TRENDS IN NUTRITION AND MORTALITY FROM PUBLICLY AVAILABLE SURVEYS DARFUR, SUDAN 2004-2008

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Definitions and abbreviations

AU	African Union	
CDR	Crude Death Rate	Risk of dying for all age groups, death per day per 10,000
CE-DAT/CRED	Complex Emergency Database	Database at CRED containing standardized and comprehensive data on the human impact of conflict
CRED	Centre for Research on the Epidemiology of Disasters	
DE	Design Effect	The factor by which variance of the point estimate using a specific sampling design e.g. cluster differs from what the variance would have been had the same number of persons been sampled totally at random.
DHNP	Darfur Humanitarian Need Profile	Quarterly report from OCHA-Sudan on the humanitarian situation in Darfur
DNU	Darfur Nutrition Update	Quarterly report from UNICEF-Sudan on the humanitarian situation in Darfur
GAM	Global Acute Malnutrition	Prevalence (%) of children from 6 to 59 months of age with weight-for-height z-score below -2 or oedema.
GoS	Government of Sudan	The Sudanese government in Khartoum
HNTS	Health and Nutrition Tracking Service	Inter-agency organization hosted by WHO
IDP	Internally Displaced Person	Displaced person within the country, in contrast to a refugee, who seeks refuge in another country
JEM	Justice and Equality Movement	Rebel movement, Darfur
NCHS	National Centre for Heath Statistics	The agency that has defined the child growth standard which is used to assess GAM and SAM
NGO	Nongovernmental Organization	
NICS/SCN	Complex Emergency Database	Database at SCN containing nutrition and mortality data published in NICS and RNIS
NICS	Nutrition Information in Crisis Situations	Reports from SCN
OCHA	Office for Coordination of Humanitarian Affairs	UN organization
RNIS	Refugee Nutrition Information System	Earlier reports from SCN, now NICS
SAM	Severe Acute Malnutrition	Prevalence (%) of children from 6 to 59 months of age with weight-for height z-score below -3 or oedema.
SCN	Standing Committee on Nutrition	UN organization
SLA	Sudan Liberation Army	Rebel movement, Darfur
UN	United Nations	
U5DR	Under-5 Death Rate	Risk of dying for live-born children below 5 years of age, death per day per 10,000
WFP	World Food Programme	UN organization

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ABSTRACT

The crisis in Darfur, Sudan has a long and complex history in a population prone to chronic food insecurity. The current crisis began in 2003 with an armed insurgency and a counter-offensive by the Government of Sudan (GoS). Although the humanitarian repercussions were dramatic, access to humanitarian aid was denied. At the beginning of 2004 the international community began to intervene; GoS ceased its direct attacks on civilians, but continued to support local militias (Janjaweed). Throughout 2004 and 2005 humanitarian aid gained momentum. Darfur is now the arena of the largest humanitarian operation in the world.

To investigate the evolution of the humanitarian situation in Darfur, trends in nutritional status and mortality from 2004 to 2008 were analysed based on 164 publicly available surveys. Malnutrition prevalence and death rates were modelled taking into account changes in the contextual situation and humanitarian aid, status of the population (residents and internally displaced persons (IDPs)) and seasonal variations.

The results of the analysis showed that by the end of 2005 the humanitarian crisis had generally been contained, with an overall yearly decrease of 16% in prevalence of global acute malnutrition (GAM) and a 28% decrease in prevalence of severe acute malnutrition (SAM) in 2004 and 2005. These decreases were homogeneous across all three states and populations (residents as well as IDPs). The decrease in the risk of dying was even more marked: the crude death rate (CDR) dropped by between 44% and 75% per year depending on the state and type of population, while the under-five death rate (U5DR) decreased by 50% each year. At the end of 2005, the risk of dying was below emergency thresholds for both the general population and for children under five years of age. However, the affected population continued to suffer under the combined effects of high levels of violence, deteriorating livelihood conditions and food shortages.

Both the security environment and the overall humanitarian context became increasingly complex after 2005. In addition to the main parties to the conflict[1], new rival factions with different motives emerged, and incidents of banditry increased. Livelihood conditions had changed. Humanitarian aid workers and convoys were increasingly attacked and harassed. However, despite this, levels of malnutrition remained stable in both North and South Darfur. In West Darfur, GAM remained stable but SAM tended to increase for IDPs, which might be interpreted as an indication of the population's reduced ability to cope, although mortality rates remained stable. Mortality rates seemed to increase slightly for residents in South Darfur after 2005, even though the nutritional status was stable. This rise may be due to the increased levels of violence in South Darfur from the end of 2007 and throughout 2008.

At the end of 2008 violence, armed assaults and banditry were still widespread, and the security situation was becoming increasingly complex with the emergence of splinter rebel groups and other armed factions. The humanitarian situation remained fragile and signs of a forthcoming breakdown emerged. In view of this, it is important that the humanitarian situation continue to be closely monitored.

[1] The two rebel groups (the Sudan Liberation Army and the Justice and Equality Movement) on the one hand and GoS on the other.

INTRODUCTION

The crisis in Darfur, Sudan has a long and complex history dating back to the 1980s or even before [Young & Maxwell 2009], with a population already affected by a high burden of disease, chronic food insecurity, inadequate health and water services and lack of sanitation facilities [FANTA2]. The current crisis began in 2003 when rebel groups went on the offensive against the Government of Sudan (GoS), which launched a forceful counter-offensive.

By January 2009, 4.8 million civilians had been affected by the crisis, of whom 2.9 million were displaced (Figure 1). Cease-fires and peace agreements as well as extensive humanitarian aid have improved matters somewhat. However, the situation remains highly volatile[2].

This study reviews nutrition and mortality trends in Darfur from 2004 to 2008 in order to evaluate the evolution of the humanitarian situation.

AIM AND LIMITATIONS

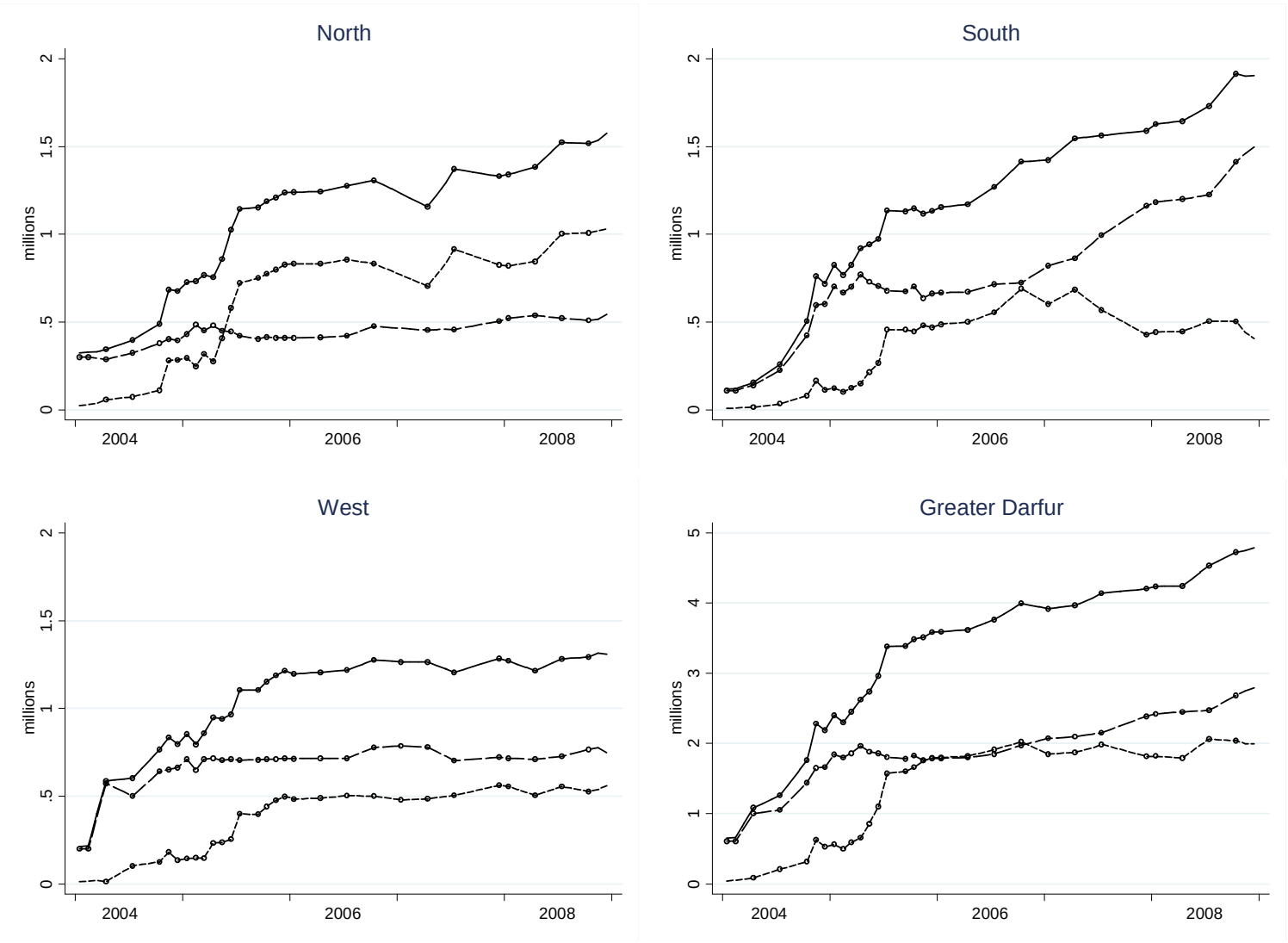
The study aims to analyse general trends in nutrition and mortality and correlate these with general contextual trends in the evolution of the crisis in Darfur.

The following issues are beyond the scope of this study:

- Thorough contextual analyses of the Darfur crisis including all perspectives such as its impact on livelihood, trade and markets. For more information on these aspects, see reports from Feinstein International Center [FIC].
- Thorough analysis of mortality by cause of death (e.g. violence or morbidity).
- More detailed analyses such as 1) the effect of nutritional status on mortality; 2) the effects of measles coverage, crowding (household size), morbidity (diarrhoea, ARI or other illness), feeding centres, food security, access to population etc. on the humanitarian situation.

[2] It is worth noting here the major developments of March 2009, when the International Criminal Court issued an arrest warrant for the Sudanese president Omar al-Bashir. GoS subsequently expelled 13 international humanitarian NGOs [Parmar 2009] and revoked the licences of three national NGOs [ALNAP-HPG 2009].

Figure 1. Development in affected population



Quick dotted line: Residents. Long dotted line: IDPs. Solid line: Total
Source: Darfur Humanitarian Needs Profiles, OCHA-Sudan

BACKGROUND

Darfur is the westernmost region of Sudan (Figure 2), the largest country in Africa. Sudan covers 2.5 million square kilometres and had a population of 39 million in 2008 [CBS-Sudan]. Darfur consists of three federal states: North, South and West Darfur. Before the current conflict, greater Darfur had a population of 6.5 million.

Darfur's many challenges through the years have included inter-tribal clashes, armed conflict in bordering countries, and agro-meteorological hazards affecting livelihood. Darfur is prone to drought and desertification in the north, leading southern farmers and northern pastoral nomads to clash over scarce resources. The conflict had generally been limited to raids by armed bandits and inter-ethnic clashes. Despite various attempts to reconcile, including peace conferences in 1989, 1997 and 2002, the conflict continued [MSF-H 2004]. In spite of this, the overall nutritional and mortality situation in Darfur in 2000 was comparable to that of other states in Sudan [Guha-Sapir and Degomme 2005], although the prevalence of childhood malnutrition was elevated in North Darfur [MICS 2000].

Figure 2


Briefing Map showing Sudan States & States Capitals
February 2006
Map Ref No: 2006-0017
World Health Organization
Egypt
Red Sea
Libya
Northern
DONGOLA
Red Sea
PORT SUDAN
Nile
ED DAMER
Chad
Northern Darfur
Khartoum
KHARTOUM
Kassala
KASSALA
Eritrea
El Gezira
WAD MADANI
Gedaref
GEDAREF
Northern Kordofan
AL GENAINA
AL FASHIR
EL OBEID
White Nile
RABAK
SINJA
Sennar
Western Darfur
NYALA
DAMAZIN
Southern Kordofan
KADUGLI
Blue Nile
Southern Darfur
Ethiopia
Upper Nile
MALAKAL
BENTIU
AWEIL
Unity
Northern Bahr El Ghaza
Warrab
WARAB
WAU
Central African Republic
Western Bahr El Ghazal
Jonglei
RUMBEK
Lakes
BOR
Legend
State Capital
State Boundary
International Boundary
Western Equatoria
Juba
YAMBIO
Eastern Equatoria
KAPOETA
Bahr El Jabal
Zaire
Kenya
Uganda
Data Source: Political boundaries from SIM and OCHA
Printing Date: February 22, 2006
Contact Darfurcrisis@sud.emro.who.int with questions or comments.
0 85 170 340 510 680
Kilometers
Disclaimer: The presentation of material on the map contained herein does not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or areas or its authorities of its frontiers of boundaries.

Over the past decades, the government in Khartoum has devoted few resources to developing Darfur's infrastructure, including schools. GoS has either ignored the conflicts in Darfur or has tried to manage them through its support of the Arab militias (Janjaweed). In the 1990s an organized rebellion began in Darfur, from which the Sudan Liberation Army (SLA) and the Justice and Equality Movement (JEM) emerged.

2003-2008

In February 2003, the SLA and JEM attacked major towns in North and West Darfur [Danet et al 2007, Muthee 2007]. GoS reacted by reinforcing government troops and joining arms with the Janjaweed. The government's forceful counter-offensive, mainly targeting the civilian groups from which the rebels were supposedly recruited, was mainly carried out by the Janjaweed with support from the Sudanese Air Force [Petersen and Tullin 2005]. From June to September 2003 the counter-offensive concentrated on the south and west of North Darfur [Danet et al 2007], drawing in West Darfur by October of that year. By then, parts of the rebel forces had withdrawn to the eastern and southern parts of Darfur. From April 2004 GoS extended its operations to greater Darfur, including South Darfur. During the counter-offensive, civilians were indiscriminately killed, beaten and raped [UnderstandingSudan 2006, Danet et al 2007, Hagan et al 2009]. Hundreds of villages were looted and razed, crops were ruined and grain in storage was destroyed [Petersen and Tullin 2005]. This led to massive population displacements as people moved within the region or fled across the border to Chad. Military operations continued despite cease-fire agreements in September 2003 and April 2004 and despite the arrival of 100 observers and 300 soldiers from the African Union (AU) in August 2004 to monitor the ceasefire.

The resulting humanitarian crisis was not on the international agenda before the end of 2003, mainly because access to Darfur was denied by GoS, thus preventing reports of the situation reaching the wider community. In February 2004, humanitarian NGOs gradually began setting up operations in Darfur. By April 2004, around one million people had been displaced and much of the previous year's food crops had been destroyed or left un-harvested, resulting in severe food shortages throughout the region.

On 30 July 2004, the United Nations (UN) and GoS signed a communiqué in which the latter pledged to improve humanitarian access, human rights and security and strive for a political resolution of the conflict. However, the violence continued. The situation did not improve following a renewed commitment by GoS later that year, nor did the October deployment of 2900 additional troops from the AU, with a mandate expanded to include the protection of civilians, result in any discernible improvement. Security remained highly volatile.

By the end of 2004 the number of internally displaced persons (IDPs) had risen to 1.8 million. Overall, 2.4 million persons were affected by the crisis (Figure 1). The area planted for the 2004 harvest was only 40% of that cultivated in 2003. Food prices had increased by 60% because of poor harvests and disrupted transportation from food-surplus areas.

In 2005 the humanitarian situation stabilized and even improved slightly. By the end of the year, mortality had decreased to below emergency levels and the nutritional status had stabilized but remained precarious. However, the security situation continued to be volatile, with continuing banditry, attacks on civilians and harassment of aid workers. Communities' coping mechanisms were close to the point of exhaustion, and the numbers of affected people rose to 3.6 million (Figure 1), mainly among residents. Half of those affected by the crisis were IDPs.

In May 2006 GoS and SLA, the largest rebel group, signed a peace agreement. Other rebel groups refused to sign, which led to disputes, further fragmentation among these

groups and continued high levels of insecurity. Attacks on humanitarian aid workers and convoys increased [NICS]. Although AU's mandate was extended in September to include 23 000 peacekeeping troops with logistic support from the UN, only 7000 troops had been deployed by January 2007.

The World Food Programme (WFP) rations have fluctuated, including a halving of the ratios in 2006, due to various factors like lack of funding, access and attacks. Other humanitarian organizations began phasing out operations, mainly because mortality and malnutrition rates had returned to below emergency levels, but also because of the continuing high insecurity. As was the case in 2005 and 2004, large areas that were previously harvested remained uncultivated due to the prevailing insecurity.

The situation did not improve in 2006. The conflict became increasingly complex with the fragmentation of the rebel groups and unclear chains of command among both the GoS-supported Janjaweed and the rebels. Furthermore, banditry was on the rise and attacks on humanitarian aid workers and convoys increased, hampering humanitarian assistance. The number of people affected by the crisis remained unchanged.

There were high levels of insecurity and violence throughout 2007. Armed confrontations between GoS forces and their proxies and the rebel groups, that did not sign the peace agreement, continued and escalated in the last quarter of 2007, particularly in South Darfur. Janjaweed attacks on unarmed civilians also continued, as did inter-tribal fighting and banditry, and humanitarian aid workers were regularly attacked and harassed. By the end of 2007, the number of people estimated to be affected by the crisis had risen to 4.2 million, of whom 2.4 million were IDPs.

The widespread insecurity and violence continued throughout 2008, although the increased levels of violence in South Darfur subsided. By the end of 2008 AU had deployed only 12 369 peacekeeping troops and 2767 police officers, well below the target of 26 000. The proliferation of arms, fragmentation of armed groups and increasing number of local and inter-tribal conflicts resulted in an extremely complex patchwork of dynamics.

Reviewing the general pattern of the Darfur crisis from 2003 to 2008, two periods emerge. The first period from 2003 to the end of 2005 begins with the armed insurgency followed by a government counter-offensive using local militias and targeting civilians. The second period, from 2006 onwards, begins with a partial peace agreement that is partly undermined by GoS's continuing indirect involvement in the crisis through the Janjaweed, who also begin pursuing own interests. The rebel groups fragment and form splinter groups, especially after the one-sided signing of the peace agreement in 2006 by the SLA. In this second period, banditry and lawlessness continue unabated. The humanitarian aid organisations were able to establish operations and gain a solid footing during the first period, and the humanitarian community has until now been able to contain the humanitarian crisis, in spite of some humanitarian NGO’s have left on their own volition or ordered by GoS.

METHODS

This section begins by describing the data and survey results included in the study and how they were evaluated and cleaned. It goes on to explain how the data were managed, completed and prepared for the statistical analysis. Lastly, the statistical model and methods used are described.

Data

The analysis of trends in nutritional status and mortality was based on publicly available survey results conducted in Darfur by different agencies and organizations. The NICS/SCN [NICS/SCN] and CE-DAT [CE-DAT] databases were the main sources of data and were completed with survey data referenced in survey reports. Survey reports that were not available on the Internet were obtained from the NGOs/agencies that conducted them.

These surveys were not intended to be representative of the whole population of Darfur. Furthermore, information is scarce, and some surveys may have been conducted in areas that were difficult to cover, or done by persons with limited experience in conducting surveys. Therefore, for the data used in the analyses to be as representative as possible, we followed the principle that all data contained some valid information and included as many surveys as possible, penalizing less sound data by reducing its influence on the analysis (see section below on data management).

Surveys

A total of 169 survey results were identified for the period 1 January 2004 to 31 December 2008 (Figure 3).

One survey conducted in September 2004 covered the whole of Darfur, and the results could not be disaggregated by state; this survey was discarded. Four other surveys were discarded for the following reasons: one was not cleared (Geneina town & camps, June 2007, Concern), two did not have a proper/random sampling (Galap camp, June 2005, MSF-S and Gereida, September 2004, ACF-F), and one (El Ferdous, Abu Matarik, Assayala in El Deain, South Darfur, October 2004) did not specify the responsible agency/organization.

Therefore 164 survey results were considered for the analysis. Of these, 135 survey reports were received, and 29 reports were not available. Assuming proper sampling in the surveys with unavailable reports, 164 surveys were eligible for analysis (Appendix A).

Information on the prevalence of global acute malnutrition (GAM) and severe acute malnutrition (SAM) according to the NCHS standard for child growth was available in 154 of the 164 surveys. Information on crude death rate (CDR) and under-5 death rate (U5DR) was available in 143 surveys (Figure 3).

Data cleaning

All point estimates (GAM, SAM, CDR and U5DR) and confidence intervals were re-calculated according to the formulas in Appendix B. All survey results with a recalculated point estimate differing by more than 0.1 from the reported estimate were manually evaluated. The variance of the point estimates were evaluated by comparing the calculated random-sampling variance (Appendix B) with the reported variance (extracted from the reported confidence interval), i.e. calculating the design effect (DE). The reported confidence intervals were manually evaluated if the calculated DE was below 0.5 or above 3. These evaluations implied the following corrections:

- One survey (Nyala town & Dereig and Mossey camps, September 2007, ACF-F) had an error in the calculation of SAM; corrected.

- One survey (Geneina town & camps, October 2005, Concern) had errors in the calculation of GAM and SAM; corrected.
- One survey (Mornei camp, January 2005, Concern) had an error in the calculation of GAM; corrected.
- One survey (Shaddad & Shanguil Tobaya camps, March 2005, MSF-S) reported much too small confidence intervals for GAM and SAM; CIs deleted.
- One survey (Zamzam Camp, September 2006, Relief International) reported unreliable confidence interval for GAM; CIs deleted.
- One survey (Kass town, June 2007, ACF-F) had a rounding error in U5DR; corrected.
- One survey (Seleah, August 2007, ACF-F) reports both 37 and 38 deaths; 38 used, as this number corresponds to the reported CDR.
- One survey (Otash camp, December 2007, ACF-F) had an error in the calculation of CDR; corrected.
- Two surveys (Seleia & Kulbus, January 2005, Concern and Otash camp, August 2004, IRC) had an error in the calculation of U5DR; corrected.
- One survey (Kutum town & Kassab camp, November 2006, GOAL) had too small confidence intervals for CDR and U5DR; CIs deleted.
- Three surveys (Gereida camp, January and July 2006, June 2007, ICRC) had not included oedema in the calculation of GAM and SAM; corrected and CIs deleted.

All “errors” in the estimates could be corrected or deleted, i.e. treated as not reported.

Supplementary information

General, contextual and/or supplementary information needed for the analysis was extracted from Internet searches, reports and personal contacts.

General information such as the number of affected persons was found in OCHA-Sudan’s Darfur Humanitarian Needs Profile (DHNP) reports [DHNP]. These, together with SCN’s reports [NICS/RNIS], were the main contextual source, supplemented with information from survey reports and other sources/reports.

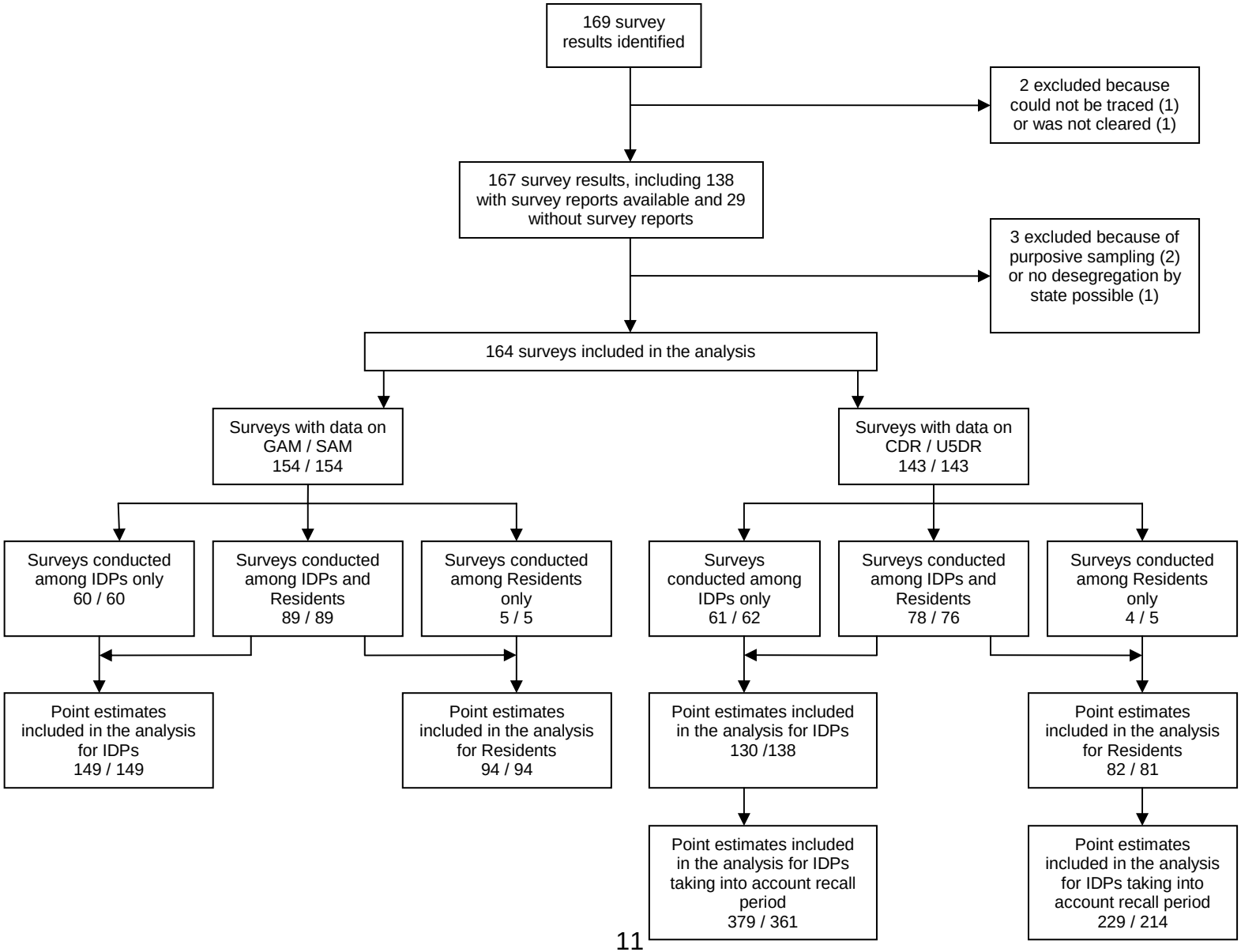
For the analyses, survey-specific information was needed on the surveyed population and the proportion of IDPs if the survey had been done on a mixed population. This information was primarily taken from the survey reports, if stated, otherwise from secondary but reliable sources such as OCHA-Sudan’s DHNP reports.

Data management

Point estimates and variances

All point estimates (malnutrition prevalences and death rates) have been recalculated according to the formulas (Appendix B) as part of the evaluation of the surveys (see Methods/Data/Data cleaning). Some of the surveys lacked information on one of the factors in the formula. The missing factor was calculated by reversing the formula, thereby making it possible to calculate the variance. However, if the number of children from 6 to 59 months of age for the calculation of malnutrition prevalence was missing, then this number was calculated from both GAM and SAM; the mean of the two was then used. The same goes for the length of recall in the retrospective mortality, where the mean of the calculated recall periods from CDR and U5DR was used.

Figure 3. Surveys 2004 to 2008



None of the surveys directly stated the variance of the point estimates, but many had 95% confidence intervals (Appendix A), and the variance could be extracted from these, i.e. a survey-variance including the sampling design effects (DE). The variance without DE, i.e. if the sampling had been random in the whole surveyed population, was calculated from the point estimates (Appendix B), and DE calculated by dividing the survey-variance with the variance obtained from assuming random sampling in the surveyed population. For surveys where DE could not be calculated, it was set to 4. The variance to be used in the statistical analyses was then calculated including these DEs. This implies that surveys without confidence intervals were penalized with a two-fold higher variance compared to those surveys that had confidence intervals in the survey reports, the latter having a DE around 2.

The size of a surveyed population is finite, and this had often been used in the sample-size calculations for the surveys. Hence, the formulas for variance of both malnutrition prevalence and risk of dying include the sampling fraction, i.e. the size of the surveyed population both total and for children below five years of age (Appendix B). For surveys with missing information on the size of the surveyed population in the survey reports, the size of the population was first taken from OCHA-Sudan's DHNP reports [DHNP]. If not possible, it was calculated by linear interpolation if several surveys had been conducted over time at the same location. Finally, information still missing on either total or under-5 population was calculated from one another, if one of them was known, by the ratio between the under-5 and total number of persons included in the survey, or if not possible, by the rule-of-thumb that the under-5 population comprises 20% of the total population.

All variance estimates were recalculated including DE and the sampling faction. However, for surveys in which the size of the whole surveyed population was not known or could not be deducted, the variance estimates were not reduced according to the size of the sampling fraction of the surveyed population (Appendix B), i.e. $(1-N/N_{pop})$ was set to 1.

Finally, for point estimates still missing a variance, we used the fact that the variance increases with value of the point estimate[3] (when it is below 50%), and the variance was set to the above described recalculated variance of the point estimate just larger in value, within each state and type of population (IDP or resident) and increased by 2 i.e. penalized by a further two-fold increased variance.

Influence of the size of the surveyed population

The size of surveyed populations varied from total population in a state down to below 10 000 (Figure 4). Surveys with different sizes of surveyed populations should be weighted accordingly. For example, a survey with a surveyed population of 20 000 should not have the same influence as a surveyed population of 100 000. A simple solution would be to weight each survey by the size of the surveyed population relative to the largest surveyed population among all the surveys. However, this presupposes a constant, or near constant, total population. The affected population in Darfur varied considerably over calendar time (Figure 1), i.e. the influence of a surveyed population of, for example, 50 000 should accordingly vary over time. We therefore used an influence index defined as the size of the surveyed population relative to the size of the affected population at the same point in calendar time.

Unfortunately, the size of the total affected population was only available for IDPs and residents separately, and not for mixtures of these corresponding to the proportion of IDPs and residents in the surveys. Therefore, all surveys on a mixed population (a little over half

[3] The formulas for variance may in principle be expressed as a function of the point estimate x (se Appendix B) having the form: $f(x) = c*x*(1-x)$. This function will be increasing from x=0 to 0.5, attaining its maximum at x=0.5 and then decrease.

of the surveys) were split to an IDP and a resident part according to the percentage of IDPs in the surveyed population. Most but not all surveys had information on the percentage of IDPs. For those missing information on the percentage of IDPs, we imputed this, first by a linear interpolation if surveys had been conducted at the same location, and if not possible, then by the mean percentage of IDPs among all surveys with a mixed population in the same state. It was not possible to differentiate the point estimates in IDP and resident populations. Hence, the point estimates in the two stereotype populations (IDPs and residents) will be the same mixture-estimates in both stereotype populations for those coming from a split survey.

For the two stereotype populations (IDPs and residents) the proportion of IDPs and residents in the surveyed population from which the stereotype population was extracted might have an impact in the analyses of the two stereotype populations, and should be included in the statistical model, expressed by percentage of IDPs in the original survey.

Further, information on affected populations (IDPs and residents) was not available on all time points (months). We interpolated the populations linearly and extrapolated (out of the time period where numbers were available) using a 6 months moving average (Figure 1).

Recall period for mortality

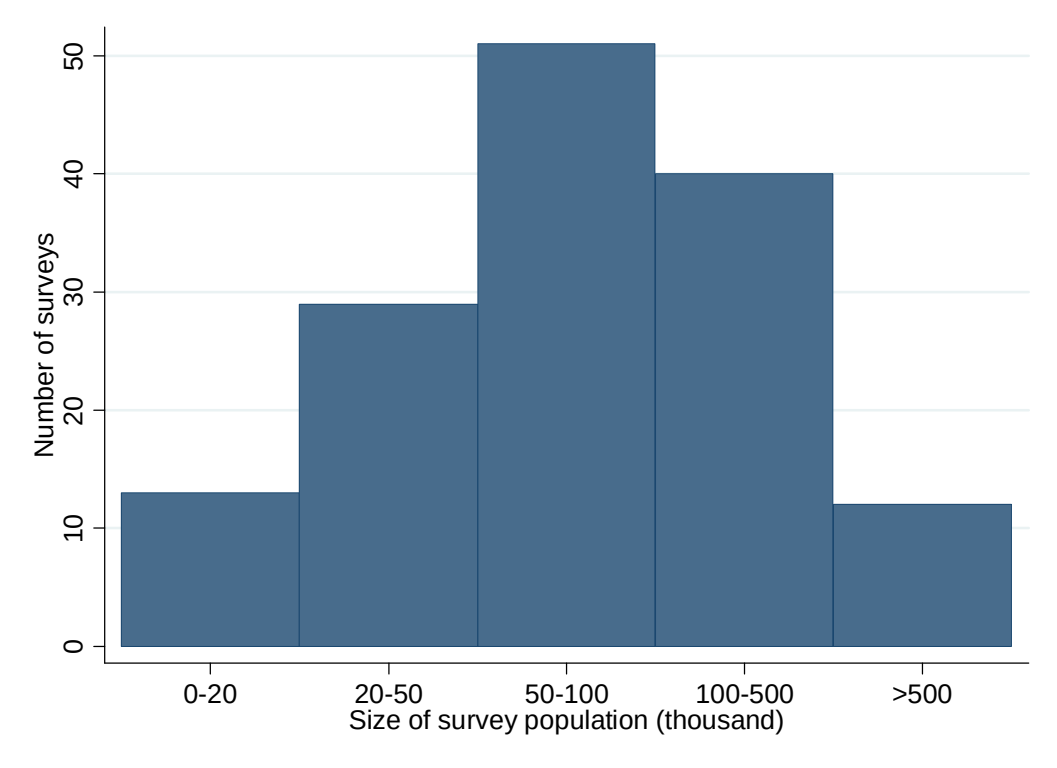
Death rates or risk of dying were estimated retrospectively based on a recall period, i.e. the death rate covers a period back in time from the date of the survey. We divided the recall period into months (time unit used in the statistical analyses) and split the survey in a series of monthly surveys covering the recall period. The death rate (CDR or U5DR) for each monthly survey had to be the death rate estimated for the whole recall period, as we did not have any information for differentiating/profiling over the recall period. However, splitting the survey in a series of monthly surveys will increase the variance of the monthly death rates in each monthly survey by total number of months covered during recall. Thus, for mortality, each survey was split in a series of monthly surveys with equal death rates (the estimated death rate over the whole recall period) and a variance of number-of-months-in-recall times the variance of the estimated death rate for the whole recall period (Appendix B). Five of the surveys had information on death rates in different periods of the total recall. These were used as “independent” surveys with their respective recall and placing in calendar time.

In summary, covering the period 2004 to 2008 we end up with 243 malnutrition (GAM and SAM) survey-estimates, and for mortality 608 CDR survey estimates and 575 U5DR survey estimates (Figure 3); all with a known variance.

Statistical methods

Nutritional status or risk of dying will change over calendar time due to changing conditions. There will be different trends over time depending on the level of violence, humanitarian aid and livelihood conditions. Seasonal variations will also affect the pattern (for example, the hunger gap associated with the yearly harvest-cycle will influence malnutrition prevalence and presumably also the risk of dying). We had two stereotypes of populations (IDPs and residents), but for around half of the surveys the surveyed population had been a mixture of residents and IDPs. Therefore, the proportion of IDPs in the original survey might affect the pattern, for example because IDPs are more likely to receive aid, a high proportion of IDPs might have a benign impact. Finally, the prevalence and risks are not exact, but point estimates with a known variance, which should be included [Nielsen et al 2005] as should clustering for surveys from the same location.

Figure 4. Size of survey population in surveys 2004-2008



Prevalence of malnutrition and death rates are *per se* positively skewed. Hence, a log-transformed model was used.

Model of the mean

The model of the mean for $Y_t = \log(X_t)$, where X_t might be GAM, SAM, CDR or U5DR at time point t, will be:

$$E(Y_t) = \beta_0 + \text{trends} + \text{proportion of IDPs} + \text{seasonal variation}$$

where β_0 is a constant indicating the level had there not been any changing condition like trends, proportion of IDPs and seasonal variations.

The humanitarian crisis in Darfur seems to have had two periods (see Background), the first from 2003 to 2005, and then from 2006 and onwards. Hence, an initial 2003-2005 and a later 2006-8 trend might be expected:

$$E(Y_t) = \beta_0 + \beta_1 * t + \beta_2 * \max(0,t-t_0) + \text{proportion of IDPs} + \text{seasonal variation}$$

where, t is calendar time and $\max(0,t-t_0)$ is time since t_0 = January 2006. Then, β_1 will be the trend 2004 through 2005 and $\beta 1 + \beta_2$ will be the trend from 2006 and onward.

For the two types of populations (IDPs and residents), the proportion of IDPs, p_idp, in the surveyed population will express the linear trend in effect of living in a mixed population:

$$E(Y_t) = \beta_0 + \beta_1 * t + \beta_2 * \max(0,t-t_0) + \beta_3 * p\_idp + \text{seasonal variation}$$

Seasonal variations which with period ω (365 days), amplitude α and displacement δ relative to January 1, take the non-linear form: $\alpha(t) = \alpha\sin((2\pi/\omega)\ (t + \delta))$, having minimum at January 1 + δ. Equivalent to the linear form: $\alpha(t) = A*\sin((2\pi/\omega)\ t) + B*\cos((2\pi/\omega)\ t)$. Where $\alpha^2 = A^2 + B^2$ and $\delta = (2\pi/\omega)*\arctan(B / A)$.

$$E(Y_t) = \beta_0 + \beta_1 * t + \beta_2 * \max(0,t-t_0) + \beta_3 * f\_idp + A*\sin((2\pi/\omega)\ t) + B*\cos((2\pi/\omega)\ t)$$

Model of the covariance

The known variance of the X_t's was included in the model as a known variance factor u_t with mean 0. Hence, the statistical model becomes:

$$Y_t = \beta_0 + \beta_1 * t + \beta_2 * \max(0,t-t_0) + \beta_3 * f\_idp + A*\sin((2\pi/\omega)\ t) + B*\cos((2\pi/\omega)\ t) + u_t + \varepsilon_t$$

The known variance u_t of Y_t was calculated using the delta method [Cox 2005]: $\mathrm{Var}(f(X)) \approx (f'(E(X)))^2 * \mathrm{Var}(X)$. Hence:

$$\mathrm{Var}(\log(X_t)) = \mathrm{Var}(Y_t) = (1/E(X_t))^2 * \mathrm{Var}(X_t) = \mathrm{Var}(X_t) / E(X_t)^2.$$

Finally, an autocorrelation/clustering between surveys from the same location, for example when splitting death risks over recall period, was included in the model.

Inference

The model, being a random-effect meta-regression with known within-survey variance [Higgins and Thompson 2004], was fitted using the Stata procedure *metareg* [Harbord 2008]. Estimation was weighted by the influence index described above. The model was fitted for all of greater Darfur in one overall regression stratified by state and type of population, thus, making it possible to test the parameters across state and population as well as test whether a reduction of the model was statistically appropriate (test for homogeneity) e.g. if the estimates might be joined over states or populations, or all together.

RESULTS

Nutritional status and death rates were analysed. First, the results of the analyses of nutritional status, GAM and SAM, are shown followed by the results of the analyses of death rates, CDR and U5DR.

Nutritional status

Even though prevalence of malnutrition normally is lower around the turn of the year, 2004 started with GAM above the internally recognized critical value of 15% for a nutritional emergency in all three states (Figure 5); highest in West Darfur.

Trend per year: 2004-2005

Overall GAM decreased significantly by 16% per year (Table 1: Trend per year = 0.84; 95%CI 0.77-0.92) and severe malnutrition decreased by 28% per year (Table 2: Trend per year = 0.72; 95%CI 0.59-0.89). Both adjusted for state, type of population, proportion of IDPs and seasonal variation. The decrease in GAM and SAM was the same for IDPs and residents and over states (test for homogeneity < 0.1).

Trend per year: 2006-2008

From 2006 and onward the level of malnutrition generally had stabilized (Trend per year around 1 in table 1 and 2), with GAM fluctuating between 10 and 20% (Figure 5) and SAM around 1-3% (Figure 6). The exception is West Darfur where the trend for SAM for IDPs was different from the other states (test for homogeneity = 0.08), and seems to be increasing by 44% per year (Table 2: Trend per year = 1.44; 95%CI 0.93-2.24), even though GAM was not or only very slightly increasing.

Characteristics of population

Generally, there seems to be a positive impact of living in a mixed population of IDPs and residents, seen by a slightly increasing relative effect (>1) by each 25% increase in proportion of IDPs in the stereotype IDP-population (more IDPs in the population increase malnutrition prevalence), and a decreasing relative effect (<1) among residents; equalizing when joining the two types of populations (≈ 1). Test for homogeneity between the populations had for both GAM and SAM p-values of 0.36 or more in all three states.

Season

Not surprisingly, the prevalence of malnutrition, GAM and SAM, showed significant seasonal fluctuation (Table 1 and 2); being highest around June/July and lowest around December/January (Figure 5 and 6). Overall, GAM fluctuated with 82% (Relative effect: 1.82; 95%CI 1.68-1.97) and SAM with 145% (Relative effect: 2.45; 95%CI 1.75-3.42). This means, with a mean GAM of 15% the mean seasonal fluctuation was between 8.85% (15*(1-0.82/2)) and 21.15% (15*(1+0.82/2)), and for a mean SAM of 1% the mean seasonal fluctuation was between 0.28% (1*(1-1.45/2)) and 1.73% (1*(1+1.45/2)).

Varying DE used to penalize for missing information on variance (Methods/Data management) did not change the pattern for either GAM or SAM.

Table 1. Trends in Global Acute Malnutrition

	IDPs	Residents	Both[1]
	Relative effect (95%CI)	Relative effect (95%CI)	Relative effect (95%CI)
North Darfur			
Trend per year:			
- 2004 – 2005	0.92 (0.78-1.10)	0.79 (0.65-0.96)	0.87 (0.76-0.99)
- 2006 – 2008	1.02 (0.90-1.16)	1.08 (0.93-1.25)	1.05 (0.95-1.16)
Characteristic of population:			
- 25% increase in proportion of IDPs	1.12 (1.04-1.21)	0.88 (0.80-0.96)	1.00 (0.95-1.06)
Season:			
- Fluctuation	1.84 (1.54-2.21)	1.82 (1.47-2.27)	1.80 (1.57-2.06)
- Minimum (month)	Jan (Jan-Feb)	Jan (Dec-Mar)	Jan (Dec-Feb)
South Darfur			
Trend per year:			
- 2004 – 2005	0.81 (0.64-1.01)	0.87 (0.70-1.09)	0.85 (0.72-1.01)
- 2006 – 2008	1.01 (0.91-1.12)	1.03 (0.93-1.13)	1.02 (0.94-1.10)
Characteristic of population:			
- 25% increase in proportion of IDPs	1.03 (0.95-1.11)	0.93 (0.85-1.02)	0.99 (0.94-1.05)
Season:			
- Fluctuation	1.93 (1.62-2.32)	1.87 (1.50-2.35)	1.85 (1.62-2.13)
- Minimum (month)	Dec (Nov-Jan)	Jan (Dec-Jan)	Jan (Dec-Jan)
West Darfur			
Trend per year:			
- 2004 – 2005	0.65 (0.47-0.90)	0.93 (0.68-1.28)	0.78 (0.62-0.98)
- 2006 – 2008	1.10 (0.93-1.30)	0.98 (0.83-1.16)	1.03 (0.92-1.16)
Characteristic of population:			
- 25% increase in proportion of IDPs	0.98 (0.86-1.10)	0.95 (0.86-1.05)	0.96 (0.89-1.03)
Season:			
- Fluctuation	1.76 (1.30-2.38)	1.97 (1.52-2.56)	1.94 (1.58-2.39)
- Minimum (month)	Dec (Oct-Feb)	Dec (Nov-Jan)	Dec (Nov-Jan)
Greater Darfur[2]			
Trend per year:			
- 2004 – 2005	0.83 (0.74-0.93)	0.86 (0.76-0.96)	0.84 (0.77-0.92)
- 2006 – 2008	1.03 (0.96-1.11)	1.03 (0.96-1.11)	1.03 (0.97-1.08)
Characteristic of population:			
- 25% increase in proportion of IDPs	1.05 (1.00-1.10)	0.92 (0.87-0.97)	0.99 (0.95-1.02)
Season:			
- Fluctuation	1.80 (1.62-1.99)	1.86 (1.64-2.11)	1.82 (1.68-1.97)
- Minimum (month)	Jan (Dec-Jan)	Jan (Dec-Jan)	Dec (Dec-Jan)

1) Controlled for population 2) Controlled for state

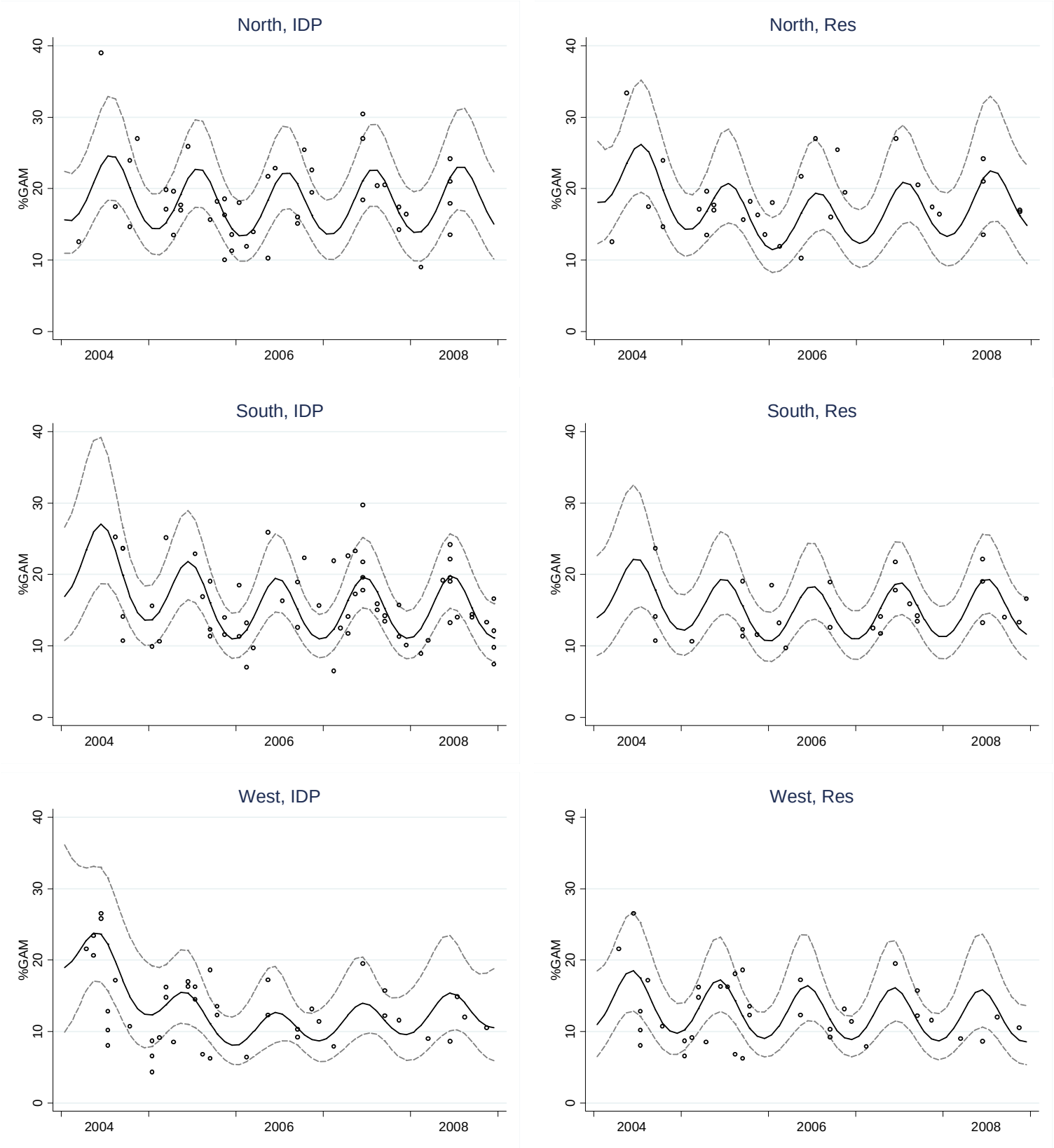
Table 2. Trend in Severe Acute Malnutrition

	IDPs	Residents	Both[1]
	Relative effect (95%CI)	Relative effect (95%CI)	Relative effect (95%CI)
North Darfur			
Trend per year:			
- 2004 – 2005	0.74 (0.45-1.23)	0.69 (0.42-1.15)	0.67 (0.48-0.95)
- 2006 – 2008	1.02 (0.70-1.49)	1.15 (0.79-1.67)	1.12 (0.86-1.46)
Characteristic of population:			
- 25% increase in proportion of IDPs	1.17 (0.93-1.47)	0.75 (0.57-0.99)	0.96 (0.85-1.09)
Season:			
- Fluctuation	3.24 (1.13-9.26)	2.10 (0.91-4.84)	2.98 (1.45-6.12)
- Minimum (month)	Jan (Dec-Feb)	Jan (Nov-Mar)	Dec (Dec-Jan)
South Darfur			
Trend per year:			
- 2004 – 2005	0.79 (0.46-1.37)	0.94 (0.56-1.59)	0.84 (0.58-1.22)
- 2006 – 2008	0.78 (0.57-1.06)	0.80 (0.60-1.06)	0.80 (0.64-0.98)
Characteristic of population:			
- 25% increase in proportion of IDPs	1.13 (0.89-1.43)	1.01 (0.78-1.30)	1.09 (0.94-1.27)
Season:			
- Fluctuation	2.14 (1.13-4.06)	2.06 (0.94-4.53)	2.00 (1.28-3.12)
- Minimum (month)	Dec (Oct-Jan)	Jan (Nov-Feb)	Dec (Nov-Jan)
West Darfur			
Trend per year:			
- 2004 – 2005	0.35 (0.15-0.82)	0.63 (0.30-1.34)	0.48 (0.27-0.84)
- 2006 – 2008	1.44 (0.93-2.24)	1.08 (0.69-1.69)	1.24 (0.91-1.69)
Characteristic of population:			
- 25% increase in proportion of IDPs	0.88 (0.63-1.23)	1.02 (0.78-1.34)	0.95 (0.80-1.13)
Season:			
- Fluctuation	3.10 (0.68-14.2)	3.13 (1.22-8.02)	3.12 (1.52-6.44)
- Minimum (month)	Feb (Nov-Apr)	Jan (Nov-Mar)	Feb (Dec-Mar)
Greater Darfur[2]			
Trend per year:			
- 2004 – 2005	0.73 (0.54-1.00)	0.76 (0.57-1.01)	0.72 (0.59-0.89)
- 2006 – 2008	0.96 (0.78-1.18)	0.98 (0.81-1.19)	0.97 (0.84-1.11)
Characteristic of population:			
- 25% increase in proportion of IDPs	1.13 (0.98-1.30)	0.93 (0.81-1.06)	1.03 (0.94-1.12)
Season:			
- Fluctuation	2.10 (1.44-3.06)	2.89 (1.61-5.22)	2.45 (1.75-3.42)
- Minimum (month)	Jan (Dec-Feb)	Jan (Dec-Jan)	Jan (Dec-Jan)

1) Controlled for population 2) Controlled for state

Note: Faded estimates indicate that the joined estimate is not statistically proper (test for homogeneity< 0.1)

Figure 5. Trend in Global Acute Malnutrition



Dots = point estimates. Solid line: Model mean. Faded dotted lines: Model confidence intervals

Figure 6. Trend in Severe Acute Malnutrition

Dots = point estimates. Solid line: Model mean. Faded dotted lines: Model confidence intervals

Mortality

Both CDR and U5DR began 2004 well over the critical value for a complex humanitarian emergency, 1 and 2 deaths per day per 10,000, respectively (Figure 7 and 8) [Depoortere, Checchi et al. 2004].

Trend per year (CDR): 2004-2005

In 2004 and through 2005 CDR decreased to levels below the critical value (Figure 7). The decrease was different between the states and populations (Test for homogeneity < 0.1). For IDPs, the decrease varied from 44% per year in North Darfur (Table 3: Trend per year = 0.66; 95%CI 0.41-1.06) to 76% per year in West Darfur (Trend per year = 0.24; 95%CI 0.16-0.36). For residents, the decrease was strongest in South Darfur with 81% per year (Trend per year = 0.19; 95%CI 0.10-0.37). In both North and West Darfur the decrease was around 47-48%. Furthermore, the decrease in CDR for IDPs and residents was not statistically different (Test for homogeneity ≥ 0.1) in North and South Darfur, while in West Darfur the decrease in CDR was statistically stronger among IDPs compared to residents.

Trend per year (CDR): 2006-2008

From 2006 and onwards CDR continued to evolved differently for IDPs and residents and in the different states (Test for homogeneity < 0.1). The declining trend continued in North Darfur for both IDPs and residents, though not as strongly as before 2006. In South Darfur, CDR has tended to rise since 2006 with 22% per year overall for IDPs and residents (Table 3: Trend per year = 1.22; 95%CI 0.97-1.55). In West Darfur, CDR had been stable, below 1 death per day per 10,000 (Figure 7).

Trend per year (U5DR): 2004-2005 and 2006-2008

Overall, U5DR decreased significantly by 50% yearly (Table 4: Trend per year = 0.50; 95%CI 0.35-0.71) through 2004 and 2005 to a level below the critical value. After the decline in U5DR in 2004 and through 2005 child death rates have generally been stable, on average below the critical value of a complex emergency (Table 4 and figure 8). However, U5DR tended to rise among residents in South Darfur.

Characteristics of population

In both North and South Darfur there seems to be a positive (25% increase in IDPs > 1 for the IDP population and < 1 for residents) and equal (25% increase in IDPs ≈ 1 for both populations together; test for homogeneity > 0.46 for both CDR and U5DR) impact of living in a mixed population of IDPs and residents. However, in West Darfur for residents the pattern was against living in a mixed population for both CDR (Table 3: 25% increase in proportion of IDPs = 1.23; 95%CI 1.06-1.44) and U5DR (Table 4: 25% increase in proportion of IDPs = 1.53; 95%CI 1.09-2.14). Among IDPs in West Darfur there seems to be no effect (CDR) or a slightly negative effect (U5DR) of living in a mixed population (increasing proportion of IDPs in the IDP-population tends to decrease U5DR, meaning living with fewer residents is better).

Season

Both CDR and U5DR fluctuated with season (Fluctuation > 1 in table 3 and 4). For CDR the lowest death rates were mainly in the last quarter of the year, though varying significantly (Table 3), i.e. slightly before the lowest malnutrition prevalence in December/January. For U5DR the lowest death rates corresponded to the lowest malnutrition prevalence, though these also were varying. Overall, CDR fluctuated with 63% (Table 3: Relative effect: 1.63; 95%CI 1.48-1.80) and U5DR with 54%. This means, with a mean CDR of 0.5 death/day/10000 the mean seasonal fluctuation was between 0.34 (0.5*(1-0.63/2)) and 0.66 (0.5*(1+0.63/2)), and for a mean U5DR of 1 death/day/10000 the mean seasonal fluctuation was between 0.73 (1*(1-0.53/2)) and 1.27 (1*(1+0.53/2)).

Both excluding casualties and varying DE used to penalize for missing information on variance (Methods/Data management) did not change the pattern for either CDR or U5DR.

Table 3. Trend in Crude Death Rate

	IDPs	Residents	Both[1]
	Relative effect (95%CI)	Relative effect (95%CI)	Relative effect (95%CI)
North Darfur			
Trend per year:			
- 2004 – 2005	0.66 (0.41-1.06)	0.47 (0.21-1.09)	0.56 (0.38-0.82)
- 2006 – 2008	0.75 (0.54-1.05)	0.73 (0.45-1.18)	0.73 (0.56-0.96)
Characteristic of population:			
- 25% increase in proportion of IDPs	1.34 (1.15-1.56)	0.85 (0.62-1.17)	1.20 (1.06-1.35)
Season:			
- Fluctuation	1.53 (1.24-1.88)	1.63 (1.19-2.24)	1.58 (1.30-1.93)
- Minimum (month)	Oct (Apr-May)	Nov (Jul-Mar)	Dec (Sep-Feb)
South Darfur			
Trend per year:			
- 2004 – 2005	0.37 (0.23-0.61)	0.19 (0.10-0.37)	0.31 (0.21-0.46)
- 2006 – 2008	1.17 (0.84-1.63)	1.34 (0.95-1.89)	1.22 (0.97-1.55)
Characteristic of population:			
- 25% increase in proportion of IDPs	1.21 (0.98-1.50)	0.72 (0.55-0.95)	1.00 (0.87-1.14)
Season:			
- Fluctuation	1.82 (1.34-2.47)	1.69 (1.10-2.60)	1.70 (1.33-2.17)
- Minimum (month)	Mar (Jan-Jun)	Jan (Sep-May)	Nov (Sep-Jan)
West Darfur			
Trend per year:			
- 2004 – 2005	0.24 (0.16-0.36)	0.48 (0.25-0.93)	0.30 (0.23-0.40)
- 2006 – 2008	1.12 (0.78-1.61)	0.88 (0.57-1.36)	1.03 (0.78-1.35)
Characteristic of population:			
- 25% increase in proportion of IDPs	1.00 (0.71-1.40)	1.23 (1.06-1.44)	1.20 (1.06-1.35)
Season:			
- Fluctuation	1.87 (1.52-2.31)	1.74 (1.23-2.47)	1.82 (1.52-2.18)
- Minimum (month)	Feb (Dec-Apr)	Oct (Jul-Jan)	Mar (Jan-Apr)
Greater Darfur[2]			
Trend per year:			
- 2004 – 2005	0.35 (0.28-0.44)	0.44 (0.31-0.62)	0.35 (0.29-0.42)
- 2006 – 2008	1.04 (0.86-1.26)	0.99 (0.79-1.24)	1.04 (0.90-1.20)
Characteristic of population:			
- 25% increase in proportion of IDPs	1.20 (1.08-1.34)	1.03 (0.92-1.16)	1.12 (1.04-1.21)
Season:			
- Fluctuation	1.64 (1.46-1.84)	1.66 (1.38-2.00)	1.63 (1.48-1.80)
- Minimum (month)	Mar (Jan-May)	Oct (Aug-Jan)	Oct (Aug-Feb)

1) Controlled for population 2) Controlled for state

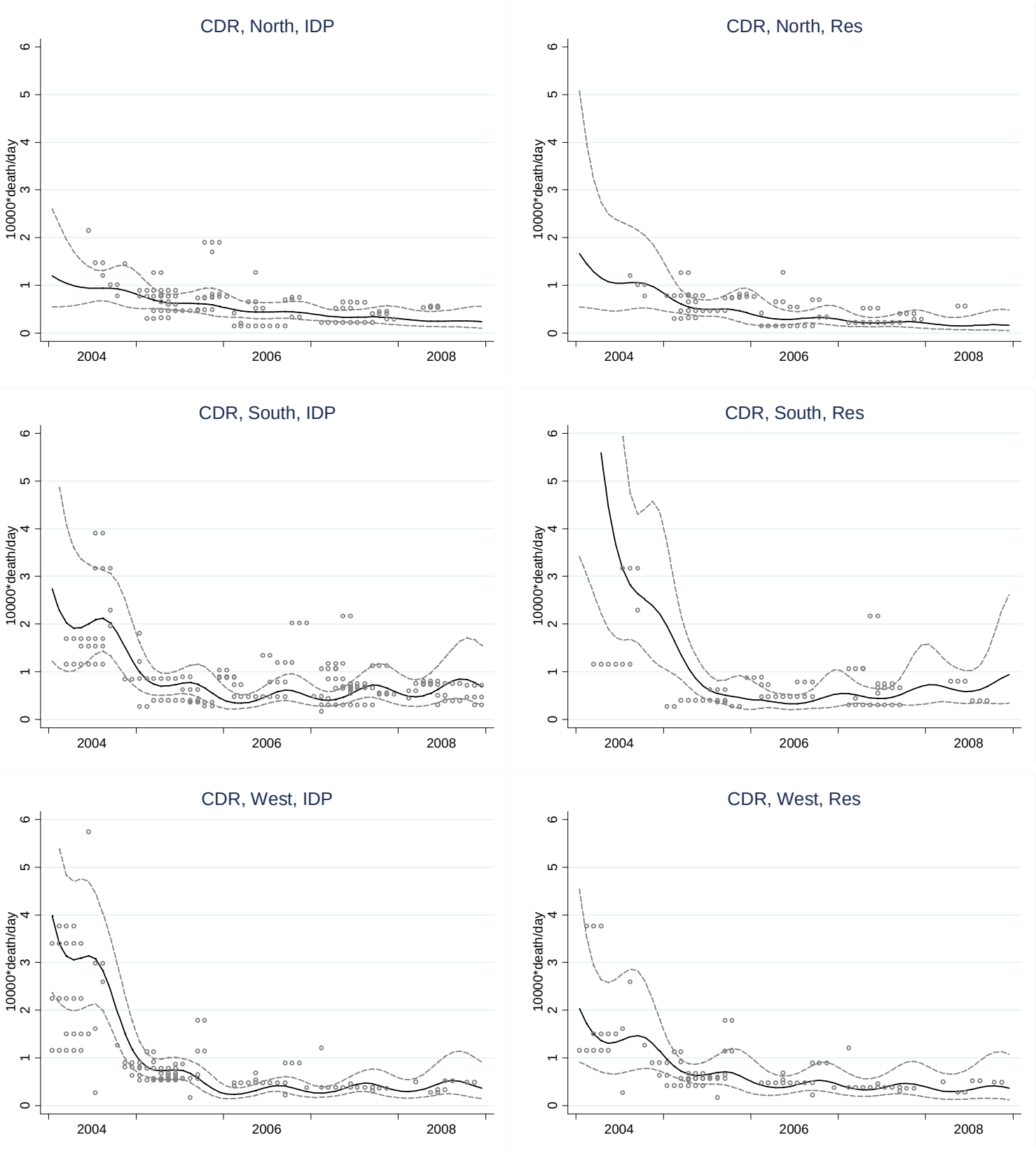
Note: Faded estimates indicate that the joined estimate is not statistically proper (test for homogeneity< 0.1)

Table 4. Trend in Under-5 Death Rate

	IDPs	Residents	Both[1]
	Relative effect (95%CI)	Relative effect (95%CI)	Relative effect (95%CI)
North Darfur			
Trend per year:			
- 2004 – 2005	0.62 (0.26-1.45)	0.84 (0.18-3.88)	0.66 (0.32-1.36)
- 2006 – 2008	0.89 (0.41-1.90)	0.62 (0.21-1.86)	0.73 (0.42-1.29)
Characteristic of population:			
- 25% increase in proportion of IDPs	1.24 (0.86-1.80)	1.02 (0.62-1.70)	1.14 (0.94-1.37)
Season:			
- Fluctuation	1.47 (1.03-2.10)	1.61 (0.90-2.87)	1.49 (1.12-1.99)
- Minimum (month)	Jan (Feb-Dec)	Mar (Jun-Dec)	Feb (Mar-Jan)
South Darfur			
Trend per year:			
- 2004 – 2005	0.36 (0.16-0.79)	0.25 (0.08-0.77)	0.37 (0.20-0.68)
- 2006 – 2008	0.96 (0.55-1.66)	1.10 (0.57-2.14)	0.95 (0.63-1.41)
Characteristic of population:			
- 25% increase in proportion of IDPs	1.12 (0.78-1.60)	0.88 (0.57-1.34)	1.04 (0.84-1.29)
Season:			
- Fluctuation	1.78 (1.11-2.84)	1.90 (0.91-3.96)	1.66 (1.13-2.44)
- Minimum (month)	Jan (Aug-May)	Oct (Jun-Feb)	Dec (Sep-Feb)
West Darfur			
Trend per year:			
- 2004 – 2005	0.38 (0.18-0.82)	0.72 (0.22-2.36)	0.49 (0.26-0.92)
- 2006 – 2008	0.92 (0.46-1.83)	0.54 (0.20-1.42)	0.91 (0.53-1.57)
Characteristic of population:			
- 25% increase in proportion of IDPs	0.67 (0.38-1.19)	1.53 (1.09-2.14)	1.12 (0.89-1.40)
Season:			
- Fluctuation	1.82 (1.20-2.78)	1.74 (1.01-3.00)	1.53 (1.23-1.91)
- Minimum (month)	Dec (Oct-Mar)	Oct (Jun-Mar)	Jan (Jun-Oct)
Greater Darfur[2]			
Trend per year:			
- 2004 – 2005	0.48 (0.31-0.74)	0.54 (0.29-1.00)	0.50 (0.35-0.71)
- 2006 – 2008	0.90 (0.62-1.28)	0.81 (0.51-1.29)	0.87 (0.66-1.15)
Characteristic of population:			
- 25% increase in proportion of IDPs	1.06 (0.86-1.32)	1.17 (0.98-1.40)	1.11 (0.97-1.26)
Season:			
- Fluctuation	1.64 (1.33-2.03)	1.50 (1.20-1.88)	1.54 (1.32-1.80)
- Minimum (month)	Jan (Oct-Apr)	Feb (Mar-Jan)	Jan (Sep-May)

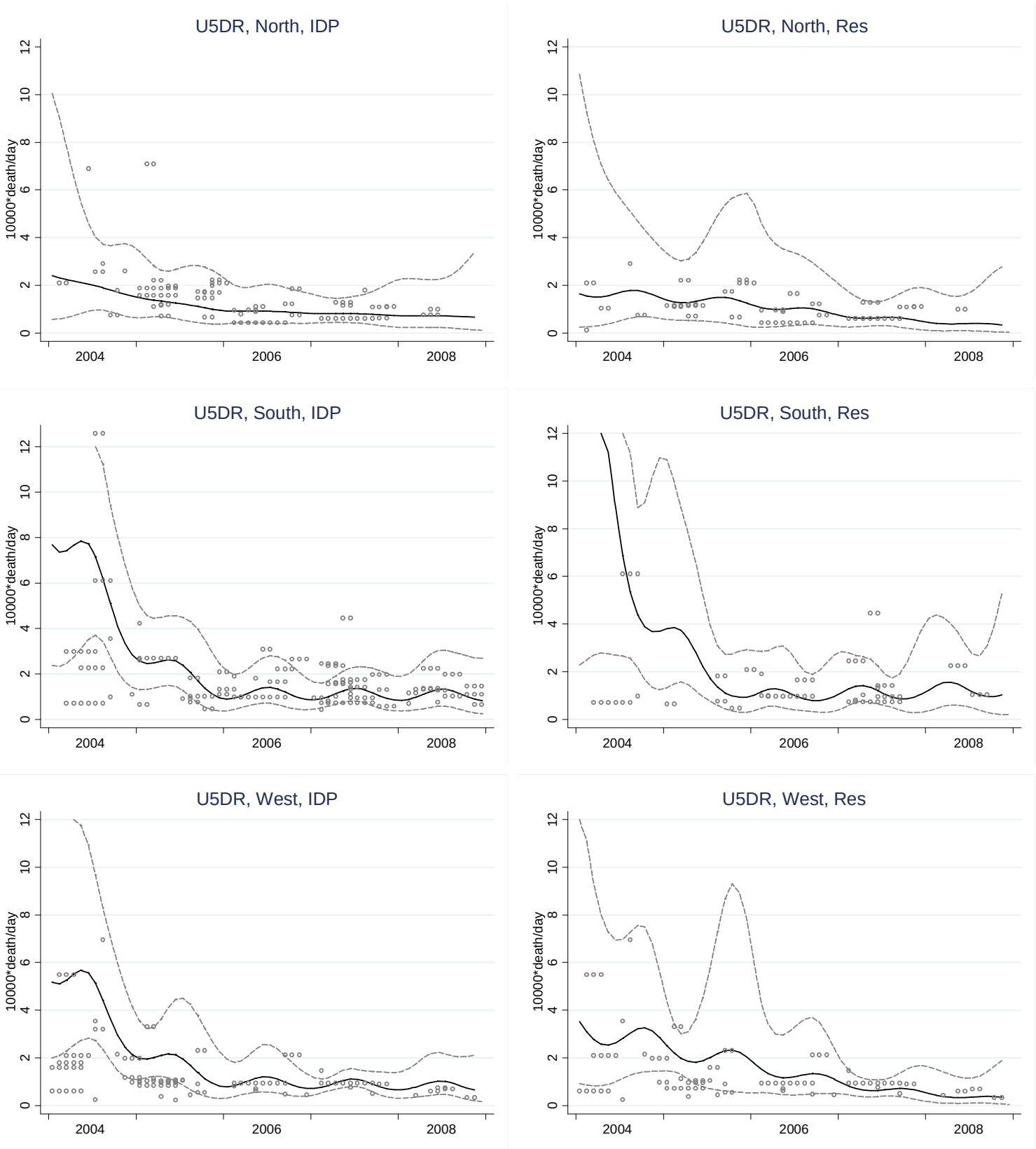
1) Controlled for population 2) Controlled for state

Figure 7. Trend in Crude Death Rate



Dots = point estimates. Solid line: Model mean. Faded dotted lines: Model confidence intervals

Figure 8. Trend in Under-5 Death Rate



Dots = point estimates. Solid line: Model mean. Faded dotted lines: Model confidence intervals

DISCUSSION

The discussion has been divided into a methodological part where data and data management as well as possible biases are discussed, and a contextual discussion of the results.

Methodology and possible biases

The analysis was based on publicly available survey data, and only surveys with random sampling were included. For some surveys reports were not available or information was missing. In these cases, information from other reliable sources was used, when possible, or missing data were estimated. The use of “secondary” information or estimation of missing information might be questioned. On the other hand, a too rigid selection of surveys might discard important contributions to representativeness and reduce the power of the analyses. All the surveys were therefore included in the analysis, but those with missing primary data were penalized by reducing their influence (increasing the variance), i.e. their weight in the analyses. We evaluated the effect of varying the penalization, and it did not substantially change the estimates or the pattern of our findings.

The surveys on mortality were retrospective, i.e. covered a recall period back in calendar time. Hence, the death rate from a survey covered a certain period and the risk of dying was estimated as constant over the recall period and therefore could not reflect possible fluctuations over the recall period. This may have minimized trend patterns and seasonal variations in the analysis. However, this will, at least to some extent, be compensated by death rates from other surveys with (partly) overlapping recall periods.

Using aggregated data like point estimates implied a known estimation variance which should be and has been taken into account in the statistical analysis.

Contribution to the analysis of surveys performed in different subpopulations must be weighted according to the size of the population surveyed relative to the size of the total population of interest (here the affected population). The surveys were conducted on IDP, resident and mixed IDP/resident populations. Overall information on the affected number of IDPs and residents as separate groups were available, but number of IDPs and residents living together was not available. Therefore, we split all surveys on a mixed IDP and resident population into two, according to the proportion of IDPs among the surveyed, i.e. treated them as two surveys of IDPs and residents, respectively. However, differences between IDPs and residents in malnutrition prevalence and death rates could not be differentiated, i.e. prevalences and death rates in both of the split surveys were mixture-estimates. Hence, analyses comparing IDPs and residents will be biased towards one another and show less differences. A little over half of the surveys had been conducted on a mixed population with varying proportions of IDPs.

Two stereotype populations were analysed: IDPs and residents. These stereotype populations had been living together with varying proportions of IDPs and residents. In the statistical model the impact of varying proportion of IDPs was included as a linear trend. However, this might be an over simplification as the effect of changes when the proportion of IDPs in the population is low - for example below 25% - might be different from the change when the proportion of IDPs is high.

Based on contextual knowledge of the development of the crisis in Darfur, two trends were included in the statistical model: 1 January 2004 to 31 December 2005, and 1 January 2006 onwards. The cut-point of 1 January 2006 might have been (slightly) different for the different states or types of populations, or there might have been more trends. However, the two periods used seem to fit data well, and including further differentiation in trends would have reduced the power of the statistical analyses.

An important issue when using available surveys is how representative these are of the whole population. Surveys will probably not be randomly distributed over the entire area and period, which might create a non-differential bias, especially if the surveys tend to be conducted where malnutrition prevalence or death rates are expected to be for example high. However, the mixture of surveys included in the analysis were conducted to assess the initial status of a population and to follow the situation, and not one-sided towards a better or worse situation of the population. Hence, the bias has remained constant over calendar time and, in that sense, the results (trend over time) are relatively unaffected by this bias. Further, only four surveys in each state were conducted among the entire affected population of the state. All other surveys were conducted by NGOs among populations in localized areas where the NGOs had access and worked. Therefore, the results will be biased towards areas with access and a security situation making it possible for the NGOs to operate. The prevalence of malnutrition and death rates would be expected to be lower in NGO surveys compared to the broader surveys. There is no indication of this in the present survey results, but this may be due to the limited number of broader surveys.

Contextual discussion of results

The current crisis in Darfur began with an insurrection in 2003 and a forceful counter-offensive by GoS. The humanitarian crisis that followed was exacerbated by GoS's decision to deny outside access to the population. Matters improved at the beginning of 2004 when the international community started to intervene. Fighting between GoS and rebel groups continued throughout 2004 and 2005, as did attacks on civilians. At the same time, humanitarian aid gained momentum, with the result that by the end of 2005 the humanitarian crisis had been contained, with an overall yearly decrease of 16% in prevalence of GAM and 28% in prevalence of SAM, and the risk of dying had decreased to below the emergency threshold.

In 2006, security became increasingly complex as new rebel groups with various motives entered the fray and power struggles over scarce resources continued. At the same time, WFP halved its food rations due to lack of funding. During these upheavals the prevalence of malnutrition remained stable in North and South Darfur. In West Darfur, where GAM remained mostly stable, SAM seemed to rise for IDPs, but not for residents (Figures 5 and 6). Thus, the general level of malnutrition was stable, but when a child became malnourished her/his chance of recovery declined. Although this pattern is difficult to interpret, it coincides with the closing of some supplementary feeding centres [DNU Issue 19]. However, there seems to have been an increase in admissions to therapeutic feeding centres during the same period [DNU Issue 9 and 19]. The increase in SAM might also be seen as an indication of the West Darfur population's reduced ability to cope, especially for IDPs.

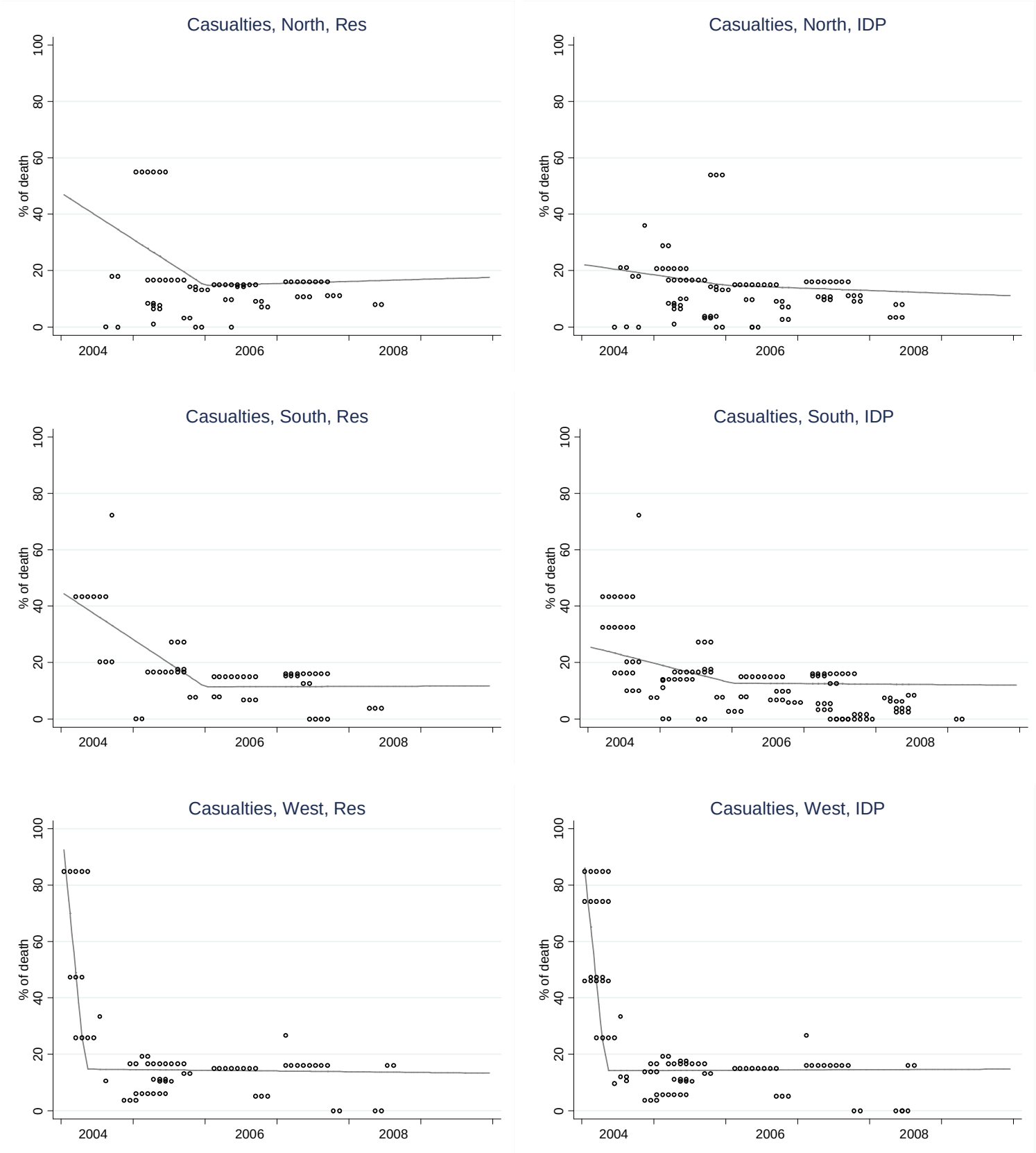
After 2005, both CDR and U5DR continued to decrease slightly in North Darfur and remained stable in West Darfur, even though the nutritional status of the West Darfur population deteriorated slightly. However, death is the ultimate endpoint of vulnerable conditions and perhaps a threatening breakdown of the population’s ability to cope had not yet translated into increasing mortality rates.

Surprisingly, CDR tends to be on the rise in South Darfur since 2006, while U5DR has remained stable. The increase in CDR might be explained by the greater violence and armed confrontations in South Darfur from the end of 2007 and through 2008. One would expect this to have been reflected in percentages of death due to violence. However, no indication of an increase in deaths due to casualties seems to occur either in South Darfur or in the other states (Figure 9). The estimated increase in death rates in South Darfur cannot be attributed to either a deteriorating nutritional status or an increase in casualties.

Generally, a greater proportion of IDPs in the population improved the humanitarian situation for both IDPs and residents, probably because IDPs were more likely to be targeted for aid. However, for residents in West Darfur, living with IDPs increased the risk of dying, while the prevalence of malnutrition was unaffected. We do not have a clear explanation for this. Factors that might have played a role include: the increase in SAM in West Darfur; the increasing violence in South Darfur causing people to flee to West Darfur; and the missing possibility of differentiating estimates in an IDP and a resident part, when splitting surveys of mixed populations into IDPs and residents might have created an unintended/wrong effect of proportion of IDPs in the statistical model.

In conclusion, the humanitarian crisis in Darfur was contained through 2004 and 2005. However, even though the humanitarian situation has improved, violence, armed assaults and banditry remain widespread, and no political solution has been reached. As of the end of 2008, the humanitarian situation remained serious and there were emerging signs of a breakdown of the population's ability to cope, especially in West Darfur.

Figure 9. Casualties, percentage of death



RECOMMENDATIONS

There are no signs of an improvement in overall security or a decrease in the violence in Darfur. The growing complexity of the security situation, with greater fragmentation, additional rival factions, unclear motives and direct banditry, increases the complexity of the political situation. Aid workers continue to be harassed and attacked, increasingly hampering humanitarian operations. However, in spite of these difficulties, finding a political solution should be high on the agenda.

Humanitarian aid has been able to contain the humanitarian crisis so far, but malnutrition and mortality levels are still high and there are signs of that the situation may be deteriorating, especially in West Darfur. Humanitarian aid operations might have to be intensified to prevent a collapse and a new complex emergency. Given the risk of a breakdown - exacerbated by the recent eviction of 16 NGOs - it is important to monitor the situation closely and be prepared to intervene.

The present study analyses general trends in nutrition and mortality. However, more might be learned about the humanitarian situation in Darfur through in-depth analyses of specific issues such as the effect of nutritional status on mortality, as well as the effects of measles coverage, crowding, morbidity, feeding centres, food security, access to population etc. These further analyses might help monitor the humanitarian situation and identify issues to be targeted.

The present study was only possible because the author had access to surveys conducted in Darfur by different organizations and agencies. These surveys were carried out for various purposes (obtaining information on the humanitarian situation at the location of interest; evaluating ongoing humanitarian assistance; suggesting new or improved operations). They have also allowed for this general evaluation of the humanitarian situation in Darfur. To have comparable surveys, it is important that survey reports contain detailed information on basic numbers used to estimate malnutrition prevalence and death rates (number of deaths, number surveyed, recall period, size of survey population, etc.). Further, the variance of the estimates - normally stated as confidence intervals - is very important information. Confidence intervals should always be calculated taking into account design effect, and included in the survey report.

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REFERENCES

ALNAP-HPG. Where to now? Agency expulsion in Sudan: Consequences and next steps. 2009: http://www.alnap.org/pool/files/alnap-hpg-sudan-paper.pdf. Accessed September 17, 2009

CBS-Sudan. Central Bureau of Statistics, Sudan. http://www.cbs.gov.sd/Tiedadat/Tiedadat3e.htm. Accessed October 3, 2009

CE-DAT: http://www.cred.be. Accessed July 14, 2009

Cox C. Delta Method. Encyclopedia of Biostatistics, Second Edition. 2005; 2: 1409-11

Danet C, Delaunay S, Depoortere E, Weissman. A critique of MSF-France operations in Darfur (Sudan). October 2003 – October 2004. CRASH, Fondation Médecins Sans Frontières, 2007

Depoortere E, Checchi F, Broillet F, Gerstl S, Minetti A, Gayraud O, Briet O, Pahl VB, Defourny I, Tatay M, Brown V. Violence and mortality in West Darfur, Sudan (2003-04): epidemiological evidence from four surveys. Lancet 2004; 364: 1315-20

DHNP, Darfur Humanitarian Need Profile, OCHA- Sudan: http://ochaonline.un.org/sudan/SituationReports/DarfurHumanitarianNeedsProfile/tabid/3368/language/en-US/Default.aspx. Accessed July 14, 2009

DNU. Darfur Nutrition Update, UNICEF, Sudan http://www.unicef.org/infobycountry/sudan_resources.html. Accessed September 07, 2009

FANTA2. Interagency review of selective feeding programs in South, North and West Darfur states, Sudan, March 8 – April 10, 2008. Food and Nutrition Technical Assistance II Project. http://www.fantaproject.org. Accessed October 4, 2009

FIC. Feinstein International Center, Tufts University, USA. http://wikis.uit.tufts.edu/confluence/display/FIC/Feinstein+International+Center. Accessed October 4, 2009

Guha.Sapir D, Degomme O. Darfur: Counting the deaths. 2005: http://www.cred.be/docs/cedat/DarfurCountingTheDeaths-withClarifications.pdf. Accessed September 17, 2009

Hagan J, Rymond-Richmond W, Palloni A. Racial targeting of sexual violence in Darfur. American Journal of Public Health 2009; 99: 1386-92

Harbord RM, Higgins JPT. Meta-regression in Stata. The Stata Journal 2008; 8: 493-519

Higgins JPT, Thompson SG. Controlling the risk of spurious findings from meta-regression. Statistics in Medicine 2004; 23: 1663-82

MICS 2000. Multiple Indicator Cluster Survey, 2000, Sudan

MSF-H. Survey report: Nutrition and food security assessment, Wade Saleh and Mukjar provinces, West Darfur. Medecins Sans Frontieres, Holland, 2004

Muthee MH. An Epidemiological Analysis of Malnutrition, Morbidity and Mortality Rates in the Darfur Humanitarian Crisis, Sudan 2003-2005. The Fletcher School, Tufts University, 2007. http://fletcher.tufts.edu/research/2007/Muthee.pdf. Accessed July 14, 2009

NICS/SCN: http://www.unscn.org/en/publications/nics/database.php. Accessed September 15, 2009

Nielsen J, Jensen H, Andersen PK. Creating a reference to a complex emergency situation using Time Series methods: war in Guinea-Bissau 1998-99. Journal of Applied Statistics 2005; 32: 75-86

Parmar P. Aid to Darfur threatened after ICC action. Disaster Medicine and Public Health Prepareness. 2009; 3: 73-4

Petersen AH, Tullin LL. The scorched earth of Darfur. Patterns in death and destruction reported by the people of Darfur. 2005; http://www.bloodhound.dk. Accessed September 17, 2009

UnderstandingSudan.org. Fact sheet on Darfur. 2006. http://understandingsudan.org/Darfur/DarfurResources/Fact%20Sheet%20on%20Darfur.doc. Accessed October 20, 2009

Young H, Maxwell D. Targeting in Complex Emergencies: Darfur case study. Feinstein International Center, Tufts University, 2009. http://wikis.uit.tufts.edu/confluence/display/FIC/Darfur--Livelihoods,+Vulnerability,+and+Choice. Accessed July 14, 2009.

APPENDIX A – List of surveys

North Darfur

date	region	survey_area	popula~n	gam	gam95l	gam95u	sam	sam95l	sam95u	cdr	cdr95l	cdr95u	u5dr	u5dr95l	u5dr95u	recall	agency
mar2004	Kutum	Kutum town & Kassab camp	IDP/Res	12.6	10.15	14.95	.8	.17	1.35	.	.	.	2	1.4	2.7	90	SC-UK
may2004	Mellit	El Malha pastoral area	Res	33.4	28.9	37.8	5.4	3.4	7.5	.	.	.	1	.43	1.56	90	SC-UK
jun2004	El Fasher	Abu Shok camp, El Fasher	IDP	39	34.5	43.6	9.6	7.2	12.8	2.2	.	.	6.8	.	.	30	ACF-F
aug2004	All	IDPs in camps	IDP	.	.	.	.	.	.	1.5	1.1	1.9	2.5	1.6	3.9	62	WHO/Epiet
aug2004	Kebkabiya	Kebkabiya town	IDP/Res	17.5	14.4	21	1	.5	1.8	1.2	.7	1.8	2.9	1.5	5.3	36	MSF/Epicentre
oct2004	Kutum	Kutum town & Kassab + Fata Borno camps	IDP/Res	23.9	21.3	26.8	1.7	1	2.8	1	.	.	.7	.	.	90	GOAL
oct2004	Kebkabiya	Serif Umra	IDP/Res	14.7	13	16.3	2.7	1.6	3.8	.8	.4	1.3	1.8	1	3	59	MSF/Epicentre
nov2004	El Fasher	Abu Shok camp, El Fasher	IDP	27	23	31.3	2.4	1.3	4.4	1.5	.	.	2.7	.	.	31	ACF-F
mar2005	El Fasher	Shaddad & Shanguil Tobaya camps	IDP	19.9	.	.	1.5	.	.	8.2	6.5	9.8	7.1	4.2	10	67	MSF-S
mar2005	El Fasher	El Fasher	IDP/Res	17.1	13.7	20.5	2.4	1.4	3.4	.3	.	.	1.1	.	.	91	SMH/joint
apr2005	El Fasher	Korma area	IDP/Res	19.6	15.9	24	1.6	1.1	2.5	1.3	.9	1.7	2.2	1.1	4.3	73	MSF/Epicentre
apr2005	Kebkabiya	Serif Umra	IDP/Res	13.5	10.4	16.5	2.5	1.5	3.5	.8	.5	1.1	1.2	.2	2.1	51	MSF/Epicentre
may2005	Kebkabiya	Kebkabiya town	IDP/Res	17	13.7	20.8	.7	.2	2.1	.7	.	.	1.2	.	.	91	ACF-F
may2005	Kutum	Kutum town & Kassab + Fata Borno camps	IDP/Res	17.7	14.8	21	.8	.3	1.9	.3	.13	.5	.7	.06	1.35	77	GOAL
jun2005	All	IDPs in camps	IDP	.	.	.	.	.	.	.8	.5	1	1.5	.9	2.4	202	WHO/MOH
jun2005	All	IDPs in host population	IDP	.	.	.	.	.	.	.9	.6	1.3	1.8	.8	3.4	202	WHO/MOH
jun2005	El Fasher	Abu Shok camp, El Fasher	IDP	25.9	22	30.2	3.6	2.2	5.9	.6	.	.	2	.	.	91	ACF-F
jun2005	All	Residents	Res	.	.	.	.	.	.	.8	.5	1.1	1.1	.7	1.7	202	WHO/MOH
sep2005	All	Emergency affected populations	IDP/Res	15.6	12.3	18.8	1.4	.7	2.2	.5	.3	.55	.	.	.	242	WFP/joint
oct2005	Kebkabiya	Kebkabiya town	IDP/Res	18.2	14.9	22.1	.7	.2	2.1	.7	.	.	1.7	.	.	77	ACF-F
nov2005	Kutum	Kutum province	IDP/Res	16.3	14	18.9	.7	.3	1.5	.8	.42	1.07	.7	.17	1.17	90	GOAL
nov2005	El Fasher	Zamzam Camp, El Fasher	IDP	10	7.7	12.3	.7	.1	1.2	1.7	.9	2.5	2	.2	3.8	56	MSF-S
nov2005	El Fasher	Abu Shok and Al Salaam camps	IDP	18.5	15.2	22.5	1.4	.5	3	.5	.	.	1.5	.	.	92	ACF-F
dec2005	El Fasher	Shaddad & Shanguil Tobaya camps	IDP	11.3	8.8	13.8	.7	0	1.3	1.9	1.3	2.5	1.7	.5	2.9	102	MSF-S
dec2005	El Fasher	Korma area	IDP/Res	13.6	10.3	16.8	.7	.1	1.2	.8	.5	1.1	2.2	1.2	3.3	65	MSF/Epicentre
jan2006	El Fasher	Mellit town and camps	IDP/Res	18	14.7	21.9	1.7	.7	3.4	.8	.	.	2.1	.	.	92	ACF-F
feb2006	El Fasher	El Fasher	IDP/Res	11.9	9.9	14.1	.4	.1	1.1	.4	.	.	1	.	.	.	MOH/UNICEF
mar2006	El Fasher	Kafood	IDP	13.9	10.8	17	2.1	.8	3.4	.2	.	.	.8	.	.	.	WRI
may2006	Kebkabiya	Serif Umra	IDP/Res	10.3	7.5	13	1.7	.9	2.5	1.3	.7	1.8	.9	0	1.8	45	MSF-B
may2006	Kebkabiya	Kebkabiya town	IDP/Res	21.7	18.1	25.8	2.1	1	4	.7	.	.	1	.	.	91	ACF-F

jun2006	El Fasher	Abu Shok and Al Salaam camps	IDP	22.8	19.1	27	2.2	1.1	4.1	.5	.	.	1.1	.	.	90	ACF-F
jul2006	El Fasher	Dar as Salaam Rural Council, El Fasher	Res	27	23.1	31.3	2.8	1.6	4.9	.5	.	.	1.6	.	.	91	ACF-F
sep2006	El Fasher	Zamzam Camp, El Fasher	IDP	15.1	.	.	2.9	.	.	.	.	.	.	.	.	.	WRI
sep2006	All	Emergency affected populations	IDP/Res	16	12.3	19.8	2.5	1.3	3.7	.2	.07	.22	.4	.13	.74	246	WFP/joint
oct2006	Kebkabiya	Kebkabiya town	IDP/Res	25.4	21.6	29.7	1.8	.8	3.6	.7	.	.	1.2	.	.	81	ACF-F
nov2006	Kutum	Kutum town & Kassab camp	IDP/Res	19.4	17.1	22	2.2	1.4	3.3	.3	.	.	.7	.	.	90	GOAL
nov2006	El Fasher	Abu Shok and Al Salaam camps	IDP	22.6	18.9	26.7	2.7	1.5	4.8	.7	.	.	1.8	.	.	90	ACF-F
jun2007	El Fasher	Zamzam Camp, El Fasher	IDP	18.4	15	22.3	1.6	.7	3.3	.	.	.	.	.	.	.	WRI
jun2007	El Fasher	Abu Shok and Al Salaam camps	IDP	30.4	26.3	34.9	2.8	1.6	4.9	.6	.	.	1.1	.	.	85	ACF-F
jun2007	Kebkabiya	Kebkabiya town	IDP/Res	27	23	31.3	1.9	.9	3.7	.5	.	.	1.3	.	.	99	ACF-F
aug2007	El Fasher	Zamzam Camp, El Fasher	IDP	20.4	16.8	24.5	1.2	.4	2.8	.6	.	.	1.8	.	.	91	WRI
sep2007	All	Emergency affected populations	IDP/Res	20.5	16.7	24.3	2	.9	3	.2	.13	.31	.6	.24	.98	248	WFP/joint
nov2007	El Fasher	Abu Shok and Al Salaam camps	IDP	14.3	11.3	17.9	.6	.1	2	.4	.	.	.6	.	.	85	ACF-F
nov2007	Kebkabiya	Kaguro, Borey & surrounding villages	IDP/Res	17.4	13.9	21.5	1.5	.6	3.4	.4	.	.	1.1	.	.	108	ACF-F
dec2007	Kutum	Kutum town & Kassab + Fata Borno camps	IDP/Res	16.4	14	18.9	.9	.2	1.6	.3	.13	.43	1.1	.16	2.42	90	GOAL
feb2008	El Fasher	Shaddad & Shanguil Tobaya camps	IDP	9	.	.	0	.	.	.	.	.	.	.	.	.	ACF-F
jun2008	Mellit	Mellit town and camps	IDP/Res	21	18.4	23.9	3.2	2.1	4.6	.	.	.	.	.	.	.	MOH
jun2008	El Fasher	El Fasher town	IDP/Res	13.5	11.2	16	1	.5	2	.	.	.	.	.	.	.	MOH
jun2008	Kebkabiya	Kebkabiya town	IDP/Res	24.2	20.4	28.4	1.3	.5	2.9	.6	.	.	.9	.	.	77	ACF-F
jun2008	El Fasher	Abu Shok and Al Salaam camps	IDP	17.9	14.6	21.8	1.5	.6	3.1	.5	.	.	.7	.	.	100	ACF-F
nov2008	El Fasher	Shanguil Tobaya	Res	17	14.6	19.8	2.1	1.3	3.4	.	.	.	.	.	.	.	MOH/UNICEF
nov2008	Mellit	El Malha pastoral area	Res	16.7	14.1	19.6	2.6	1.6	4.1	.	.	.	.	.	.	.	MOH/UNICEF

South Darfur

date	region	survey_area	popula~n	gam	gam95l	gam95u	sam	sam95l	sam95u	cdr	cdr95l	cdr95u	u5dr	u5dr95l	u5dr95u	recall	agency
aug2004	Nyala	Kalma camp	IDP	.	.	.	.	.	.	3.8	2.9	5	11.7	7.4	18.1	62	WHO/Epiet
aug2004	Nyala	Otash camp, Nyala	IDP	25.2	21	29.6	8.8	6.1	13.4	1.5	1	2.02	2.3	.	.	122	IRC
sep2004	Nyala	Nyala town & Dereig, Mossey and Otash camps	IDP/Res	23.6	19.9	27.8	3	1.7	5.1	.	.	.	.	.	.	60	ACF-F
sep2004	Kass	Kass town	IDP/Res	14.1	11.2	17	1.9	.8	3	3.2	2.2	4.1	5.9	3.8	8	121	MSF/Epicentre
sep2004	Shaeria	Muhajiria town	IDP/Res	10.7	8.2	13.3	.9	.2	1.5	2.3	1.2	3.4	1	.03	1.9	30	MSF/Epicentre
sep2004	Nyala	Kalma camp	IDP	23.6	20.2	27.1	3.3	1.9	4.7	2	1.3	2.7	3.5	1.5	5.7	30	MSF/Epicentre
jan2005	Nyala	Kalma camp	IDP	9.9	8.1	12.1	2.6	1.7	3.9	1.2	.04	2.39	2.6	.75	4.5	30	MSF-H
jan2005	Nyala	Gereida camp	IDP	15.6	12.5	19.3	4	2.4	6.3	1.8	.	.	4.2	.	.	31	ACF-F
feb2005	Nyala	Nyala town	IDP/Res	10.6	8	13.9	.6	.1	2	.3	.	.	.6	.	.	90	ACF-F
mar2005	El Daein	Camps, Ed Daein	IDP	25.2	21.6	29.2	4.3	2.9	6.3	.	.	.	.	.	.	.	Tearfund
jun2005	All	IDPs in camps	IDP	.	.	.	.	.	.	.8	.6	1.2	2.6	1.6	3.9	204	WHO/MOH
jul2005	Buram	Gereida camp	IDP	22.9	.	.	2.6	.	.	.	.	.	.	.	.	.	ACF-F
aug2005	Nyala	Kalma camp	IDP	16.9	13.6	20.7	2.3	1.2	4.2	.9	.	.	.9	.	.	90	ACF-F
sep2005	Nyala	Nyala town & Dereig, Mossey and Otash camps	IDP/Res	19.1	15.6	23	2.4	1.3	4.4	.4	.	.	.8	.	.	90	ACF-F
sep2005	All	Emergency affected populations	IDP/Res	12.3	9.2	15.2	2.1	.8	3.3	.4	.23	.57	.	.	.	242	WFP/joint
sep2005	Shaeria	Shariya town	IDP/Res	11.4	9.3	13.8	.5	.2	1.4	.6	.38	.86	1.8	.	.	102	MSF/Epicentre
nov2005	Nyala	Sanya Afendu & surrounding villages	IDP/Res	11.6	8.9	14.9	1.1	.4	2.7	.3	.	.	.5	.	.	90	ACF-F
nov2005	El Daein	Camps, Ed Daein	IDP	13.9	11.4	16.5	1.4	.5	2.2	.4	.	.	1	.	.	122	Tearfund
jan2006	Adilla	Jed Elsid, Al Mazraoub, Haskanita, Fataha	IDP/Res	18.5	15	22	2	1.04	3	1.2	.	.	2.1	.	.	90	Tearfund
jan2006	Buram	Gereida camp	IDP	11.3	.	.	1.6	.	.	1	.	.	1.1	.	.	82	ICRC
feb2006	Nyala	Kalma camp	IDP	7	4.9	9.8	.4	0	1.7	.9	.	.	1.3	.	.	92	ACF-F
feb2006	Nyala & Tulus	Nyala-Tulus locality	IDP/Res	13.2	11	15.7	2.3	1.5	3.6	.9	.	.	1.9	.	.	.	ARC
mar2006	Nyala	Nyala town & Dereig, Mossey and Otash camps	IDP/Res	9.7	7.2	12.8	.7	.2	2.1	.7	.	.	1	.	.	90	ACF-F
may2006	El Daein	Camps, Ed Daein	IDP	25.9	23.2	28.8	4.6	3.4	6.2	.	.	.	1.8	.	.	.	Tearfund
jul2006	Buram	Gereida camp	IDP	16.3	.	.	3.2	.	.	1.3	.	.	3	.	.	89	ICRC
sep2006	All	Emergency affected populations	IDP/Res	12.6	8.6	16.6	1.9	.9	2.9	.5	.27	.68	1	.39	1.55	246	WFP/joint
sep2006	Nyala	Nyala town & Dereig, Mossey and Otash camps	IDP/Res	18.9	15.5	22.9	1	.4	2.6	.8	.	.	1.6	.	.	94	ACF-F
oct2006	Nyala	Kalma camp	IDP	22.3	18.6	26.4	2.2	1.1	4.1	1.2	.	.	2.2	.	.	112	ACF-F
dec2006	Nyala	Otash camp, Nyala	IDP	15.6	12.5	19.3	1.8	.8	3.6	2	.	.	2.6	.	.	97	ACF-F
feb2007	El Daein	Camps, Ed Daein	IDP	21.9	19.4	24.7	3.9	2.8	5.4	.2	.	.	.4	.	.	.	Tearfund
feb2007	Buram	Gereida camp	IDP	6.4	4.9	8.1	.7	.3	1.5	.5	.	.	.9	.	.	90	ICRC
mar2007	Kass	El Ad Fursan and Kass localities	IDP/Res	12.5	8.9	16.1	1.7	.7	2.8	.4	.	.	.8	.	.	.	NCA/ACT/Caritas

apr2007	Nyala & Tulus	Nyala-Tulus locality	IDP/Res	14.1	12	16.5	1	.5	1.9	1.1	.	.	1	.	.	.	ARC
apr2007	Nyala	Kalma camp	IDP	22.6	.	.	1.9	.	.	.	.	.	.	.	.	.	ACF-F
apr2007	Nyala	Nyala town & Dereig and Mossey camps	IDP/Res	11.8	9.1	15.2	.7	.2	2.1	1	.	.	2.4	.	.	104	ACF-F
may2007	Nyala	Otash camp, Nyala	IDP	17.2	14	21.1	2.1	1	4	1.2	.	.	2.4	.	.	92	ACF-F
may2007	Nyala	Al Salam camp	IDP	23.3	19.2	27.9	2.8	1.5	5.2	.9	.	.	1.6	.	.	100	ACF-F
jun2007	El Daein	Camps, Ed Daein	IDP/Res	21.7	18.5	24.9	2.6	1.1	4	.6	.	.	1.3	.	.	.	Tearfund
jun2007	Buram	Gereida camp	IDP	19.6	.	.	4	.	.	.8	.	.	1.4	.	.	.	ICRC
jun2007	Kass	Kass town	IDP/Res	17.8	14.4	21.6	2.8	1.6	4.9	2.1	.	.	4.3	.	.	86	ACF-F
jun2007	El Daein	Camps, Ed Daein	IDP	29.7	25.8	33.7	4.4	3.1	5.7	.6	.	.	1.1	.	.	.	Tearfund
aug2007	Nyala	Kalma camp	IDP	15	11.9	18.7	1.3	.5	2.9	.7	.	.	1.7	.	.	126	ACF-F
aug2007	Nyala	Seleah	IDP/Res	15.9	12.5	20	2	.9	4	.7	.	.	1.4	.	.	107	ACF-F
sep2007	All	Emergency affected populations	IDP/Res	14.2	10.4	17.9	1.5	.1	2.9	.3	.15	.45	.7	.29	1.18	248	WFP/joint
sep2007	Nyala	Nyala town & Dereig and Mossey camps	IDP/Res	13.4	10.5	17	1	.	.	.7	.	.	.9	.	.	139	ACF-F
nov2007	El Daein	Camps, Ed Daein	IDP	15.7	13.5	18.2	1.4	.8	2.5	.6	.	.	1.3	.	.	90	Tearfund
nov2007	Nyala	Al Salam camp	IDP	11.3	8.6	14.6	1.3	.5	2.9	1.1	.	.	1.9	.	.	108	ACF-F
dec2007	Nyala	Otash camp, Nyala	IDP	10.1	7.6	13.3	.5	.1	1.8	.5	.	.	.6	.	.	113	ACF-F
feb2008	Buram	Gereida camp	IDP	8.9	7.2	11	.9	.4	1.8	.4	.	.	.7	.	.	.	ICRC
mar2008	Nyala	Kalma camp	IDP	10.7	8.1	14	1.1	.4	2.7	.6	.	.	1.2	.	.	82	ACF-F
may2008	Nyala	Al Salam camp	IDP	19.2	15.7	23.1	1.9	.9	3.7	.8	.	.	1.3	.	.	118	ACF-F
jun2008	Kass	Kass town	IDP/Res	13.2	10.4	16.8	1.3	.5	2.9	.8	.	.	2.2	.	.	110	ACF-F
jun2008	Nyala	Otash camp, Nyala	IDP	19.5	16.1	23.5	2.3	1.2	4.2	.7	.	.	1.3	.	.	96	ACF-F
jun2008	Nyala & Tulus	Nyala-Tulus locality	IDP/Res	22.1	19.5	24.9	1.9	1	2.8	.	.	.	.	.	.	.	ARC
jun2008	El Daein	Camps, Ed Daein	IDP	24.2	21.5	27.2	2.9	2	4.3	.3	.09	.52	.8	.2	1.32	.	Tearfund
jun2008	Ed AL Fursan	Katayla	IDP/Res	19	16.6	21.6	1.8	1.1	3	.	.	.	.	.	.	.	MOH
jul2008	Buram	Gereida camp	IDP	14	11.8	16.1	.6	.1	1	.5	.	.	1.3	.	.	90	ICRC
sep2008	Nyala	Nyala town & Dereig and Mossey camps	IDP/Res	14	11.1	17.6	1.1	.4	2.7	.4	.	.	1	.	.	95	ACF-F
sep2008	Nyala	Kalma camp	IDP	14.4	11.4	18	.8	.2	2.3	.8	.	.	2	.	.	102	ACF-F
nov2008	Nyala	Seleah	IDP/Res	13.3	10.6	15.9	.6	.1	1.2	.	.	.	.	.	.	.	Merlin
dec2008	Balil	Yassin	IDP/Res	16.6	13.8	19.4	1.7	.9	2.4	.	.	.	.	.	.	.	Merlin
dec2008	El Daein	Camps, Ed Daein	IDP	12.1	10.1	14.5	1.1	.5	2	.3	.11	.48	.7	.08	1.24	.	Tearfund
dec2008	Nyala	Al Salam camp	IDP	7.4	5.3	10.3	.4	0	1.7	.7	.	.	1.4	.	.	111	ACF-F
dec2008	Nyala	Otash camp, Nyala	IDP	9.8	7.3	12.9	.8	.2	2.3	.5	.	.	1.1	.	.	114	ACF-F

West Darfur

date	region	survey_area	popula~n	gam	gam95l	gam95u	sam	sam95l	sam95u	cdr	cdr95l	cdr95u	u5dr	u5dr95l	u5dr95u	recall	agency
apr2004	Wadi Saleh & Mukjar	Wade Saleh & Mukjar provinces	IDP/Res	21.5	18.5	23.9	3.2	1.9	4.2	3.6	2.7	4.6	5.2	1.8	2.6	92	MSF-H
may2004	Zalinge	Zalingei camps	IDP	23.4	19.4	28	4.5	2.8	7	2.2	1.8	2.7	1.8	1.1	3	183	MSF/Epicentre
may2004	El Geneina	Mornie camp	IDP	20.6	17.4	24.2	4.1	3.1	5.6	3.4	3.1	3.8	1.6	1.1	2.2	193	MSF/Epicentre
jun2004	El Geneina	El Geneina	IDP	25.8	22.9	28.8	5.5	4.1	7.3	5.6	4.1	7.6	14.1	9.7	20.1	39	MSF/Epicentre
jun2004	Jebel Marrah	Niertiti town	IDP/Res	26.5	23	30	5.2	3.3	7.2	1.5	1.2	1.9	2.1	1.5	3	145	MSF/Epicentre
jul2004	Habila	Arara	IDP/Res	10.2	7.1	13.7	1.6	.4	3.2	.	.	.	.	.	.	.	Tearfund
jul2004	El Geneina	Mesteri	IDP/Res	12.7	10.1	17.3	2.4	1.2	4.7	.	.	.	.	.	.	.	Tearfund
jul2004	El Geneina	Azirni, Sanidadi and Um Tajouk localities	IDP/Res	8	.	.	5	.	.	.3	.	.	.3	.	.	.	WRI
aug2004	Habila	Habilah town	IDP/Res	17.2	14.8	19.8	3.9	2.8	5.5	2.6	1.8	3.6	6.7	4.2	11	55	MSF/Epicentre
aug2004	All	IDPs in camps	IDP	.	.	.	.	.	.	2.9	2.4	3.6	3.1	2.1	4.7	62	WHO/Epiet
oct2004	Wadi Saleh & Mukjar	Wade Saleh & Mukjar provinces	IDP/Res	10.7	8.4	13.1	2.6	1.2	4	1.3	.83	1.69	2.2	1.09	3.22	.	MSF-H
jan2005	Kulbus	Seleia & Kulbus	IDP/Res	8.7	6.6	11.3	.4	.2	1.1	.6	.	.	1	.	.	88	Concern
jan2005	Habila	Fur Baranga	IDP/Res	6.6	4.6	8.5	.3	0	.6	.9	.54	1.25	1.8	.79	2.81	93	SC-US
jan2005	El Geneina	Mornie camp	IDP	4.3	.	.	.6	.3	1.4	.8	.	.	1.2	.	.	106	Concern/joint
feb2005	Habila	Beida locality	IDP/Res	9.1	7.3	10.9	1.4	.6	2.1	.	.	.	.	.	.	.	Tearfund
mar2005	El Geneina	Azirni, Sanidadi and Um Tajouk localities	IDP/Res	14.8	13.6	15.9	1.4	1	1.79	.9	.	.	1.1	.	.	.	WRI
mar2005	Jebel Marrah	Golo, Gildu & Rokero	IDP/Res	16.2	12.6	20.4	1.5	.7	3.1	1.1	.82	1.42	3.2	2.09	4.35	90	GOAL
apr2005	Habila	Fur Baranga	IDP/Res	8.5	.	.	.4	.	.	.5	.	.	.4	.	.	.	SC-US
jun2005	All	Residents	Res	.	.	.	.	.	.	.4	.3	.6	.7	.2	1.7	206	WHO/MOH
jun2005	El Geneina	El Geneina	IDP	16.9	14.5	19.6	1.5	.8	2.6	.5	.	.	.2	.	.	90	SMH/joint
jun2005	All	IDPs in camps	IDP	.	.	.	.	.	.	.8	.5	1.2	1	.5	1.7	206	WHO/MOH
jun2005	All	IDPs in host population	IDP	.	.	.	.	.	.	.5	.3	.8	.8	.5	1.4	206	WHO/MOH
jun2005	Kulbus	Sirba	IDP/Res	16.3	13.9	18.7	1.8	.8	2.8	.7	.35	.99	1	.27	1.68	93	SC-US
jul2005	Zalinge	Zalingei camps	IDP	14.5	12.3	16.6	1.9	1.1	2.8	.9	.	.	1.1	.	.	91	NCA/ACT/Caritas
jul2005	Kulbus	Seleia & Kulbus	IDP/Res	16.2	13.3	19.6	1.9	1	3.2	.6	.	.	1	.	.	101	Concern
aug2005	Habila	Fur Baranga	IDP/Res	6.8	.	.	.8	.	.	.2	.	.	.4	.	.	.	SC-US
aug2005	Zalinge	Zalingei town	Res	18.1	15.8	20.5	2.1	1.2	3	.6	.	.	1.6	.	.	91	NCA/ACT/Caritas
sep2005	All	Emergency affected populations	IDP/Res	6.2	4.3	8.1	.7	0	1.5	.6	.36	.78	.	.	.	242	WFP/joint
sep2005	El Geneina	Azirni, Sanidadi and Um Tajouk localities	IDP/Res	18.6	16.1	21.3	5.6	4.3	7.4	.6	.	.	.9	.	.	.	WRI
oct2005	El Geneina	Geneina town & camps	IDP/Res	12.3	.	.	.5	.	.	1.1	.	.	.6	.	.	80	Concern
oct2005	Jebel Marrah	Golo, Gildu & Rokero	IDP/Res	13.5	11.4	15.9	.4	.1	1.2	1.8	1.29	2.29	2.3	.97	3.67	91	GOAL
feb2006	El Geneina	Mornie camp	IDP	6.4	5	8.2	.6	.2	1.4	.4	.	.	.8	.	.	.	Concern/joint

may2006	El Geneina	Geneina town & camps	IDP/Res	12.3	10.3	14.6	1.6	.9	2.6	.7	.	.	.6	.	.	.	Concern
may2006	Habila	Beida locality	IDP/Res	17.2	13.9	21	3.4	2	5.5	.5	.	.	.7	.	.	.	Tearfund
sep2006	El Geneina	Azirni, Sanidadi and Um Tajouk localities	IDP/Res	9.2	7.3	11.1	.9	.2	1.6	.2	.	.	.5	.	.	.	WRI
sep2006	All	Emergency affected populations	IDP/Res	10.3	8	12.6	1.3	.5	2.1	.5	.3	.65	.9	.43	1.48	246	WFP/joint
nov2006	Zalinge	Umshalaya	IDP/Res	13.1	11.3	15.2	.6	.2	1.3	.9	.46	1.32	2.1	.91	3.27	98	Concern
dec2006	Habila	Beida locality	IDP/Res	11.4	8.4	14.8	1.3	.5	2.9	.4	.062	.8	.4	.095	.99	.	Tearfund
feb2007	Habila	Fur Baranga	IDP/Res	7.9	6.2	9.9	.6	.2	1.4	1.2	.57	1.85	1.5	.43	2.51	.	SC-US
jun2007	Habila	Beida locality	IDP/Res	19.5	16.5	23	3.7	2.4	5.6	.5	.25	.66	.8	.17	1.35	.	Tearfund
sep2007	El Geneina	Azirni, Sanidadi and Um Tajouk localities	IDP/Res	15.7	12.9	17.7	3.6	2.4	4.8	.3	.	.	.5	.	.	.	WRI
sep2007	All	Emergency affected populations	IDP/Res	12.2	9.7	14.7	2.3	1.3	3.2	.4	.21	.54	.9	.66	1.12	248	WFP/joint
nov2007	Zalinge	Umshalaya	IDP/Res	11.6	8.8	15	.6	.1	2	.4	.	.	.9	.	.	91	Concern
mar2008	Habila	Beida locality	IDP/Res	9	6.6	12.1	1.4	.5	3	.5	.1897	.8034	.4	.049	.8196	.	Tearfund
jun2008	Mukjar	Um Dukhun	IDP/Res	8.6	6.2	11	1	.3	1.6	.3	.07	.47	.6	.	.	90	IMC
jul2008	El Geneina	Mornie camp	IDP	14.9	11.8	18.6	1.1	.4	2.7	.3	.	.	.7	.	.	91	Concern
aug2008	El Geneina	Geneina town & camps	IDP/Res	12	9.3	15.5	1.1	.4	2.6	.5	.	.	.7	.	.	90	Concern
nov2008	Habila	Beida locality	IDP/Res	10.5	8	13.8	1.6	.7	3.3	.5	.14	.84	.3	.27	1.06	90	Tearfund

APPENDIX B – Formulas

Point estimates of both malnutrition prevalences and risks of dying have been calculated as risk rates i.e. number of events divided by number at risk. The confidence intervals of the point estimates in nearly all of the survey reports have been estimated assuming normal distribution of the point estimate based on a binomial estimation of the variance, as shown below, i.e. 95% confidence intervals = point estimate ± 1.96 * $\sqrt{V_{sample}}$

Malnutrition prevalence (%)

prevalence = 100 * n / N

V_{sample}(prevalence) = DE * (prevalence * (100 – prevalence) / N) * (1- N/N_{pop})

V_{random}(prevalence) = (prevalence * (100 – prevalence) / N) * (1- N/N_{pop})

where V_X is variance, n is number of children fulfilling the criteria for GAM or SAM, N is the number of children surveyed/measured, DE is the Design Effect and N_{pop} is the size of the total (sub)population surveyed.

Death rate (death per day per 10,000)

death rate (dr) = 10000 * d / ("mid-recall population" * recall)

= 10000 * d / ((N-d/2) * recall)

V_{sample}(dr) = DE * ((dr * (10000 – dr) / ((N-d/2) * recall))) * (1- (N-d/2)/N_{pop})

V_{random}(dr) = ((dr * (10000 – dr) / ((N-d/2) * recall))) * (1- (N-d/2)/N_{pop})

where V_X is variance, recall is the recall period (in days), d is number of death during the recall period either total or under-5, N is the size of the surveyed/measured population at date of the survey. DE is the Design Effect and N_{pop} is the size of the total (sub)population surveyed.

The mid-recall-period population was in the formula only adjusted for death during recall. However, if information on birth (b), arrivals (a) and/or leavings (l) during recall is known, then this should be included in the formula:

N-d/2 should be: N - (d+b+a+l)/2

presupposing half-recall for all changes in the survey population.

Note: V_{sample} / V_{random} = DE, and V_{random} can be calculated without knowledge of the sampling design. Hence, DE might be determined, if V_{sample} is known. If V_{sample} is not known then DE might be set to for example 4[4] to penalise for the missing sample-variance or unknown DE.

Splitting over the recall period

A death rate dr estimates over m months, covers these m months, and must be considered constant over these m months, unless information for profiling over the recall period is available.

[4] In a cluster design DE is normally expected to be around 2

When splitting a death rate in the m months corresponding to the recall period and containing the death rate constant (the death rate for the whole recall period = dr) implies increased variance for each for the equal monthly death rates (dr).

$V_{\text{whole recall}}(dr) = DE * ((dr * (10000 – dr) / ((N-d/2) * recall))) * (1- (N-d/2)/N_{pop})$

$V_{\text{whole recall}}(dr) = DE * ((dr * (10000 – dr) / ((N-d/2) * m*mdays))) * (1- (N-d/2)/N_{pop})$

where mday is number of days in a months; recall = m*mdays. The variance for one month will be:

$V_{1\ \text{month}}(dr) = DE * ((dr * (10000 – dr) / ((N-d/2) * mdays))) * (1- (N-d/2)/N_{pop})$

which divided by $V_{\text{whole recall}}(dr)$ will be:

$V_{1\ \text{month}}(dr) \ / V_{\text{whole recall}}(dr) = m$

Hence: $V_{1\ \text{month}}(dr) = m * V_{\text{whole recall}}(dr)$, when the recall period cover m months.