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Full Length Research Paper

Long term mortality after community and facility based treatment of severe acute malnutrition: Analysis of data from Bangladesh, Kenya, Malawi and Niger

Paluku Bahwere[1,3]*, Angella Mtimuni[3], Kate Sadler[2,3], Theresa Banda[3] and Steve Collins[3]

[1]Centre of Research in Epidemiology, Biostatistics and Clinical Research, Free University of Brussels, Brussels, Belgium
[2]Feinstein International Center, Tufts University, Medford, MA 02155, United State
[3]Valid International, 35 Leopold Street, Oxford, OX4 1TW, United Kingdom.

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The effectiveness of the community based therapeutic care (CTC) in treating severe acute malnutrition (SAM) has been demonstrated. However, there is still resistance from some policy makers and donors to invest into this cost-effective intervention. The mortality rate ratio (MRR) calculated by dividing the observed deaths after discharge by expected deaths was used to compare survival of 1,670 children discharged from the Dowa CTC from August 2002 to May 2005 and that of other cohorts reporting on long term survival of children after treatment of SAM retrieved from literature. A MMR of 1.1 (0.9 to 1.4) was observed for the Dowa CTC cohort while the MMR of 2.7 (1.3 to 4.9), 5.5 (3.9 to 7.6) and 20.0 (11.0 to 33.4) were observed for studies retrieved from the literature. Data showed that the survival of children who defaulted was worse than that of those who were discharged cured, and that of children treated at home after stabilisation or directly was better than those treated as inpatient until exit from the programme. The study outlines the need of using MMR when reporting on long term survival after SAM treatment and suggests that CTC should be included in the package of interventions with high potential for accelerating the progress towards reaching Millennium Developmental Goal four.

Key words: Severe acute malnutrition, children, long term, survival, mortality ratio.

INTRODUCTION

It is estimated that in 2007, 9.3 million under-five children died and 93% of these deaths occurred in Asia or Africa (UNICEF, 2008). This situation is regarded as unacceptable and the Millennium Development Goal 4 (MDG-4) focuses on reducing this mortality by two-thirds between 1990 and 2015 (Mittelmark, 2009; World Bank, 2004). Although, since the 1990s, progress has undoubtedly been made towards this objective, the 9.3 million deaths that occurred in 2007 show that under-five mortality remains unacceptably high (Accorsi et al., 2010; Freeman et al., 2009; You et al., 2010). Indeed, most of the low income countries are not on track to meet the MDG-4 (Accorsi et al., 2010; You et al., 2010); and as of 2008, overall, the decrease in under-five mortality in Africa (22% reduction), Middle East and North Africa (44% reduction) and South Asia (39% reduction) is not on track (Accorsi et al., 2010; You et al., 2010).

Malnutrition is recognized as a major public-health problem throughout the developing world and is an

*Corresponding author. E-mail: paluku@validinternational.org. Tel: +3226522641/+32473199253.

Abbreviations: CTC, Community based therapeutic care; **DHS,** demographic and health surveys; **HC,** health centre; **MICS,** multiple indicators cluster survey; **MMR,** mortality rate ratio; **MUAC,** mid upper arm circumference; **NCHS,** national center for health statistics; **SAM,** severe acute malnutrition; **SMR,** standardized mortality ratio.

underlying factor in over 50% of the deaths in under-five children (Collins et al., 2006a; 2007; Pelletier et al., 1993; Pelletier, 1994). However, while the child-survival movement commonly acknowledges the importance of undernutrition, the importance of severe acute malnutrition (SAM) was not well recognized until recently, when a review published in the Lancet highlighted the important contribution of SAM to mortality of under-five children from low income countries (Collins et al., 2006a). The paper demonstrated that SAM is one of the major contributors to under-five mortality for which cost-effective interventions exist (Collins et al., 2006a). The introduction of CTC has recently further improved this cost-effectiveness (Collins et al., 2006b, WHO et al., 2007). CTC allows a reduction of the institutional and caretakers' opportunity costs, and increases coverage and improves the outcomes for children. With this approach, all the indicators are largely better than the minimum SPHERE standards of >75% cure rate, <10% mortality rate and <15% defaulter rate (Collins et al., 2006a, b; WHO et al., 2007).

Although the information available on the cost-effectiveness of therapeutic feeding centres, and especially community-based management approaches, is sufficient to justify the inclusion of the management of SAM in the child survival strategy, there is still resistance from some policy makers and donors to invest into this intervention (Collins et al., 2006a, b; Bachmann, 2009; Jha et al., 1998). A commonly cited reason behind this resistance is the supposed persistence of a high risk of mortality after recovery from SAM once the patient has exited the treatment programme (Ashworth, 2006). Data on the longer term mortality associated with discharge from inpatient therapeutic feeding centres is variable; some studies have reported a cumulative mortality rate of 1 to 1.5 years after discharge of up to 41% (Ashworth, 2006; Chapko et al., 1994; Pecoul et al., 1992; Reneman and Derwig, 1997; Roosmalen-Wiebenga et al., 1987), whilst others have reported lower figures of 2.3% after 12 months of follow up, and 4.1% after 1.5 years of follow up (Bahwere et al., 2008; Khanum et al., 1998). An earlier study reported a mortality of 1.5%, 12 months after discharge among children treated using the domiciliary approach (Khanum et al., 1998).

None of these studies assess the reasons behind the high mortality after discharge from therapeutic feeding programmes, nor do they examine how post-discharge mortality compares with the mortality rate of children in the same community. Given the strong association between high childhood mortality, poverty and SAM, it may be that baseline mortality rates partly explain both the observed high post discharge mortality and the study-to-study variation in this mortality. The present study was conducted to describe the post discharge mortality after graduation from a CTC programme, and to compare this with the observed baseline mortality in the local population. A standardized mortality ratio (MMR) for other studies reporting on long term survival has also been made.

MATERIALS AND METHODS

Four cohorts reporting on long term survival of children discharged from therapeutic feeding programmes have been used in the present paper including the cohorts of children we retrospectively surveyed in Dowa, Malawi (main data used for this paper) and three cohorts from papers retrieved during a literature search.

Description of the cohort of children discharged from Dowa *community* based *therapeutic* care

In a cross-sectional study, 1670 children discharged from the Dowa CTC from August 2002 to May 2005 (retrospective cohort) were followed up to ascertain vital status on average 15.5 months after discharge. Admission and discharge criteria used during this research have been extensively described elsewhere (Bahwere et al., 2008). In summary, the therapeutic feeding programme admitted any children under 5 years of age with SAM; defined as presence of bilateral pitting oedema, a mid-up arm circumference (MUAC) <110 mm or a weight for height <70% of the median of NCHS curves. Children were discharged cured if they had no oedema for 2 consecutive weeks and had a weight for height >80% of the NCHS curve and MUAC >110 mm (Bahwere et al., 2008). No particular follow up or intervention was provided after discharge from the therapeutic programme.

Description of cohorts from papers identified through a literature search

To strengthen our findings, a review of the literature was carried out. A literature search in Medline and Google scholar without period restriction was conducted using the term "protein energy malnutrition", "protein caloric malnutrition", "severe malnutrition", "marasmus", "kwashiorkor", "mortality" and "after recovery", "post-discharge" or "long term" Eight studies examining post-discharge mortality were retrieved (Chapko et al., 1994; Pecoul et al., 1992; Reneman and Derwig, 1997; Roosmalen-Wiebenga et al., 1987; Khanum et al., 1998; Kerac, 2010, Hennart et al., 1987; Keet et al., 1971) but five studies were excluded either because the definition of SAM was different from what is currently used (n = 2) or because of incomplete data for the calculation of the incidence of deaths (n = 3) (Chapko et al., 1994; Roosmalen-Wiebenga et al., 1987; Kerac, 2010; Hennart et al., 1987; Keet et al., 1971). Among those included in this paper, the first study was carried out in Tahoua, a region of Niger. In this study, a cohort of 210 children discharged from a therapeutic feeding centre was followed up around 3 months after discharge (Pecoul et al., 1992). The second cohort, from a study conducted in Kenya in Mumais district, followed up 39 of 50 eligible children around 18 months after discharge from a therapeutic feeding centre (Reneman and Derwig, 1997). The third cohort is from a study conducted in Bangladesh that included 400 children who graduated from a research programme that compared 3 different approaches for managing severe acute malnutrition namely inpatient (n = 150), day care (n = 128) and domiciliary (n = 122) approaches (Khanum et al., 1998). Treatment of SAM followed the facility-based approach (inpatient) for the first two mentioned studies, the third study had two sub-cohorts of children treated using the facility based approach (inpatient and day care) and a sub-cohort for which the community based approach was used (domiciliary).

Calculation of mortality rates and of years of observations for the Dowa study

Baseline mortality is defined in this study as: "the mortality rate of children aged one to four years (4q1MR), of the general one to four years children population of the district or region in which study children were recruited at the time of the cohort follow up." The conversion of the baseline mortality from 4q1MR, expressed per 1000 live births (LB) as in the Demographic Health Survey (DHS) or Multiple Indicator Cluster Survey (MICS), to a baseline 4q1MR expressed in person-years 4q1MPY was done using the procedure recommended by the Interagency Group for Child Mortality Estimation (IGME) (IGME, 2006). This equation enables estimation of the number of deaths in a particular year by applying the mortality rate expressed per 1000 live births to the estimate of the number of births in that year corrected for age of the children that died and the birth rate.

(a) We first calculated the one to 4 years mortality rate (4q1MR) as:

4q1 deaths = Births *4q1MR* constant Kt,

Where Births is the number of births for the year, 4q1MR the mortality rate for children 1 to four years obtained from DHS for the period covering the year and Kt the constant correcting for the rate of growth and the pattern of mortality obtained from life tables. The formula for calculating K_t is:

$K_t = (a_f + b_f * r_b)/100000$

Where a_f and b_f are constant from life table of the Coale-Demeny family describing the underlying pattern of child mortality and r_b is the growth rate of the population.

(b) Then we calculated the 4q1 mortality per person-years (4q1MPY) as:

4q1MPY = (4q1 deaths*1000)/[total number of 4q1 children + (0.5*total number of births of the year) - (0.5*number of 4q1deaths in the year)] (IGME, 2006).

For the Dowa study, we used the Ministry of Health Malawi figures of the births and the number of 4q1 children for the year 2005 was calculated, using data from the 2008 population and housing census. To calculate the constant Kt, we used the population growth rate for Dowa published in the 2008 population and housing census of 3.1% for the period 1998 to 2008, and the North Coale-Demeny Family (Ekanem and Som, 1984; National Statistics Office, 2009).
The years of observation (YO) of each child was calculated using the date of assessment (DA) and the date of discharge from the outpatient programme (OTP) as:

$$LOFy = \frac{DA - DOTP}{365.24}$$

For children confirmed alive during the community outreach that accompanied this study, and for whom the invitation to re-attend the clinic for assessment was delivered to the parents, the date of assessment was the date the health centre (HC) they attended was surveyed. For children who died after discharge, the date of assessment was replaced in the formula by the date of death obtained during verbal autopsy. When the date of death was not obtained, we considered that the dead child was alive for half of the time between the date of discharge from OTP and the date the HC she/he attended was surveyed. For children for whom it was difficult to ascertain the status because the families had moved out of Dowa district, we considered that they were alive for half of the time between the date of discharge from OTP and the date of survey of the HC they attended.

Standardized *mortality ratio* of studies from the literature

The calculation of the incidence of deaths used the approach described earlier for the Dowa study. For the calculation, we used 4q1MR per 1000 live births obtained from DHS or other relevant papers, the number of one to four years children and infants in the region or the health district obtained from DHS or published reports, and the relevant population growth rate obtained from DHS and MICS reports. For the Khanum et al. (1998) study, we used the children mortality obtained from the 1994 Bangladesh DHS that gave an average probability of death for Dhaka children of 1 to 4 years for the 10 years preceding the 1993 to 1994 survey of 43.8 per 1000 LB. For the Pecoul et al. (1992) study, the figure was obtained from the 1992 Niger DHS that revealed that children aged 1 to 4 years of Tahoua had a probability of death of 226.5 per 1000 LB. For the Reneman and Derwig (1997) study, we used children probability of death between 1 and 4 years of children of the Western province reported in the 1998 Kenya DHS of 62.5 per 1000 LB.

The number of years of observation necessary for the calculation of the incidence of deaths was calculated based on the information provided in the papers. For the study by Pecoul et al. (1992), we used the number of days of follow up provided by the authors to calculate the total number of years of follow up (Pecoul et al., 1992). For the study by Khanum et al. (1998), we considered that all the children who completed the follow up period, including those excluded in their analysis for an insufficient number of visits were under follow up for a full year (Khanum et al., 1998). We considered that those who died contributed for half a year each (Khanum et al., 1998). For the study by Reneman and Derwig (1997), we used the mean follow up time provided by the authors of 1.5 years.

Calculation of mortality rate ratio (MRR)

The mortality rate ratio was calculated according to a standard formula by dividing the observed deaths (O) in the cohort followed up after discharge by the number of deaths expected (E) using the mortality rate of children from the general population aged between one and four years as the standard population (Breslow and Day, 1987). Available data could not provide age specific mortality rate for the age groups of 6 to 11 months, 12 to 23 months, 24 to 35 months and 36 to 59 months. DHS and MICS only provide age specific mortality for the <1 month, 12 months and 12 to 59 months age groups. Thus, we used the reported mortality of the one to four years age group (without further stratification). Because of using the broad age group of one to four years for the standard rate to apply to our population, the estimate could not be considered as a standardized mortality rate (SMR) but confidence interval and p-value were calculated using statistics recommended for SMR (Breslow and Day, 1987a).

The number of deaths expected was obtained using the following formula: $E = 4q1MPY^*\Sigma LOF_y$, where E = the expected number of deaths for the cohorts and ΣLOF_y = the sum of years of follow up of the cohort of children. The results of the calculation are shown in Table 1. The number of observed deaths was calculated for the study cohort as a whole and for sub-cohorts according to type of exit from the therapeutic feeding programme (cured, defaulted, others) and therapeutic feeding approach used (inpatient, community based, day care).

Table 1. Published baseline mortality rate and calculated incidence mortality rate for the study districts or regions.

Authors, year of publication	Country/ disctrict or region	Year	Reported 4q1MR / 1000 LB†	Calculated 4q1MPY /1000 PY‡
Pecoul et al. (1992)	Niger, Tahoua	1988	226.5	75.82
Khanum et al. (1998)	Bangladesh, Dhaka	1991	43.8	9.4
Reneman and Derwig (1997)	Kenya, Mumais	1994	62.5	11.88
Present study	Malawi, Dowa	2005	76.0	31.07

† Probability of dying between the age of 1 and 4 years per 1000 live births; ‡ incidence of deaths among children of 1 to 4 years per children-years.

Choice of the standard population

Ideally, we would have compared the observed mortality in the surveyed cohort with that of children with a similar mortality risk profile but that had never been treated for severe acute malnutrition (Jones and Swerdlow, 1998). However, such data are not readily available and it is often challenging and very costly to collect such data (Jones and Swerdlow, 1998). Thus, we opted for the use of the general population as the standard as is commonly done in epidemiological and demographic studies, including in industrialized countries (Breslow and Day, 1987a; Jones and Swerdlow, 1998; Ackers et al. , 2011; Crook et al., 2003; Datiko and Lindtjorn, 2010; Jones et al., 2011; Kamper-Jorgensen et al., 2008; Reulen et al., 2010; Secrest et al., 2010; Symmons et al., 1998; Trombert-Paviot et al., 2008; Wilson et al., 2010; Brinkhof et al., 2009).

Statistics

We used proportions to describe the data. The MMR between observed and expected deaths and their 95% confidence intervals were calculated using the approach and statistics proposed by Breslow (Breslow and Day, 1987b). The test of Breslow and Day (1987b) and Samuels et al. (1991) were used to determine if the MMR was significantly different from 1 when the expected number of deaths was above or less than 10, respectively. A p-value < 0.05 was considered significant.

Ethics

Written informed consent was obtained from all study caregivers, usually the mother. The study protocol was approved by the College of Medicine Research and Ethics Committee in Malawi.

RESULTS

Based on the equation presented earlier, and using the 2005 estimation for Dowa of one to four years age population, births and population growth rate of 73093 children, 36853 births and 3.1% respectively, the incidence of deaths in 2005 was approximately 31.07 deaths per 1000 PY.

For the Dowa CTC study, out of the 1783 children discharged from discharged from the programme residing in the catchment area targeted for the follow up, 1670 could be traced and were followed up. The remaining 113 gave a wrong address and were excluded because they were probably from outside Dowa district. Table 2 describes gender and the age of the children we followed up. There were more females than males (Table 2). The majority were between the ages of 1 and 4 years at admission as well as at discharge and follow up (Table 2).

The 1670 children of Dowa study cohort followed up contributed to 2,013 person-years of observation during which 69 deaths occurred. This corresponds to proportion of death and an incidence of deaths of 4.1% and 34.3 per 1000 PY, respectively (Table 3). As shown in Table 3, 4q1MPY differed significantly according to the condition at exit from the programme. Children discharged having met the nutritional criteria for discharge, had lower 4q1MPY than those who defaulted ($p < 0.001$). During the period of the study, the 4q1MPY of children discharged from the CTC programme was not significantly different to the baseline 4q1MPY of 31.07 deaths/1000 PY (Table 3). Children who recovered completely from SAM in the programme prior to being discharged had a MMR not significantly higher than 1, indicating survival similar to children of one to four years of the same community. In contrast, children who defaulted prior to being cured had worse survival chances than the one to four years children of their community (Table 3).

Table 3 also presents results for the different cohorts included in the paper. These results show that while the proportion of death and the 4q1MPY observed in Khanum et al. (1998) study in Bangladesh, was lower than that observed in the Dowa study, the MMR shows that, compared to the general population of their respective areas, there was excess mortality in the cohort followed by Khanum et al. (1998) in Bangladesh, while there was no excess mortality for the children of the Dowa cohort (Table 3). Similarly, compared to the mortality reported for the two other cohorts, the excess mortality is of much lower magnitude when ratios are compared than when the proportion of death and 4q1MPY are compared (Table 3).

The proportion of death, the 4q1MPY, and MMRs observed in Niger and Malawi cohorts also show that children who absconded prior to treatment completion had a worse survival after discharge than children discharged cured. In Pecoul et al. (1992) cohort, when compared to children of the same community, they had a 24.3-fold increase in mortality, while the figure was only

Table 2. Description of the 1670 children followed up after discharge from Dowa CTC from August 2002 to May 2005.

Variable	n	%	Mean (SD)
Sex			
Male	797	47.7	
Female	873	52.3	
Total	1670	100	
Type of discharge			
Cured	1294	77.5	
Defaulted	115	6.9	
Transferred	9	0.5	
Non-responders	20	1.2	
Not mentioned/missing	232	13.9	
Total	1670	100.0	
Category of age at admission into CTC			
Mean age			30.8 (17.6)
<12 months	144	11.4	
12-59 months	1038	82.1	
≥ 60 months	83	6.6	
Total	1265		
Category of age at admission into follow up			
Mean age			32.5 (17.3)
<12 months	103	8.1	
12-59 months	1070	84.6	
≥ 60 months	92	7.3	
Total	1265		
Category of age at the time of follow up			
Mean age			47.6 (18.7)
<12 months	1	0.1	
12-59 months	1006	79.5	
≥ 60 months	258	20.4	
Total	1265		
Follow up results			
Seen	1265	75.7	
No show	156	9.3	
Moved	180	10.8	
Died	69	4.1	
Total	1670	100.0	

3.3-fold increase for discharged cured. A similar situation was observed for the Dowa cohort: 2.3-fold increase for those who absconded and no statistically significant increase for those discharged cured.

MMR of cohorts of children discharged from programmes using the community based approach varied from 8.9 to 1.1 while that of cohorts of children discharged from programmes using the facility based approach varied from 1.7 to 5.4 (Table 3). The results presented in Table 3 also show that within the Khanum et al. (1998) cohort children managed using the domiciliary approach had a lower MMR after discharge than that of children

Table 3. Incidence mortality rates and ratio of observed to predict deaths for children discharged from Dowa CTC from August 2002 to May 2005 and of children followed up by other teams.

Studies	Treatment approach	Total/sub-group	n	Total person/years	Observed deaths	% deaths	Observed 4q1MPY†/1000 PY	Expected deaths	Ratio O/E‡ (95%CI)	p-value
Present study	Community based	Total	1670	201 3	69	4.1	34.3	62.55	1.1 (0.9-1.4)	0.454
		Cured	1095	1588	40	3.7	25.2	34.03	1.2 (0.8- 1.6)	0.348
		Absconded/unknown	347	393	28	8.1	71.2	12.21	2.3 (1.5-3.3)	<0.001
		Others	29	32	1	3.4	31.2	0.99	1.0 (0.0-5.6)	0.752
Pecoul et al. (1992)	Facility based	Total	143	85.2	36	25.2	422.5	6.5	5.5 (3.9-7.6)	<0.001
		Cured	107	75.7	19	17.2	251.0	5.7	3.3 (2.0- 5.2)	<0.001
		Absconded	36	9.5	17	47.2	1793.0	0.7	24.3(14.2-38.7)	<0.001
Khanum et al. (1998)	Facility based	Total	400	395	10	2.5	25.3	3.7	2.7 (1.3-4.9)	0.013
		Inpatient	150	147	6	4.0	40.8	1.4	4.3 (1.6-9.3)	0.011
		Day care	128	127	2	1.6	15.7	1.2	1.7 (0.2-6.0)	0.521
	Community based	Domiciliary	122	121	2	1.6	16.5	1.1	1.8 (0.2-6.5)	0.466
Reneman and Derwig (1997)	Facility based	Total	39	58.5	14	35.9	239.3	0.7	20.0(11.0-33.4)	<0.001

†4q1MPY = Mortality rate express by Person-Year of children aged 1 to 14 years; ‡ 0/E = Observed/Expected.

children managed using the inpatient approach.

DISCUSSION

Data presented in this paper confirm the importance of investing in the scale up of CTC, also called Community Based Management of Acute Malnutrition (CMAM), which can maximize the short term and long term survival of previously severely malnourished children and minimize default from treatment. The study also demonstrates for the first time the need to include a ratio that compares the observed post discharge mortality rate to the baseline mortality of children of the same community, when reporting on the long term effects of treatment of SAM.

The most important limitation of this study design was that the use of the mortality rate of children aged one to 4 years obtained from DHS may have led to an overestimation of the expected number of deaths. This is because in Dowa and most therapeutic feeding programmes, it is children less than 24 months that tend to contribute the largest proportion of mortality and they are likely to make up a different proportion of the population in a TFP vs. the community at large. Ideally, we would have used mortality of children aged 6 to 59 months standardized based on the age structure of the population but figures to allow such calculation were not available, and given the retrospective nature of the present study, it was difficult to include control groups of the same age, sex and socio-economic background. For the Dowa study particularly, we may also have overestimated the expected baseline mortality by using the one to 4 years mortality rate for its calculation, while our cohort may have included some children who were older than 5 years.

Indeed, it was difficult to ascertain the age in this area which has a high level of illiteracy and high level of stunting. However, it is worth mentioning

that Jones and Swerdlow demonstrated that the use of the general population is justifiable when precise data are not available and that the bias usually falls within acceptable limits especially when the prevalence of the event under study and the ratio observed are below 5 and 3%, respectively (Jones and Swerdlow, 1998).

The use of DHS data that is retrospective and presents mortality by 5 or 10 year periods may also have introduced a bias. By using the average mortality rate over several decades in a context of declining mortality, we probably overestimated the actual mortality and therefore underestimated the MMR. In industrialized countries, yearly national statistics are available and MMR calculation allows adjustment to the principal risk factors including age and socio-economic background. In Africa, precise estimations have been obtained in a limited number of prospective studies by conducting concurrent surveys of the unexposed population or when the study is conducted in an area with an ongoing demographic survey (Habluetzel et al., 1997; Binka et al., 1998; Lindblade et al., 2007; Ye et al., 2007). However, it is usually not possible to obtain this current data and the DHS survey is often the best option available (Mahapatra et al., 2007). Several studies in Bangladesh, Senegal and Burkina Faso have reported that mortality estimates obtained with the DHS are comparable to those obtained from contemporary longitudinal prospective studies covering the same period (Bairagi et al., 1997; Hammer et al., 2006; Garenne and Van Ginneken, 1994). The possible bias introduced by the use of DHS data is therefore unlikely to be significant. Also, we believe that any overestimation of expected deaths as discussed earlier is partially compensated by the slight underestimation due to the use of the one to four years as standard population. The majority of children usually admitted for SAM treatment are younger than 3 years, and they will normally have higher mortality that those who are older. Thus, we believe that the MMRs obtained are not very far from the true estimates. Another possible bias introduced in the Dowa (Malawi) study is the estimation of the duration of follow up for those who moved or died and for whom the date of event was not confirmed. This may have led to a slight overestimation of the survival of these children. However, the impact of this possible overestimation should be limited given the low proportion of deaths. Given that it has been shown that child mortality may be higher among children of casual labourers, we may have underestimated the mortality among those who moved or among those who were lost to follow-up, as most of them were casual labourers who temporarily migrated in Dowa district to work in tobacco estates (Crampin et al., 2003). However, we believe that their mortality was not higher than that of those we were able to locate, as most of those located were also from poor households relying very much on casual work. Finally, calculation of expected deaths was based on data from DHS of the respective countries.

The relatively good survival of children after discharge from the Dowa CTC adds to the existing evidence showing that an appropriate treatment of SAM, especially when the CTC approach is used, not only significantly reduces case fatality rate but also improves survival after discharge. Indeed, over the period of this follow-up study, the survival of children discharged cured from Dowa CTC programme was similar to that of the general population of the same age in the District. Several factors may be involved in the improved survival of those discharged cured. The improvement of the nutritional status, including the correction of micronutrient deficiencies and the restoration of the immunity, as a result of therapeutic feeding delivered at the most vulnerable time in a young child's development is likely to play an important role (Briend, 2000; Chevalier et al., 1996; 1998; Fjeld et al., 1989; Golden et al., 1977; Hansen-Smith et al., 1979; Vasquez-Garibay et al., 2002; Weisstaub et al., 2008). Treatment of infections and vaccination of children not yet fully immunized also probably contribute to improved survival after discharge.

For those children that self-discharged (that is, did not complete treatment) in Malawi and in Niger, the MRR were 2 and 24 times higher than that calculated as expected in among children aged one to four years, and 3 to 7 times higher than in children discharged cured. This underlines the importance of investment in a treatment approach such as CTC that promotes high coverage and minimizes defaulting (Collins et al., 2006; Collins, 2001). It also clearly demonstrates that the impact of an effective treatment is considerable and suggests that absent or poor financing of SAM treatment, especially in the development context, has been having a negative impact on survival (Bhutta et al., 2008; Black et al., 2008). Indeed, CTC uses a simplified but scientifically sound treatment protocol that decentralises care to allow treatment as near as possible to where people live, and is associated with low default rates because of the reduction of opportunity costs for the carers and because carers gain a much better understanding of the treatment (Collins et al., 2006; Collins, 2001).

It was not possible to assess adherence to current best practices for all studies reported in this paper. However, it is likely that feeding and medical guidelines recommended in global and national guidelines at the time of writing for each study was not the same. Poor adherence to discharge criteria may explain the high MMRs for some of the studies. Reneman and Derwig (1997) suggested that this factor played a role in the high post-discharge mortality observed for children of the cohort he surveyed. Kerac (2010) suggested that the high prevalence of HIV infection in their cohorts of children discharged from the main tertiary hospital of Malawi explain the excess post-discharge mortality. However, the excess mortality in this study is also observed in the sub-cohort of HIV uninfected children suggesting that other factors may be playing a role (Kerac, 2010).

Mortality during SAM treatment also remained high in the hospital that treated these children and after the adoption of the community based approach indicating that late presentation was a problem (Kerac et al., 2009; Kerac, 2010; Sadler et al., 2008). Contrary to Kerac's study, the study conducted in Dowa a rural district of Malawi showed low MMR especially among children who were discharged cured (Bahwere et al., 2008). We hypothesise that those mothers that participated more actively in the treatment may have improved their care practices and strengthened their capacity to manage future nutritional and other threats (Guerrero et al., 2009). Also, although some studies have suggested full recovery of principal functions after effective treatment, it is plausible to suggest that the early initiation of treatment before profound disturbance occurs may result in better recovery of principal organ functions, while children who presented later in the course of the disease may have delayed or insufficient recovery. However, the timing of presentation during the course of the disease and nutrition and health counselling cannot explain the differences in MMR observed between sub-cohorts of the Khanum et al study conducted in Bangladesh (Khanum et al., 1998). This also suggests that community-based approaches may be associated with improved long term survival when compared to the inpatient approach. Indeed, it is likely that children of the 3 sub-cohorts were comparable at start of treatment of SAM (Khanum et al., 1998). We also assume that, except for the higher number of nutrition and health counselling sessions for carers of children who were treated as inpatients, the quality of care and health and nutrition conditions at discharge were comparable for the 3 sub-cohorts (Khanum et al., 1998). If this finding is confirmed by other prospective studies, there will be a need to investigate possible mechanisms including hospital acquired infection manifesting after discharge from therapeutic feeding.

The MMRs obtained for three of the four cohorts included in this paper indicate an excess mortality after discharge from therapeutic feeding interventions. Although, the excess mortality may be linked to the fact that children who developed SAM come from subgroups of the general population with a higher risk of death than the general population, the very high MMR observed in some of the cohorts outline the need for continued efforts to improve the management of SAM not only to minimise case fatality during treatment but also to maximize survival after discharge. Investigating the determinants of the excess mortality is the first step.

Reneman and Derwig (1997) identified inappropriate management of complications and early discharge as potential factors explaining the observed excess mortality after discharge. Pecoul et al. (1992) pointed to the low uptake of preventive interventions such as measles immunization and nutrition status at discharge as a possible explanation.

Surprisingly, despite a recent renewed focus on nutrition by the international community, treatment of SAM is still not receiving due attention which translates into inadequate funding. Although it is unanimously recognised that undernutrition, including SAM, contributes directly and indirectly to a high proportion of deaths of under-five children, debate that started in the early seventies on whether it is worth investing in the treatment of SAM particularly in the community based management of SAM, continues (Bhutta et al., 2008; Black et al., 2008; Cook, 1971; Roosmalen-Wiebenga et al., 1987). This is despite the fact that most countries and NGOs that have adopted the CTC approach have been able to reduce the case fatality rate to levels lower than 10%, with some programmes reporting case fatality rates of lower than 5% (Bezanson and Isenman, 2010; Collins et al., 2006b). Studies have also reported very low relapse rates (Bahwere et al., 2008; Khanum et al., 1998).

For this trend to change, policy makers need to be provided with evidence that demonstrates the potential impact of investment in the treatment of SAM on MDG-4 and that this impact could be much higher than that of other diseases targeted by the Integrated Management of Children and Neonatal Illnesses (IMCNI). Studies have shown that long term survival of children discharged after treatment for malaria, diarrhoea and respiratory infection may be worse than that reported here for children discharged from therapeutic feeding programmes (Islam et al., 1996; Phiri et al., 2008; Roy et al., 1983; Snow et al., 2000; Veirum et al., 2007; West et al., 1999). Indeed, in Bangladesh an incidence mortality rate of 465 deaths per 1000 PY has been reported in children followed in the community after recovery from acute diarrhoea (Islam et al., 1996). This is much higher than the figure of 25.3 deaths per 1000 PY for SAM reported in this paper for the same country (Khanum et al., 1998). In a study in Guinea-Bissau, Veirum et al. (2007) also showed that the post hospital discharge period, especially the first 3 to 12 months, was a critical period for children when compared to the level of mortality in the community. In their study, children discharge from hospital had increased risk of dying, varying between 2.5 and 12 times depending on the duration of the period of observation (Veirum et al., 2007). In the Veirum et al. (2007) study, all the common childhood diseases were associated with excess long term mortality, but as in the Snow et al. (2000) Kenyan study diarrhoea had the highest level of mortality excess, up to 3.3 times higher than that of the general under-five population (Veirum et al., 2007; West et al., 1999). All these figures are higher than most of those reported for SAM in this paper.

In the context of persistently high childhood mortality in developing countries, the right question to ask when evaluating mortality after discharge from therapeutic feeding programmes is whether children who recovered from SAM continue to experience excess mortality compared to other children of the same community. None of the

studies reviewed by this paper discussed the observed mortality in the context of that of the general population and came to conclusions, based on observed proportion or incidence of death, about excess mortality that could be wrong. Pecoul et al. (1992) recognized that this was a limitation of their study (Pecoul et al., 1992; Reneman and Derwig, 1997; Khanum et al., 1998). Indeed, Table 1 shows clearly that some of the studies were carried out in settings with persistently high childhood mortality in the general population. The results of this study clearly demonstrate that policy makers need information on the MMR if they are to be armed with the right information for decision-making

In conclusion, despite the limitations of design discussed earlier, our results complement previous studies that suggest that treatment of SAM should be included in the package of interventions promoted as having high potential for accelerating progress towards reaching MDG4. The study outlines the need to use a mortality ratio when reporting the impact of therapeutic feeding at population level. We recommend that similar studies be conducted using a prospective design to allow the follow up of non-malnourished children of the same age group and communities and to provide further data on the appropriateness of using estimates from demographic surveys such as DHS and MICS, where it is not possible to implement concurrent surveys in the non-exposed comparable population.

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