The story of Community Management of Acute Malnutrition (CMAM) in Nigeria is one of success and learning; documented in the three following articles by UNICEF/ACF/Mark Myatt; ACF; and Results for Development (R4D). What began in 2009 as a small emergency response in 30 outpatient treatment (OTP) sites, has grown into one of the largest non-emergency CMAM programmes globally. With technical support from UNICEF and funding from the Children’s Investment Fund Foundation (CIFF), ECHO, EU, USAID, JICA, the Bill and Melinda Gates Foundation, CERF and DFID, there are 642 government-run CMAM sites delivering life-saving treatment across 11 states1 in Northern Nigeria today. From 2009 to May 2015, 1,085,498 children have been admitted for treatment – resulting in an estimated 831,686 children cured2 and 207,805 lives saved.

Demonstrating delivery at scale
Despite fluctuating instability in the country, the programme continues to demonstrate that high-quality CMAM services can be delivered at scale. The programme has demonstrated that high-quality CMAM services can be delivered at scale.

The authors acknowledge the input of the following reviewers in producing this article: Augustin Flory, Executive Director at CIFF; Georgina Fekete, Director of Nutrition at CIFF; Christine Kaligirwa, Nutrition Specialist at UNICEF Nigeria; and Assaye Bulti at UNICEF Nigeria.

The authors recognise and thank all partners that have supported the work highlighted in this article, including the Nigeria Federal Ministry of Health and UNICEF for technical support for programme implementation. Additional recognition goes to ACF, Valid International, Save the Children, Results for Development (R4D) and their Nigerian partners Centre for Communication Programmes Nigeria (CCPN), Binomial Optimus Limited (BOL), and Health Systems Consult Ltd (HSCL). Financial support for the programme was provided by the Children’s Investment Fund Foundation (CIFF), DFID, ECHO, EU, USAID, Bill and Melinda Gates Foundation, CERF and JICA over the years. Most importantly, the authors would like to recognise the Local Government Authority (LGA) and State governments in Northern Nigeria and the people delivering these vital services.

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1 Adamawa, Bauchi, Borno, Gombe, Jigawa, Kano, Katsina, Kebbi, Sokoto, Yobe, and Zamfara. As of May 2015.
2 75.2% average cure rate from 2009-2014
successfully delivered at large scale through a government health system. The programme has grown exponentially over the last five years, with more than 320,000 children admitted for treatment in 2014 alone. Overall performance has significantly improved and the majority of states (nine out of 11) now consistently meet SPHERE treatment standards. The 11 states achieved an average 84.5% cure rate as of March 2015. To support further programmatic improvement, a series of SLEAC and SQUEAC coverage surveys found an average coverage of 36.6% across the 11 states. The leading causes of reduced access to treatment and default rates were lack of awareness of malnutrition and the CMAM programme. This was true across all 11 states. This information is critical for understanding how to improve the programme and ensure high-quality services are available and reaching children in need.

Delivering a cost-effective service

The data from Nigeria confirms that the delivery of CMAM services is a highly cost-effective and affordable treatment. A comprehensive costing analysis shared in the article by R4D found an average cost of $219 per child cured, of which $160 are financial costs attributable to the government and UNICEF and $59 are economic costs to beneficiaries and community volunteers. Taking the government and UNICEF costs of $160 per child cured, this translates into $1,117 per life saved and $30 per DALY gained. This is considered highly cost-effective based on WHO-CHOICE cost-effectiveness thresholds. The Ready to Use Therapeutic Food (RUTF) product is the single largest cost, at roughly $76 per child cured (close to 50% of government and UNICEF costs). Efforts are underway to begin producing RUTF locally in Nigeria but it will take time before production can meet demand and it is not clear if this would lower costs significantly in the short-term. CIFF is currently funding Washington University in St. Louis to develop a tool and alternative formulations for RUTF using local ingredients with the aim to reduce cost. Further cost-efficiencies can be achieved at scale as the programme performance continues to improve and existing infrastructure is used to reach more children. In the end, funding for the product is likely to remain the main limiting factor for treating children in Nigeria; the health system is available and able to deliver treatment to many more children but without supplies, this cannot be done.

More children are in need of treatment

Rates of malnutrition remain high in Nigeria and this is an issue that cannot be ignored. In 2015, there will be an estimated 1.8 million children with severe acute malnutrition (SAM) in need of treatment. Despite the impressive scale-up seen in recent years, two out of every three children still do not receive the treatment they need in the 11 states where the programme currently operates. As we look forward to the future of CMAM in Nigeria, it is clear that availability of treatment must continue to increase.

This requires increased investment

Based on the above analyses, scaling up the programme will cost up to $160 per child cured. For an average OTP site, with over 500 admissions and 360 children cured per year, estimated annual costs are $58,157. With an average of five sites per LGA, this translates into a total annual cost per LGA of $290,783 to admit over 2,500 children and cure over 1,800 children. While these costs are not insignificant, they are affordable and scale-up to reach more children with effective, life-saving treatment is essential for a country like Nigeria where the burden is high. Funding support to date has primarily come from international donors but domestic budget allocation of this affordable service is essential for sustainability of the programme to ensure continued treatment of children with SAM. The current domestic budget for nutrition as a percentage of overall government expenditure is low, though exact data are not currently available. In recent years, a number of state governments in Nigeria have specifically included CMAM services in their budgets, with a total of over $2 million committed in 2014. One of these states included significant funding for RUTF procurement but this needs to increase. CIFF will be incentivising this through a matched-funding approach over the next three years.

A success story with lessons for Nigeria and beyond

The incredible success of this programme, with hundreds of thousands of children cured each year, offers an unparalleled opportunity to reach some of the most vulnerable mothers and children in Nigeria. The OTP sites of the CMAM programme offer an exciting opportunity to integrate additional preventive nutrition services such as Infant and Young Child Feeding (IYCF) and health services in the community and deliver critical interventions to reduce the overall burden of children with SAM in Nigeria.

This programme is also a lesson – for other countries and for Nigeria itself. The programme shows that it is possible to move from a small emergency operation to a national programme delivered through the existing health system and that high quality treatment can be provided to hundreds of thousands of children in regions with chronically high rates of undernutrition. As a highly cost-effective and life-saving service, CMAM and procurement of RUTF for treatment must be a priority for governments to include in their budgets and as part of their routine health services.

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6 UNICEF routine monitoring data (May 2015)
7 Simplified LQAS Evaluation of Access and Coverage; LQAS: Lot Quality Assurance Sampling
8 Semi-Quantitative Evaluation of Access and Coverage
9 Including cost to beneficiaries as well as government costs and UNICEF costs
10 As seen in Mark Myatt’s article, this number is much lower when looking only at the UNICEF costs.
11 Of total children admitted, only a proportion will be cured so the cost of RUTF per child cured ($76) is higher than the cost of RUTF per child admitted ($54).
12 NNHS 2014
13 This assumes a 72% cure rate found in the sites included in the costing study. This is slightly lower than the current national average of 84.5% cured.
How many lives do our CMAM programmes save?

A sampling-based approach to estimating the number of deaths averted by the Nigerian CMAM programme

By Assaye Bulti, Stanley Chitekwe, Chloe Puett and Mark Myatt

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Chloe Puett leads the cost-effectiveness research project at Action Against Hunger (ACF International). She holds a PhD in Food Policy and Applied Nutrition from Tufts University. Her areas of expertise include cost analysis and intervention research, particularly around community access to and utilisation of services.

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This article is accompanied by two postscripts; Andre Briand comments on how this article contributes to the evidence around cost-effectiveness of CMAM, whilst Max Bachmann was invited to explain the statistical methods. In the process of review, informal feedback provided by Max was shared with the authors who subsequently elaborated on content (most notably, the addition of sensitivity analysis and an expanded discussion section). The Field Exchange editors and articles authors extend thanks to the reviewers for their valuable contributions (Eds).

Introduction

Since the inception of the community-based management of acute malnutrition (CMAM) programme in Nigeria in September 2009 until October 2014, a total of 919,876 children with severe acute malnutrition (SAM) have been treated by the programme across eleven states (Adamawa, Bauchi, Borno, Gombe, Jigawa, Kano, Katsina, Kebbi, Sokoto, Yobe, and Zamfara) in northern Nigeria.

The CMAM programme is a child survival programme. However, the number of lives saved by the Nigerian CMAM programme is not yet documented. This is a common and persistent problem with nutrition interventions that dates back to the time of limited impact and limited coverage inpatient therapeutic feeding programmes. Health impact assessment statistics such as the number of deaths averted (lives saved) as well as cost-effectiveness statistics such as cost per death averted (cost per life saved), and cost per disability adjusted life year (DALY) averted are increasingly being used by governments and donor organisations to decide funding priorities. Their absence for common nutrition interventions may, therefore, jeopardise funding.

This article describes a simple and practicable method that has been used to estimate the number of lives saved by the Nigerian CMAM programme with the intention that this estimate be used as an advocacy tool to attract more government and international resources to the programme. The method
described in this article was developed by UNICEF Nigeria and Brixton Health from previous work undertaken by Tufts University, the World Bank, the International Food Policy Research Institute and Brixton Health investigating the cost-effectiveness of different types of therapeutic feeding programme[1].

The method described in this article can be performed using readily available data (i.e. routine programme monitoring data, data such as mid upper arm circumference (MUAC) at admission that is commonly collected in SQUEAC coverage assessments, and programme accounting summaries). This means that the described method provides every CMAM programme with the ability to produce key health impact assessment statistics.

A counterfactual for estimating the number of deaths averted by a CMAM programme

Estimating the number of deaths averted by an intervention requires the construction of a counterfactual (i.e. an informed guess at what may have happened if the intervention had not happened). In the case of the number of deaths averted by a CMAM programme, the counterfactual is informed by the number of SAM cases treated by the programme (NT), the proportion of treated SAM cases cured by the programme (PC), and the expected excess mortality (EM) in untreated SAM cases with similar severity of wasting as those treated by the programme. If these are known or can be estimated, then the number of deaths averted can be calculated:

\[
\text{Deaths averted} = EM \times PC \times NT
\]

We know that 919,876 SAM cases were treated by the Nigerian CMAM programme between September 2009 and October 2014:

\[
NT = 919,876
\]

We estimated the proportion cured (PC) using data from:

1. A recently completed retrospective cohort study investigating outcomes in the 102,245 SAM cases admitted to the CMAM programme in Katsina and Jigawa states between January 2010 and December 2013. The proportion of programme beneficiaries discharged as cured in this study was 70.9%. We used this data to represent programme performance for the entire programme over the fifty-two months from September 2009 to December 2013.

2. Routine programme monitoring statistics for the entire programme for January 2014 to the end of October 2014 for 229,520 programme exits. The proportion of programme beneficiaries discharged as cured in this data was 83.3%. We used this data to represent programme performance over the ten months from January 2014 to October 2014.

A weighted (i.e. by time in months) average of these data is:

\[
\text{Proportion cured} = \frac{0.709 \times 52 + 0.833 \times 10}{52 + 10} = 0.729 (72.9\%)
\]

This figure is, however, likely to underestimate the true proportion of beneficiaries that benefited substantially from the programme. This is because it is likely that a significant proportion of defaulting cases will have "defaulted" because the child had recovered and was clinically well. Such cases might be considered as self-discharged as cured.

The proportion of programme beneficiaries who defaulted in the retrospective cohort study was 19.7%. The proportion of programme beneficiaries who defaulted in the routine programme monitoring data for the first ten months of 2014 was 13.3%. A weighted (i.e. by time in months) average of these data is:

\[
\text{Proportion defaulted} = \frac{0.197 \times 52 + 0.133 \times 10}{52 + 10} = 0.187 (18.7\%)
\]

Many of the cases that defaulted in the cohort study did so early in the treatment episode (i.e. more than 50% of cases defaulted after a single visit). It is unlikely, therefore, that more than about 20% of defaulters could reasonably be considered to have been self-discharged as cured. It is also unlikely that none of the defaulters received a substantial benefit from attending the programme. It is likely, therefore, that the proportion self-discharged as cured lies somewhere between about 5% and 20% of all defaulters. There was no compelling reason to believe that any value between 5% and 20% is more likely than any other so the average of 5% and 20% (i.e. 12.5%) was used.

We estimated the proportion cured (PC) accounting for those self-discharged as cured to be about:

\[
\text{PC} = 0.729 + (\text{proportion defaulted} \times 0.125)
\]

\[
\approx 0.729 + (0.187 \times 0.125)
\]

\[
\approx 0.752 (75.2\%)
\]

The expected excess mortality (EM) can be estimated from background mortality and expected mortality (i.e. the case fatality rate) in untreated SAM cases:

\[
\text{excess mortality (EM)} = \text{case fatality rate}_{\text{untreated SAM cases}} - \text{background mortality}
\]

We used the under-five years mortality rate (USMR) for 2009 to 2013 for Nigeria from an international database and took the average to estimate background mortality as 24.8 deaths per one thousand children per year (see Box 1).

Mortality (i.e. the case fatality rate) in both treated and untreated SAM cases varies with the severity of wasting. Mortality risk increases with increasing severity of wasting. Data on mortality risk in untreated SAM cases is available only from historical cohort studies. Since the advent of therapeutic feeding programmes capable of simultaneously delivering effective treatment (i.e. the current therapeutic feeding protocols and products) to large numbers of SAM cases (i.e. CTC/CMAM programmes) earlier this century, leaving SAM cases untreated and waiting for them to recover or die is no longer an ethically defensible option. This means that we are restricted to working with historical data.

The Nigerian CMAM programme uses only MUAC and oedema for deciding admission. About 95.1% of admissions in the retrospective

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**Box 1 Estimating background mortality from summary statistics**

We used the under-five years mortality rate (USMR) for 2009 to 2013 for Nigeria from an international database and took the average to estimate background mortality.

The World Bank [http://data.worldbank.org/indicator/SH.DYN.MORT](http://data.worldbank.org/indicator/SH.DYN.MORT) reports USMR for Nigeria for 2009 to 2013 to have been:

<table>
<thead>
<tr>
<th>Year</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014*</th>
</tr>
</thead>
<tbody>
<tr>
<td>USMR</td>
<td>136</td>
<td>131</td>
<td>126</td>
<td>122</td>
<td>117</td>
<td>112</td>
</tr>
</tbody>
</table>

* USMR for 2014 was estimated by linear extrapolation.

The USMR is the probability that a newborn child will die before reaching age five and is expressed as deaths per one thousand live births. The USMR data can be expressed as an annual individual risk by dividing by five (to give an annual mortality risk per thousand children) and then dividing by one thousand (to give an individual annual mortality risk). This is also an estimate of the proportion of children aged under five years that die each year:

<table>
<thead>
<tr>
<th>Year</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014*</th>
</tr>
</thead>
<tbody>
<tr>
<td>USMR</td>
<td>2.72%</td>
<td>2.62%</td>
<td>2.52%</td>
<td>2.44%</td>
<td>2.34%</td>
<td>2.24%</td>
</tr>
</tbody>
</table>

* USMR for 2014 was estimated by linear extrapolation.

The mean of these estimates is 2.48% (i.e. 24.8 deaths per one thousand children per year or 0.68 deaths per ten thousand children per day).

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1 Community Therapeutic Care
cohort study were admitted using MUAC with the remainder admitted using MUAC and oedema (1.4%), oedema alone (0.2%), or discretionary criteria such as visible severe wasting (3.3%). The very high proportion of admissions made using MUAC means that we were able to use mortality estimates for MUAC cases to estimate expected mortality in untreated SAM cases.

Figure 1 shows the relationship between MUAC and mortality, expressed in deaths per one thousand child-years, reported by four separate historical cohort studies [2,3,4,5]. Mortality increases exponentially with declining MUAC. There is little between-study variation in the observed relationships between MUAC and mortality despite the fact that these studies were undertaken by different teams in different locations at different times with varying lengths of follow-up and inconsistent censoring of accidental and violent deaths. This suggests that each study is estimating the same underlying rate and that the observed differences were due to varying lengths of follow-up, inconsistent censoring of accidental and violent deaths, measurement error and sampling error.

The estimate of mortality associated with MUAC used in the analysis reported here was calculated using the published data on mortality associated with MUAC in untreated SAM cases summarised in Figure 1 [2,3,4,5]. Linear interpolation was used to estimate expected excess mortality at the mean admission MUAC (106.1 mm) observed in the cohort study (this data is also collected in SQUEAC coverage assessments). The reported mortality rates were corrected to allow for a background mortality rate of 24.8 deaths per one thousand children per year (see Box 1). The correction is made by subtracting background mortality from the estimated case fatality rate:

\[
\text{excessmortality (EM)} = \frac{\text{casefatalityrate}_{\text{untreatedSAMcases}} - \text{backgroundmortality}}{\text{casefatalityrate}_{\text{untreatedSAMcases}} - 24.8}
\]

The linear interpolation and correction process is illustrated in Table 1.

It was assumed that the four mortality estimates in Table 1 were estimating the same underlying rate and that the observed differences were due to varying lengths of follow-up time, inconsistent censoring of accidental and violent deaths, measurement error, sampling error, errors introduced by our use of simple linear interpolation and propagation of rounding errors. Under this assumption, an average of the four estimates is likely to be more accurate than any single estimate.

A useful way of finding an average when you have very few data points is:

\[
E(x) = \min(x) + \frac{\max(x) - \min(x)}{2}
\]

The resulting estimated excess mortality rate from the mortality data presented in Table 1 is:

\[
EM \approx 171.85 + \frac{327.86 - 171.85}{2} = 249.86 \text{ deaths per 1,000 children per year}
\]

This is the equivalent of 24.986% (i.e. about one quarter) of untreated SAM cases with the same mean MUAC (i.e. 106.1 mm) as cases admitted to the programme dying each year.

An objection that is occasionally raised against the use of historical cohorts of untreated SAM cases to estimate excess mortality is that there is considerable evidence of significant drops in childhood mortality over the years since the cohort studies were done [6]. Such drops can be seen in Box 1 where the U5MR drops by almost 20% over five years. The objection is mistaken because the drops in childhood mortality are, in very large part, due to a combination of reductions in incidence and improvements in treatment coverage and improvements in treatment efficacy. In our counterfactual, we use the SAM cases admitted to the Nigerian CMAM programme and model what would happen to these cases if the programme had not existed. These cases already have the disease so reductions in incidence are not relevant. These cases are, in the counterfactual, untreated so improvements in treatment coverage and treatment efficacy are also not relevant. The SAM cases in the counterfactual have the same disease and the same absence of treatment as the SAM cases in the historical cohorts. In the absence of additional and contradictory evidence on the case-fatality rates for untreated SAM at different levels of severity (which would now be unethical to collect), there is no good reason to believe that the SAM cases in the counterfactual will not experience similar case-fatality rates to the SAM cases in the historical cohorts.

Having found/estimated the number treated (NT), the proportion cured (PC), and the expected excess mortality (EM) we estimated the number of deaths averted by the CMAM programme:

\[
\text{Deaths averted} = EM \times PC \times NT
\]

\[
\approx 0.24986 \times 0.752 \times 919,876
\]

\[
\approx 172,840
\]

It is important to note that EM and PC are expressed in the same way (i.e. as proportions).

The problem with the estimate of deaths averted calculated above is that it is only a point estimate. A credible range of values that accounts for the uncertainty in estimates of programme cure-rates (PC) and the expected excess mortality rate (EM) would be more useful and more credible.

**Accounting for uncertainty – A sampling-based approach**

Uncertainty can be incorporated into the calculation of deaths averted by the CMAM programme using fuzzy numbers. A fuzzy number is a generalization of a “regular” real number in the sense that it does not refer to a single value but rather to a connected set of possible values.
The linear interpolation process used to estimate expected excess mortality associated with untreated SAM at the mean admission MUAC (106.1 mm) in the Nigerian CMAM programme

<table>
<thead>
<tr>
<th>Source</th>
<th>Reported mortality at two MUAC thresholds in deaths/1,000/year</th>
<th>Slope (β)</th>
<th>Expected excess mortality in deaths/1,000/year at MUAC = 106.1 mm (EM)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MUAC threshold</td>
<td>Mortality</td>
<td>110−100</td>
</tr>
<tr>
<td>Briend &amp; Zimicki (1986)</td>
<td>100 mm</td>
<td>304</td>
<td>178−304</td>
</tr>
<tr>
<td></td>
<td>110 mm</td>
<td>340</td>
<td>340−23.5×1.1−24.8**=171.85</td>
</tr>
<tr>
<td>Briend et al (1987)</td>
<td>100 mm</td>
<td>593</td>
<td>366−31.1×1.1−24.8**=306.99</td>
</tr>
<tr>
<td></td>
<td>110 mm</td>
<td>366</td>
<td>366−31.1×1.1−24.8**=306.99</td>
</tr>
<tr>
<td>Vella et al (1994)</td>
<td>105 mm</td>
<td>340</td>
<td>340−23.5×1.1−24.8**=171.85</td>
</tr>
<tr>
<td></td>
<td>115 mm</td>
<td>55</td>
<td>55−366</td>
</tr>
<tr>
<td>Pelletier et al (1993)</td>
<td>100 mm</td>
<td>340</td>
<td>340−23.5×1.1−24.8**=171.85</td>
</tr>
<tr>
<td></td>
<td>110 mm</td>
<td>105</td>
<td>105−340</td>
</tr>
</tbody>
</table>

* The calculation here is excess mortality (EM) = \( \frac{\text{case fatality rate untreated SAM cases}}{\text{background mortality}} \). ** This is the background mortality (i.e. 24.8 deaths per 1,000 children per year).

where each possible value has its own weight (or membership function). The membership function typically ranges between zero and one. This range of weights has been found to be useful in many applications and when membership is defined on a semi-quantitative basis. Much of the data used in the calculation of deaths averted is taken from samples. This allows us to use sampling distributions (probability distributions) to define fuzzy numbers.

For example, the proportion discharged as cured (i.e. 72.9%) was estimated from a retrospective cohort study with a sample of size \( n = 102,245 \) and routine programme monitoring data for 229,520 programme exits. The total sample size for this estimate is:

\[ n = 102,245 + 229,520 = 331,765 \]

The proportion discharged as cured is a binomial proportion and can be modelled using the binomial distribution:

\[ B(n = 331,765, p = 0.729) \]

This particular distribution is shown in Figure 2. This is the theoretical sampling distribution of the proportion discharged as cured. The shape of the plot in Figure 2 reflects the level of belief about the true value of the proportion cured (i.e. we have most belief that it is close to the point estimate and little belief that it could be very far from the point estimate). In this case degrees of belief are determined by the statistical properties (i.e. the point estimate and sample size) of a sample.

In other cases the probability distribution used reflects informed guesses or reasoned belief alone. This is the case (e.g.) with the proportion self-discharged as cured (i.e. defaulters who were cured before they defaulted). In such cases a probability distribution is chosen on a semi-quantitative basis. Given the distribution of lengths of stay in the programme for different outcomes we decided that it is likely that the proportion self-discharged as cured lay somewhere between 5% and 20% of defaulters. There was no compelling reason to believe that any value between 5% and 20% is more likely than any other so the continuous uniform distribution \( U(0.05, 0.20) \) was used. If we multiply the proportion defaulting by this distribution we get a second uniform distribution:

\[ U(0.05, 0.20) \times B(n = 331,765, p = 0.729) + U(0.05, 0.20) \times B(n = 331,765, p = 0.187) \]

This approach neglects uncertainty in the proportion defaulting. We can model this using the binomial distribution:

\[ B(n = 331,765, p = 0.187) \]

The fuzzy number for the proportion self-discharged as cured that captures both sources of uncertainty is:

\[ U(0.05, 0.20) \times B(n = 331,765, p = 0.187) \]

The fuzzy number for the proportion cured (PC) that captures all sources of uncertainty is:

\[ B(n = 331,765, p = 0.729) + U(0.05, 0.20) \times B(n = 331,765, p = 0.187) \]

This is shown graphically in Figure 3.

The approach of using sampling or probability distributions to define fuzzy numbers using a network of probability distributions is known as sampling-based uncertainty analysis [1].

A fuzzy counterfactual

Table 2 shows the probability distributions that we used to estimate the number of deaths averted by the CMAM programme. This network of probability distributions is shown graphically in Figure 4.
**Figure 3** Determining the fuzzy number for the proportion cured

<table>
<thead>
<tr>
<th>Proportion discharged as cured</th>
<th>Proportion of defaulters cured</th>
<th>Proportion defaulting</th>
<th>Proportion cured (PC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.726</td>
<td>0.728</td>
<td>0.730</td>
<td>0.732</td>
</tr>
<tr>
<td>0.05</td>
<td>0.10</td>
<td>0.15</td>
<td>0.20</td>
</tr>
<tr>
<td>0.184</td>
<td>0.185</td>
<td>0.186</td>
<td>0.187</td>
</tr>
<tr>
<td>0.188</td>
<td>0.189</td>
<td>0.190</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2** Probability distributions used to estimate the number of deaths averted by the CMAM programme

<table>
<thead>
<tr>
<th>Input</th>
<th>Source</th>
<th>Distribution*</th>
<th>Notes</th>
<th>Estimates ...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number treated</td>
<td>UNICEF Nigeria</td>
<td>919,876</td>
<td>A fixed number</td>
<td>NT</td>
</tr>
<tr>
<td>Proportion discharged as cured</td>
<td>Cohort study Routine data</td>
<td>B(n = 331,765, p = 0.729)</td>
<td>See the Accounting for uncertainty – A sampling-based approach section, Figure 2 and Figure 3.</td>
<td>PC</td>
</tr>
<tr>
<td>Proportion defaulting</td>
<td>Cohort study Routine data</td>
<td>B(n = 331,765, p = 0.187)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proportion of defaulters cured</td>
<td>Cohort study</td>
<td>U(min = 0.05, max = 0.20)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Background mortality</td>
<td>World Bank</td>
<td>N(μ = 0.0248, σ = 0.0008)</td>
<td>μ = mean(USMR)</td>
<td>EM</td>
</tr>
<tr>
<td>Mortality in untreated cases</td>
<td>Historical cohort studies</td>
<td>U(μ = 0.2747, σ = 0.0260)</td>
<td>σ'' = (\frac{\text{max}(\text{USMR}) - \text{min}(\text{USMR})}{6})</td>
<td></td>
</tr>
<tr>
<td>Deaths averted</td>
<td>All of the above data</td>
<td>DA*** = EM × PC × NT</td>
<td>Final result</td>
<td>Deaths averted</td>
</tr>
</tbody>
</table>

* B(n, p) for binomial, U(min, max) for continuous uniform, and N(μ, σ) for normal (one million observations were generated from each distribution).

** The method for estimating variability (σ) about a mean used here is a statistical rules of thumb commonly used in PERT/CPM project management applications and is useful when there are only a few data points.

*** CFR = Case Fatality Rate (the proportion of untreated cases dead after one year).

**** DA is the joint or conjugate distribution of EM, PC, and NT.

**Figure 4** Network of probability distributions used to estimate the number of deaths averted by the Nigerian CMAM programme

- Number Treated (NT) = 919,876
- Case fatality rate
- Background mortality
- Excess mortality
- Deaths averted
- DA*** = EM × PC × NT
- Deaths averted
Each of the distributions in the network was generated using appropriate pseudo-random number generators. In the analysis presented here, each distribution consisted of one million pseudo-random numbers. All calculations were performed using the R Language for Data Analysis and Graphics. The R language script for the sampling-based uncertainty analysis used to estimate the number of deaths averted by the Nigerian CMAM programme is shown in Box 1.

Since the output of the network of probability distributions is also a probability distribution, we can produce a point estimate (i.e. the 50% percentile of the output distribution) and a 95% credible interval (i.e. the 2.5th and 97.5th percentiles of the output distribution). In the analysis presented here, the estimate of the number of deaths averted by the Nigerian CMAM programme is estimated to be 172,898 (95% CI = 137,526; 208,434).

This type of analysis is usually accompanied by a sensitivity analysis. A sensitivity analysis explores how sensitive an output variable is to each of the input variables that are used to derive the output. A simple but useful way of performing a sensitivity analysis for a sampling-based uncertainty analysis is to produce scatter-plots of the output variable against each of the input variables. Each scatter-plot gives a direct visual indication of the sensitivity of the output variable to a single input variable. A strong pattern in the scatter-plot indicates sensitivity to a given input variable. Quantitative measures (e.g. correlation coefficients) may also be calculated. A large absolute value of a correlation coefficient indicates sensitivity to a given input variable. The R language script in Box 1 also performs this type of sensitivity analysis. In this study, the output (i.e. deaths averted) is slightly sensitive to the proportion of defaulters cured and very sensitive to the expected case fatality rate in SAM cases not receiving the CMAM intervention (see Figure 5).

**Box 1** R language script for estimating deaths averted in the Nigerian CMAM programme

```r
# Input variables for the sampling based uncertainty analysis:
# rep Number of sampling replicates (a large number)
# NT Number of SAM cases treated by the CMAM programme
# sampleN Sample size for the proportion of exit discharged as cured and defaulting
# curedP Proportion of exits discharged as cured
# defaultP Proportion of exits defaulting
# USNR Under five years mortality (proportion dead at one year) for each year of programme operation
#
# Sampling distributions for the proportions discharged and defaulting
# pDisCured <- rbionom(n = rep, size = sampleN, p = curedP) / sampleN
# pDefault <- rbionom(n = rep, size = sampleN, p = defaultP) / sampleN
# # Sampling distribution for the proportion cured in DEFAULTING CASES
# pDefCured <- runif(n = rep, min = 0.05, max = 0.20)
# # Sampling distribution for the proportion Cured (PC) accounting for "self-discharged as cured".
# PC <- pDisCured + (pDefCured * pDefault)
# # Background mortality (proportions dead at one year) from USNR
# bgm <- rnorm(n = rep, mean = mean(USNR), sd = (max(USNR) - min(USNR)) / 6)
# # Case fatality rate from historical cohort data (proportions dead at one year)
# oldData <- c(0.22714, 0.35266, 0.33179, 0.19665)
# cfr <- rnorm(n = rep, mean = min(oldData) + (max(oldData) - min(oldData)) / 2, sd = (max(oldData) - min(oldData)) / 6)
# # Excess mortality (EM) as case fatality rate - background mortality
# EM <- cfr - bgm
# # Estimate number of deaths averted (lives saved)
# DA <- EM + PC + NT
# round(quantile(DA, probs = c(0.025, 0.5, 0.975)))
# # Sensitivity analysis by scatter-plots
# par(mfrow = c(3, 2))
# par(pty = "s")
# plot(pDisCured, DA, pch = ".", col = "grey", main = paste("r = ", round(cor(pDisCured, DA), 4)))
# plot(pDefault, DA, pch = ".", col = "grey", main = paste("r = ", round(cor(pDefault, DA), 4)))
# plot(pDefCured, DA, pch = ".", col = "grey", main = paste("r = ", round(cor(pDefCured, DA), 4)))
# plot(PC, DA, pch = ".", col = "grey", main = paste("r = ", round(cor(PC, DA), 4)))
# plot(EM, DA, pch = ".", col = "grey", main = paste("r = ", round(cor(EM, DA), 4)))
```

Each of the distributions in the network was generated using appropriate pseudo-random number generators. In the analysis presented here, each distribution consisted of one million pseudo-random numbers. All calculations were performed using the R Language for Data Analysis and Graphics. The R language script for the sampling-based uncertainty analysis used to estimate the number of deaths averted by the Nigerian CMAM programme is shown in Box 1.
Additional analysis

Having estimated the number of deaths averted it is possible, with little extra data, to estimate the cost per death averted (or cost per life saved). The total cost of the programme over the five years it had been running (which is also our assessment period) was US$47,416,818. The estimate of the cost per death averted is:

\[
\frac{\text{Cost of Programme}}{\text{Number of deaths averted}} = \frac{\text{US$47,416,818}}{172,898} = \text{US$274.25} \quad (95\% \text{ CI} = \text{US$227.49} \; \text{to US$344.78})
\]

For comparison, Table 3 shows the cost per death averted reported for a variety of child survival interventions.

With a little extra data (e.g. the duration of an untreated episode of SAM, average age of SAM cases, sex-ratio of SAM cases, sex-specific life-expectancies at birth, disability weighting for SAM, and a reasonable and widely accepted discounting/age-weighting function), it is also possible to estimate the number of disability adjusted life years (DALYs) averted and cost per DALY averted [1].

Table 3 Cost per death averted for a range of child survival interventions

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Context(s)</th>
<th>Cost per death averted*</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMAM delivered by community health workers**</td>
<td>Bangladesh</td>
<td>US$869.00 [1]</td>
</tr>
<tr>
<td>Standard EPI package***</td>
<td>Africa/</td>
<td>US$313.00 [7]</td>
</tr>
<tr>
<td></td>
<td>South Asia</td>
<td></td>
</tr>
<tr>
<td>Intermittent Preventive Treatment in Infants (IPTi) for malaria***</td>
<td>Mozambique / Tanzania</td>
<td>US$232.00 [8]</td>
</tr>
<tr>
<td>Breastfeeding support (range of programming models)</td>
<td>Sub-Saharan Africa</td>
<td>US$114.00 - US$342.00 [7]</td>
</tr>
<tr>
<td>Universal vitamin A distribution****</td>
<td>Philippines</td>
<td>US$76.30 [9]</td>
</tr>
<tr>
<td>Mass chemoprophylaxis for malaria***</td>
<td>Gambia</td>
<td>US$163.00 [9]</td>
</tr>
<tr>
<td>Social marketing of insecticide treated nets (ITN)**</td>
<td>Tanzania</td>
<td>US$1780.00 [9]</td>
</tr>
</tbody>
</table>

* All dollars values have been standardised to 2012 (i.e. the approximate mid-point of the Nigerian CMAM programme) values by multiplying the reported cost by the percentage increase in the United States Bureau of Labour Statistics’ consumer prices index for all urban consumers (CPI-U).
** The quoted cost is for all staff salaries and allowances, site rental, all logistics costs, all community mobilisation costs, training, supervision, monitoring and evaluation including SQUEAC coverage assessments, case-finding and ‘watch-list’ follow-up in the community, curative care, and costs to households [1]. Note that this is a much broader range of costs than is used in the analysis for the Nigerian CMAM programme (see ‘A note of caution’).
*** The quoted cost is for implementing the programme as a semi-vertical addition to existing healthcare package.
**** The quoted cost is for delivering the intervention within an existing EPI programme.

A note of caution

It is important with any calculation to consider the term garbage in - garbage out. If the data we use to inform our calculations is wrong or of poor quality (i.e. garbage in), then the resulting estimates will also be wrong or of poor quality (i.e. garbage out). It is important, therefore, to consider the quality, completeness, and trustworthiness of the input data that we use:

Routine programme monitoring data: Monitoring data is often not well recorded. A common problem is that the proportion cured is overestimated. In the work reported here, we used data from beneficiary record cards and applied data cleaning and decision rules to the data. This corrected a tendency for defaulters to be recorded as discharged as cured at some CMAM sites. We did use routine programme monitoring data to cover the ten months programme operation not covered by the retrospective cohort study. The proportion cured in the routine programme data was higher than that observed in the retrospective cohort study but this was consistent with an upward trend observed on the retrospective cohort data and with recent reforms to programme activities and siting aimed at reducing default rates. If you use routine programme monitoring data, then you should check the quality of (at least) a subset of data (e.g. using SQUEAC tools) and correct estimates of the proportion cured and the proportion defaulted accordingly. Checking may be difficult to do in settings of remote management or conflict. If checking cannot be done, then you could use the SPHERE minimum standard (e.g. 75%) for the proportion cured.

Data related to programme costs: Costing data often does not include all costs that contribute to programme outcomes. Important programme inputs such as Ready to Use Therapeutic Food (RUTF) may be received as in-kind donations and thus will not be included in the programme’s accounting records. Costs for (e.g.) security, transport, storage and staff may be allocated to (or seconded from) other programmes and not included in accounting records for the programme being assessed. In, for example, an integrated programme delivering CMAM services at government health facilities, you may only have the cost of adding CMAM to an existing primary healthcare programme, which provides resources essential to delivering CMAM that are also not included in the programme’s accounting records. Data relating to direct and indirect costs to beneficiary households (e.g. travel costs, lost labour, &c.) are never included in budgetary data. These costs may be considered during programme design and in programme coverage assessments but almost never in budget documents which concentrate on institutional costs. Inclusion of this data will usually require a dedicated survey to collect it [1]. When you use budgetary data, it is important to assess and report on any and all gaps in the budgetary data that you use. In the analysis reported here, the cost estimate used covers:

- Purchase of RUTF from abroad.
- Port handling and warehousing fees for RUTF.
- Transport costs for RUTF from ports to state capitals only (states were responsible for storage and transport to districts, districts were responsible for storage and transport to health facilities).
- Training of staff to deliver the CMAM protocol.
- Monitoring and evaluation activities related to the CMAM programme (excluding coverage assessments).
- Administrative costs at the national level.

The cost estimate used does not cover:

- Purchase and supply of drugs (e.g. antimicrobials) needed to deliver the CMAM protocol.
- Storage and transport of RUTF and other CMAM-related supplies from states capitals to districts and from districts to health facilities.
- Salaries, wages, allowances, and recruitment costs for staff in primary healthcare facilities. The Nigerian CMAM programme is implemented as part of an existing primary healthcare system without employing new staff or raising staff salaries. The incremental value of health workers’ time spent implementing the CMAM programme was also not measured for the analysis reported here.
It should be noted that salaries, wages, allowances, and recruitment costs usually account for about 50% of the cost of an NGO-delivered CMAM programme.

- Allowances, incentives, and "shadow" labour costs for community-based volunteers.
- Costs of maintaining infrastructure including clinic buildings and equipment.
- Direct and indirect costs to beneficiary households.
- SQUEAC and SLEAC coverage assessments.

The cost estimate used in the analysis reported here covers the costs needed to initiate and deliver CMAM services (excluding salary costs and local transportation costs) within an existing primary healthcare system in eleven states in northern Nigeria.

It is also important to realise that there may be a temptation for service providers seeking funding for continuation or expansion of programmes to underestimate programme costs in order to make the programme look more cost-effective than it really is.

Any counterfactual is based on assumptions, guesses, make believe and some difficult to define and measure data. A counterfactual is a type of fiction. It is important that is it not too much of a fiction. This requires care in selecting and using data and in carrying out calculations. Users of the fiction need to be made aware of the limitations of the data used.

Conclusions

The analysis presented here is simple to do and can be done with readily available (or easily collected) data. It is simple enough to allow current estimates to be produced using updated inputs from routine programme monitoring statistics and budgetary data for inclusion in, for example, monthly or quarterly programme reports and in advocacy material.

It is important to realise that the simple method used here is subject to limitations arising from the data sources used. The main limitation is the use of incomplete cost data. The cost data available to us was the cost to a donor organisation of initiating and implementing a large-scale CMAM programme within an existing primary healthcare programme. Our estimate of the cost per death averted reflects only this cost.

Different sets of programme costs will be of interest to different stakeholders. Whilst estimates such as those produced and reported here are relevant to donor organisations and some policy makers, they provide a limited understanding of the full extent of resources required/used by a programme. Capturing a more complete set of costs yields data that can inform programme design (e.g. to estimate and minimise costs to beneficiary households) and programme implementation (e.g. to estimate staff time allocation to new services added to existing workloads and avoid “knock-on” quality of care issues). This information can aid our understanding of how much (and what kind of) resources are needed to enable effective implementation. It may prove particularly useful when scaling-up programmes. These methods require additional data to be collected, and using this information will require, for example, judgement on staff cost contributions to CMAM (or other new services).

The simple costing method that we used will always produce lower cost estimates than methods that capture and use a more complete set of costs. Care should always be taken when making comparisons between studies using different methods.

The Nigerian CMAM programme, despite failing to meet SPHERE minimum standards for proportions cured and defaulting in the initial years of operation, has saved a considerable number of lives at a reasonable cost per life saved. This information can be used to advocate for continuation and expansion of the existing CMAM programme.

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References

Postscript

Promoting community based management of severe acute malnutrition as a child survival intervention

By Andre Briend

Andre Briend is Adjunct Professor at the Department for International Health, University of Tampere School of Health nutritionists working in poor countries. A key element to make decisions is to consider the potential impact of different interventions and also their cost-effectiveness. In this regard, management of severe acute malnutrition (SAM) stands out as it saves lives, whereas the effect of other interventions is often to marginally increase weight or height gain, with small or immeasurable effects on mortality. This was highlighted by an article of the Lancet series which suggested that SAM management is the most cost-effective nutrition interventions to prevent malnutrition related deaths. These results are important, but should receive confirmation, as the evidence base to support this claim is indirect and arguably weak compared to standards used to evaluate other health interventions. SAM treatment is typically one of these interventions for which a solid evidence base relying on a meta-analysis of a series of randomised controlled trials will never be available. This is a rather common situation in nutrition where waiting for this type of strong evidence is impossible or even unethical. Estimates of the number of deaths prevented by SAM treatment given by the Lancet series are based on observation of mortality reduction in hospital settings with the progressive improvement of treatment protocols and then transfer of these treatment protocols to the community. A Delphi process to obtain consensus on these mortality estimates with and without adequate treatment from key experts was also used in the process. These figures are then applied to current estimates of severe wasting prevalence in different parts of the world to calculate the number of deaths which could be averted. Prevalence data, however, are notoriously inadequate to estimate the burden of acute conditions: children who are acutely ill or malnourished can have died or recovered at the time of a cross sectional survey, and will not be counted, a point which was already noted by Cicely Williams more than 40 years ago.

The paper published in this issue of ENN’s Field Exchange trying to estimate “how many lives do our CMAM programmes save” is an interesting contribution to get evidence of effectiveness of SAM treatment. This paper is based on an approach relying as far as possible on locally obtained data which has been used previously to estimate the cost-effectiveness of community based management of severe acute malnutrition (CMAM) programs in Bangladesh. To estimate the mortality of SAM children in absence of treatment, it relies on historical data of untreated children with a low mid-upper arm circumference (MUAC) adjusted for the level observed on admission in the programme. This approach is preferable, as MUAC is more closely related to mortality than weight-for-height. Also, programme admissions are used to estimate the number of deaths prevented. In the presence of active case finding, this gives a more reliable estimate of the SAM burden than prevalence data used in the Lancet article. Also, the authors used data on background mortality in the country to estimate the excess of deaths which would happen in the absence of treatment, which seems a reasonable approach. Costs of mortality reduction are also based on locally collected data. This is welcome, as these costs, which include staff cost, transport costs, and are influenced by the type of health system, is highly context specific.

The result of this study suggests that CMAM saves lives at a cost of US $274.25 per life (95% CI = US $227.49; US $344.78). There are two ways to use these results. They can be compared directly with other child survival interventions as done by the authors and this shows that CMAM is a cost effective strategy to prevent deaths. This figure can also be compared in pure economic terms with the annual Gross National Product (GDP) of the country, as recommended by WHO. With this approach, cost of a death averted by CMAM is less than the regional GDP and can be regarded as “highly cost-effective”.

The methodology described in this study has clear limitations as it is based on assumptions on mortality which cannot be validated. However, these estimates are the best we can have with currently available data. It is a transparent approach which can be applied to other settings. Replication of this study in other contexts will help to collect more solid evidence on the cost-effectiveness of CMAM treatment. These studies may prove a more powerful advocacy tool at the national level than current global estimates, which are always difficult to apply to the local context.

How many lives do our CMAM programmes save?  
Statistical commentary

By Max O Bachmann

Max Bachmann is Professor of Health Services Research at Norwich Medical School, University of East Anglia, UK

The authors of this study aimed to answer this question by estimating how many children who received CMAM in Nigeria died, then estimating how many of them would have died if they had not received CMAM, then subtracting the first estimate from the second. They then go on to estimate how much CMAM cost for every death averted.

Some readers may be put off by the equations and graphs in the article, but the basic principles are quite simple. The calculations are all based on just seven sets of numbers (called “inputs” or “parameters” in this type of modelling study). The six parameters used to estimate deaths averted are listed in the first column of Table 2. The seventh parameter is the total cost of the CMAM programme.

The results of such a study are uncertain, partly because of uncertainty about the true values of the parameters. Much of the paper – in the section headed “Accounting for uncertainty – A sampling-based approach” – is about how the authors dealt with this “parameter uncertainty”. This method is what health economists call a “probabilistic sensitivity analysis”. In other words, if we don’t know the true value of some parameters, we change their values many times, each time repeating the calculations, then seeing how much the final results vary with repeated sampling. We get a computer to do this, each time sampling from a frequency distribution which we have assumed for each parameter. We can then report the uncertainty about each estimate, conventionally using the 5th and 95th percentiles.

The third column of Table 2, and Figures 2-4, describe the frequency distributions used in this study. As the figures illustrate, the computer will mostly sample numbers near the middle of the distribution, which is where the average or mostly likely value of the parameter lies. Values further away from the middle are sampled less often, because there is reason to believe they are less likely to be true. The only exception is for the proportion of defaulters cured, which for some reason the authors assume has an equal probability of being anywhere between 5% and 20%, but zero probability of being less than 5% or more than 20%. There is no statistical uncertainty about the number treated. The statistical uncertainty about the proportions discharged as cured or defaulting are tiny because of the enormous sample size (almost a million children). I don’t understand the reasoning behind the uncertainties for background mortality and mortality in untreated cases (called σ in Table 2), which does not seem to be based on any statistical principle that I am aware of. In any case, although there is little or no uncertainty about six of the seven parameters used to estimate the numbers of deaths averted, when they are all combined through the various calculations in the model, the confidence interval around the number of deaths averted is quite large, that is, plus or minus 20% of the central estimate.

Commercially available software programmes commonly used by health economists, such as TreeAge, make it easy to do probabilistic sensitivity analyses like this, with the assistance of graphics and menus. However they can be expensive and are more than is really needed for an analysis such as this. The advantages of using open access software such as R are that it is free4 and, as Box 1 shows, quite simple and transparent to anyone who is not put off by simple programming language.

1 In response to this commentary, a footnote marked ** was subsequently added to Table 2 of the article by the authors to explain the basis of their reasoning.
2 R is a programming language and software environment for statistical computing and graphics. R is a GNU project (a free software, mass collaboration project). http://en.wikipedia.org/wiki/GNU_Project

Postscript

Children attending a CMAM programme
The Coverage Project: a national partnership for evaluating CMAM services in Nigeria

By Maureen Gallagher, Saúl Guerrero, Ifeanyi Maduanusi and Diego Macías

Maureen Gallagher is the Senior Nutrition & Health Advisor Action Against Hunger US based in New York. She is a public health specialist with an MSc in Social Policy and Planning specialising in health policy. She has been working in nutrition programming for the last 15 years in Niger, East Timor, Uganda, Chad, DRC, Burma, Sudan and Nigeria.

Saul Guerrero is Director of Operations at Action Against Hunger (ACFUK). Prior to joining ACF, he worked for Valid International Ltd. in the research, development and roll-out of CTC/CMAM. He has worked in over 20 countries in Africa and Asia.

Ifeanyi Maduanusi is a Programme Quality and Accountability Technical Advisor for Action Against Hunger in Nigeria. He led the implementation of most the SQUEACs while he worked as CMAM Deputy Programme Manager for the Coverage Project.

Diego Macías is a Learning Officer for ACF, working on learning outcomes from coverage programmes, including data analysis and qualitative assessments.

The authors would like to thank the participating Federal and States’ authorities, health workers and communities for their commitment to CMAM, support and active participation throughout the Coverage Project. Thanks also to the Coverage Monitoring Network for their technical support. Thank you to UNICEF, Save the Children, Valid International and Centre for Communications Programme in Nigeria for their collaboration as partners of the consortium. The authors would like to acknowledge the contribution of the Children’s Investment Fund Foundation (CIFF) for their support to the Coverage Project and CMAM in Nigeria.

The Severe Acute Malnutrition (SAM) burden in Nigeria is known to be amongst the highest in the world, with over 10% of the global burden, resulting in an estimated 2 million children affected. Since 2009, the Government of Nigeria, with the support of UNICEF, started tackling the problem by piloting Community-based Management of Acute Malnutrition (CMAM) in two Local Government Areas (LGAs), one in Kebbi State and the other in Gombe State. Since then, Nigeria has proven their strong commitment to the fight against SAM, with geographical coverage extending to 91 LGAs in 11 states of the country, including 642 health facilities, as presented in Figure 1. This has also been possible as partners and donors have supported federal and state Ministries of Health (MoH) to institutionalise SAM management as part of regular routine health services. More than 1,000,000 children received treatment between 2009 and mid-2015.1

A large component of this scale up has been possible due to a strong partnership launched between the Children’s Investment Fund Foundation (CIFF), UNICEF and the Government of Nigeria (GoN) in 2013 (see article in this 50th issue of Field Exchange). This also generated the opportunity for comprehensive evaluation and learning about progressively scaling up CMAM services. As a result, another partnership – for assessment and learning of coverage – was formed. ACF, Save the Children and Valid International worked together with UNICEF and MoH to design the Coverage Project, a collaboration in support of evaluation of SAM services funded by CIFF. The project included two key components: 1) Assessment of coverage and 2) Community Mobilisation Pilot Project. The findings, recommendations and lessons learned from the project were brought together in a Learning Review document2. Both project components were undertaken in close consultation and collaboration with the MoH and UNICEF.

Figure 1  Maps highlighting States and LGAs offering CMAM services

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1 ACF (2015). SAM Management in Nigeria: Challenges, Lessons & the Road ahead
The Coverage Project in Nigeria

The Assessment of Coverage component was implemented in two phases. First, a SLEAC\(^1\) was conducted by Valid International to classify coverage of 71 of the 91 LGAs implementing CMAM programming between October 2013 and March 2014, providing an overall picture of the coverage levels of CMAM throughout a high proportion of LGAs. The SLEAC offered a clear view on both the geographical and the direct coverage of CMAM in the region, identifying regions, especially in the northwest, where efforts were needed most. The results are presented in Figure 2.

A national workshop was held with key stakeholders to review findings and identify locations for the second phase of this component. More in depth information on coverage was obtained through 12 Semi Quantitative Evaluation and Access of Coverage (SQUEAC) surveys which were implemented by ACF and Save the Children, with support of the Coverage Monitoring Network (CMN) and Valid International. A practical training was conducted in March 2014, when the first survey was jointly done. Then, Save the Children conducted five surveys in the northwest and ACF conducted six surveys in the northeast. All surveys were completed by December 2015. Key findings of the more in depth analysis provided by the SQUEACs on barriers to access are presented in Figure 3.

Based on SLEAC and SQUEAC findings, which clearly revealed the lack of awareness about SAM and of services available as common barriers to access across states, the Community Mobilisation Pilot Project was developed in partnership with the Centre for Communication Programmes Nigeria (CCPN) in June 2014. The pilot approach for a sensitisation campaign was developed and tested in two LGAs in Sokoto State – Goronyo and Sokoto South LGAs (both had SLEACs conducted in November 2013 and one SQUEAC was conducted in Goronyo in March 2014). The choice of State and LGAs was discussed and agreed between ACF, Save the Children and UNICEF based on common criteria.

UNICEF then supported the visit and introduction of CCPN to Sokoto State. Workshops were held with key stakeholders in the State to explain the goals of the initiative and engage participants in the design of the awareness strategy and tools. The campaign was implemented by Hikima Community Mobilisation and Development Initiative (HCOMDI), a local grassroots organisation. During the four months of the campaign (October 2014 - Jan 2015), over 110 community dialogues, 300 household visits and active case-finding activities were delivered with the support of community volunteers and involvement of key stakeholders of the outreach area; about 32,000 people are estimated to have been reached during the campaign. In order to measure the impact of the approach and compare it between LGAs, end line SQUEACs were conducted in both LGAs in February 2015. The results of the pilot project are presented in Box 1.

A final workshop was held mid-March 2015 in order to present the SQUEAC and pilot project results, as well as to engage key stakeholders on next steps and recommendations in order to strengthen key findings. Directors of Primary Health Care (PHC), State Nutrition Officers (SNO) from the 11 states and FMOH Nutrition Department members attended the workshop and shaped key recommended actions. A summary of actions proposed by the Directors, SNOs, and other partners to tackle the key challenges revealed by the coverage assessments is presented in Box 2.

Lessons learned for SAM scale up in Nigeria

The Learning Review – SAM Management in Nigeria: Challenges, Lessons & the Road Ahead\(^2\) outlines the current state of SAM in Nigeria, provides the detailed in depth analysis and results of the coverage assessment, the outcomes of the pilot project and the recommendations for improving SAM in Nigeria. It was revised and agreed on by all partners of the project. Some of the key lessons learned from the Coverage project, pulled together from multiple streams – including the comprehensive SAM context analysis, coverage assessments, pilot project and workshop inputs – and reflected in the learning review are outlined below.

1. Two out of every three SAM cases in North Nigeria are not accessing treatment. Recent surveys carried out by the SLEAC of 2013-14 suggest that CMAM services across the 11 northern states are reaching an estimated 36.6 per cent of SAM cases.
2. SAM management services are located in states with the greatest need, but the spread of services within those states remains limited. Most states only offer SAM treat-
Box 1 Community mobilisation pilot project results

- Admissions. In both LGAs, the admissions between September and December 2014 were higher in proportion to total yearly admissions compared to the earlier part of the year (41% in Goronyo and 40.6% in Sokoto South). Seasonality did not affect admission rates in this case, as the lean season is between May and August, which would have led to higher admissions during that part of the year rather than Sept-Dec and/or Jan-April.
- Barriers to access. The study demonstrated that barriers can be positively tackled. In Goronyo, awareness related barriers (about malnutrition, the ongoing programme and/or how the programme works) accounted for 71% of the reasons provided by all non-covered cases for not accessing services prior to the campaign. This proportion reduced to 48% after the campaign. Whilst this is based on a small sample, it does suggest that targeted campaigns can have a measurable impact on awareness related barriers. As a result of the decrease in awareness related barriers reported, two other key barriers were more widely reported – quality of service delivery (including stock outs) and constraints faced by the mother (opportunity costs, money for transport). This suggests that addressing awareness is effective yet not sufficient to increase coverage alone as other barriers become more prominent.
- Coverage. Estimated coverage levels did not significantly change between baseline and endline. Sokoto South’s level indicated slight improvement in comparison to the SLEAC (below 20%), whereas Goronyo (14.7%) did not reflect meaningful changes*. This is likely to have been due to a combination of wide confidence intervals but also because other barriers became more prominent, indicating that all barriers need to be addressed at the same time to result in increased coverage.

Box 2 Key actions proposed by stakeholder to tackle main barriers to increasing coverage of CMAM in Northern Nigeria

1) Innovative awareness-raising method
   - Diversify groups and locations for meetings: community dialogues, social, town hall, compound and household meetings
   - Diversify key stakeholders involved: include community & religious leaders, traditional birth attendants (TBAs), school teachers and students
   - Use of community based organisations (CBOs) and existing support groups
   - Use of media, mobile phones/SMS, IEC (information, education & communication) materials to sensitise the public
   - Community action-oriented activities such as: local dramas, local songs, food demonstrations, community nutrition champions

2) Resource learning to institutionalise CMAM and scale up
   - Evidence-based advocacy and sensitisation to engage philanthropists, policy makers, and first ladies to support CMAM, at all levels
   - Include nutrition and CMAM into state budget / Costed Nutrition Plans and timely release of funds
   - Engage in public-private partnership to support nutrition and CMAM
   - Collaborate with other projects such as Millennium Development Goals Fund projects and Maternal Child Health initiatives
   - Reactivate and strengthen committees for food and nutrition for resource mobilisation

3) Strengthen adherence to national protocol
   - Increasing number of health workers trained and refresher training on national protocol and its application
   - Continuous training of community volunteers on detection and referral
   - Routine and supportive supervision by the State MoH teams
   - Engage trained and skilled community health extension workers for management of SAM

4) Improve data quality
   - Strengthen capacity of service providers on data collection, management and analysis and M&E systems
   - Timely supportive supervision, on-site monitoring, dissemination and feedback at all levels (consider the use real time monitoring through smart phones)
   - Verification and validation of data, including data quality assessments
   - Provision of a central databank for nutrition programmes

5) Strengthen community volunteer (CV) network
   - Training and retraining of CVs with regular meetings and experience sharing with health workers
   - Strengthen CVs to support outpatient activities in the communities (screening, tracing of defaulters, referral and home visits)
   - Performance awards for motivated and engaged CVs
   - Motivation and incentives schemes should be considered for CVs

The Coverage project and a key output in the form a learning review has been a positive joint partner initiative to work in support of the GoN to further advance and succeed in their fight against SAM. Key next steps will involve close follow-up of application of recommendations and monitoring of coverage for further strengthening CMAM in Nigeria.

For more information, contact: Maureen Gallagher, email: mgallagher@actionagainsthunger.org

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* The first programme SQUEAC took place precisely in Goronyo and its coverage estimate was 13.3%. In the SLEAC in late 2013, the LGA had an estimated coverage of 0.5%.

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* See footnote 2
Costs, cost-effectiveness, and financial sustainability of CMAM in Northern Nigeria

By Sasha Frankel, Mark Roland and Marty Makinen

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Marty Makinen is a Managing Director at the Results for Development Institute. He is a health economist with more than 30 years of experience and has worked extensively in the areas of health financing and the economics of nutrition.

Results for Development Institute (R4D) was supported by consultants Joel Lehmann – who provided technical support to the study and instrument design, as well as training and field supervision – and Bryan Plummer, who assisted in data cleaning and analysis. For on-the-ground data collection, R4D worked with Binomial Optimus Limited (BOL), an evaluation firm based in Abuja, Nigeria. BOL co-managed the data collection effort, including recruitment, training, and supervision of enumerators. Initial instrument development was supported by Health Systems Consult, Ltd. This analysis was made possible thanks to the support of the Children’s Investment Fund Foundation (CIFF). The report benefited from strong technical guidance from a number of counterparts at CIFF, in particular Amy Mayberry.

Background

To date, the evidence on the efficacy and cost-effectiveness of CMAM has been encouraging. Previous studies suggest that CMAM can reduce the cost and barriers to access associated with inpatient care, and in certain contexts, reduce mortality. This study1 provides an estimate of the cost, cost-effectiveness, and financial sustainability of the CMAM programme in northern Nigeria based on data collected in four states.

This information is intended to equip government, external financers, and programme implementers with data to inform decisions around programmatic expansion. Cost and financial sustainability data will allow the Nigerian government, at both the federal and state levels, to understand what financial actions must be taken to ensure that sufficient resources are directed toward the CMAM programme. Cost-effectiveness data can help policymakers understand the value of their investments in CMAM relative to alternatives and provide evidence to help make the argument for appropriate budgetary commitments.

Methodology

The categorisation of costs varies across similar studies conducted to date2, as do the methods used to collect cost information. This study uses a “bottom-up” methodology, in which data about cost line items were gathered through facility-level interviews rather than relying upon existing budgets/programmatic reporting. As a result, this study appears to have assembled a more robust and comprehensive estimate of costs associated with obtaining CMAM treatment (through inclusion of items not found in official CMAM budgets, such as proportion of facility overhead costs).

Economic vs. financial costs

Total cost per child cured includes several cost components that can be categorised as either financial or economic. Financial costs or cash outlays are those that support the functioning of the CMAM programme and economic costs are costs

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2 Cost per child cured in other examined studies are as follows: Ethiopia: $135 (Tekeste et al), Malawi: $169 (Wilford et al), Bangladesh: $180 (Puett et al), Zambia: $203 (Bachmann), Indonesia: $332 (Purwesti), Ghana: $805 (Abdul-Latif)
Table 1 Economic and financial costs collected

<table>
<thead>
<tr>
<th>Economic costs</th>
<th>Financial costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff time not paid for by CMAM, caregiver time, user fees, use of health facilities, community volunteer time and costs</td>
<td>Cash outlays for drugs, materials for CMAM programme administration, resources for trainings and monitoring visits, supply chain activities involved in managing the CMAM drugs and materials, transportation, RUTF, stipends for the CV, salaries of CMAM-specific health workers</td>
</tr>
</tbody>
</table>

Table 2 Organisation level and associated cost elements elicited from survey instrument

<table>
<thead>
<tr>
<th>Organisational level</th>
<th>Cost elements collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNICEF</td>
<td>Staff time, monitoring, RUTF, supply chain, training, start-up equipment</td>
</tr>
<tr>
<td>State Nutrition Officer</td>
<td>Staff time, monitoring, supply chain, CMAM drugs, MIS tools, miscellaneous CMAM costs</td>
</tr>
<tr>
<td>Local Government Authority (LGA) Nutrition Officer</td>
<td>Staff time, monitoring, supply chain, CMAM drugs, MIS tools, miscellaneous CMAM costs</td>
</tr>
<tr>
<td>Stabilisation Centre (SC) Health Worker</td>
<td>Staff time, drugs, overhead</td>
</tr>
<tr>
<td>Caregiver at SC</td>
<td>Transportation, opportunity cost, out-of-pocket expenditures</td>
</tr>
<tr>
<td>Outpatient Therapeutic Programme (OTP) Health Worker</td>
<td>Staff time, drugs, number of RUTF used, overhead</td>
</tr>
<tr>
<td>Caregiver at OTP</td>
<td>Transportation, opportunity cost, out-of-pocket expenditures</td>
</tr>
<tr>
<td>Community Volunteer (CV)</td>
<td>Transportation, opportunity cost, stipend</td>
</tr>
</tbody>
</table>

Table 3 Number of surveys completed and average surveys per facility by cost centre and cost collection wave

<table>
<thead>
<tr>
<th>Wave</th>
<th>Total</th>
<th>Per facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wave 1</td>
<td>89</td>
<td>7.4</td>
</tr>
<tr>
<td>Wave 2</td>
<td>102</td>
<td>8.5</td>
</tr>
<tr>
<td>Wave 3</td>
<td>101</td>
<td>8.4</td>
</tr>
<tr>
<td>Wave 4</td>
<td>104</td>
<td>8.7</td>
</tr>
<tr>
<td>Total Across all Waves</td>
<td>396</td>
<td></td>
</tr>
</tbody>
</table>

Table 4 CMAM costs by type of cost

<table>
<thead>
<tr>
<th>Cost type</th>
<th>Cost per child cured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff time</td>
<td>$74.28</td>
</tr>
<tr>
<td>RUTF</td>
<td>$76.06</td>
</tr>
<tr>
<td>Out-of-pocket costs</td>
<td>$33.98</td>
</tr>
<tr>
<td>Opportunity cost(^3)</td>
<td>$7.08</td>
</tr>
<tr>
<td>CMAM drugs</td>
<td>$9.24</td>
</tr>
<tr>
<td>Monitoring</td>
<td>$1.34</td>
</tr>
<tr>
<td>Supply chain</td>
<td>$11.17</td>
</tr>
<tr>
<td>Other CMAM</td>
<td>$0.47</td>
</tr>
<tr>
<td>Management Information System (MIS) tools</td>
<td>$0.48</td>
</tr>
<tr>
<td>Overhead</td>
<td>$4.27</td>
</tr>
<tr>
<td>Training</td>
<td>$0.80</td>
</tr>
</tbody>
</table>

Borne by the economy as a whole (including opportunity cost). Examples of both types of costs can be found in Table 1. Inclusion of both financial and economic costs in costing analyses is crucial to understand the full cost of the programme. Financial costs only are used for the cost-effectiveness and fiscal space analysis to represent the estimated cost to government and UNICEF in this scenario.

Study design and settings

Costs were observed at eight organisational levels and specific survey instruments were then developed for each level to elicit relevant cost information. Table 2 lists each of them, along with the cost elements collected.

Table 3

Sampling

Four of the eleven CMAM states in northern Nigeria were selected for the study: Bauchi, Jigawa, Sokoto and Kano, with security being a primary criterion for selection. Data were collected in four waves, conducted quarterly from 2013-2014 to take into account seasonal variations (see Table 3). Within each state, three of the LGAs where CMAM services are delivered were randomly sampled to participate in the survey. Within each LGA there are multiple OTPs, one of which was selected at random to participate in the study. A total of 25 different LGAs, 25 SCs, and 40 OTPs participated in the study across the four waves.

Data collectors used the survey instrument to interview a focal person in each state, LGA, OTP, and SC, so for each wave there were a total of four respondents at the state level, and 12 at each LGA, OTP, and SC level. At the state level, the focal person was typically the State Nutrition Officer (SNO), although in a few cases, when the SNO was unavailable, the Assistant SNO or the Community Health Officer was interviewed. At the LGA level, the Nutrition Focal Person or their deputy were interviewed. At the OTP, data collectors identified the health workers most directly involved with provision of CMAM services. If that person was unavailable, the next most senior person at the OTP was interviewed. At the SC, the CMAM focal person was interviewed.

Results

Costs

Cost per child cured. The cost per child cured estimate includes all costs collected from organisational levels, both economic and financial costs, as well as costs associated with SAM patients who either died or defaulted, meaning they did not complete treatment. Our findings show that for every 1,000 children who complete treatment, 17 children die and 254 default on average across the four states.

The comprehensive average cost per child cured\(^4\) is $219, of which $160 (73%) are financial costs borne by the government and UNICEF and $59 (27%) are economic costs. This cost was predominantly driven by RUTF, staff, and out-of-pocket costs, which together comprise more than 85% of total costs (see Table 4). RUTF constitutes the single largest share of total costs: for every child cured, $76 worth of RUTF was needed. Of nearly identical magnitude were staff costs, which comprise 34% ($74 dollars per child cured). Staff costs were drawn from salaried and non-salaried actors, with non-salaried CVs accounting for almost a third of staff costs through stipend, transportation and opportunity costs. The remaining 15% of costs are comprised of opportunity costs, supply chain, drugs, monitoring, overhead, and training costs.

Staff costs by type. Staff costs, which are the second largest driver of costs, were drawn from salaried and non-salaried actors. Non-salaried community volunteers account for nearly a third of staff costs, which includes opportunity cost, stipend and transportation for the CVs (see Figure 1).

Cost per child by state. It is important to highlight that costs per child cured varied across states, from $175 in Jigawa and Kano to $273 in Sokoto, reflecting a range of contexts in which the programme is operating\(^5\) (see Figure 2). Although Sokoto’s annual costs are the second-lowest among all states, the number of children reported to be cured in those OTPs is less than half as many as in the other OTPs. The number of RUTF issued per patients cured is also highest in Sokoto (133 sachets in Sokoto compared to 115 on average across the other states). This means that more patients default and die per patient cured in Sokoto than in other states, so for every one patient cured, the OTPs give out relatively more RUTF – including to patients who are not getting cured – which may contribute to Sokoto’s higher costs. Sokoto had similar cure rates to the other states and did not have the highest rate of defaulters. However, it had the highest rate of deaths per 1,000 admissions at 25 compared to 8, 17, and 19 in Bauchi, Kano, and Jigawa respectively. However, RUTF

\(^3\) Opportunity cost was calculated through self-reported proportion of time spent on CMAM activities and self-reported income by caregivers.

\(^4\) Cost per child cured by state is as follows: Bauchi $188, Jigawa $179, Kano $175, and Sokoto $273.
Table 5 Financial implications of base and scale-up scenarios

<table>
<thead>
<tr>
<th>State</th>
<th>OTP sites</th>
<th>Caseload</th>
<th>Total cost</th>
<th>% national health budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base scenario</td>
<td>633</td>
<td>320,247</td>
<td>$36,813,175</td>
<td>2.3%</td>
</tr>
<tr>
<td>25% increase</td>
<td>791</td>
<td>400,309</td>
<td>$46,016,469</td>
<td>2.9%</td>
</tr>
<tr>
<td>50% increase</td>
<td>949</td>
<td>480,371</td>
<td>$55,219,763</td>
<td>3.5%</td>
</tr>
</tbody>
</table>

Cost effectiveness

The financial costs described above were used for the cost-effectiveness analysis to estimate the cost to government and donors to deliver treatment. CMAM treatment in the four states included in this study was estimated to cost $1,117 per death averted7 and $30 per Disability-Adjusted Life Year (DALY) gained8, which situates it favourably among existing literature that calculates CMAM cost per death averted. In calculating cost per death averted, a 15.7% mortality reduction for those cured is estimated, based on Bachmann 20099, but adjusting for Nigeria’s implied untreated death rate (18.5%) and background mortality rate (2.9%). Cost per death averted ($219) is considerably higher than cost per death cured since not every child cured would have died; SAM may incapacitate or otherwise disable those who do not die.

The WHO deems interventions where cost per death averted is below GDP per capita as highly cost-effective; cost-effective if between one and three times GDP per capita, and not cost-effective if more than three times GDP per capita10. In 2014, average GDP per capita in Nigeria was approximately $3,000, suggesting that the CMAM intervention is highly cost-effective11. Perhaps more importantly, GDP per capita in the four states where the study was conducted ranged from $983 in Bauchi to $1,274 in Sokoto12, further suggesting CMAM is cost-effective in Northern Nigeria.

Financial sustainability analysis

The average total financial cost of CMAM to scale up will be up to $160 per child cured. For an average OTP site, with over 500 admissions and 360 children cured per year13, estimated cost is $58,157 per year. From this, we can estimate that the total financing needed to support an average LGA with five OTPs would be approximately $290,783. While these costs are not insignificant, they are affordable. As of March 2015, CMAM is functioning in 633 OTPs in 97 LGAs, yielding a total cost of $36,813,175, which represents 2.3% of the 2014 national health budget14 and $20 per capita. As Nigeria looks forward to the future of the CMAM programme and potential scale-up to meet the unmet burden, it is important to understand the financial implications. Scale-up scenarios to cover up to nearly half a million children per year are detailed in Table 5.

Financial sustainability thresholds developed by RAND suggest that, while the costs are by no means crippling relative to available domestic resources (especially in light of the potential number of lives saved), concerted effort should nevertheless be paid to the financial sustainability of the CMAM programme.

Discussion

At $219, the cost per child cured in the CMAM programme is comparable to cost estimates in other studies. Other studies do not necessarily include the costs of community volunteers and most rely upon programme budgets, which have the effect of producing lower cost estimates, making the estimate for this study even more encouraging.

Costs associated with community volunteers are responsible for approximately 10% of total costs, and 30% of all staff time costs. The costs of community volunteers relate to their opportunity cost, i.e. the economic value of their time and their implicit lost wages. While CVs contribute significantly to the economic costs, not all of these costs are actually compensated. As a result, care should be taken to ensure that an adequate supply of quality CVs continue, given that compensation does not match the true economic value of their contributions. Qualitative data from the evaluation support the idea that some diminution of interest over time on the part of CVs is present.

While the financial sustainability numbers suggest that fiscal space constraints should be considered, the low programmatic costs and encouraging cost-effectiveness estimates indicate high value for money, especially relative to other potential health investments. As such, the case for further investment in the programme is a compelling one.

Figure 1 Staff costs by type

Figure 2 Cost per child cured by state

RUTF is the major cost driver for the CMAM programme, comprising approximately 35% of total costs and close to 50% of financial costs. As such, some investment in strategies to reduce RUTF costs could prove worthwhile. Sensitivity analysis is illustrative insofar as it reveals how reductions in the cost of RUTF can provide moderate savings. For example, a 25% reduction in the cost of RUTF would provide a savings of $16, or 7%, of the total cost per child treated. Additionally, efforts to increase the effectiveness and maximise efficiencies in the programme could also reduce total costs.


All figures in 2010 USD, http://services.gov.ng/states accessed 4/23/15

This assumes a 72% cure rate found in the sites where data was collected.

This calculation uses the 2014 Appropriations Bill which establishes a FMoH Budget of 262,742,351,874 Naira. We use an exchange rate of 167 Naira per dollar.