Malnutrition, Measles, Mortality, and the Humanitarian Response During a Famine in Ethiopia

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Context The World Food Programme estimated that 10 million people were at risk of starvation in Ethiopia in 2000 but later reported that a famine had been averted. However, no population-based data on mortality or nutrition existed for Gode district, at the epicenter of the famine in the Somali region of Ethiopia.

Objectives To estimate mortality rates, determine the major causes of death, and estimate the prevalence of malnutrition among children and adults for the population of Gode district.

Design and Setting Two-stage cluster survey conducted from July 27 through August 1, 2000, which included anthropometric measures and 8-month retrospective mortality data collection.

Participants A total of 595 households comprising 4032 people living in Gode district of Ethiopia.

Main Outcome Measures Crude mortality rates and mortality rates for children younger than 5 years, causes of death, weight for height of less than –2 *z* scores among children aged 6 months to 5 years, and body mass index of less than 18.5 kg/m^2 among adults and older persons.

Results Of the 595 households, 346 (58.2%) were displaced from their usual places of residence. From December 1999 through July 2000, a total of 293 deaths occurred in the sample population; 159 (54.3%) deaths were among children younger than 5 years and 72 (24.6%) were among children aged 5 to 14 years. The crude mortality rate was 3.2/10000 per day (95% confidence interval [CI], 2.4-3.8/10000 per day), which is 3 times the cutoff used to define an emergency. The mortality rate for children younger than 5 years was 6.8/10000 per day (95% CI, 5.4-8.2/10000 per day). Approximately 77% of deaths occurred before major relief interventions began in April/May 2000. Wasting contributed to 72.3% of all deaths among children younger than 5 years. Measles alone or in combination with wasting accounted for 35 (22.0%) of 159 deaths among children younger than 5 years and for 12 (16.7%) of 72 deaths among children aged 5 to 14 years. The prevalence rate for wasting (weight for height of $<$–2 *z* score) among children aged 6 months to 5 years was 29.1% (95% CI, 24.7%-33.4%). Using a method to adjust body mass index for body shape, the prevalence of undernutrition (body mass index $<$18.5 kg/m^2) among adults aged 18 to 59 years was 22.7% (95% CI, 17.9%-27.5%).

Conclusions To prevent unnecessary deaths, the humanitarian response to famine needs to be rapid, well coordinated, and based on sound epidemiological evidence. Public health interventions, such as mass measles vaccination campaigns with coverage extended to children aged 12 to 15 years should be implemented as the first priority. The prevalence of wasting and undernutrition among children and adults, respectively, should be assessed in all prolonged, severe famines.

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See also p 588.

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priorities may be met more systematically in refugee camps than for famine-affected populations that are dispersed over extensive geographic areas.[9]

Ethiopia has been subject to recurrent drought and food shortages exacerbated by civil strife.[10,11] These crises have generally resulted in massive excess mortality and internal population displacement without the formation of discrete camps. Beginning in 1999, data from early warning systems in many regions of Ethiopia indicated that the food security and nutrition situation was deteriorating rapidly.[12] The World Food Programme estimated that more than 10 million people needed food assistance at the peak of this crisis.[13] The Somali region, in which the predominantly pastoral and agro-pastoral communities had lost a large proportion of their livestock, was the worst affected. Ongoing civil conflict and extremely poor health infrastructure in this region exacerbated the food security situation. In addition, in early 2000, measles cases began to be reported by nongovernmental organizations (NGOs). It was not until April 2000, however, when media attention began to focus on the town of Gode in the Somali region,[14] that a large-scale international humanitarian response was triggered. Interventions included food aid and selective programs, such as supplementary feeding programs for moderately wasted children and therapeutic feeding centers for severely wasted children, and resulted in populations becoming concentrated around the major sites of humanitarian services.[15] In May 2000, some United Nations agencies reported that the situation, although serious, was not a famine and that mortality was "under control."[16] Later, the World Food Programme claimed that a widespread famine was averted by the rapid humanitarian response.[17]

Mortality and nutrition data are both critical to define high-risk groups and to target programs during famine. Because no population-based data on mortality or nutrition were available for Gode district, Save the Children Fund USA, with support from the United Nations Children's Fund and the Centers for Disease Control and Prevention, carried out a survey in the district from July 27 through August 1, 2000, with the following objectives: to estimate mortality rates, to determine the major causes of death, and to estimate the prevalence of malnutrition among children and adults.

METHODS

We carried out a 2-stage, 30-cluster household survey in Gode district. Assuming a design effect of 2, a sample size of 768 children younger than 5 years was needed to achieve 5% precision around an estimated prevalence of wasting of 50% with a 95% confidence interval (CI). Although the 1994 Somali region census[18] gives the proportion of children younger than 5 years as 12.6%, we assumed this group made up 20% of the population on the basis of data from more recent surveys in other parts of Somali region.[19] Assuming a mean family size of 6,[18] a total sample of 638 households with 3828 persons was required. For people aged 18 to 59 years, defined as adults, a prevalence of undernutrition of 50% was also assumed. Although we also collected anthropometric data on persons 60 years or older, defined as older persons, we anticipated that the sample size would be small because this age group makes up only 3% of the population in the region.[18]

Baseline mortality rates were not available by region, but national data for Ethiopia indicates that the crude mortality rate (CMR) is approximately 0.5/10 000 per day.[20] We estimated the mean CMR during the previous 8 months to be 4/10 000 per day or 4 times the cutoff used to define an emergency.[1] This rate corresponded to a cumulative mortality of approximately 10% from December 9, 1999, through July 26, 2000, defined as the retrospective period of interest for this study. Because mortality was more likely to be clustered than malnutrition, we assumed a design effect of 4. Our sample size of 3832 people would result in a CMR estimate with a precision of 2 percentage points and a 95% CI.

We used the 1994 census as a basis for our population sampling frame for Gode district,[18] and adjusted it using more recent estimates by NGOs involved in food distribution and by the Ethiopian military, which had conducted comprehensive headcounts. In the first stage of the survey, 30 clusters were assigned proportionally to village population size. In the second stage, we selected households using Expanded Programme on Immunization methods.[21] A household was defined as a group of people who usually live under the same roof and share meals. If more than 1 household was present in the same dwelling, 1 was randomly selected. The questionnaire was administered to the head of household or another adult member who also provided oral informed consent. If no adult member of the household was home at the time of the survey, the survey team returned to that household later in the day. If there was still no one at home when the study team returned, the team selected the next house. If children in a household had been admitted to a therapeutic feeding center, we weighed and measured them at the center. The survey protocol was reviewed by representatives of the Centers for Disease Control and Prevention, the United Nations Children's Fund, and Save the Children Fund USA for ethical considerations.

No major linguistic variations existed within the district, and the questionnaire was translated into the Somali dialect used by the majority Tolmoge clan and back-translated into English. A local calendar of events was used to determine age and date of death. We determined the total number of people and children younger than 5 years present in each household at the beginning of the period, December 9, 1999, the first day of Ramadan and a major religious event in the region. Deaths in the family occurring during the period of interest were recorded and the month of death was identified. We then used a series of questions in a structured format to assign cause of death into 10 categories according to

standard case definitions. To simplify most analyses, causes of death were aggregated into 4 broad categories: (1) wasting alone; (2) wasting in combination with symptoms of measles, diarrhea, malaria, or respiratory tract infection; (3) symptoms of measles, diarrhea, malaria, or respiratory tract infection without wasting; or (4) other. The questionnaire was piloted in the Save the Children Fund USA feeding center in Gode among 20 mothers of malnourished children and among 30 families in a village that was not included in the survey.

The 6 survey teams consisted of 4 persons each. Before the survey, team members received 3 days of training that included exercises designed to reduce interobserver and intraobserver error in anthropometric measurement. A health professional from the Save the Children Fund USA, United Nations Children's Fund, or Centers for Disease Control and Prevention supervised each survey team. For children, weight was measured to the nearest 100 g with Salter scales Model MP 25 (CMS Weighing Equipment Ltd, London, England) and for adults, weight was measured to the nearest 0.5 kg with Camry bathroom scales (Camry, Beijing, China). Scales were calibrated daily using standard weights of 0.5 kg, 2 kg, and 5 kg. Height was measured to the nearest 0.1 cm using Oxfam children's height boards and locally produced adult height boards made to Oxfam specifications (Oxfam, Oxford, England). We measured demispan (the distance between the tip of the middle finger and the sternal notch) using CMS demispan tapes (CMS Weighing Equipment Ltd). Each measurement was confirmed by at least 1 other team member. Because vaccination cards had not been distributed with previous vaccination campaigns, an oral report from the child's mother was used to define measles vaccination status.

Among children aged 6 months to 5 years, we classified wasting using a weight for height *z* score derived from the NCHS, Centers for Disease Control and Prevention, and World Health Organization (WHO) reference population. Moderate wasting was defined as a weight for height *z* score between –2.0 and –3.0. Severe wasting was defined as a weight for height *z* score of less than –3.0 or nutritional edema. Because percentage median weight for height is generally the accepted method used by NGOs to determine admission and discharge criteria for feeding centers, we used percentage median weight for height in calculations of feeding center coverage (the proportion of malnourished children in each category attending feeding centers). Undernutrition was defined as a body mass index (BMI) of less than 18.5 kg/m^2 and severe undernutrition as a BMI of less than 16.0 kg/m^2 for adults.[22] Data were analyzed using Epi Info software (version 6.04b), which includes C-sample for determining 95% CIs and SEs for cluster surveys.[23]

Because the Somali population is tall and thin, before we could apply standard international cutoffs we needed to adjust BMI for differences in Cormic index (the ratio of sitting height to standing height) between the sample population and the populations from which the WHO's BMI cutoffs for defining undernutrition were derived (BOX). We found the Cormic index to be 0.485 (SE, 0.001) in the Somali population compared with 0.520 in the standard international population.

Because height decreases with normal aging, the WHO recommends the measurement of long bones and subsequent correlation with height for

Box. Adjusting Body Mass Index (BMI) for Cormic Index and Loss of Height

Many factors, including the Cormic index, body proportion of muscle and fat, and nutritional status influence the BMI. Among adults, we used the methods described by Norgan[24] to adjust for body shape. Regression equations, which were derived from our own data, were calculated for both men and women, relating Cormic index to BMI.

Cormic Index

Because no significant difference existed between the sexes, we used a combined equation (BMI = 47.1 × [Cormic index] – 3.9) to estimate the relationship between Cormic index and BMI in the sample population. This equation was then used to calculate the estimated BMI, which uses each individual's Cormic index from the sample population. The calculation of estimated BMI assumes that there is no variation among individuals in the relationship between BMI and Cormic index and thus eliminates variation associated with nutritional status. The difference between measured BMI (the observed BMI for the individual) and estimated BMI represents the individual variation attributable to nutritional status. The same regression equation was then used to calculate the BMI assuming that each individual in the population had a Cormic index of 0.52 ($BMI_{0.52}$). The $BMI_{0.52}$ eliminates variation due to the Cormic index and nutritional status. The quantity (observed BMI minus estimated BMI) was then added back to $BMI_{0.52}$ to restore the variation due to nutritional status. The final adjusted BMI is therefore calculated as:

$$\text{Adjusted BMI} = BMI_{0.52} + (\text{Observed BMI} - \text{Estimated BMI}).$$

Loss of Height

To derive height for older men using demispan, we used the following equation:

$$\text{Height} = 1.56 \times \text{Demispan} + 31.8 \ (r = 0.8, r^2 = 0.7).$$

To derive sitting height, we used the equation:

$$\text{Sitting Height} = 0.33 \times \text{Height} + 26.8 \ (r = 0.7, r^2 = 0.5).$$

We used the following equations for older women:

$$\text{Height} = 1.15 \times \text{Demispan} + 65.6 \ (r = 0.7, r^2 = 0.5)$$
$$\text{Sitting Height} = 0.28 \times \text{Height} + 34.0 \ (r = 0.6, r^2 = 0.3).$$

calculating BMI in persons aged 60 years or older.[25] Because published regression equations correlating demispan or armspan with height were not available for the Somali population, we used data from adults aged 18 to 59 years in our survey for this purpose. The adjustment for body shape using the Cormic index, as outlined in the Box, was then performed for older persons.

RESULTS

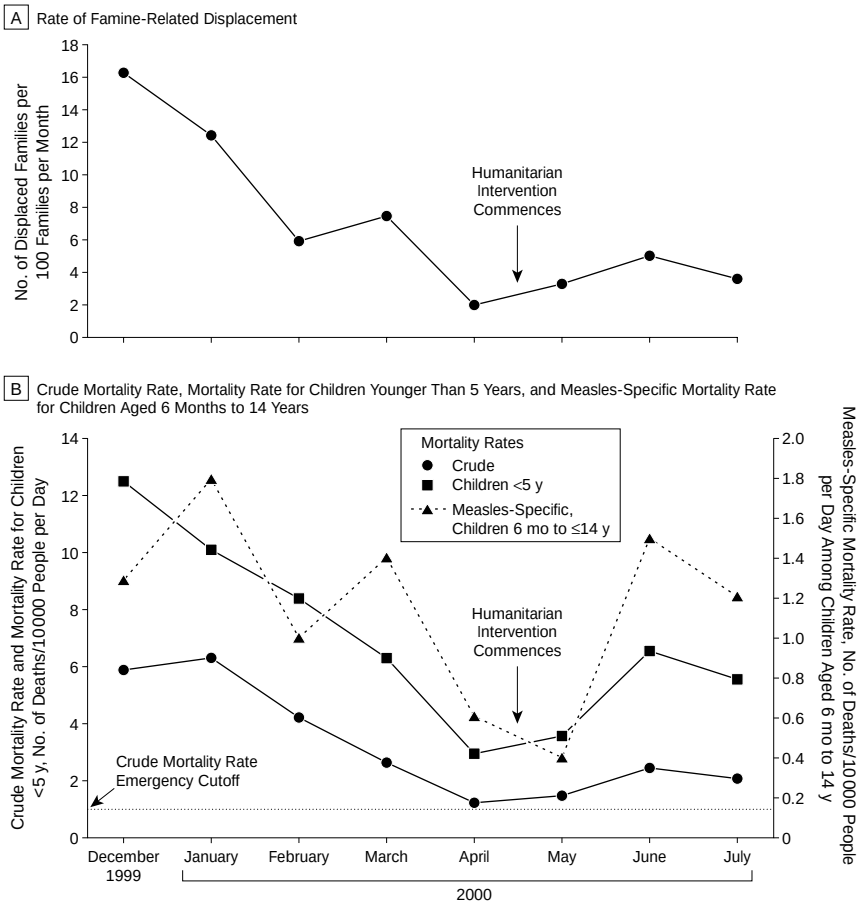
We completed a standardized questionnaire for 595 households comprising 4032 people at the beginning of the period of interest; 346 (58.2%, 95% CI, 46.4%-70.0%) households were displaced from their usual place of residence. The monthly rate for displacement was highest before April 2000 and paralleled the mortality trends (FIGURE, A). The mean household size was 6.4, and children younger than 5 years constituted 25.3% of household members. Three households refused to participate, and security curfews and long travel times to some villages resulted in 43 fewer households being surveyed than originally intended. Nonetheless, the required sample size for children younger than 5 years was achieved because households were larger than anticipated.

Mortality

Overall, 293 deaths occurred in the sample population during the period of interest; 159 (54.3%) deaths were among children younger than 5 years. The CMR was 3.2/10 000 per day (95% CI, 2.4-3.8/10 000 per day). Assuming a baseline CMR of 0.5/10 000 per day, approximately 6070 excess deaths (95% CI, 4442-7600) occurred among the 98 700 population of Gode district during the period of interest. The mortality rate among children younger than 5 years of 6.8/10 000 per day (95% CI, 5.4-8.2/10 000 per day) was approximately double the CMR throughout the period of interest. Mortality trends among children younger than 5 years tended to parallel measles mortality trends. Mortality rates were high at the beginning of the period of interest, but by April 2000 mortality rates were near the cutoff levels for definition of an emergency (Figure, B). Of the total deaths, 225 (76.8%) had occurred before any major humanitarian intervention commenced. Mortality rates began to increase again after the intervention began in April/May 2000.

Cause of death by age group is shown in TABLE 1. Almost 80% of all deaths were among children aged 14 years or younger and around 8% occurred among older persons. Wasting or wasting together with 1 of 4 major communicable diseases contributed to 206 (70.3%) deaths. Measles alone or together with wasting contributed to 47

Figure. Famine-Related Displacement and Mortality Rates



The retrospective period was from December 9, 1999, through July 26, 2000.

Table 1. Cause of Death by Age Group for December 1999 Through July 2000*

Age Category, y	Cause of Death, No. (%)				Total No. (%) of Deaths
	Wasting Alone	Wasting and Measles, Diarrhea, Malaria, or RTI	Measles, Diarrhea, Malaria, or RTI	Other	
<5	29 (43.3)	86 (61.9)	30 (60.0)	14 (37.8)	**159** (54.3)
5-14	22 (32.8)	30 (21.6)	12 (24.0)	8 (21.6)	**72** (24.6)
15-59	9 (13.4)	13 (9.4)	4 (8.0)	12 (32.4)	**38** (13.0)
≥60	7 (10.4)	10 (7.2)	4 (8.0)	3 (8.1)	**24** (8.2)
Total	**67** (100)	**139** (100)	**50** (100)	**37** (100)	**293** (100)

*RTI indicates respiratory tract infection.

(16.0%) deaths and 35 (22.0%) of the 159 deaths among children younger than 5 years. Measles alone or together with wasting contributed to 12 (16.7%) of the 72 deaths among children aged 5 to 14 years. Of the 47 measles-related deaths, 35 (74.5%) were among children younger than 5 years, 8 (17.0%) were among children aged 5 to 9 years, and 4 (8.5%) were among children aged 10 to 14 years.

Cause of death differed before and after April/May 2000 when major humanitarian interventions had been implemented. Excluding the category "other," of the 210 deaths occurring from December 1999 through May 2000, 29% were attributed to wasting alone, 55% to wasting and 1 of the 4 major communicable diseases, and 16% to 1 of the 4 major communicable diseases alone. After April/May 2000, excluding the "other" category, only 15% of the 46 deaths were due to wasting alone, 50% to wasting and 1 of the 4 major communicable diseases, and 35% to 1 of the 4 major communicable diseases alone ($P<.01$ for all).

Malnutrition and Morbidity

Anthropometric measurements were taken for 867 children aged 6 months to 5 years. The mean weight for height *z* score was –1.53 (95% CI, –1.60 to –1.46). Overall, at least 8 months after the famine began, 252 (29.1%; 95% CI, 24.7%-33.4%) children in this age group had wasting; 203 (23.4%; 95% CI, 19.7%-27.0%) had moderate wasting and 49 (5.7%; 95% CI, 4.1%-7.3%) had severe wasting. Differences between sexes were not statistically significant. Of the 144 children who met NGO criteria for admission to supplementary feeding programs (percentage median weight for height of 70%-80%), only 31 (21.5%; 95% CI, 7.4%-35.7%) were enrolled in feeding programs at the time of the survey. Of the 33 children who met NGO criteria for admission to therapeutic feeding centers (percentage median weight for height of <70%), only 4 (12.1%; 95% CI, 1.1%-23.1%) were actually receiving therapeutic feeding at the time of the survey.

Of the 867 surviving children who were younger than 5 years in the survey, 519 (59.9%; 95% CI, 48.5%-71.0%) had been vaccinated against measles and 530 (61.1%) were reported to have had an illness in the 2 weeks before the survey. Of these 530, 188 (21.7%) had a respiratory tract infection; 159 (18.3%), watery diarrhea; 102 (11.8%), fevers and chills; 55 (6.3%), measles; and 26 (3.0%), bloody diarrhea. Cumulative incidence rates of measles in the previous 2 weeks increased with increasing levels of wasting: 4.7% of well-nourished children had measles; 8.4% of moderately wasted children had measles (relative risk, 1.8; 95% CI, 1.0-3.3); and 18.4% of severely wasted children had measles (relative risk, 3.9; 95% CI, 1.8-8.5).

Among the 722 adults (aged 18-59 years) with complete data, 97 pregnant women were excluded from the analysis of BMI. For the 625 remaining adults, the mean (SE) unadjusted BMIs were 18.0 (0.2) kg/m^2 for men and 19.3 (0.1) kg/m^2 for women; mean (SE) adjusted BMIs were 19.7 (0.2) kg/m^2 and 20.9 (0.1) kg/m^2, respectively. Overall, the prevalence of undernutrition (BMI, <18.5 kg/m^2) using the unadjusted BMI was 49.3% (95% CI, 44.0%-54.5%) and using the adjusted BMI was 22.7% (95% CI, 17.9%-27.5%), a difference of 26.6 percentage points. For both men and women, the prevalence of both moderate and severe undernutrition decreased substantially after the BMI adjustment (TABLE 2).

Among the 104 older persons, the mean (SE) unadjusted BMIs were 17.2 (0.3) kg/m^2 for men and 18.4 (0.4) kg/m^2 for women; mean (SE) adjusted BMIs were 19.1 (0.3) kg/m^2 and 19.3 (0.4) kg/m^2, respectively. With the exception of mildly undernourished women, the prevalence of undernutrition declined after BMI adjustment (Table 2).

COMMENT

Mortality

From December 1999 through July 2000, the CMR in Gode district was approximately 6 times higher than the prefamine baseline and 3 times higher than the accepted cutoff for the definition of the acute phase of a complex emergency.[1] Given the widespread and severe food shortages, high preva-

Table 2. Comparison of Prevalence Rates for Undernutrition Among Adults and Older Persons Using Adjusted and Unadjusted Body Mass Index

	No. (%) [95% Confidence Interval]							
	Adults (18-59 y) (n = 625)				Older Persons (≥60 y) (n = 104)			
	Men		Women		Men		Women	
Body Mass Index, kg/m^2	Unadjusted	Adjusted*	Unadjusted	Adjusted*	Unadjusted	Adjusted*	Unadjusted	Adjusted*
<18.5 (Total)	107 (61.5) [53.1-69.9]	49 (28.6) [19.6-36.7]	199 (44.5) [38.5-50.6]	92 (20.6) [15.8-25.4]	25 (71.4) [55.2-87.6]	13 (37.1) [24.4-49.9]	40 (58.0) [48.1-67.9]	30 (43.5) [33.5-53.5]
17.0-18.4 (Mild)	49 (28.2) [20.5-35.8]	38 (22.2) [14.2-29.5]	97 (21.7) [17.7-25.7]	65 (14.5) [10.5-18.6]	11 (31.4) [16.4-46.5]	9 (25.7) [12.6-38.9]	12 (17.4) [9.2-25.6]	14 (20.3) [12.6-28.0]
16.0-16.9 (Moderate)	33 (19.0) [12.2-25.7]	6 (3.5) [1.1-5.8]	53 (11.9) [8.5-15.2]	15 (3.4) [1.8-4.9]	6 (17.1) [3.9-30.4]	2 (5.7) [0-12.4]	10 (14.5) [6.8-22.2]	9 (13.0) [4.8-21.3]
<16.0 (Severe)	25 (14.4) [9.1-19.7]	5 (2.9) [0.1-5.6]	49 (11.0) [8.1-13.9]	12 (2.7) [1.4-4.0]	8 (22.9) [10.0-35.8]	2 (5.7) [0-13.7]	18 (26.1) [16.2-36.0]	7 (10.2) [2.6-17.7]

*Adjusted for body shape.

lence rates for wasting, and reports of measles in the other districts within the zone,[15] we believe that the mortality rates for the entire zone were likely to be similar to those for Gode district. The CMRs of around 3.5/10 000 per day were consistently reported from sites in other districts in Gode zone during the same period (oral communication, Rudi Coninx, MD, International Committee of the Red Cross, June 30, 2000). By extrapolating our mortality rates to the larger zonal population of approximately 330 000, we estimate that approximately 19 900 (95% CI, 14 500-25 000) excess deaths occurred across Gode zone during the same period. Evidence suggests that other zones, such as Degehabur, Shinile, Fik, and Korahe, were at least as badly affected by famine as Gode zone even though they attracted less humanitarian aid.[15,26,27] For example, in Iodora town (Shinile zone), a rapid assessment in June 2000 estimated that the prevalence of wasting (weight for height z score, <-2) among children 6 months to 5 years was 70%.[15] If mortality rates in these other 4 zones were similar to those for Gode zone, an estimated 98 000 (95% CI, 71 600-122 700) excess deaths may have occurred during the famine among the 1.5 million people living in these 5 zones.

Children younger than 5 years generally account for the majority of deaths during complex emergencies in developing countries.[28] Wasting and common communicable diseases have historically caused most deaths during such emergencies.[29] Consistent with these findings, wasting alone or in combination with 4 major communicable diseases (ie, measles, diarrhea, malaria, and respiratory tract infections) was the most common cause of mortality in Gode district. More than half the deaths were in children younger than 5 years. However, a relatively large proportion of deaths in our sample occurred among children aged 5 to 14 years whose baseline mortality rates would be expected to be far lower. These results underscore the importance of considering relative increases in age-specific mortality as well as absolute mortality in such situations.[30]

Mortality rates were highest in December 1999 and January 2000 coinciding with the highest rates for famine-related displacement. Both displacement and mortality rates decreased until reaching a nadir in April 2000. After humanitarian interventions began in Gode from April to May 2000, more people moved to sites such as Gode town, from which major food distributions and humanitarian services were delivered. Hygiene and sanitation conditions for these displaced persons were poor. Communicable diseases contributed to a significantly higher proportion of deaths in the period after major humanitarian interventions began, suggesting that the population concentration and poor hygiene and sanitation may have contributed to disease transmission. Rates for mortality, particularly measles-specific mortality, increased after April 2000 supporting this contention.

Malnutrition

During assessments in complex emergencies, the nutritional status of children younger than 5 years is considered a good proxy for community nutritional status. Therefore, children have generally been the only demographic group regularly included in nutrition surveys. However, by the time NGOs begin operating in such emergencies, the most severely wasted children may have already died. Finding low prevalence rates for wasting among children in such situations may lead to the erroneous conclusion that the nutritional situation is stable or improving.[31] Therefore, the collection and analysis of retrospective mortality data are particularly important for the interpretation of results from nutrition surveys during prolonged famine. In our survey, mortality rates for children younger than 5 years had been high early in the period of interest and, as a result, prevalence rates for severe wasting among children in July 2000 were likely to be subject to survival bias and thus underestimated. Under such circumstances, the assessment of adult nutritional status may contribute to a better understanding of community nutritional status. The importance of adult undernutrition itself, as a cause of mortality during prolonged, severe famine is now recognized.[31-33] Adults, however, are still not regularly included in nutrition surveys in complex emergencies.

The lack of consensus among international agencies on the most suitable anthropometric indicator and anthropometric cutoffs for defining adult undernutrition has been a major obstacle to the nutritional assessment of adults becoming a standard component of health and nutrition assessments in complex emergencies. The WHO's BMI cutoffs[22] represent the current standard for the definition of undernutrition among adults, but the lack of comparability between ethnic groups that results primarily from variation in body shape has prevented widespread acceptance of criteria based on BMI. Many communities subject to recurrent food shortages and famine in eastern Africa and the Horn of Africa are pastoral groups with low Cormic indices, such as the Dinka and Nuer in southern Sudan, or the Turkana and Masai in Kenya.[34,35] Prevalence rates for undernutrition in these communities, if based on unadjusted BMI, are likely to include a large proportion of adults who are actually not undernourished.[36] Comparison of the prevalence rates for undernutrition among adults from our survey, using unadjusted and adjusted BMI, demonstrates the major differences that result from adjusting for relative leg length in tall, thin populations.

In our survey, the overall prevalence rates for undernutrition among adults aged 18 to 59 years, using unadjusted BMI, was 1.5 to 2 times higher than that for wasting among children aged 6 months to 5 years. In addition, using unadjusted BMI, a substantial proportion of adults were classified as severely undernourished. If these rates were valid, we would expect deaths among adults to have accounted for a relatively high proportion of total mortality during the

period of interest. However, the proportion of deaths among adults was not high during this period indicating that the prevalence rate for undernutrition using adjusted BMI may be a far more plausible estimate than the rate derived from unadjusted BMI. The decrease in prevalence among the severely undernourished group after adjusting BMI is particularly important because those adults with a BMI less than 16.0 kg/m^2 have the highest mortality[37] and are most likely to benefit from therapeutic feeding. Adjusting BMI for differences in Cormic index may allow comparisons with WHO standards and better targeting of scarce resources during famine.

Evidence is accumulating that in some emergencies, older persons may be more vulnerable than other population groups.[38-40] Furthermore, high age-specific mortality rates have been observed among older persons during previous famines in Ethiopia.[41] Older persons were frequently left alone during the famine in Gode as younger adults left home to search for suitable pasture for surviving livestock or for food aid. In our study, the high prevalence rates for undernutrition among older persons may partially account for the relatively large proportion of deaths among this group during the period of interest. Recently, recommendations have been made to include this group in population-based nutritional assessments during famine.[42] However, 2 major constraints will be encountered in such surveys. First, in developing countries, persons aged 60 years or older generally make up a small proportion of the total population and a large total sample size is needed to attain sufficient precision around prevalence estimates for undernutrition. Second, anthropometry in this group is complicated by the need to adjust height for the loss of height that occurs with aging as well as for the difference in Cormic index.

Measles

Measles vaccination, in combination with vitamin A distribution, to children up to ages 12 to 15 years is the first program priority in refugee camps.[8] Large outbreaks of measles have occurred in camps even when vaccine coverage rates have been higher than 80%.[1] Measles was a major preventable cause of morbidity and mortality in Gode among both children younger than 5 years and among children aged 5 to 14 years. Among rural populations with low natural immunity in Ethiopia,[43] and elsewhere in Africa,[44] substantial measles morbidity and mortality have previously been observed among children older than 5 years. Although the relationship between measles and wasting is complex, children with measles are generally more susceptible to wasting, and children who have wasting are more likely to develop complications of measles and have higher case-fatality rates.[45] Among children aged 6 months to 5 years in our study, we found a dose-response relationship between the degree of wasting and cumulative incidence of measles in the previous 2 weeks. A higher infectious dose of measles is associated with more severe disease, and children contracting measles from siblings or in crowded places generally receive higher infectious doses.[46,47] In Gode, children who had wasting were more likely to be in crowded feeding centers or displaced centers in the presence of infectious children. Therefore, these children probably had a higher chance than well-nourished children of receiving a larger infectious dose of measles virus and of developing clinical signs of measles of sufficient severity to be reported by their mothers.

Limitations

There are a number of limitations to our study. Recall bias is an important limitation in any retrospective study of mortality. Events occurring more recently are generally better remembered. For this reason, we chose to limit our study period to 8 months and to define the beginning of the study period by a religious date known to the entire population. Second, because only households present on the day of the survey were sampled, households in which all members had died during the famine could not have been selected, and we may have underestimated mortality. Finally, because there was no functioning surveillance system, no death registration, and no distribution of vaccination cards in the district, we relied on oral reports of the responding household member (usually the mother) to determine morbidity, cause of death, and vaccination status of children. We attempted to improve the accuracy of reporting by asking a series of questions detailing each death. The use of standardized case definitions and specific terms in Somali for causes of death also improved the accuracy of verbal reports. Furthermore, to avoid misclassification of deaths due to a combination of wasting and a communicable disease (a common cause of death during famine) into one or another category, such combinations were included as potential causes of death. Although such verbal autopsy techniques may be specific and sensitive in African settings for certain common causes of death, such as measles,[48] some misclassification may still have occurred.

Conclusions and Recommendations

A prolonged and severe famine occurred in Gode district and the surrounding area from December 1999 or earlier and continued at least until July 2000. Most deaths were due to wasting and major communicable diseases and occurred before the humanitarian intervention began in April/May 2000. The humanitarian response in Gode was delayed and inadequate, consisting primarily of food aid and selective feeding programs at a few central locations. Despite this programmatic emphasis on food-related interventions, coverage of feeding programs remained extremely low, particularly in remote villages, because of long distances to centers, poor transport infrastructure, and poor awareness and acceptance by the population. Our results raise the possibility that the humanitarian interventions may have increased communicable disease trans-

mission and mortality by attracting nonimmune, malnourished people to central locations. In such situations in the future, less centralized, community-based programs for selective feeding need to be considered.

Despite low measles vaccination coverage and an ongoing measles epidemic from December 1999 through July 2000, a measles vaccination campaign with coverage sufficient to stop the epidemic was not implemented in Gode district until August 2000. Public health recommendations for complex emergencies, now codified as guidelines and minimum standards and systematically implemented in refugee camps, need to be enforced in other types of emergencies. Measles vaccination, in combination with vitamin A distribution, is a lifesaving intervention that needs to be implemented immediately in all types of complex emergencies. Vaccination coverage should be above 90% and extended to children up to age 12 to 15 years.[8]

Nutrition and mortality data should be collected, analyzed, and interpreted together during famine emergencies. Such data may help identify the underlying public health causes of malnutrition in famine, such as measles or diarrhea, that may interact with poor availability and access to food to increase the risk for mortality. Such data may also challenge the assumption that only children younger than 5 years are at a higher risk for malnutrition and mortality. In Gode, the lack of anthropometric data on adults, particularly older persons, resulted in groups at potentially high risk of mortality due to undernutrition not being targeted for selective feeding interventions.

The nutritional assessment of adults and older persons, however, is constrained by the lack of international consensus on definitions of undernutrition in these groups. Using a BMI that is not adjusted for body shape to assess adult undernutrition is unlikely to be useful in the many famine-prone areas of the world in which most pastoral communities are particularly vulnerable to undernutrition and have a low Cormic index. The method described herein to adjust BMI for body shape and thus allow comparison with international cutoffs should be repeated and the results validated against mortality and functional health outcomes in other famines and among other ethnic groups. After this method is further validated, a database of baseline mean BMIs and Cormic indices for populations regularly affected by famine should be collated for future reference and computer software to perform the relevant calculations should be developed for field surveys.

Finally, unlike refugee camps in which the United Nations High Commissioner for Refugees coordinates the humanitarian response, in complex emergencies involving large famine-affected populations and/or internally displaced persons, no international agency has a mandate for overseeing surveillance systems, designing programs based on such data, or for coordinating the humanitarian agencies. Ultimately, governments are responsible for such activities but when their capacity to fulfill this role is overwhelmed, they should assign it to a competent international organization. By working in partnership with government ministries, such an agency could also build capacity for improved emergency response in the future. In the absence of such structural changes to the humanitarian system, entirely preventable loss of life is likely to continue to occur on a large scale during complex emergencies.

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> Man must evolve for all human conflict a method which rejects revenge, aggression and retaliation. The foundation of such a method is love.
> —Martin Luther King, Jr (1929-1968)