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ARTICLES

Research Articles

- Prevalence of gastrointestinal helminthes among dogs and owners perception about zoonotic dog parasites in Hawassa Town, Ethiopia** 205
Dagmawi Paulos, Mekonnen Addis, Abebe Fromsa and Berhanu Mekibib
- Premature introduction of foods and beverages in Guatemalan infants: A comparative perspective across geographic zones** 210
Noel W. Solomons, María José Soto-Méndez, Elena Diaz Ruíz and Marieke Vossenaar
- Long term mortality after community and facility based treatment of severe acute malnutrition: Analysis of data from Bangladesh, Kenya, Malawi and Niger** 215
Paluku Bahwere, Angella Mtimuni, Kate Sadler, Theresa Banda and Steve Collins

Full Length Research Paper

Prevalence of gastrointestinal helminthes among dogs and owners perception about zoonotic dog parasites in Hawassa Town, Ethiopia

Dagmawi Paulos¹, Mekonnen Addis^{1*}, Abebe Fromsa¹ and Berhanu Mekibib²

¹Microbiology and Veterinary Public Health Team, School of Veterinary Medicine, College of Agriculture and Veterinary Medicine, Jimma University, P. O. Box 307, Jimma, Ethiopia.

²Faculty of Veterinary Medicine, Hawassa University, Hawassa, Ethiopia.

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A cross sectional study was carried out between November, 2009 and March, 2010 in Hawassa town, Ethiopia with the aims of determining the prevalence of intestinal helminthes of dogs and evaluating owner's awareness about zoonotic dog parasites. A total of 455 dogs were sampled randomly and 58% (n=264) were positive for *Strongyloides stercoralis*, 49.2% (n=224), 40% (n=182), 25% (n=114), 6% (n=28) and 3.3% (n=15) were positive for *Ancylostoma caninum*, *Dipylidium caninum*, *Toxocara canis*, *Echinococcus granulosus* and *Trichuris vulpis*, respectively. Results from fecal examination showed that only 60 dogs were free of the above parasites (13.2%). From coprological examinations concurrent infections with one, two, three, four and five types of parasite were 19% (n=75), 33.9% (n=134), 32.2% (n=127), 13.6% (n=54) and 1.5% (n=6), respectively. There was statistically significant difference (P<0.05) in *A. caninum*, *T. canis* and *S. stercoralis* in the two age groups, but there was no statistically significant difference (P>0.05) in *D. caninum*, *E. granulosus* and *T. vulpis* in the two age groups. Questionnaire survey concerning owner's knowledge about zoonotic dog parasites showed that only 4.4% of the respondents know that dogs have zoonotic parasites, specifically, 95.6% have awareness about the zoonotic importance of rabies and only 7.3% have awareness about the availability of anthelmintics to treat dogs parasites. The high level of helminthiasis in dogs in the present study represent high rate of infection and immense public health risks. In line with this finding, it is recommended that owners who keep dogs should improve their hygienic standards. Besides, they should be able to regularly treat their dogs with the appropriate anthelemtics and awareness should be created on the prevention and control methods of helminthiasis.

Key words: Prevalence, gastrointestinal helminthes, dogs, Hawassa Town, Ethiopia.

INTRODUCTION

Regardless of the availability of effective medications to treat parasites, most parasites of dogs have highly evolved life cycles that makes their elimination impossible. In addition, dogs are routinely infected with

internal parasites, sometimes without apparent evidence of the infestation until it is too late. This means that a dog can have internal parasites even though the fecal sample is negative (Barutzki and Schaper, 2003).

Since dogs live in close proximity with human being, there are zoonotic diseases that can be transmitted to humans and cause serious consequences. The most common zoonotic helminth parasites of dogs are *Strongyloides stercoralis*, *Ancylostoma caninum*,

*Corresponding author. E-mail: mekonnenaddis2010@yahoo.com. Tel: +251-912112251.

Dipylidium caninum, *Toxocara canis*, *Echinococcus granulosus* and *Trichuris vulpis*. The transmission of zoonotic parasites could be through indirect contact with dogs secretions and excretions, infected water and food, and through direct contact with the dogs (Lappin, 2002).

In Ethiopia very little attention was given for diseases of dogs and the works done so far on the prevalence of the different gastrointestinal parasites of dogs are scanty (Muktar, 1988; Temesgen, 1990; Shihun, 1994; Eshetu et al., 2005; Yacob et al., 2007). Therefore, this study was designed with the aims of:

1. Estimating the prevalence of zoonotic helminth parasites of dogs in Hawassa town, Southern Ethiopia;
2. Assessing owner's awareness about zoonotic parasites that could be contracted from dogs.

MATERIALS AND METHODS

Study area

The study was conducted in Hawassa town, South Ethiopia. Hawassa lies between 4°27' and 8°30' N latitude, and 34°21' and 39°1'E longitude at an altitude of 1790 m above sea level (m.a.s.l.). The area receives 800-1000 mm average annual rainfall of which 67% falls in the long rainy season, which extends from June to September. The total human population of Hawassa is estimated to be 150,000. Hawassa town covers an area of 50 km². The mean minimum and maximum temperature of the area is 20.1 and 30°C, respectively and mean relative humidity is 51.8% (CSA, 2008).

Study animals

Faecal samples were collected from 455 dogs brought to Hawassa town veterinary clinic and dogs kept at home in the town. These dogs were never exposed to any deworming before. The history and sex of dogs were recorded during examination and approximate age of dogs was estimated using criteria described by Tizard (1996). Those dogs less than one year were classified as young (n=150) and those over one year as adult (n=305). The numbers of male and female dogs were 358 and 97, respectively.

Study design

A cross-sectional study was carried out to determine the prevalence of major intestinal helminthes of dog in Hawassa town using sedimentation and flotation techniques. The study animals were selected by simple random sampling method.

Sampling method and determination of sampling size

Simple random sampling technique was used to determine the abundance of intestinal helminthes of dog in Hawassa town. To calculate the total sample size, the following parameters were used: 95% level of confidence (CL), 5% desired level of precision and with the assumption of 50% expected prevalence of zoonotic helminthiasis in dogs in the study area. The sample size was determined using the formula given in Thrusfield (2005):

$$n = \frac{1.96^2 * P_{exp} (1-P_{exp})}{d^2}$$

n = required sample size, P_{exp} = expected prevalence, d = desired absolute precision.

Based on the aforementioned formula, the minimum sample size was about 384, but to increase the precision, 455 dogs were used for the study.

Sample collection and study procedure

The samples were collected directly from the rectum of the dogs and from top layers of fresh voided feces, examined macroscopically for proglottides, kept into labeled disposable container and transported immediately to Hawassa University Veterinary Parasitology laboratory. During collection each sample was labeled with the dog's number corresponding to owners name, date, age group, sex and place of collection. The presence of zoonotic helminth infections were confirmed by sedimentation and flotation techniques. After laboratory examination, the result was considered as positive when at least one parasite egg or cyst was observed in one of the employed technique (Lorenzini et al., 2007). Common salt was used as flotation fluid. The procedure given by Urquhart et al. (1996) was followed for the aforementioned parasitological methods. The eggs were identified using ova identification keys (Soulsby, 1982).

Age estimation

Age was conventionally classified as young (0-3) month, sub-adults (3 month to 1 year), adult (1-8) year and old (>8) years (Tizard, 1996), but in this study, age was classified into two category: young (0-1 year) and adult (>1 year).

Questionnaire survey

Sixty eight randomly selected dog owners were interviewed by a predesigned questionnaire. The questions were focused on determining the respondent awareness about their dog's habitat, possible transmission of diseases from dogs to humans, and availability of anthelmintics to treat dogs' parasites. The owners were also interviewed about tendency of cooking animals' products especially meat intended for dogs and awareness about the public health risks of keeping dogs with close intimacy.

Data management and analysis

The raw data that were recorded from this study were entered in to Microsoft excel data base system and computation of descriptive statistics was conducted using SPSS version 16.0. Descriptive statistics such as percentages, proportions and frequency distributions were applied to compute some of the data. The prevalence of the parasites was calculated by dividing the number of dogs harboring a given parasite by the number of dogs examined. Pearsons chi-square (χ^2) was used to measure association between prevalence of the parasite with the age and sex of dogs. In all the analysis, the confidence level was held at 95% and the results were considered significant when P<0.05.

RESULTS

Out of 455 dogs sampled, 395 (86.8%) of the dogs were found to be infected with *A. caninum* (49.9%), *S. stercoralis* (57.5%), *T. canis* (25.1%), *T. vulpis* (3.3%),

Table 1. Overall prevalence of zoonotic helminthes in dogs of Hawassa town.

Species	Positive	Prevalence (%)	95% CI
<i>Ancylostoma caninum</i>	229	49.9	30.9-55.8
<i>Strongyloides stercoralis</i>	264	57.5	48.8-95.75
<i>Toxocara canis</i>	115	25.1	15.89-45.64
<i>Trichuris vulpis</i>	15	3.3	7.50-22.49
<i>Dipylidium caninum</i>	183	39.9	27.98-63.92
<i>Echinococcus granulosus</i>	37	8.4	5.5-16.74

Table 2. Prevalence of mixed helminthes infection in dogs.

Infection with	Positive	Prevalence (%)
One helminth parasite	107	23.5
Two helminth parasites	167	36.7
Three helminth parasites	98	21.5
Four helminth parasites	17	3.7
Five helminth parasites	5	1.1
Six helminth parasites	0	0.0

Table 3. The prevalence of zoonotic helminth parasites of dogs by age and sex in Hawassa town.

Parasites	Age	Prevalence (%)	X ²	p-value	Sex	Prevalence (%)	χ ²	p-value
<i>A. caninum</i>	Young	73.5	55.6	0.00	Male	49.7	0.16	0.68
	Adult	36.7			Female	47.4		
<i>S. stercoralis</i>	Young	64.5	4.07	0.044	Male	58.4	0.08	0.76
	Adult	54.7			Female	56.7		
<i>T. canis</i>	Young	54.8	1.11	0.00	Male	23.5	2.26	0.13
	Adult	9.7			Female	30.9		
<i>T. vulpis</i>	Young	4.5	1.08	0.29	Male	3.1	0.28	0.59
	Adult	2.7			Female	4.2		
<i>D. caninum</i>	Young	41.3	0.16	0.66	Male	40.5	0.17	0.6
	Adult	39.3			Female	38.1		
<i>E. granulosus</i>	Young	7.8	3.05	0.21	Male	7.3	3.89	0.1
	Adult	5.3			Female	2.1		

D. caninum (39.9%) and *E. granulosus* (8.4%) (Table 1).

Concurrent infections with two species of helminthes were more common (36.7%) than infection with one (23.5%), three (21.5%), four (3.7%), and five (1.1%) species of helminthes parasites and none of the dogs examined were positive for concurrent infections with the six species of the zoonotic helminthes investigated. Sixty dogs (13.2%) were found to be free of any of the parasites of our interest (Table 2).

Out of the six zoonotic helminthes parasites

encountered in the study, *A. caninum*, *S. stercoralis* and *T. canis* showed a significant differences ($P < 0.05$) between young and adult dogs, but there was no significant variation between sex ($p > 0.05$) (Table 3).

Questionnaire survey

The result of questionnaire survey concerning owner's knowledge about zoonotic dog parasites showed that

Table 4. Summary of the questionnaire survey.

Awareness	Prevalence (%)
Presence of zoonotic dog parasites	4.4
Zoonotic importance of rabies	95.6
Availability of anthelmintics to treat dogs parasites	7.4
Public health risk of keeping dogs with close intimacy	8.8
Tendency of cooking meat intended to feed dogs	5.8
Necessary precaution while cleaning the kennels	55.8

only (4.4%) (n=3) of the respondents know that dogs have zoonotic parasites, specifically (95.6%) (n=65) have awareness about the zoonotic importance of rabies and only (7.3%) (n=5) have awareness about the availability of anthelmintics to treat dogs parasites. Also the result of the questionnaire showed that (5.8%) (n=4) of the respondents have a tendency of cooking animal products especially meat that is intended to feed dogs and only (8.8%) (n=6) of the respondents have awareness about public health risk of keeping dogs with close intimacy (Table 4).

DISCUSSION

The coproscopical examinations revealed an overall prevalence of helminthes infection to be 86.6%. Coproscopical examination revealed that *S. stercoralis* (57.5%) and *A. caninum* (49.9%) were the dominant zoonotic helminth parasites of dogs of Hawassa town. The finding is in line with previous reports from African countries (Hassan, 1982; Ugochukwu and Ejimadu, 1985a).

The prevalence of *T. canis* (25.1%) was in agreement with the earlier reports of Ugochukwu and Ejimadu (1985a), Haralabidis et al. (1988), Vanparijs and Hermans (1991) and Totkova et al. (2006) who reported the prevalence of 24.3, 24.6, 25.4 and 25.8%, respectively. A Prevalence of *T. vulpis* (3.3%) in the current study was in line with the findings of Yacob et al. (2007), Haralabidis et al. (1988), Oliveria-Segueira et al. (2002) and Senlik et al. (2006).

The difference in the prevalence of the helminthes infection between countries could be attributed to the difference in climatic factors required for the biology of the parasites, veterinary facilities and public awareness to take care of the dogs. During the survey, it was noted that a large number of dogs scavenge at abattoirs and butcher shops and those kept indoors are also frequently fed uncooked offals that are not in good hygienic condition. It is also common to find animal cadaver thrown into street where dogs communally feed on, which could be a suitable media for transmission of the parasites.

The significantly higher prevalence of nematode

infection, specifically with *A. caninum* and *T. canis* in young dogs as compared to adult is consistent with previous studies (Haralabidis et al., 1988; Overgaauw, 1997; Ugochukwu and Ejimadu, 1985b). The higher prevalence of these nematodes in younger dogs could be due to the mode of transmission of the parasites and puppies could be infected transplacentally and transmammmary, which increase the occurrence of the parasites at an early age, whereas, adult dogs may develop immunity, which decrease the establishment, as well as the fecundity of the parasites (Soulsby, 1982; Urquhart et al., 1996).

The study showed that there was no significant difference ($P>0.05$) in frequency of intestinal helminthes of dogs between male and female dogs. The results are consistent with previous works (Yacob et al., 2007; Haralabides et al., 1988; Fontanarroa et al., 2006). More than one species of GI helminthes in a single host were observed with prevalence of 63.3%. It might be due to the fact that the dogs act as scavenger and do not get regular veterinary care.

The presence of different helminth parasites species in a single host, as well as high prevalence of these parasites in the study area require serious attention due to pathogenic impact of the parasites and their zoonotic importance. Therefore, a strategic deworming of dogs using broad-spectrum anthelmintics and public education on the care and management of dogs to create awareness of the transmission and control of zoonotic diseases is of paramount importance.

Conclusion

This study revealed that helminth parasites occurring in Hawassa's dogs were largely *S. stercoralis*, *A. caninum*, *D. caninum*, *T. canis*, *E. granulosus* and *T. vulpis*. The predominant parasite was *S. stercoralis* followed by *A. caninum*, *D. caninum* and *T. canis*. The study confirmed that young dogs were found to be the most susceptible and severely infested compared to adult dogs. Sex has no significant differences in the level of infestation with helminthes parasites and concurrent infection with two helminthes parasite species was very common than infection with single species. It was concluded that age

was one of the important factors influencing the occurrence of zoonotic helminth parasites in dogs.

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Full Length Research Paper

Premature introduction of foods and beverages in Guatemalan infants: A comparative perspective across geographic zones

Noel W. Solomons, María José Soto-Méndez, Elena Diaz Ruíz and Marieke Vossenaar*

Center for Studies of Sensory Impairment, Aging and Metabolism (CeSSIAM), Guatemala City, Guatemala.

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The objective of the current analysis was to compare the pattern of age-of-introduction of commonly consumed complementary foods in the western highlands with what has been reported from the central highlands of Guatemala. Age-of-introduction of 10 sentinel foods was queried by means of structured face-to-face interviews in mothers of 6 to 11 months old infants living in Quetzaltenango (n = 114). The mean age-of-introduction was earlier in the metropolitan Quetzaltenango series than in both of the central highland locations, rural and urban. We concluded that different patterns of early introduction of food and beverage items contribute to the precocious occurrence of mixed feeding (MF) in the first semester of infancy in distinct regions of Guatemala.

Key words: Complementary foods, self-reported, infant nutrition, Guatemala.

INTRODUCTION

The World Health Organization (WHO, 2003) recommended as basic infant feeding: “exclusive breast-feeding for 6 months and continued breastfeeding up to 2 years of age or beyond”. Any violation of exclusivity of breastfeeding with introduction of water based liquids converts that pattern to one of partial breastfeeding (PBF). Nevertheless, both exclusive breastfeeding (EBF) and PBF constitute a state of “full breastfeeding” according to the WHO criteria (WHO, 2003). It is, however, the introduction of foods and complex beverages which converts the pattern to one of mixed feeding (MF). MF is considered potentially detrimental to the health and nutrition of infants because of the increased risk of gastrointestinal infection (Jones et al.,

2003; Kramer and Kakuma, 2009). A series of studies in a rural village in the central highlands (Campos et al., 2010; Soto-Méndez et al., 2012) and a poor settlement in Guatemala City (Hernández et al., 2011; Soto-Méndez et al., 2012) revealed high rates of premature introduction of foods or beverages, that is, before 6 months of age. In these two settings, moreover, retrospective inquiry as to the age at introduction of 10 sentinel foods was conducted in Guatemala and reported in an original research report by Soto-Méndez et al., (2012). The same battery of sentinel items was included in our cross-sectional study among infants and toddlers in the western highlands, and additional questions were included relating the exact age-of-introduction of foods other than breast milk, such as water-based drinks, infant formula and other foods. In Guatemala, there is little understanding of exactly which practices first violate adherence to EBF during the first semester of life. The objective of the current analysis was to compare the pattern of age-of-introduction of commonly consumed complementary foods in the western highlands with what has been reported from two areas in the central highlands of Guatemala.

*Corresponding author. E-mail: mvosenaar@hotmail.com or cessiam@guate.net.gt. Tel/Fax: +502 24733942.

Abbreviations: EBF, exclusive breastfeeding; CeSSIAM, center for studies of sensory impairment, aging and metabolism; MF, mixed feeding; PBF, partial breastfeeding; WHO, world health organization.

MATERIALS AND METHODS

Study population

This survey is part of a study that was conducted in the highlands of Guatemala in Quetzaltenango (latitude 14.83, longitude -91.52), the second most important city of the country and in the nearby suburb of La Esperanza (latitude 14.87, longitude -91.56). Mothers visiting the local public health centers for vaccinations, routine check-ups, or illness were recruited as mother-infant dyads into the study. The mothers ranged in age from 15 to 44 years, mean 26 ± 6 years; 41% were classified as Maya indigenous by their typical garments, with the remainder considered to be non-indigenous. Exclusion criteria were: 1) pre-mature birth (defined as born more than 4 weeks pre-term); 2) had siblings who were already participants; 3) had congenital anomalies or chronic illness; and 4) were unwilling to sign the study consent form. The population sample of this sub-analysis was infants aged between 6 and 11 months. Enrollment and selection resulted in a group of 114 infants, 53 boys and 61 girls with a mean age of 8 ± 2 months. A larger number of infants were recruited in the urban area of Quetzaltenango ($n = 65$) than in the semi-urban area of La Esperanza ($n = 49$). The study recruitment period was from February to October, 2011.

Ethical approval was obtained from the Human Subjects Committee of the Center for Studies of Sensory Impairment, Aging and Metabolism (CeSSIAM) and the study conforms to the provisions of the Declaration of Helsinki in 1995 (as revised in Edinburgh, 2000). The study protocol was approved by the local authorities of the Guatemala Health Ministry. The procedures and privacy issues of the study were explained and informed consent was obtained from all mothers.

Data collection

A single face-to-face interview using a structured data collection tool designed to evaluate dietary intake and morbidity in young children was administered. A recall of feeding practices since birth was collected. Ever having offered formula milk, water-based drinks other than breast milk, foods and ritual fluids was queried as a 'yes' or 'no' question. Ritual fluids, locally known as "agüitas", are herbal infusions and rice water. If affirmative, the mother was asked the age-of-introduction of these four items as an open-ended question. Thereafter, age-of-introduction of 10 pre-determined commonly consumed complementary foods (*Incaparina*®, oatmeal, rice, fruits, vegetables, white rolls, sweet rolls, baby food in jars, potatoes and coffee) was queried by means of structured interviews. Mothers were asked to report the age of the infant at which each item was introduced, if at all. The 10 foods queried were chosen by experienced field investigators and were not the foods most likely to be introduced earlier or later, nor most commonly consumed by young Guatemalan infants.

Data analysis

The average reported age of infant at introduction of the 10 pre-determined foods and the proportion of children who were offered these foods before 6 months of age were calculated for the pooled sample. The results of the current analysis were compared to finding of previous studies in Central Guatemala and published elsewhere. The first study was conducted in urban mothers and infants attending a health care centre in the district of "Centro America" in Zone 7 of Guatemala City (latitude 14.64, longitude -90.55). The second study was conducted in the rural village of Santo Domingo Xenacoj, located in the central highlands of

Guatemala (latitude 14.68, longitude -90.70). The three study areas are shown in Figure 1. Paired *t*-test comparisons between the urban area of Quetzaltenango in the western highlands against both Guatemala City and the rural area of Xenacoj were used to compare mean reported age-of-introduction of the 10 foods queried and rates of premature introduction (that is, before 6 months of age).

RESULTS AND DISCUSSION

Profile of early introduction of non-breast milk foods and drinks into infants' diets in Quetzaltenango

A general perspective on the timing of introduction of different elements to the infant diets can be gained from the response of the mothers to queries in the questionnaire. At the time of interview in the second semester of life, the vast majority of infants had already consumed ritual fluids (80%), water-based drinks other than breast milk (68%), milk formula (54%) and foods (67%). Among consumers, the median age-of-introduction was 14 weeks (range 0 to 41 weeks), 10 weeks (range 0 to 41 weeks), 0 weeks (range 0 to 54 weeks) and 25 weeks (range 5 to 36 weeks) for ritual fluids, water-based drinks, formula and foods, respectively. Almost all infants were introduced to ritual fluids (84%), water-based drinks (83%), formula (85%) prematurely, that is, before 6 months of age. Approximately half the infants (45%) only commenced eating foods in the second semester of life, as recommended by WHO (2003).

Guatemala was one of the settings that facilitated the description of "weanling diarrhea," the epidemiological association of increased occurrence of gastrointestinal infections with the introduction of foods other than human milk (Gordon et al., 1963). Although maternal milk has protective immunological properties, Victora et al. (1987) showed that they could not resist the food-borne microbes associated with the onset of mixed feeding. These are among the considerations leading the WHO strongly to urge women to breastfeed their babies exclusively throughout the first semester of life (WHO, 2003, Kramer and Kakuma, 2009). The findings from our interviews within this sample demonstrate poor adherence to exclusivity of breastfeeding; the resultant mixed-feeding exposes the child to early onset of intestinal infections (Golding et al., 1997; Gribble, 2011), and there is definitive or suggestive evidence for increased life-time risk of other conditions (allergies, obesity, cardiovascular disease, autoimmune illnesses) associated with shorter and less intense breastfeeding (Turck, 2007; Dorea, 2009; Fewtrell, 2011; Owen et al., 2011).

Age at introduction of sentinel foods

As shown in Table 1, for each of the 10 sentinel items, the mean age-of-introduction is earlier in the metropolitan



Figure 1. Map of Guatemala showing the three study areas.

Table 1. Average reported age of infant at introduction of 10 pre-determined commonly consumed complementary foods listed per residential area.

Food item	Average reported age of infant at introduction of complementary food listed (mo)		
	Urban sample of Quetzaltenango (n = 114)	Urban sample of Guatemala City (n = 64) ¹	Rural sample of Santo Domingo Xenacoj (n = 50) ¹
Vegetables	5.8 ± 1.1 (n = 99)	6.5 ± 1.2 (n = 59)	6.6 ± 1.2 (n = 44)
Fruits	6.2 ± 1.5 (n = 94)	6.7 ± 1.6 (n = 58)	6.9 ± 1.5 (n = 35)
Incaparina®	5.8 ± 1.6 (n = 78)	6.9 ± 2.0 (n = 33)	6.7 ± 1.5 (n = 36)
Potatoes	6.0 ± 1.3 (n = 87)	6.8 ± 1.5 (n = 53)	6.6 ± 1.3 (n = 46)
Baby food in jar	5.6 ± 1.2 (n = 54)	6.2 ± 1.4 (n = 35)	6.3 ± 1.2 (n = 16)
Sweet Rolls	6.2 ± 1.5 (n = 76)	6.9 ± 1.4 (n = 38)	6.9 ± 1.3 (n = 17)
Oatmeal	5.9 ± 1.7 (n = 50)	7.1 ± 2.2 (n = 29)	6.7 ± 1.6 (n = 34)
White Rolls	6.2 ± 1.4 (n = 57)	7.3 ± 1.6 (n = 26)	6.9 ± 1.2 (n = 40)
Rice	6.2 ± 1.6 (n = 63)	6.9 ± 1.9 (n = 41)	6.9 ± 1.2 (n = 39)
Coffee	6.7 ± 1.8 (n = 43)	7.0 ± 1.8 (n = 32)	6.7 ± 1.1 (n = 29)

Values are mean ± SD for participants who reported having introduced the given food item. ¹Data previously presented by Soto-Méndez.

Table 2. Proportion of children who were offered 10 pre-determined commonly consumed complementary foods before 6 months of age.

Food item	Proportion (%) of children offered these foods before 6 mo					
	Among consumers only			Entire sample		
	Urban sample of Quetzaltenango	Urban sample of Guatemala City	Rural sample of Santo Domingo Xenacoj	Urban sample of Quetzaltenango (n = 114)	Urban sample of Guatemala City (n = 64)	Rural sample of Santo Domingo Xenacoj (n = 50)
Vegetables	34	16	19	30	14	17
Fruits	34	20	21	28	14	19
<i>Incaparina</i> ®	33	17	21	23	12	11
Potatoes	29	24	19	22	22	16
Baby food in jar	37	31	26	18	10	14
Sweet rolls	23	18	13	16	6	8
Oatmeal	28	18	21	12	12	9
White rolls	23	13	12	11	10	5
Rice	19	10	20	11	8	13
Coffee	23	14	16	9	8	8
P-value		0.001 ¹	<0.001 ²		0.012 ¹	0.003 ²

P-value for the difference in rates of premature introduction of the 10 foods queried between the urban sample of Quetzaltenango and urban sample of Guatemala City using dependent t-test analysis. P-value for the difference in rates of premature introduction of the 10 foods queried between the urban sample of Quetzaltenango and rural sample of Santo Domingo Xenacoj using dependent t test analysis.

Quetzaltenango series than in both the central highland locations, rural and urban. The only exception is coffee, which was introduced at a mean age of 6.7 months in both Quetzaltenango and Santo Domingo Xenacoj. As such, it is not surprising that the paired *t*-test comparisons of western, urban highlands against both the rural area of Xenacoj ($p = 0.006$) and Guatemala City ($p < 0.001$) were highly significant.

The percentage of eventual consumers who had been introduced to the various items in the three geographic settings before 6 months is shown in Table 2. For the western highlands, for instance, vegetables and fruits before 6 months was 30 and 28%, respectively. At the other end of the spectrum,

the first presentation of rice and coffee occurred before reaching 6 months of age in only 11 and 9% of eventual consumers in the western highlands' metropolitan site. Moreover, when the series of percentage of consumers who first consumed the items before 6 months of age were compared between the western area of Quetzaltenango and central Guatemalan locations, as shown in Table 2, the rates were universally higher in the western area than either the eastern urban ($p = 0.001$) or rural area ($p < 0.001$).

Of further interest, regarding a larger cultural consensus about early feeding across the whole nation of Guatemala is the general similarity in all

sites in the items of early introduction, for example, baby food in a jar, vegetables and fruits, and those of later presentation to young children, for example, white rolls, rice and coffee. It is interesting that two forms of gruels - *Incaparina*® and oatmeal - are in the earliest bracket in the western region and introduced relatively later in the sequence in the eastern sites.

Different patterns of early introduction of food and beverage items contribute to the precocious occurrence of MF in the first semester of infancy in distinct regions of Guatemala. There is a trend towards earlier introduction of foods in the western highlands than in Guatemala City and the rural area in eastern Guatemala.

STRENGTHS AND LIMITATIONS

The strengths of this study are its linkage to a previous set of inquiries using identical questionnaire language and item list, and the interval of retrospective memory identical, as well, with questioning occurring in the 7th through the 12th months of infant life. Imbedded in this is a potential weakness as different field teams conducted the interviews in the central highlands studies; without standardization with the former. Some subtle signals could have systematically affected the clues for responses to the same questions given by the present interviewers. The sample of our study is not necessarily representative of the Quetzaltenango area. Children were recruited from the vaccination site of the health centres, and thus probably had better access to health care than others. Furthermore, some misclassification of ethnicity based on clothing may have occurred given that Mayan indigenous women sometimes wear western clothes. An admitted limitation of the exercise from its origins (Soto-Méndez et al., 2012), moreover, is that the selection of edible items was arbitrarily derived from the notions of the original field team. On the positive side of the ledger, however, is the homology of pattern of earlier and later introduced foods, which provides construct validity to the relative response pattern of the Quetzaltenango interviewees.

Conclusion

The aforementioned caveats notwithstanding, it appears that women from a metropolitan region in the interior of Guatemala introduce the selected foods earlier in life than their homologues in the nation's capital and in a Mayan village near the capital. Early MF, that is, the introduction of non-breast milk items to the diet before the completion of the 6 months of age, is revealed as a widespread practice among the mothers of this sample in Quetzaltenango.

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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 Mtimuni³, Kate Sadler^{2,3}, Theresa Banda³ and Steve Collins³

¹Centre of Research in Epidemiology, Biostatistics and Clinical Research,
Free University of Brussels, Brussels, Belgium

²Feinstein International Center, Tufts University, Medford, MA 02155, United State

³Valid 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:

$$4q1 \text{ deaths} = \text{Births} * 4q1MR * \text{constant } K_t,$$

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 K_t the constant correcting for the rate of growth and the pattern of mortality obtained from life tables. The formula for calculating K_t is:

$$K_t = (a_t + b_t * r_b) / 100000$$

Where a_t and b_t 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:

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

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 K_t , 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:

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

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: $E = 4q1MPY * \sum LOF_y$, where E = the expected number of deaths for the cohorts and $\sum LOF_y$ = 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/ district 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; ‡ O/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 than 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 Ikenman, 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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