1374
		Std Error	0.007276	0.008741	0.010061	0.010957	0.014255	
	2005-07	Mortality	0.032417	0.03416	0.066576	0.039033	0.10301	0.072958
		Std Error	0.006652	0.005578	0.009528	0.00591	0.010441	
	2009-11	Mortality	0.043553	0.028502	0.072054	0.025511	0.095727	0.05455
		Std Error	0.012099	0.009569	0.017913	0.00558	0.017561	
Blantyre + City	1999-01	Mortality	0.039367	0.035873	0.075239	0.06585	0.136135	0.100734
		Std Error	0.006422	0.004939	0.00876	0.006446	0.01039	
	2005-07	Mortality	0.031083	0.038534	0.069617	0.033114	0.100426	0.071568
		Std Error	0.007121	0.007418	0.009998	0.005226	0.011478	
	2009-11	Mortality	0.03979	0.039596	0.079386	0.027233	0.104457	0.067346
		Std Error	0.011451	0.007929	0.012772	0.006526	0.013597	
Mwanza + Neno	1999-01	Mortality	0.04319	0.038757	0.081948	0.067434	0.143855	0.105209
		Std Error	0.006362	0.007799	0.010204	0.00695	0.011339	
	2005-07	Mortality	0.032714	0.032096	0.06481	0.035343	0.097862	0.067351
		Std Error	0.006632	0.004709	0.008472	0.004264	0.009851	
	2009-11	Mortality	0.034489	0.021817	0.056306	0.028448	0.083153	0.050402
		Std Error	0.007011	0.004741	0.008426	0.004671	0.00997	
Thyolo	1999-01	Mortality	0.047682	0.064917	0.1126	0.073492	0.177816	0.13665
		Std Error	0.007238	0.007153	0.009903	0.007932	0.01209	
	2005-07	Mortality	0.035371	0.038119	0.07349	0.02484	0.096505	0.063376
		Std Error	0.00703	0.007024	0.009545	0.004232	0.010021	
	2009-11	Mortality	0.033105	0.036293	0.069397	0.043551	0.109925	0.079451
		Std Error	0.010822	0.010607	0.013716	0.009646	0.016335	
Mulanje	1999-01	Mortality	0.045542	0.064703	0.110245	0.086344	0.18707	0.148281
		Std Error	0.00627	0.007974	0.01083	0.008726	0.012568	
	2005-07	Mortality	0.027466	0.041745	0.069212	0.028503	0.095741	0.070203
		Std Error	0.008275	0.007582	0.010419	0.005266	0.011452	
	2009-11	Mortality	0.044935	0.053361	0.098296	0.028924	0.124377	0.08318
		Std Error	0.014345	0.011145	0.019863	0.007717	0.020363	
Phalombe	1999-01	Mortality	0.046739	0.064518	0.111256	0.088058	0.189517	0.149779
		Std Error	0.007676	0.008648	0.01041	0.01138	0.013632	
	2005-07	Mortality	0.028352	0.043927	0.072279	0.039531	0.108952	0.082952
		Std Error	0.005525	0.0074	0.008852	0.00536	0.011213	
	2009-11	Mortality	0.034103	0.027817	0.06192	0.026708	0.086974	0.054738
		Std Error	0.009374	0.00647	0.010804	0.005179	0.010849	
Chikwawa	1999-01	Mortality	0.050425	0.056043	0.106468	0.072352	0.171117	0.127101
		Std Error	0.008953	0.008377	0.009453	0.008803	0.01115	
	2005-07	Mortality	0.027506	0.032596	0.060102	0.045988	0.103326	0.077964
		Std Error	0.005438	0.006534	0.009052	0.00812	0.01023	

District	Period		Probabilities of Dying from Pooled Data Sets					
			NNMR	**PNMR**	**IMR**	**4q1**	**U5MR**	**59q1**
	2009-11	Mortality	0.044698	0.04353	0.088227	0.019189	0.105724	0.063881
		Std Error	0.01561	0.013955	0.027361	0.004754	0.026136	
Nsanje	1999-01	Mortality	0.045375	0.06304	0.108416	0.087313	0.186262	0.147583
		Std Error	0.008804	0.008017	0.010208	0.009695	0.013625	
	2005-07	Mortality	0.03187	0.034865	0.066736	0.042091	0.106018	0.076588
		Std Error	0.006086	0.005675	0.009179	0.006071	0.010851	
	2009-11	Mortality	0.048106	0.029857	0.077963	0.030476	0.106063	0.060886
		Std Error	0.008813	0.006257	0.009445	0.006099	0.010934	
Balaka	1999-01	Mortality	0.040337	0.050715	0.091051	0.071516	0.156056	0.120583
		Std Error	0.006676	0.007291	0.00942	0.010367	0.01238	
	2005-07	Mortality	0.036548	0.028364	0.064911	0.038329	0.100752	0.06664
		Std Error	0.005827	0.005853	0.007972	0.004915	0.008527	
	2009-11	Mortality	0.042416	0.029108	0.071524	0.029342	0.098767	0.058848
		Std Error	0.010149	0.00681	0.012124	0.005492	0.012403	

NMR: Neonatal Mortality Rate (0-28 days); PNMR: Post-neonatal mortaliy rate (29-364 days)

IMR: Infant Mortality Rate; 4q1: risk of dying between age 1 and age 4; U5MR: Under-5 Mortality Rate

59q1: risk of dying between 1 month and 60 months

Table A6: Urban and Rural estimates of Mortality

Area	1999-2001[1]		2009-2011[2]	
	NMR	U5MR	NMR	U5MR
Urban	0.0135	0.1434	0.0404	0.0838
lower 95%CI	NA	0.083	NA	0.037
upper 95%CI	NA	0.241	NA	0.131
Rural	0.0379	0.1733	0.0368	0.1017
lower 95%CI	NA	0.139	NA	0.068
upper 95%CI	NA	0.210	NA	0.134
Relative Risk: Urban v.s. Rural	0.36	0.83	1.10	0.82
Relative Risk: Rural v.s. Urban	2.81	1.21	0.91	1.21

[1]Estimated from 2004 DHS

[2]Estimated from 2014 MDG Endline survey

NA = Not Available

Table A7: Estimates of Mortality by Mothers Education

Area	1999-2001[1]		2009-2011[2]	
	NMR	U5MR	NMR	U5MR
None	0.0400	0.1762	0.0301	0.0949
lower 95%CI	NA	0.154	NA	0.056
upper 95%CI	NA	0.199	NA	0.141
Primary	0.0437	0.1603	0.0371	0.0952
lower 95%CI	NA	0.145	NA	0.076
upper 95%CI	NA	0.176	NA	0.117
Secondary plus	0.0381	0.1055	0.0346	0.0830
lower 95%CI	NA	0.064	NA	0.044
upper 95%CI	NA	0.153	NA	0.131
Relative Risk: None v.s. Secondary plus	1.05	1.67	0.87	1.14
Relative Risk: Secondary plus v.s. None	0.95	0.60	1.15	0.87

[1]Estimated from 2004 DHS

[2]Estimated from 2014 MDG Endline survey

NA = Not Available

Table A8: Regional Mortality Estimates by Mother's Education

			Derived from Pooled Data Set		
Region	**Period**	**Ed Cat**	**NMR**	**IMR**	**U5MR**
North	1999-01	All	0.0432	0.0874	0.1354
		None	0.0583	0.1118	0.1627
		Primary	0.0443	0.0893	0.1396
		Secondary	0.0257	0.0584	0.0873
	2009-11	All	0.0370	0.0567	0.0696
		None	0.0670	0.0311	0.0325
		Primary	0.0414	0.0609	0.0758
		Secondary	0.0293	0.0487	0.0674
Central	1999-01	All	0.0402	0.0915	0.1660
		None	0.0364	0.0958	0.1864
		Primary	0.0415	0.0909	0.1612
		Secondary	0.0434	0.0779	0.1087
	2009-11	All	0.0296	0.0581	0.0888
		None	0.0191	0.0460	0.0831
		Primary	0.0323	0.0595	0.0919
		Secondary	0.0272	0.0634	0.0792
South	1999-01	All	0.0441	0.1014	0.1623
		None	0.0425	0.1011	0.1643
		Primary	0.0457	0.1053	0.1670
		Secondary	0.0386	0.0729	0.1108
	2009-11	All	0.0403	0.0737	0.1016
		None	0.0411	0.0719	0.1049
		Primary	0.0395	0.0733	0.1029
		Secondary	0.0430	0.0773	0.0901
Malawi	1999-01	All	0.0422	0.0957	0.1611
		None	0.0400	0.0988	0.1762
		Primary	0.0437	0.0972	0.1603
		Secondary	0.0381	0.0722	0.1055
	2009-11	All	0.0357	0.0659	0.0934
		None	0.0301	0.0604	0.0949
		Primary	0.0371	0.0667	0.0952
		Secondary	0.0346	0.0678	0.0830

NMR: Neonatal Mortality Rate
IMR: Infant Mortality Rate; U5MR: Under-5 Mortality Rate

Appendix Part 6: National coverage results and 95%CI

Intervention	2000 (%)	2004 (%)	2006 (%)	2010 (%)	2014 (%)	2000 95% CI (LL, UL)	2014 95% CI (LL, UL)
Antenatal care (1+)	91.38	93.04	92.53	96.69	97.79	90.1, 92.5	97.2, 98.2
Antenatal care (4+)	54.27	54.19	51.7	43.16	45.63	52.0, 56.5	44.0, 47.3
Breastfeeding - Early Initiation	71.35	68.63	59.18	96.05	74.46	69.9, 72.7	72.8, 76.1
Breastfeeding - Exclusive	44.05	52.8	56.81	71.43	70.34	40.8, 47.3	66.6, 73.8
C-section	2.74	3.26	N/A	4.95	5.34	N/A	N/A
Careseeking for pneumonia	26.68	36.49	16.69	66.46	61.59	24.6, 28.9	59.2, 63.9
Child slept under an ITN	N/A	15.16	24.68	40.9	65.24	N/A	63.9, 66.6
Contraceptive prevalence rate	26.12	28.15	40.54	42.24	60.84	N/A	N/A
Demand for FP satisfied	43.31	45.59	N/A	58.45	75.21	41.2, 45.4	73.9, 76.5
Facility delivery	53.31	55.7	54.25	77.69	89.91	50.7, 55.9	88.7, 91.0
Hygienic disposal of children's stools	71.98	N/A	78.39	N/A	87.63	N/A	N/A
Improved sanitation - HH	49.18	51.18	52.46	50.51	59.03	N/A	N/A
Improved sanitation - Individual	83.4	85.5	87.68	89.58	94.88	82.1, 84.6	94.3, 95.4
Improved water - HH	66.24	66.14	76.05	81.68	87.26	N/A	N/A
Improved water - Individual	66.54	65.02	75.32	81.4	87.01	63.7, 69.3	85.5, 88.4
IPTp	28.35	42.93	46.72	53.83	58.5	26.9, 29.8	56.8, 60.2
Iron folate supplementation	10.49	16.8	19.51	33.8	N/A	N/A	N/A
ITN	5.46	27.41	37.85	56.84	77.69	N/A	N/A
ITN/IRS	5.46	27.41	37.85	57.79	79.54	4.9, 6.1	78.7, 80.3
Neonatal tetanus protection	57	64.25	71.9	66.56	62.46	55.0, 59.0	60.7, 64.2
ORS	47.86	61.12	51.42	68.98	63.58	45.2, 50.6	61.7, 65.5
ORT	51.44	54.05	24.82	47.58	48.54	N/A	N/A
Postnatal care - Babies	N/A	N/A	55.37	78.44	N/A	N/A	N/A
Postnatal care - Mothers	55.03	59.92	56.28	79.49	N/A	52.5, 57.5	N/A
Skilled birth attendance (SBA)	53.64	55.34	53.93	77.29	88.81	51.2, 56.1	87.6, 89.9
Stunting	54.29	52.19	52.65	47.05	42.4	N/A	N/A
Treatment of diarrhea - Antibiotics	N/A	N/A	N/A	19.15	N/A	N/A	N/A
Treatment of diarrhea - Zinc	N/A	N/A	N/A	0.17	27.7	N/A	N/A
Treatment of malaria - ACT	0	0	0.14	24.68	31.28	N/A	N/A
Treatment of malaria - Any antimalarials	22.36	22.74	21.15	29.31	33.74	N/A	N/A
Treatment of malaria - First line	19.36	18.67	17.38	24.68	31.28	17.7, 21.1	29.5, 33.2
Underweight	20.46	17.29	15.48	12.73	16.31	N/A	N/A
Vaccine - DPT	84.46	82.31	86.38	93.23	92.72	82.2, 86.5	91.4, 93.9
Vaccine - Hib	0	82.31	86.38	93.23	92.72	0, 0	91.4, 93.9
Vaccine - Measles	83.36	79.29	84.36	92.99	92.18	81.5, 85.1	90.8, 93.4
Vitamin A supplementation	71.71	66.19	75.25	86.23	N/A	70.2, 73.2	N/A
Wasting	6.75	6.1	4.33	4.12	3.8	N/A	N/A
Water connection - HH	7.14	6.23	4.98	6.64	7.46	N/A	N/A

Appendix Part 7 Examples of district differences in intervention coverage

Figures A2-A9 provide illustrations of the extent of district differences in intervention coverage using eight of the interventions found to be most important in the Lives Saved Tool (LiST) analysis as examples. Each figure contains all available data points for each district since 2000, with the backdrop for each district being the national-level coverage for that indicator.

Figure A2: Trends in coverage of facility delivery by district in Malawi, 2000-2014. Mean coverage (%) based on available data from the 2000, 2004, 2010 DHS, 2006 MICS and 2014 MDG Endline Survey.

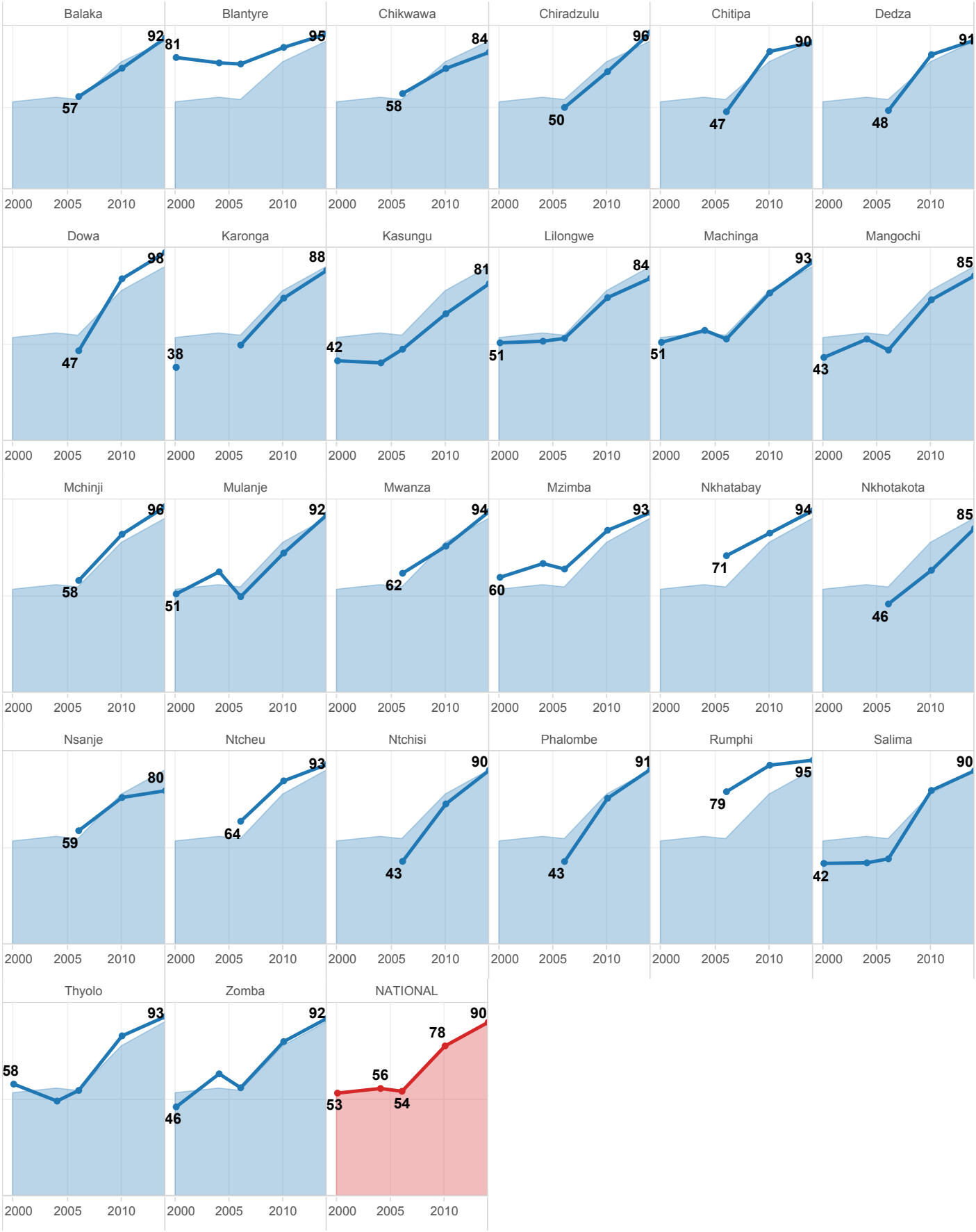
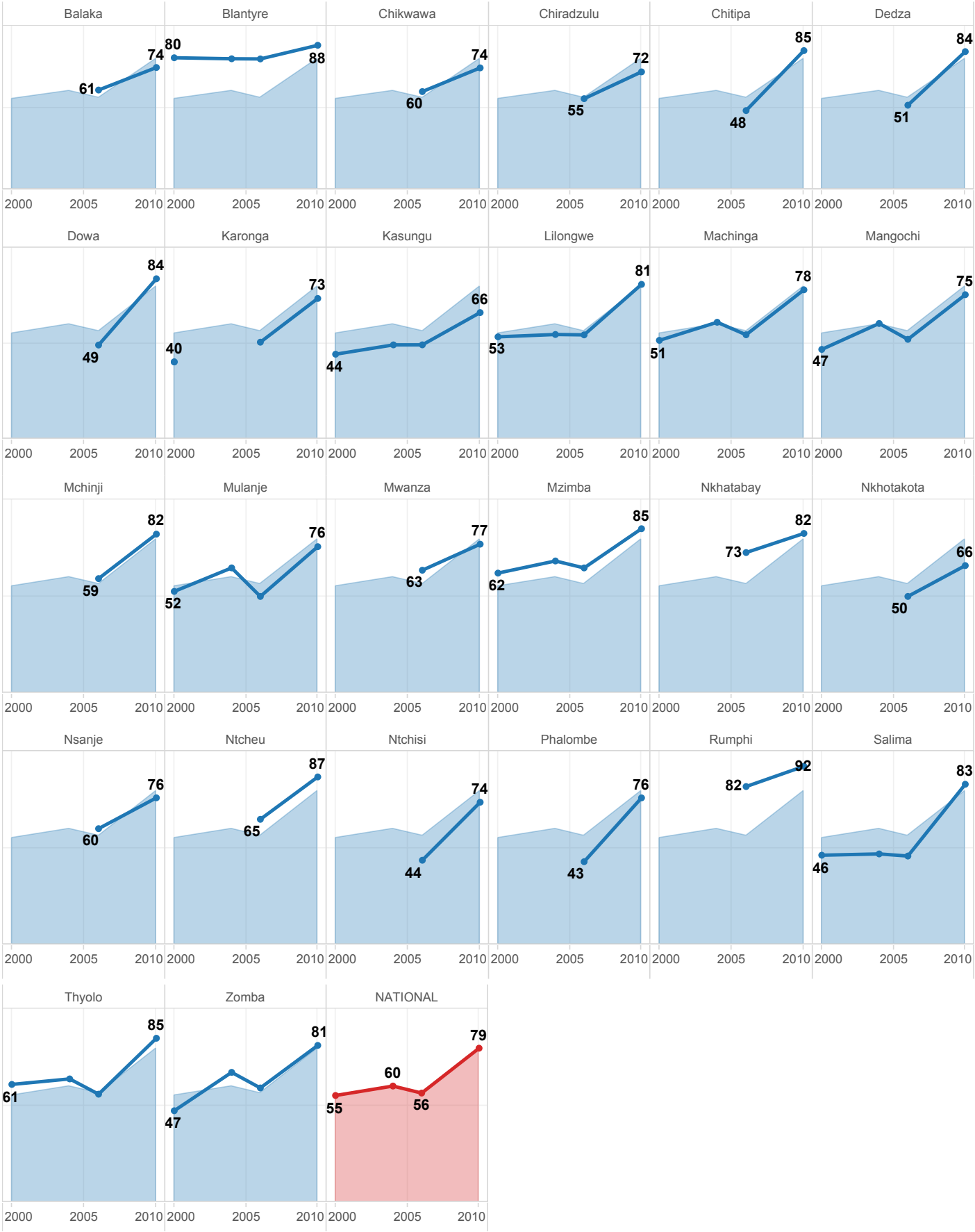


Figure A3: Trends in coverage of postnatal visit for mothers by district in Malawi, 2000-2010. Mean coverage (%) based on available data from the 2000, 2004, 2010 DHS and 2006 MICS.



Note: Data were not available in the 2014 survey to calculate this indicator in a manner that was consistent with the definition used to calculate previous estimates.

Figure A4: Trends in coverage of exclusive breastfeeding by district in Malawi, 2000-2014. Mean coverage (%) based on available data from the 2000, 2004, 2010 DHS, 2006 MICS and 2014 MDG Endline Survey.

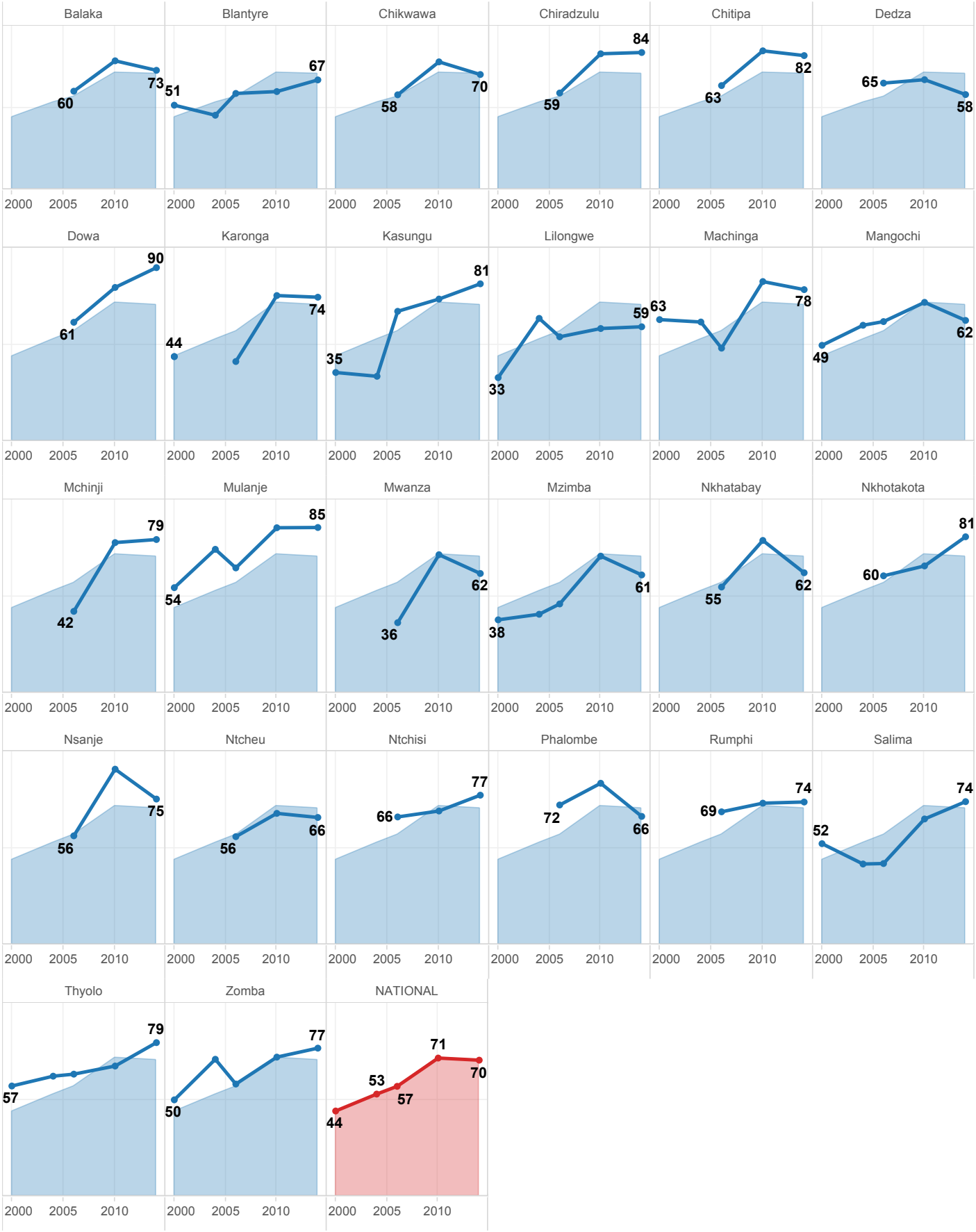


Figure A5: Trends in coverage of households with ITN/IRS by district in Malawi, 2000-2014. Mean coverage (%) based on available data from the 2000, 2004, 2010 DHS, 2006 MICS and 2014 MDG Endline Survey.

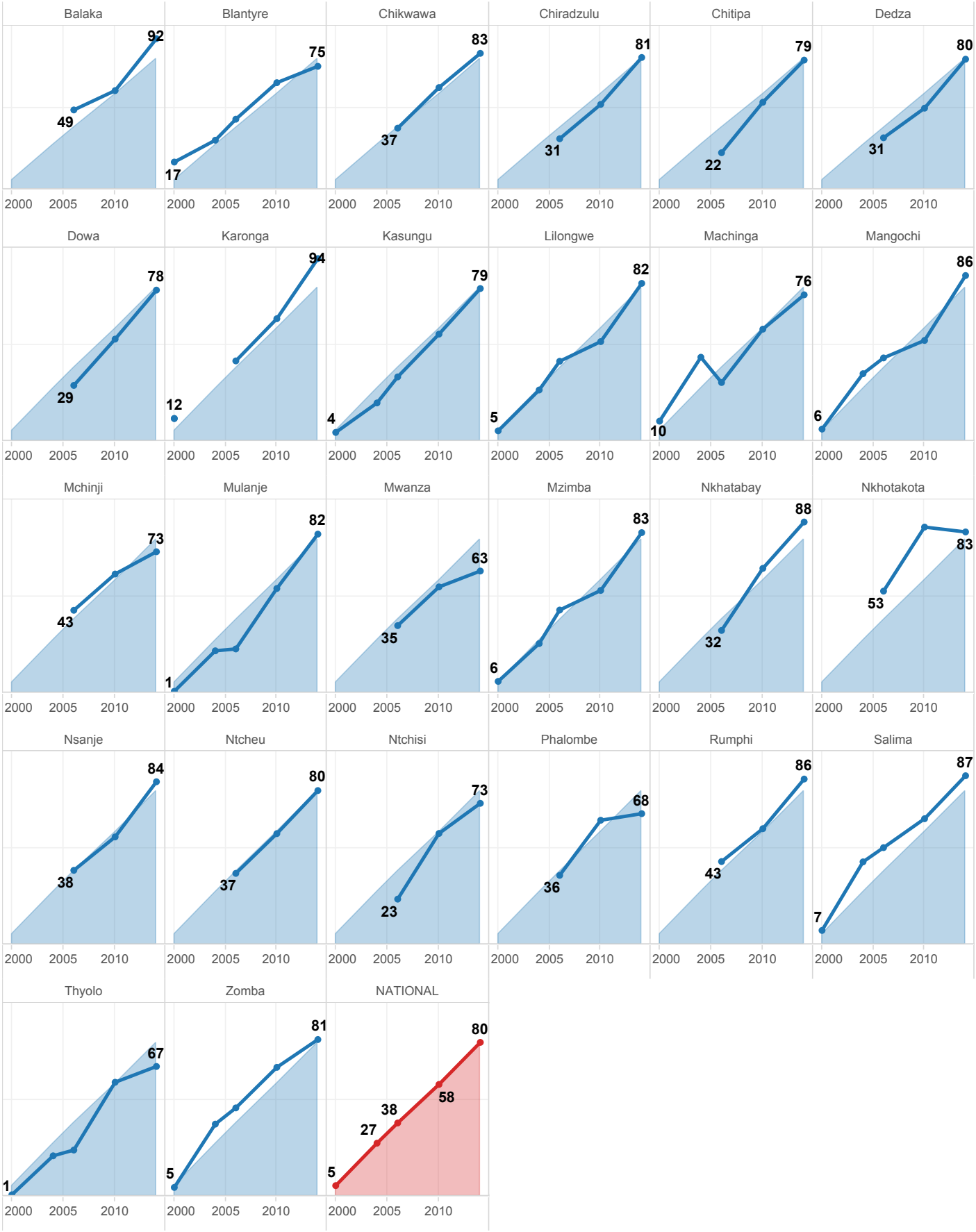


Figure A6: Trends in coverage of Hib3 vaccination by district in Malawi, 2004-2014. Mean coverage (%) based on available data from the 2004, 2010 DHS, 2006 MICS and 2014 MDG Endline Survey.

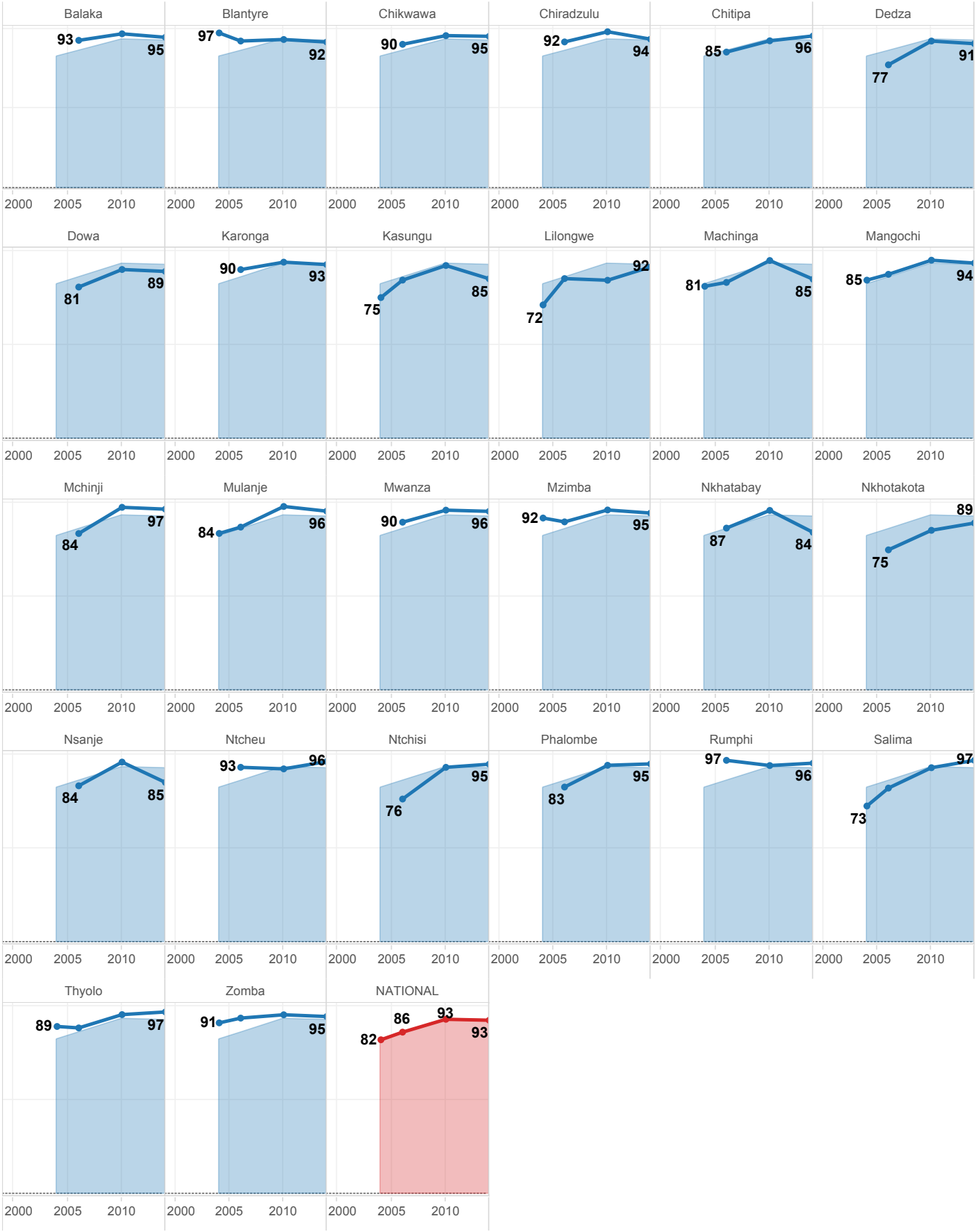


Figure A7: Trends in coverage of careseeking for pneumonia by district in Malawi, 2000-2014. Mean coverage (%) based on available data from the 2000, 2004, 2010 DHS, 2006 MICS and 2014 MDG Endline Survey.

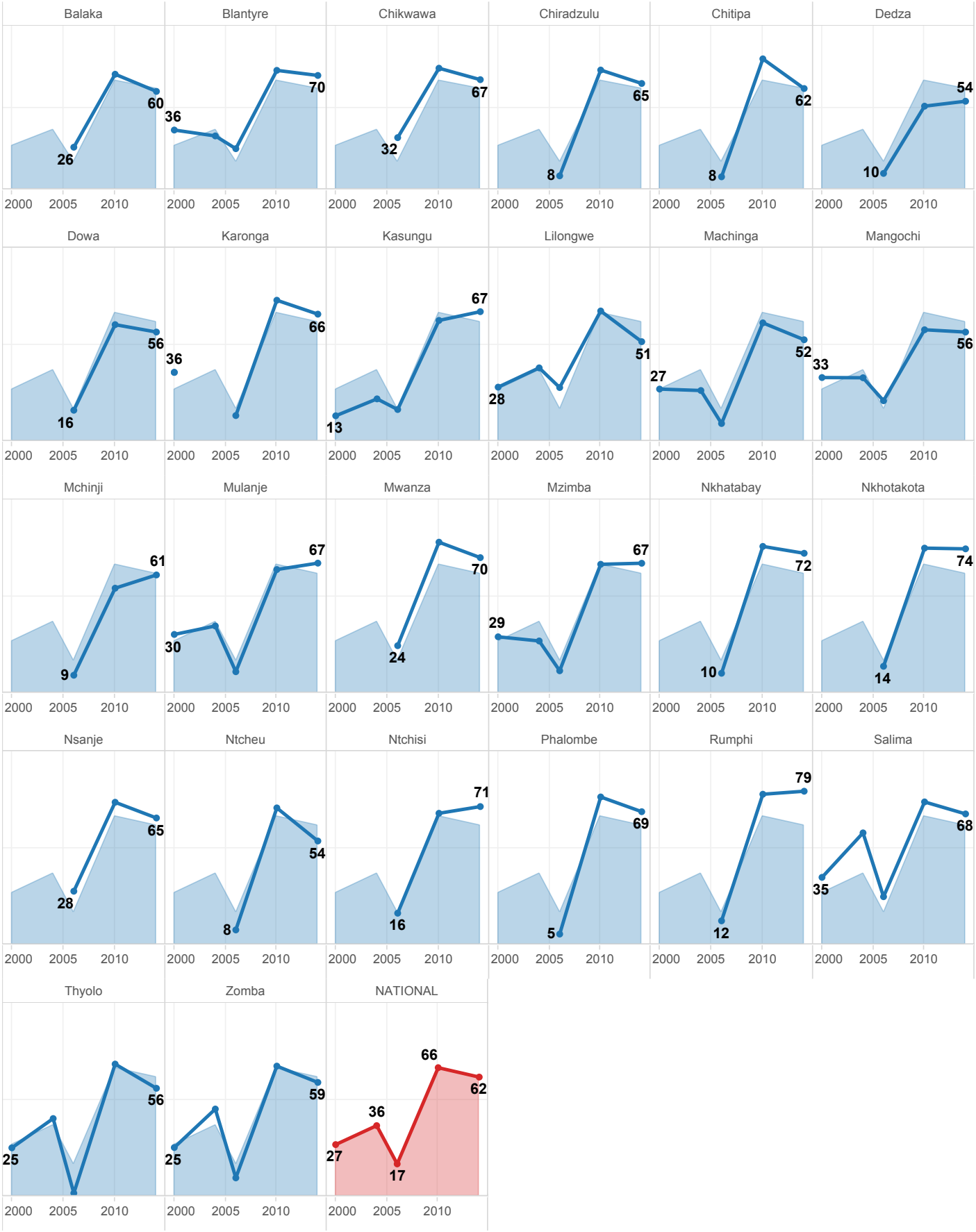


Figure A8: Trends in coverage of malaria treatment of children by district in Malawi, 2000-2014. Mean coverage (%) based on available data from the 2000, 2004, 2010 DHS, 2006 MICS and 2014 MDG Endline Survey.

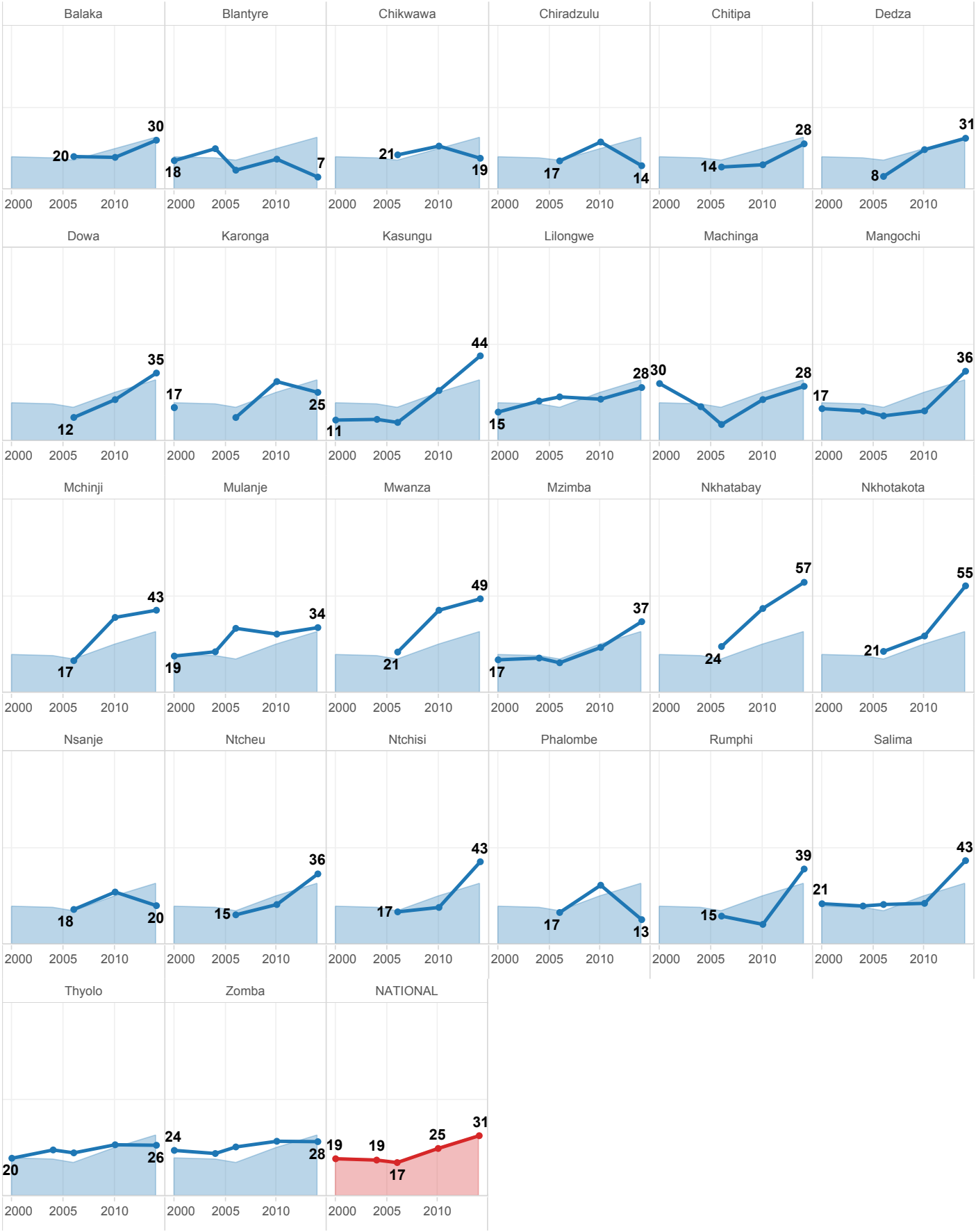
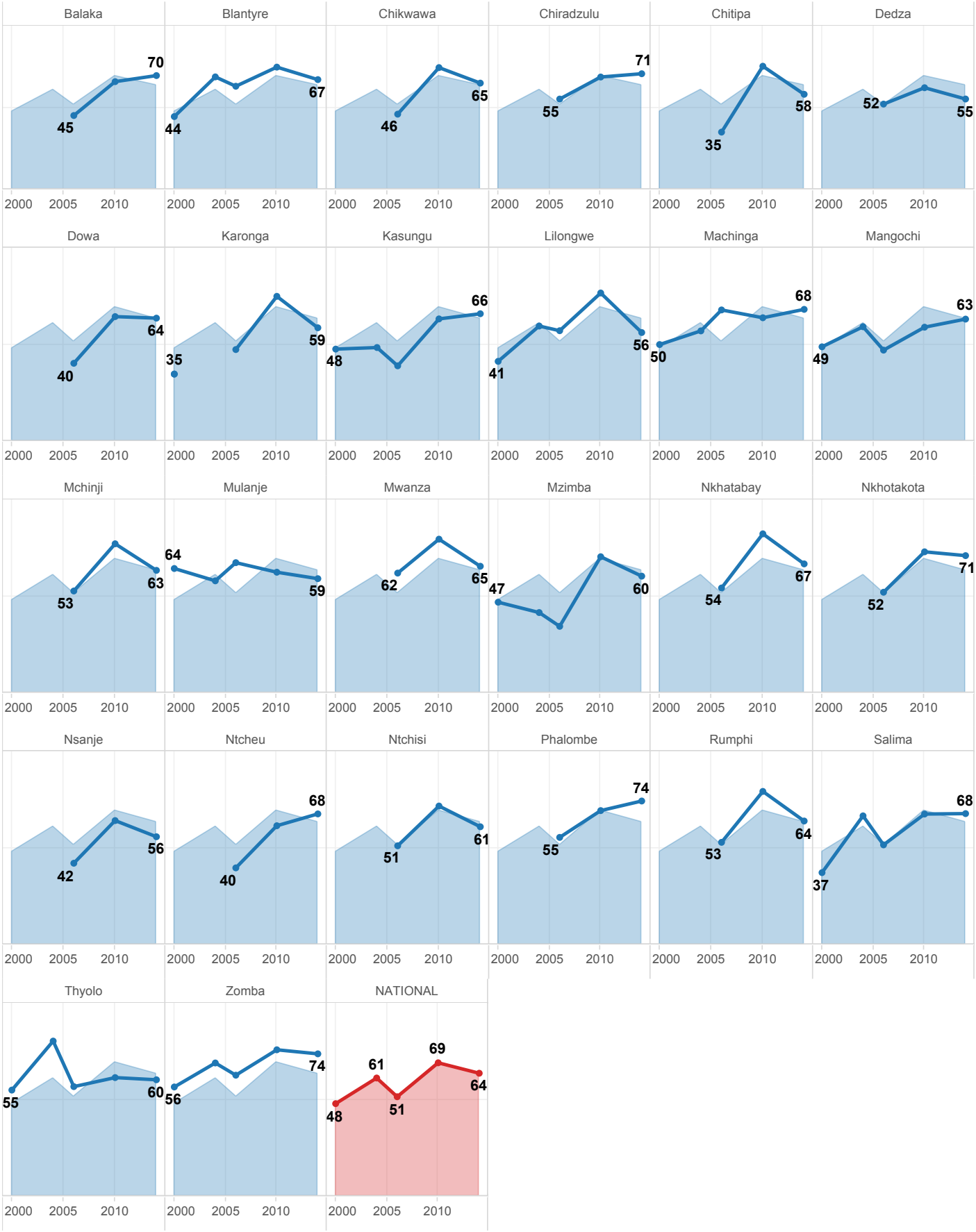


Figure A9: Trends in coverage of diarrhoea treatment with ORS by district in Malawi, 2000-2014. Mean coverage (%) based on available data from the 2000, 2004, 2010 DHS, 2006 MICS and 2014 MDG Endline Survey.



Panel 1

Trends in Undernutrition:

A Key Success Factor for MDG-4

Malawi has long been known for its high prevalence of children who were stunted, underweight or suffering from wasting. Nutrition actions took off in a more concerted way after Malawi experienced a severe drought in 2001. Rates of severe acute malnutrition were so high that international NGOs, in collaboration with local experts, started pioneering the implementation of community based treatment of severe acute malnutrition, initially using imported ready-to-use therapeutic foods (RUTF). By 2004, local production of RUTF had commenced, facilitating the expansion of community management of acute malnutrition (CMAM) to all districts by 2009, and to 95% of all health facilities by 2014 (Figure 6).

Changes in undernutrition among Malawi's under-five children, 2000-2013

Prevalence in children < 5 years	2000	2013	Change (percentage points)
Stunting	54.3	42.2	↓ 11.1
Underweight	20.5	16.7	↓ 3.8
Wasting	6.8	3.8	↓ 3.0

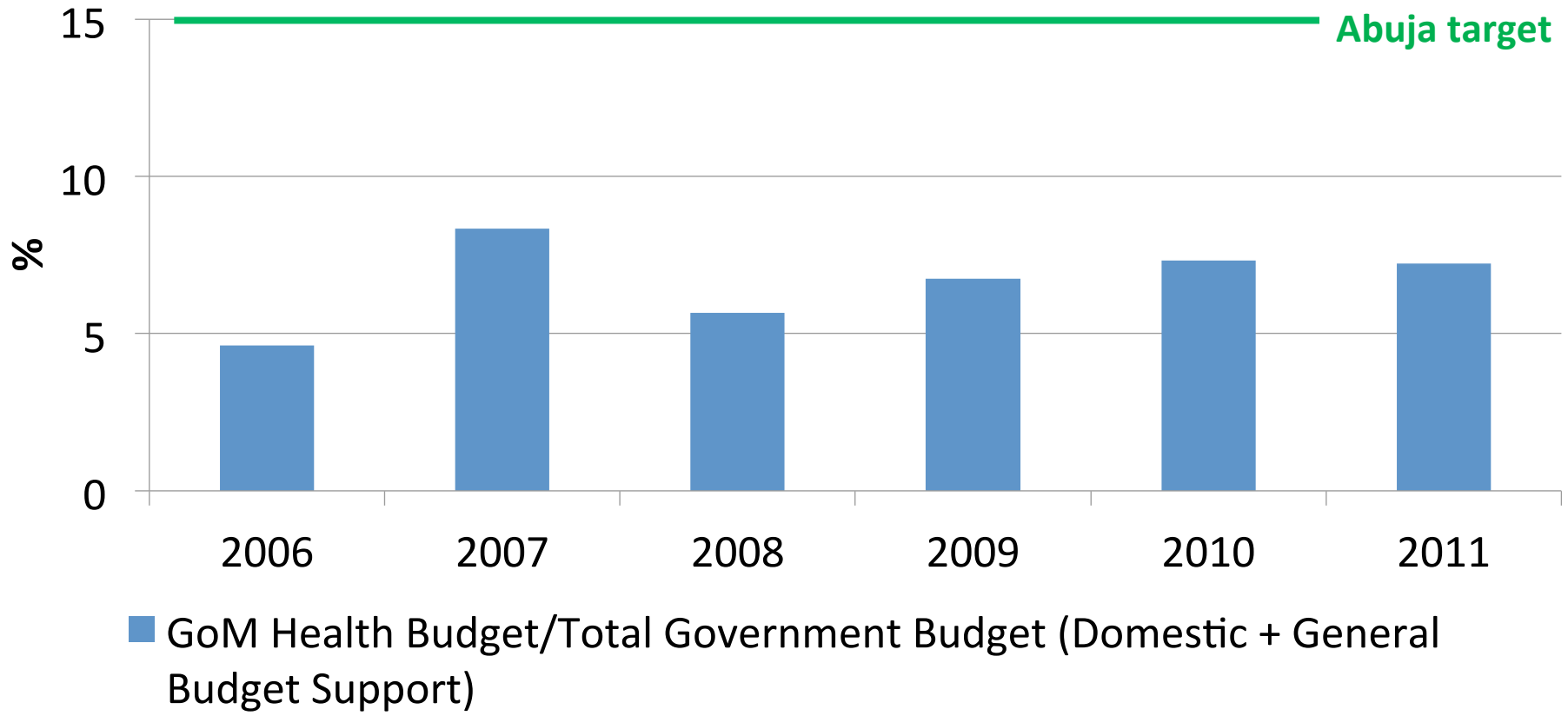
Sources: 2000 DHS, 2013/14 MDGE

In 2004, the Department of Nutrition, HIV and AIDS was established in the Office of the President with the mandate to oversee multi-sectoral nutrition actions. Strong implementation of the Baby-friendly Hospital Initiative (BFHI) since 2007 was complemented by Vitamin A supplementation and deworming during twice yearly child health days since 2005. In 2010, inpatient treatment of children with complicated severe acute malnutrition in health facilities was strengthened, and supplementation of children with moderate acute malnutrition was rolled out. The scale up of PMTCT in maternity facilities was complemented by efforts to strengthen the BFHI in maternity facilities. Community-based nutrition interventions in the mid-2000s followed the USAID-supported "essential nutrition actions" strategy. In 2011, the global SUN (Scaling Up Nutrition) initiative gave a major impetus to a new unified nutrition communications strategy, *SUN 1000 Special Days*. This promotes nutrition during pregnancy and infant and young child feeding through the establishment of community volunteers organized into Care Groups for training and supervision. National scale-up of this strategy is on-going.

In spite of droughts in 2005 and 2008, Malawi has made steady progress in addressing child undernutrition as indicated by the significant reductions in stunting, underweight and wasting between 2000 and 2013 shown in the inset figure. Reductions in the prevalence of stunting and wasting accounted for 19.6% of under 5 lives saved at national level during the period (Figure 4A).

Strong political commitment, fertilizer subsidies instituted in 2005 that led to greater food security in the country, and effective nutrition interventions, including those delivered through integration with PMTCT and IMCI, have led to increases in essential interventions to prevent and treat undernutrition in childhood. Malawi has demonstrated the power of community actions to combat severe acute malnutrition, thereby making a major contribution to the formulation of global policy.

Appendix Part 8: Government of Malawi Health Budget as a proportion of Total Government Budget



Panel 2

The path to success: Major MNCH-related policies, programmes and interventions implemented in Malawi, 2000 - 2014

This panel provides an overview of the major policy and programme inputs targeting child survival and MDG-4 in Malawi in the period 2000 to 2014. A timeline showing the major policy and programme inputs is available in Figure 6.

Broad health sector policies focusing on women and children

In 2004, the Government and partners introduced the "Joint Programme of Work" that defined a national essential health package, and accompanying Sector Wide Approach (SWAp). These initiatives provided basket funds for districts and enabled delivery of the essential package, enabled health system constraints to be addressed in ways that would almost certainly not have been possible under earlier vertical approaches. The SWAp provided a boost to district level management, both in terms of additional financing and increased autonomy at the district level to manage resources.

These commitments were accompanied by a six-year emergency human resources plan (EHRP), contributing to a 53% increase in professional health care workers, from 5,453 in 2004 to 8,369 in 2010.[1] The Ministry of Health also intensified the Public Private Partnership (PPP) with the Christian Health Association of Malawi (CHAM) which was, and continues to be, responsible for close to 40% of health service delivery in the country. Through service level agreements (SLAs), CHAM facilities were enabled to provide free MNCH services, increasing accessibility and utilization among poor and rural populations. Establishment of the Central Medical Stores Trust and improvements in the Health Management Information System were also part of efforts to bolster health service provision, in particular at district level. However, bottlenecks associated with the economic hardship and withholding of donor funds for the health sector in the early years of the current decade have shown the fragility of what was achieved.[2]

The timeline shows that beginning in 2005, there was a major focus on women and children in Malawi's national health sector strategies, complemented by specific acceleration plans. The *Road Map for Accelerating the Reduction of Maternal and Neonatal Mortality and Morbidity in Malawi* was adopted in 2005, and revised in 2011 to incorporate new evidence and interventions. In 2008, Malawi's *Accelerated Child Survival and Development (ACSD) strategy 2008–2012* provided a major impetus for accelerated programme implementation. The strategy highlighted 15 high-impact interventions, and facilitated their scale up at all levels of health service delivery. Particularly important was the re-definition of the functions of Health Surveillance Assistants (HSAs), who are community-based workers charged with providing preventive and limited curative services to catchment areas of about 1,000 population. The number of HSAs in service was doubled to 10,534 between August 2007 and December 2009, and they became engaged in provision of home-based newborn care and integrated community case management (iCCM) of childhood illness.

Technical policies and programs for high-impact interventions

During the case study period, essential child health programmes were continuously updated to include state-of-the-art, evidence-based interventions. Malawi has implemented a robust immunisation programme continuously since before 2000, using a range of delivery channels including the community-based Health Surveillance Assistants (HSAs) and community outreach. The country achieved universal childhood immunisation (UCI) coverage in 2004, with over 80% coverage for all antigens. The government was among the first in Africa[3] to introduce *Haemophilus influenzae* type B (Hib) vaccine against pneumonia as part of the pentavalent vaccine in 2002, and added pneumococcal vaccine in late 2011, also being one of the first in Africa to do so[4], with rapid attainment of high coverage levels for both (Figure 3). In 2012, the government introduced rotavirus vaccine to combat the incidence and severity of diarrhoeal disease.

Malaria is endemic throughout Malawi, and was the single greatest cause of death among children under five in 2000.[5] Malawi adopted recommended strategies for treatment and prevention of childhood malaria promptly. For example, in 2007, the MoH changed the first line of treatment to Artemisinin Combination Therapy (LA), a policy that was immediately integrated into the Integrated Management of Childhood Illness (IMCI) and integrated community case management of childhood illness (iCCM) guidelines. In 2012, an important strategic shift was made towards universal mass campaigns and distribution of long-lasting insecticide-treated mosquito nets (LLINs) every three years, followed by targeted distribution of LLINs to pregnant women and under-five children in the interval. Given geographic variations in intensity of transmission, since 2012 the programme has also implemented indoor residual spraying (IRS), targeting seven districts bordering Lake Malawi. As a consequence of intensive control effort, the national parasite prevalence rate has declined from 43% in 2010 to 28% in 2012.[6]

Oxygen concentrators were introduced into district and central hospitals between 2002 and 2004 as part of the Child Lung Health Programme (CLHP)[7] and a 2007 evaluation found most to still be working,[8] though the extent of their use and impact on pneumonia mortality is not clear.[9] From 2013, following successful piloting[10], Continuous Positive Airway Pressure (CPAP) to manage very severe respiratory cases is being rolled-out to hospitals across the country.

Addressing major risk factors – nutrition and HIV

Combating HIV and addressing undernutrition are essential for sustaining and enhancing child health and development. Undernutrition is a major cause of child mortality globally, contributing to up to 45% of child deaths.[11] Panel 1 focuses on nutrition challenges and the actions taken in Malawi that have contributed to the achievement of MDG4.

Malawi has also faced a major HIV epidemic during this period. The adult HIV prevalence rose to around 18% in 2000 and has since dropped to around 10% in 2013.[12] Services to prevent mother-to-child transmission have been available free since 2004, but rapid scale-up began only in 2007 and in 2011 were further upgrade to include Option B+ to provide life-long treatment for pregnant women. By 2010, 35% of pregnant women were receiving antiretrovirals, and this increased rapidly to 76% in 2013 with the successful roll-out of the Option B+ programme.[13]

Service integration, access and quality

The aim of the Malawi government was to provide high-quality, integrated child health services across all levels of the health system, including the community. In 1998, the MoH in Malawi was among a very few “early adopters” of the IMCI strategy, integrating their existing programmes for acute respiratory infections (ARI) and control of diarrheal diseases (CDD). A national IMCI Unit was established, and mandated to ensure that all children suffering from common illnesses are managed holistically through out-patient and in-patient services at health facilities and at home. The Government adopted a formal policy supporting IMCI in 2007, and since that time the strategy has been expanded to all districts and primary health facilities. In 2010, responding to a health facility survey showing weaknesses in the quality of IMCI care, the IMCI unit introduced a computerized IMCI training tool. By 2014, IMCI was integrated in the pre-service curricula of all training schools for medical personnel in Malawi.

An important addition was the adoption of the iCCM approach in 2008. By 2009, government and partners were supporting the implementation of iCCM in all districts in the country. HSAs were trained in iCCM and strategically deployed to areas defined by District Health Management Teams as “hard to reach” (i.e., where access to health services was restricted by distance and other geographical barriers). The HSAs are based in village clinics where they are responsible for managing uncomplicated cases of malaria, pneumonia, diarrhoea, malnutrition and red eye, and for referring severe cases to higher-level health facilities. By 2013, a total of 3,746 HSAs were trained and deployed to provide iCCM services, achieving coverage of 94% of the total 4,000 hard-to-reach areas identified nationwide. Assessment

and timely referral of small and sick newborns has been incorporated in the protocol, but as of mid-2015 has not been fully rolled out. An independent evaluation of the iCCM scale-up is in progress.

Quality of care in rural and district hospitals is important, not only to save lives of severely ill and most at risk children but also to set standards for quality of care in the health service as a whole. The MoH has established a Paediatric Hospital Improvement Initiative following the CLHP, which aims at improving management of seriously ill children through Emergency Triage Assessment and Treatment (ETAT), establishment of well-functioning emergency rooms and areas. There has been a substantial decrease in case fatality due to clinical pneumonia in hospitalized children between 2001 and 2012 in Malawi.[9] Looking ahead, it is expected that all district hospitals will have neonatal units equipped with basic lifesaving equipment in the near future.

Maternal and newborn health

Our analysis indicates newborn mortality accounted for 38% of under-five mortality in Malawi in 2010. Malawi also has a high prevalence of 18% of babies born pre-term.[14] Nevertheless, newborn survival was hardly mentioned in health policies before the year 2000, and attention only intensified after 2005.[15] Official development assistance for maternal, newborn, and child health in Malawi doubled from 2003 to 2008, yet only 6% of this funding mentioned newborn and only 0.1% funding was indicated to be exclusively for newborn health (Figure 5B).[16]

The "Road Map" described above provided a strong foundation for increased attention to newborns. Neonatal content was included in IMCI clinical algorithms in 2007, and revised training materials were finalized in 2010. Also in 2007, the MoH adopted the Community-Based Maternal and Newborn Care (CBMNC) package, with a focus on antenatal and postnatal home visits. Implementation was piloted in six districts between 2008 and 2009, and by 2014 had been scaled up to 25 districts. Evaluation of the experience showed an increase in antenatal attendance and health facility deliveries.[17]

The MoH launched the *Malawi Every Newborn Action Plan* in July 2015. The ENAP aims to contribute to ending preventable maternal and newborn deaths and stillbirths. Plan objectives include improving the quality of care around the time of childbirth, ensuring universal coverage of essential interventions, engaging communities in newborn care, and improving accountability.

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Appendix Part 9 District variation in achieving reductions in under-five mortality: The example of Salima and Machinga districts

We used *LiST* to compare two districts, Machinga and Salima, in terms of how mortality reductions were achieved. We chose these two districts because: (1) both had district level data on coverage from surveys since 2000 (see Tables A9 and A10 below); (2) they are in different regions of the country; and (3) they had widely different levels of HIV prevalence in adults, and (4) they had different patterns of coverage change over time. For each district we created a baseline for the year 2000.

Levels and trends in under-five mortality were similar for the two districts. The under-five mortality rate in 2000 in Machinga was 153 (95% CI: 140, 166); in Salima it was 163 (95% CI: 150, 176). *LiST* applications show that under-five mortality dropped in both districts by just over 50% by 2013, to 76 and 81 in Machinga and Salima, respectively. Survey-based mortality estimates show similar rates of decline between 2000 and 2010, to 89 (76,102) in Machinga, and 92 (76, 108) in Salima.

The interventions accounting for these gains in child survival, however, were very different in the two districts. Table A8 below shows the top five intervention packages accounting for declines in under-five mortality for the two districts, as estimated by *LiST* (see Tables A11- and A12 below for full results). In Machinga, the five top packages had roughly similar impact in terms of lives saved, with the largest percentage being for ITNs (17.5 and the fifth largest was vaccines (11.1). In Salima treatment of childhood illness played a much larger role accounting for over one third of all lives saved during the period. As in Machinga, ITN ownership was also important accounting for almost one quarter of all lives saved during the period.

Table A8 Percent reduction in under-five mortality due to intervention packages

Machinga		***Salima***	
ITNs	17.5%	Treatment of child illness	36.0%
HIV interventions	15.2%	ITNs	24.3%
Treatment of child illness	14.5%	Vaccines	12.6%
Birth Care	14.4%	Birth care	11.6%
Vaccines	11.1%	Wasting	8.2%

We also assessed levels of health system inputs, contextual factors and bottlenecks in the health financing system in the two districts. We found that although both districts had similar levels of *per capita* health expenditure in 2011 (31,100 Kwacha in Machinga and 30,800 Kwacha in Salima), Salima had a higher *per capita* expenditure on health (23,247 Kwacha) than Machinga (11,842 Kwacha) in 2006. In addition, Salima had 47 development partners active in RMNCH-related activities, whereas Machinga had 31. In terms of other health system inputs, Machinga had a lower density of facilities and human resources *per capita* (Machinga 0.38 facilities *per capita* and 9.4 human resources *per capita* compared to 0.61 facilities *per capita* and 12.9 human resources *per capita* in Salima). In addition, Machinga has higher levels of poverty (39.2% of households in extreme poverty) than Salima (16.5%). Key informant interviews revealed that both districts face similar bottlenecks, including delays in funding and the receipt of funds that were lower than budgeted for. It is remarkable that childbirth care accounted for a large proportion of lives saved in Machinga, which had the fewest resources in terms of health workforce and infra-structure. This may speak to the importance of political will, strong advocacy, and community engagement in implementing government policies supporting facility births with a skilled attendant.

Table A9: Machinga district coverage estimates for the Countdown priority indicators

Intervention	2000 (%)	2004 (%)	2006 (%)	2010 (%)	2014 (%)
Antenatal care (1+)	93.04	93.76	95.04	95.47	95.33
Antenatal care (4+)	42.75	60.19	47.38	44.95	51.02
Breastfeeding - Early Initiation	81.07	79.28	54.46	97.88	72.61
Breastfeeding - Exclusive	62.79	61.55	48.03	82.47	78.3
Careseeking for pneumonia	26.87	26.12	9.06	61.11	52.37
Child slept under an ITN	N/A	22.95	14.01	44.72	50.31
Contraceptive prevalence rate	22.56	23.76	37.2	31.12	52.41
C-section	2.31	1.88	N/A	2.51	1.68
Demand for FP satisfied	42.25	43.87	N/A	42.93	66.89
Facility delivery	51.03	57.24	52.75	76.55	92.74
Hygienic disposal of children's stools	82.55	N/A	89.94	N/A	92.93
Improved sanitation - HH	61.29	57.42	66.75	67.34	65.57
Improved sanitation - Individual	86.79	83.45	85.49	91.41	93.84
Improved water - HH	58.36	71.37	69.99	80.27	79.2
Improved water - Individual	58.86	71.36	70.57	80.83	80.71
IPTp	21.6	37.25	34.74	41.38	50.34
Iron folate supplementation	3.68	20.63	4.08	39.92	N/A
ITN	10.28	43.33	30.26	57.61	75.61
ITN/IRS	10.28	43.33	30.26	57.85	75.61
Neonatal tetanus protection	57.15	57.88	76.69	64.9	56.37
ORS	49.9	56.96	67.8	63.75	68.09
ORT	56.87	51.96	17.16	43.5	56.68
Postnatal care - Babies	N/A	N/A	53.41	77.29	N/A
Postnatal care - Mothers	51.49	60.97	54.41	77.94	N/A
Skilled birth attendance (SBA)	50.3	56.83	52.19	74.32	92.2
Stunting	50.43	48.84	62.59	49.53	38.65
Treatment of diarrhea - Antibiotics	N/A	N/A	N/A	44.52	N/A
Treatment of diarrhea - Zinc	N/A	N/A	N/A	1.33	35.25
Treatment of malaria - ACT	0	0	0	21.43	28.29
Treatment of malaria - Any antimalarials	32.72	21.28	11.92	24.77	32.56
Treatment of malaria - First line	29.73	17.75	8.55	21.43	28.29
Underweight	20.74	15.08	18.09	9.86	16.49
Vaccine - DPT	88.45	81.41	83.48	95.16	85.18
Vaccine - Hib	0	81.41	83.48	95.16	85.18
Vaccine - Measles	85.39	73.03	81.94	94.45	91.41
Vitamin A supplementation	83.42	55.04	79.05	80.36	N/A
Wasting	4.78	6.34	2.48	4.24	2.24
Water connection - HH	2.06	0.28	0.76	5.11	4.84

Table A10: Salima district coverage estimates for the Countdown priority indicators

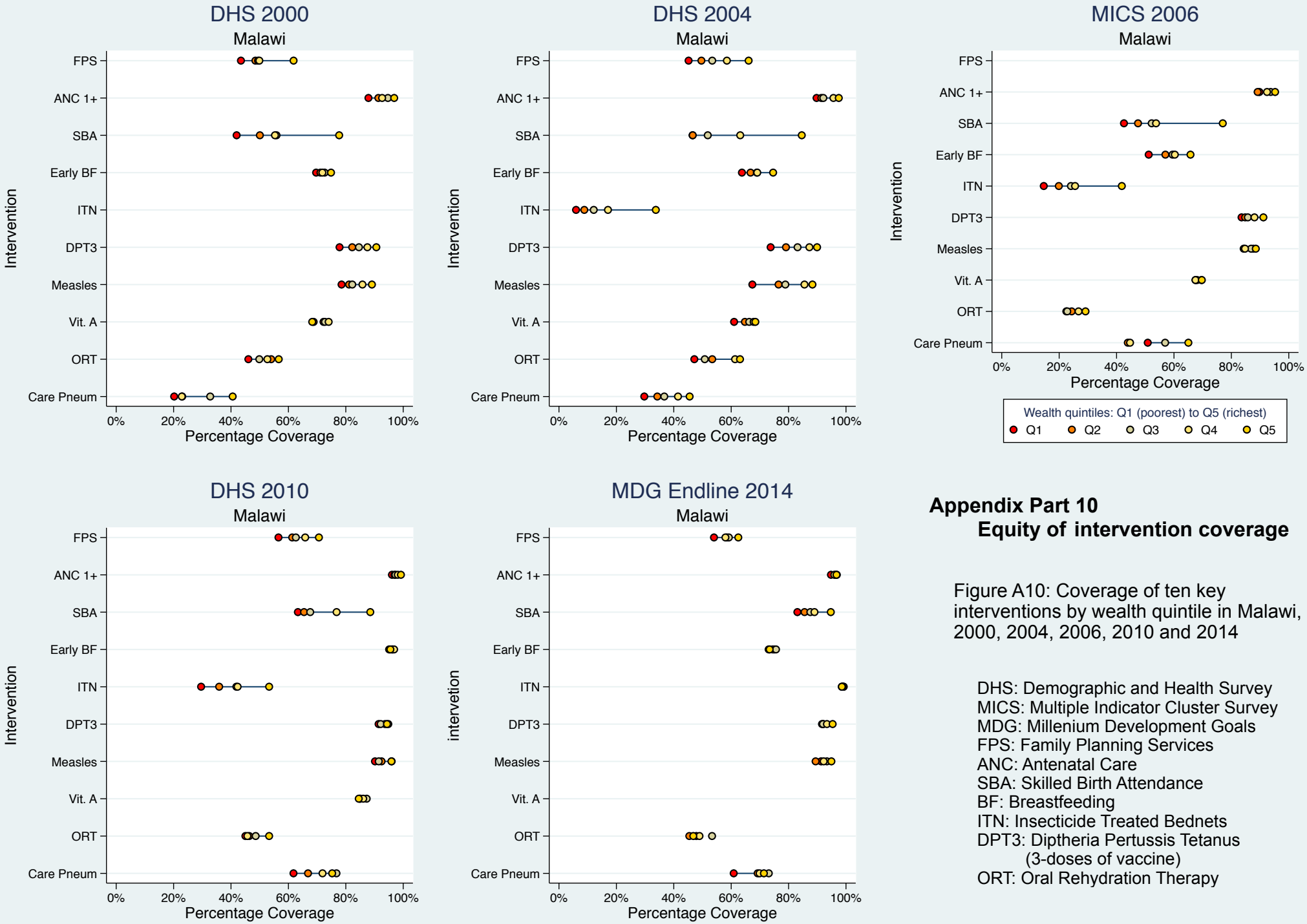
Intervention	2000 (%)	2004 (%)	2006 (%)	2010 (%)	2014 (%)
Antenatal care (1+)	91.7	96.65	94.77	99.65	98.12
Antenatal care (4+)	56.26	53.5	48.62	42.86	38.23
Breastfeeding - Early Initiation	66.97	80.39	69.39	95.87	68.79
Breastfeeding - Exclusive	52.13	41.61	41.85	64.9	73.86
Careseeking for pneumonia	34.7	57.71	24.7	73.72	67.51
Child slept under an ITN	N/A	29.06	36.18	43.89	79.71
Contraceptive prevalence rate	15.45	19.56	34.79	33.53	53.35
C-section	2.2	3.04	N/A	4.61	4.89
Demand for FP satisfied	29.07	35.65	N/A	50.29	72.16
Facility delivery	41.93	42.21	44.3	79.65	89.83
Hygienic disposal of children's stools	64.3	N/A	76.42	N/A	91.8
Improved sanitation - HH	52.45	52.37	56.23	57.12	69.01
Improved sanitation - Individual	71.27	77.19	79.5	79.6	90.68
Improved water - HH	74.7	62.82	80.74	91.93	93.68
Improved water - Individual	76.37	64.36	80.28	90.86	93.24
IPTp	32.11	55.05	63.16	71.06	75.06
Iron folate supplementation	3.5	7.47	33.89	31.34	N/A
ITN	7.25	42.71	50.08	65.03	80.59
ITN/IRS	7.25	42.71	50.08	65.03	87.26
Neonatal tetanus protection	54.12	71.81	80.94	73.61	69.69
ORS	37.15	66.51	51.51	67.45	67.67
ORT	39.86	60.09	20	46.79	62.16
Postnatal care - Babies	N/A	N/A	45.02	81.73	N/A
Postnatal care - Mothers	46.16	46.82	45.73	82.85	N/A
Skilled birth attendance (SBA)	42.67	41.77	44.24	79.32	88.99
Stunting	60.63	55.49	43.25	38.94	47.08
Treatment of diarrhea - Antibiotics	N/A	N/A	N/A	24.91	N/A
Treatment of diarrhea - Zinc	N/A	N/A	N/A	1.83	36.37
Treatment of malaria - ACT	0	0	0	21.25	43.36
Treatment of malaria - Any antimalarials	23.91	22.66	22.84	28.41	44.31
Treatment of malaria - First line	21.07	19.89	20.67	21.25	43.36
Underweight	23.7	17.44	15.11	13.09	14.45
Vaccine - DPT	71.44	72.75	82.3	93.16	97.07
Vaccine - Hib	0	72.75	82.3	93.16	97.07
Vaccine - Measles	77.96	78.67	83.42	91.81	96.97
Vitamin A supplementation	54.1	80.44	80.2	85.86	N/A
Wasting	6.47	6.12	4.46	3.44	5.7
Water connection - HH	4.3	1.84	6.55	6.34	4.85

Table A11 **Deaths Averted by Intervention Groupings in 2013**

	Machinga		Salima	
	Number	Percentage	Number	Percentage
Child birth care	188	14.5%	123	12.6%
Vaccination	129	9.9%	136	13.9%
Treatment	201	15.5%	270	27.7%
Stunting	134	10.3%	-1	
Wasting	61	4.7%	33	3.4%
AIDS	290	22.3%	102	10.5%
WASH	26	2.0%	47	4.8%
ITNs	175	13.5%	192	19.7%
Other	96	7.4%	74	7.6%
Total	1,300		976	

Table A12 **Total Deaths Averted by Intervention Groupings 2001 - 2013**

	Machinga		Salima	
	Number	Percentage	Number	Percentage
Child birth care	1,024	14.4%	720	11.6%
Vaccination	787	11.1%	784	12.6%
Treatment	1,028	14.5%	2232	36.0%
Stunting	687	9.7%	-360	
Wasting	425	6.0%	508	8.2%
AIDS	1,079	15.2%	384	6.2%
WASH	193	2.7%	264	4.3%
ITNs	1,241	17.5%	1509	24.3%
Other	642	9.0%	160	2.6%
Total	7,106		6,201	



Appendix Part 10
Equity of intervention coverage

Figure A10: Coverage of ten key interventions by wealth quintile in Malawi, 2000, 2004, 2006, 2010 and 2014

DHS: Demographic and Health Survey
MICS: Multiple Indicator Cluster Survey
MDG: Millenium Development Goals
FPS: Family Planning Services
ANC: Antenatal Care
SBA: Skilled Birth Attendance
BF: Breastfeeding
ITN: Insecticide Treated Bednets
DPT3: Diptheria Pertussis Tetanus (3-doses of vaccine)
ORT: Oral Rehydration Therapy