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NUTRITION

Trends in malnutrition and mortality in Darfur, Sudan, between 2004 and 2008: a meta-analysis of publicly available surveys

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Background The humanitarian response to the crisis in Darfur is the largest humanitarian operation in the world. To investigate the evolution of the conditions of the affected population, we analysed trends in malnutrition and mortality, the most widely accepted indicators for assessing the degree of severity of a crisis.

Methods We did a meta-analysis of 164 publicly available surveys taking into account changes in the contextual situation and humanitarian aid; type of population [residents and internally displaced persons (IDPs)]; and seasonal variations. Data on global acute malnutrition (GAM), severe acute malnutrition (SAM), crude death rate (CDR) and under-five death rate (U5DR) were analysed using a random effect model.

Results GAM and SAM decreased by 16% and 28%, respectively, in 2004–05, whereas CDR dropped by 44–75% per year depending on state and type of population and U5DR decreased by an overall 50% yearly. Both security and the humanitarian contexts became increasingly complex after 2005, but levels of malnutrition stabilized in North and South Darfur. In West Darfur, GAM remained stable but SAM tended to increase for IDPs, although mortality rates remained constant. Mortality increased slightly for residents in South Darfur after 2005, even though nutritional status was stable. GAM, SAM, CDR and U5DR fluctuated markedly with seasons.

Conclusion A meta-analysis of myriads of surveys permitted us to draw an overall picture of the situation in Darfur and to identify some of its influencing factors. The large humanitarian operation, which gained momentum through 2004–05, was able to contain the crisis despite huge difficulties, but did not compensate for seasonal variations. The situation has remained fragile with some negative patterns tending to emerge. It is crucial that the humanitarian situation continues to be closely monitored.

Keywords Darfur, malnutrition, mortality, emergency, humanitarian, seasonality

Introduction

Since 2004, Darfur has been the arena of the largest humanitarian operation in the world.[1,2] At the beginning of 2009, 4.8 million civilians were affected by the crisis, of whom 2.9 million were displaced.[3] Darfur's many challenges through the years have included inter-tribal clashes, armed conflict in bordering countries, considerable seasonality in food security and agro-meteorological hazards affecting livelihood.[4,5] 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. Civilians were indiscriminately killed, beaten and raped.[6–8] Villages were looted and razed and crops were destroyed,[9] resulting in severe food shortages. This led to massive displacements as people moved within the region or fled across the border to Chad. Military operations continued despite several ceasefire agreements and deployment of peacekeeping troops from the African Union.[10] Initially, access was denied to humanitarian workers, but after international pressure, GoS accelerated the system for visas and travel permits to Darfur.

Two main periods in the crisis seem to emerge from the contextual information.[3,10,11] The first period from early 2004 to the end of 2005 was characterized by the start of the armed insurgency, the government counter-offensive using local militias and mostly targeting civilians, a sharp rise in the size of affected population and the deployment and gradual scale-up of humanitarian aid. During the second period, from 2006 onwards, the conflict became increasingly complex with the fragmentation of the rebel groups, unclear chains of command among both GoS-supported militia and the rebels and intensification of banditry. Humanitarian aid organizations were able to establish operations and to gain a solid footing from mid-2004 and subsequently maintained a significant level of aid. The situation has, however, remained highly volatile and could be aggravated as the GoS, in spring 2009, expelled 13 international humanitarian non-governmental organizations (NGOs)[12] and revoked the licences of three national ones.[13]

Nutritional status and mortality are widely used as essential indicators to assess severity of a crisis, to follow trends and to guide decision making.[14,15] These indicators are commonly assessed through cross-sectional surveys conducted according to international guidelines.[15,16] Dozens of nutrition and mortality surveys have been conducted in Darfur and trends in the initial period of the crisis[17,18] as well as patterns in mortality 2004–08[19] have been investigated, but none has offered a comprehensive review of both nutrition and mortality.

We aimed to develop a methodology to perform a meta-analysis of publicly available results of nutrition and mortality surveys, to compose an overall picture of the situation in Darfur and its evolution. We investigated the role of potential influencing factors such as seasonality and the displacement status of the population.

Methods

Search strategy and selection criteria

NICS/SCN[20] and CE-DAT[21] databases were the main sources of data. Survey results were collected, duplicates were excluded and reports of the surveys were traced. Survey reports that were not available on the Internet were obtained from the organizations which conducted the surveys.

Survey sampling methodology was reviewed and surveys that could not be disaggregated by state or used as a purposive sampling were discarded.

Nutritional status was analysed by the prevalence of global acute malnutrition (GAM) and severe acute malnutrition (SAM) defined as weight-for-height *z*-score according to the National Center for Health Statistics reference[22] -2 or less, and -3 or less, respectively, and/or oedema.[23] Mortality was analysed by crude death rate (CDR) and under-five death rate (U5DR), expressed as deaths/10 000 persons/day.[14]

Data extraction

Information extracted included date of the survey, state (North, South and West Darfur), location, type of population [internally displaced persons (IDPs), residents or a mix of these], proportion of IDPs, total and under-five population size of sampling frame and sampling design. For nutrition, number of children surveyed, number of children with GAM or SAM, prevalence of GAM and SAM and 95% confidence intervals (95% CIs) were recorded. For mortality, data extracted included size of population surveyed, total number of deaths, number of under-five deaths, recall period, CDR, U5DR and 95% CI.

Data quality assessment

Point estimates of GAM, SAM, CDR and U5DR were verified by recalculating them from data available in the reports. Reported point estimates differing from calculated estimates by >0.1 were corrected after potential errors were further investigated. Variance of point estimates were calculated from the 95% CIs. Likelinesses of the 95% CIs were evaluated by calculating the design effect (DEFF), which is the ratio of the variance of the estimate under the actual design (mostly cluster) to the variance of the estimate assuming simple random sampling.[24] If DEFF was <0.5 or >3, 95% CI values were further investigated and corrected.

Statistical analysis

When 95% CIs were missing, DEFF was fixed at 4, penalizing these estimates by a variance twice the variance of estimates with known DEFF, which mainly was around 2. Furthermore, a finite population correction, taking into account the size of the sampling frame (SSF) was applied to the variance. If not available, SSF was estimated by the following steps, in order of preference: (i) data from Sudan's Darfur Humanitarian Needs Profile;[3] (ii) linear interpolation over surveys conducted at the same location; (iii) applying the 'rule of thumb' that the under-five SSF is 20% of the total SSF; (iv) if SSF could not be estimated, no correction for a finite population was included in the variance of the point estimate.

Surveys with different SSFs should be weighted accordingly. We used an influence index defined as SSF divided by the size of the affected population at the same point of time for each type of population and for each state. However, size of total affected population was only available for IDPs and residents separately, and not for a mix of these, corresponding to the proportion of IDPs and residents in the surveys. Therefore, all surveys conducted in a mixed population were split into an IDP and a resident part according to the percentage of IDPs in the surveyed population. As it was not possible to differentiate the point estimates in an IDP and resident part, the same point estimates, corresponding to the original point estimate of the mixed population, were used in both stereotype populations.

Death rates were estimated retrospectively, i.e. covering a period back in time from the date of the survey. For mortality, each survey was split in a series of monthly surveys, covering the recall period, with equal death rates and a variance of number of months in recall times the variance of the estimated death rate for the whole recall period.

Prevalence of malnutrition and death rates are per se positively skewed. Hence, a log-transformed model was used. Variances of point estimates were included in the model,[25] as was clustering at the same location. From the contextual information, two periods with different characteristics in terms of pattern of the conflict seemed to emerge: 2004–05 and 2006–08; periods with different trends. Hence, two linear trends corresponding to these periods were included in the model. Furthermore, proportion of IDPs in the surveyed population was taken into account as it might influence nutrition and mortality for several reasons, including higher vulnerability of IDPs and aid preferentially targeted to them. Seasonality is also likely to have an influence on nutrition and mortality due to variations in food security and morbidity and was included in the analyses as a sine wave. The formula for the statistical model is shown in Figure 1.

The model, being a random effect meta-regression with known within-survey variance,[26] was fitted using the Stata procedure *metareg*.[27] Estimation was weighted by the influence index. The model was fitted for all Darfur in one overall regression stratified by state and type of population. Hence, homogeneity of regression coefficients and population means across states and population groups could be tested.

Results

Of the 169 survey results identified for the period from 1 January 2004 to 31 December 2008, 164 were included in the analysis (Figure 2). Among these surveys, 11 had an error. All of these errors could be either corrected or penalized on DEFF. Prevalences of GAM and SAM were recorded in 154 surveys and 150 had 95% CI. CDR and U5DR were recorded in 143 surveys; 120 and 119, respectively, had 95% CI. Variance could be estimated for all with missing 95% CI. A total of 143 point estimates for GAM and SAM were included in the analysis, whereas 154 point estimates were included in the analysis for CDR and U5DR (Figure 2). More surveys were conducted in South Darfur than in the other states, especially in 2007 and 2008. Overall the number of surveys peaked in 2005. More than 90% of all the surveys included IDPs (IDPs alone and IDPs and residents) whereas only 50–65% included residents.

Through 2004 and 2005 GAM and SAM decreased significantly by 16% per year [relative effect (RE) = 0.84; 95% CI 0.77–0.92] and 28% per year (RE = 0.72; 95% CI 0.59–0.89), respectively, (Table 1). From 2006 onwards, prevalence of GAM stabilized (trend per year around 1) among IDPs and residents in all three states, but fluctuated between 10% and 20% due to seasonality (Figure 3). Trends in prevalence of SAM were not homogeneous among the three states, with SAM continuing to fall by 20% in South Darfur (RE = 0.80; 95% CI 0.64–0.98), remaining stable in North Darfur (RE = 1.12; 95% CI 0.86–1.46) and having an overall tendency to increase by 24% per year (RE = 1.24; 95% CI 0.91–1.69) in West

$$\log(X_t) = Y_t = \beta_0 + \beta_1 * t + \beta_2 * \max(0, t-2006) + \beta_3 * \text{f\_idp} + A*\sin((2\pi/365)\ t) + B*\cos((2\pi/365)\ t) + u_t + \varepsilon_t$$

where X_t might be GAM, SAM, CDR or U5DR at time point t. β_1 is the linear trend 2004–06, β_2 is the linear trend 2006–08, β_3 is the impact of proportion of IDPs, the cosine and sinus's are seasonal variation and u_t is the known variance of Y_t

Figure 1 Statistical model

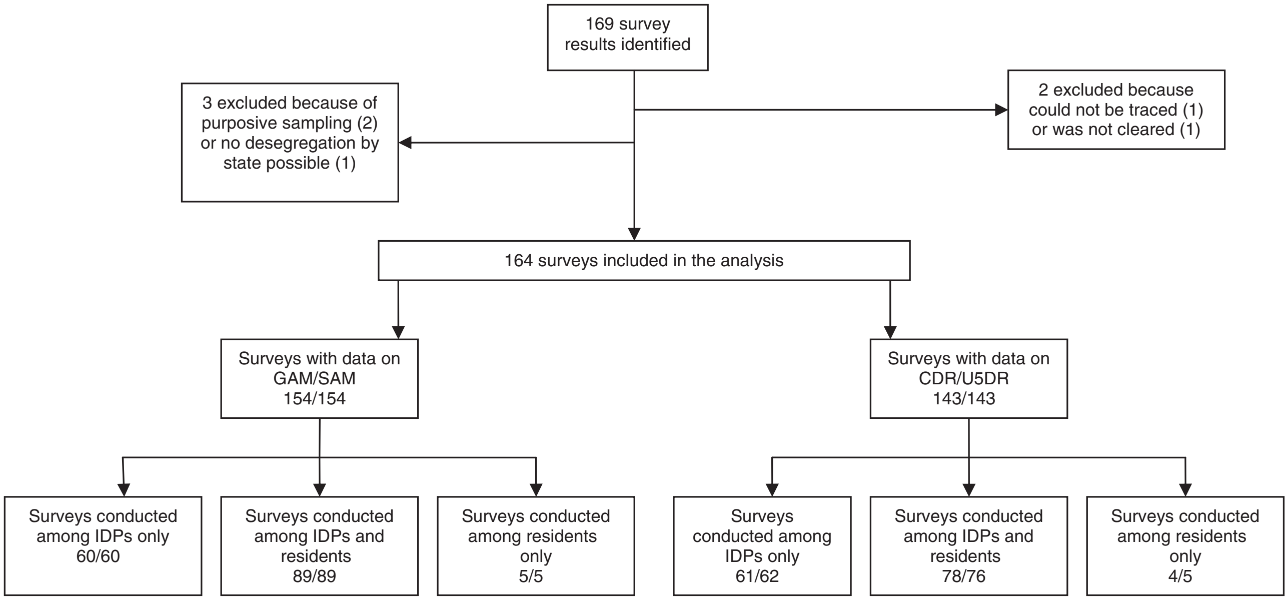

Figure 2 Survey results, selection and point estimates included in the analysis

Darfur (Table 2), with a more marked increase among IDPs. For both GAM and SAM, the effect of rising proportion of IDPs in the population was small and homogeneous across the states (test for homogeneity $\geqslant 0.1$); it increased among IDPs and equally decreased among residents, meaning the relative effect of a rising proportion of IDPs was equal in the two types of populations (joint RE = 1). GAM and SAM showed marked seasonal fluctuation, peaking around June–July (Figures 3 and 4). Overall, GAM fluctuated by 82% (RE = 1.82; 95% CI 1.68–1.97) and SAM by 145% (RE = 2.45; 95% CI 1.75–3.42). Seasonal fluctuation was homogeneous across populations and states.

At the beginning of 2004, both CDR and U5DR were critically elevated (Figures 5 and 6). CDR evolved differently between states (Table 3). CDR dropped by 69% per year (RE = 0.31; 95% CI 0.21–0.46) in South Darfur and by 44% per year (RE = 0.56; 95% CI 0.38–0.82) in North Darfur in 2004–05, adjusted for proportion of IDPs and seasonality. In West Darfur, the reduction in CDR was higher among IDPs (RE = 0.24; 95% CI 0.21–0.46) compared with residents (RE = 0.48; 95% CI 0.25–0.96). From 2006 onwards, CDR continued to evolve differently for IDPs and residents and in the different states (test for homogeneity <0.1). The declining trend continued in North Darfur, although slower than in 2004–05. In South Darfur, CDR tended to rise by 22% per year for IDPs and residents (RE = 1.22; 95% CI 0.97–1.55) and remained stable in West Darfur. U5DR decreased homogeneously among IDPs and residents and in the three states by 50% yearly (RE = 0.50; 95% CI 0.35–0.71) through 2004 and 2005 (Table 4). From 2006 onwards, U5DR remained stable. In South Darfur, a 25% increase in proportion of IDPs in the population had a negative effect on CDR among IDPs and an equal positive effect among residents i.e. nullifying when joint (joint RE = 1). In North Darfur, the negative effect among IDPs was relatively increased compared with the effect among residents. In West Darfur, CDR for IDPs was unaffected, whereas proportion of IDPs in the population had a significant negative effect among residents, relatively more pronounced compared with IDPs. The same pattern was observed for U5DR. U5DR fluctuated by 54% (RE = 1.54; 95% CI 1.32–1.80) with season homogeneously across populations and states and was generally lower around the first quarter of the year. The same pattern of seasonal fluctuation was observed for CDR, the overall seasonal variation being 63% (RE = 1.63; 95% CI 1.48–1.80).

Increasing or decreasing DEFF used to penalize surveys for missing information on variance (95% CI) did not change the results.

Discussion

Previous analyses of trend in initial period of the crisis[17,18] were confirmed in our meta-analysis, showing a marked improvement in the nutrition and mortality situation during the first 2 years of the crisis. This might be attributed to the sharp increase in humanitarian aid during this period after the crisis finally came to international prominence in spring 2004.[28] By December 2004, approximately 55 international humanitarian organizations deploying around 8000 aid workers were active in Darfur, compared with 11 agencies and 200 staff in April 2004.[29] A food security assessment conducted in October 2004 shows that the 2004–05 harvest, due in November–December, would be only 5–20% of pre-crisis level and that food insecurity was a vast

Table 1 Effects of periods, proportion of IDPs in the surveyed population and seasonality on GAM

	IDPs Relative effect (95% CI)	Residents Relative effect (95% CI)	Both[a] Relative effect (95% CI)
North Darfur			
Trend per year			
2004–05	0.92 (0.78–1.10)	0.79 (0.65–0.96)	0.87 (0.76–0.99)
2006–08	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)	January (January–February)	January (December–March)	January (December–February)
South Darfur			
Trend per year			
2004–05	0.81 (0.64–1.01)	0.87 (0.70–1.09)	0.85 (0.72–1.01)
2006–08	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)	December (November–January)	January (December–January)	January (December–January)
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)	December (October–February)	December (November–January)	December (November–January)
Greater Darfur[b]			
Trend per year			
2004–05	0.83 (0.74–0.93)	0.86 (0.76–0.96)	0.84 (0.77–0.92)
2006–08	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)	January (December–January)	January (December–January)	December (December–January)

[a]Controlled for population.
[b]Controlled for state.

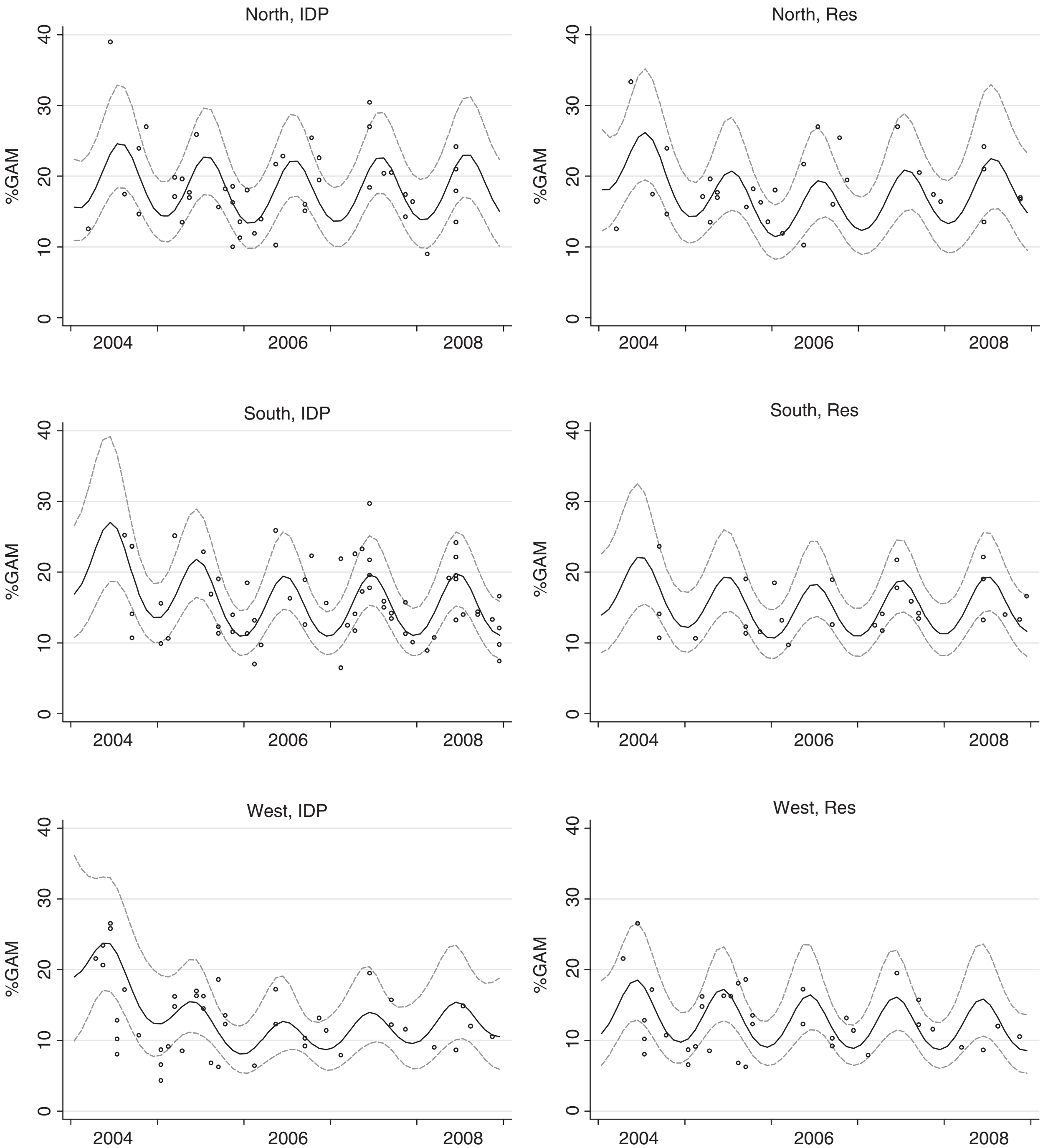

Figure 3 Trend in GAM by state and type of population. Dots = point estimates; solid line = model mean; faded dotted lines = model CIs

problem among the resident rural population, with the coping mechanisms about to be exhausted.[30] Household food consumption seemed to have increased considerably between 2004 and 2005 and this was attributed to substantial food aid interventions.[31] Nutrition and mortality situations somewhat stabilized but remained precarious over the following years, with some negative patterns tending to emerge such as increasing SAM in West Darfur and rising CDR in the South. Although humanitarian aid was hampered by several factors such as lack of coordination at the beginning of the response and difficulties in accessing populations due to insecurity, it probably played a significant role in mitigation of the humanitarian crisis, even with an increasing number of affected people. Household food security remained

Table 2 Effects of periods, proportion of IDPs in the surveyed population and seasonality on SAM

	IDPs Relative effect (95% CI)	Residents Relative effect (95% CI)	Both[a] Relative effect (95% CI)
North Darfur			
Trend per year			
2004–05	0.74 (0.45–1.23)	0.69 (0.42–1.15)	0.67 (0.48–0.95)
2006–08	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)	January (December–February)	January (November–March)	December (December–January)
South Darfur			
Trend per year			
2004–05	0.79 (0.46–1.37)	0.94 (0.56–1.59)	0.84 (0.58–1.22)
2006–08	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)	December (October–January)	January (November–February)	December (November–January)
West Darfur			
Trend per year			
2004–05	0.35 (0.15–0.82)	0.63 (0.30–1.34)	0.48 (0.27–0.84)
2006–08	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)	February (November–April)	January (November–March)	February (December–March)
Greater Darfur[b]			
Trend per year			
2004–05	0.73 (0.54–1.00)	0.76 (0.57–1.01)	0.72 (0.59–0.89)
2006–08	**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)	January (December–February)	January (December–January)	January (December–January)

[a]Controlled for population.
[b]Controlled for state.
Bold estimates indicate that the joined estimate is not statistically proper (test for homogeneity <0.1).

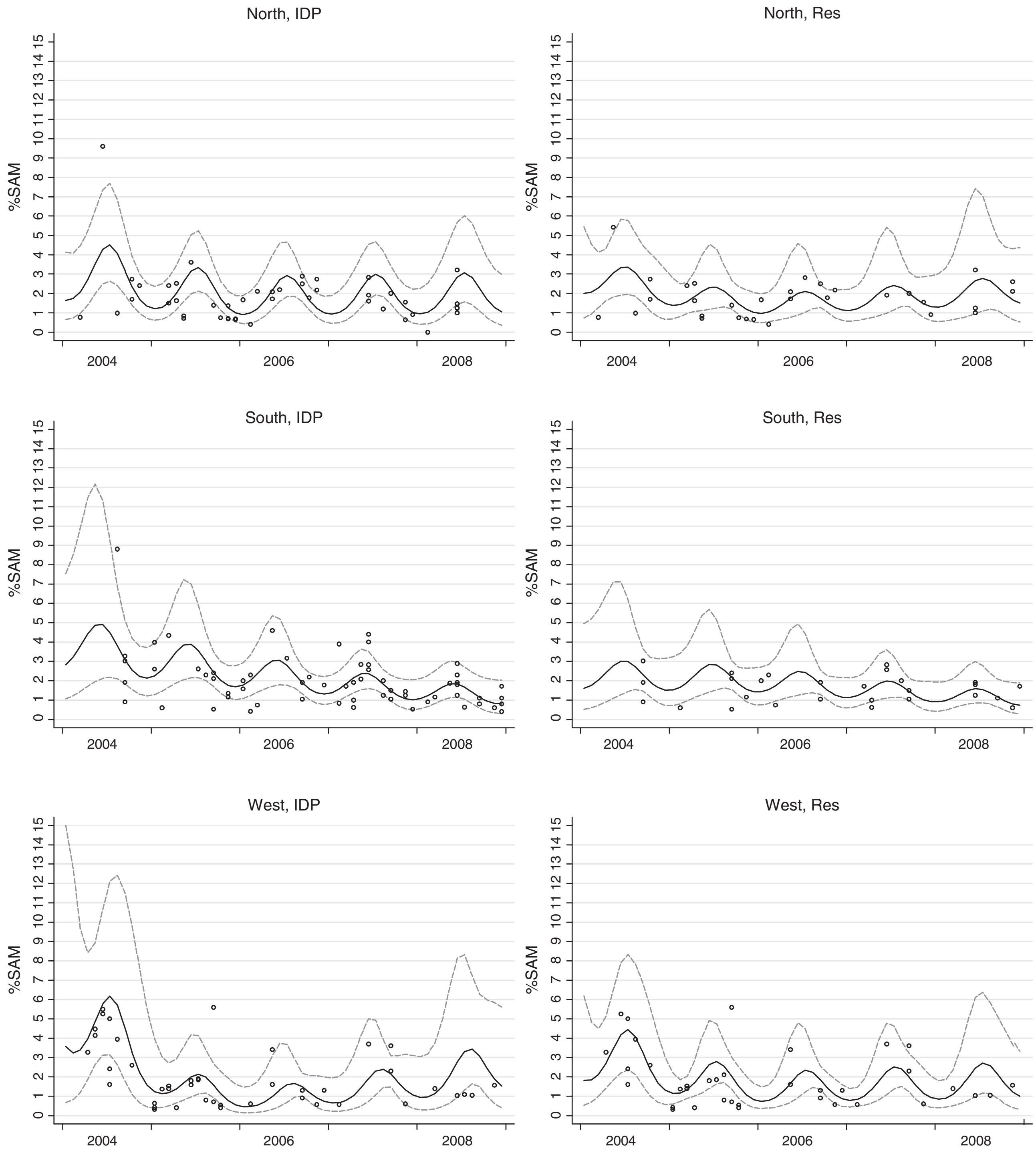

Figure 4 Trend in SAM by state and type of population. Dots = point estimates; solid line = model mean; faded dotted lines = model CIs

overall stable in Greater Darfur between 2005 and 2007.[32] Prevalence of GAM generally remained above 10%, illustrating a precarious situation. However, high GAM prevalences were already shown in 2000, where GAM was 22.5, 12.4 and 8.8% in North, South and West Darfur, respectively, and SAM was above 3% in all three states.[33] This illustrates an already high vulnerability of Darfur before the current crisis. No clear explanation could be found of the rising tendency of SAM in West Darfur after 2006, particularly among IDPs, despite the stability of GAM. However, this coincided with the closing of some supplementary feeding centres treating moderate malnutrition,[11] and a deterioration

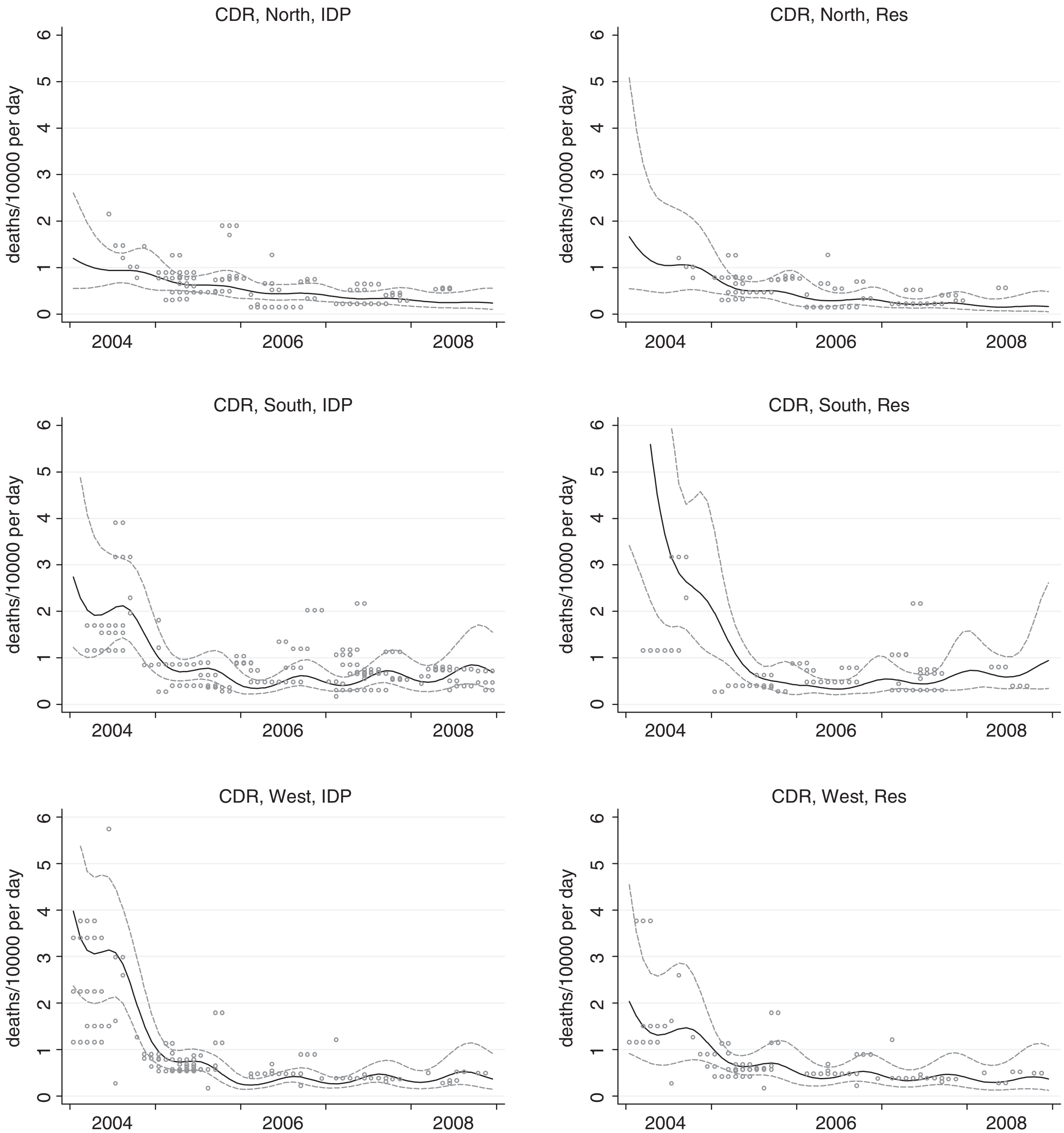

Figure 5 Trend in CDR by state and type of population. Dots = point estimates; solid line = model mean; faded dotted lines = model CIs

of the food security situation, with the highest percentage of severely food insecure households, compared with the other states.[32] Similarly, the tendency of CDR to increase in South Darfur between 2006 and 2008, whereas other factors remained stable, could not be explained. A reason could be an increase in casualties due to greater violence and armed confrontations from the end of 2007 and through 2008,[3,11] but we found no evidence for this in our data. Seasonality played a major role on nutrition and mortality patterns among both IDPs and residents in all years investigated. Higher malnutrition and mortality were associated with the hunger-gap rainy season, when food insecurity and morbidity increased. Our study suggested that humanitarian aid did not compensate for seasonal variations and could be more effective if aid was tailored to seasonality.

Our study represents a thorough methodology for drawing comprehensive trends from data of myriads of surveys, which are difficult to interpret otherwise. This method can be replicated in other contexts. The

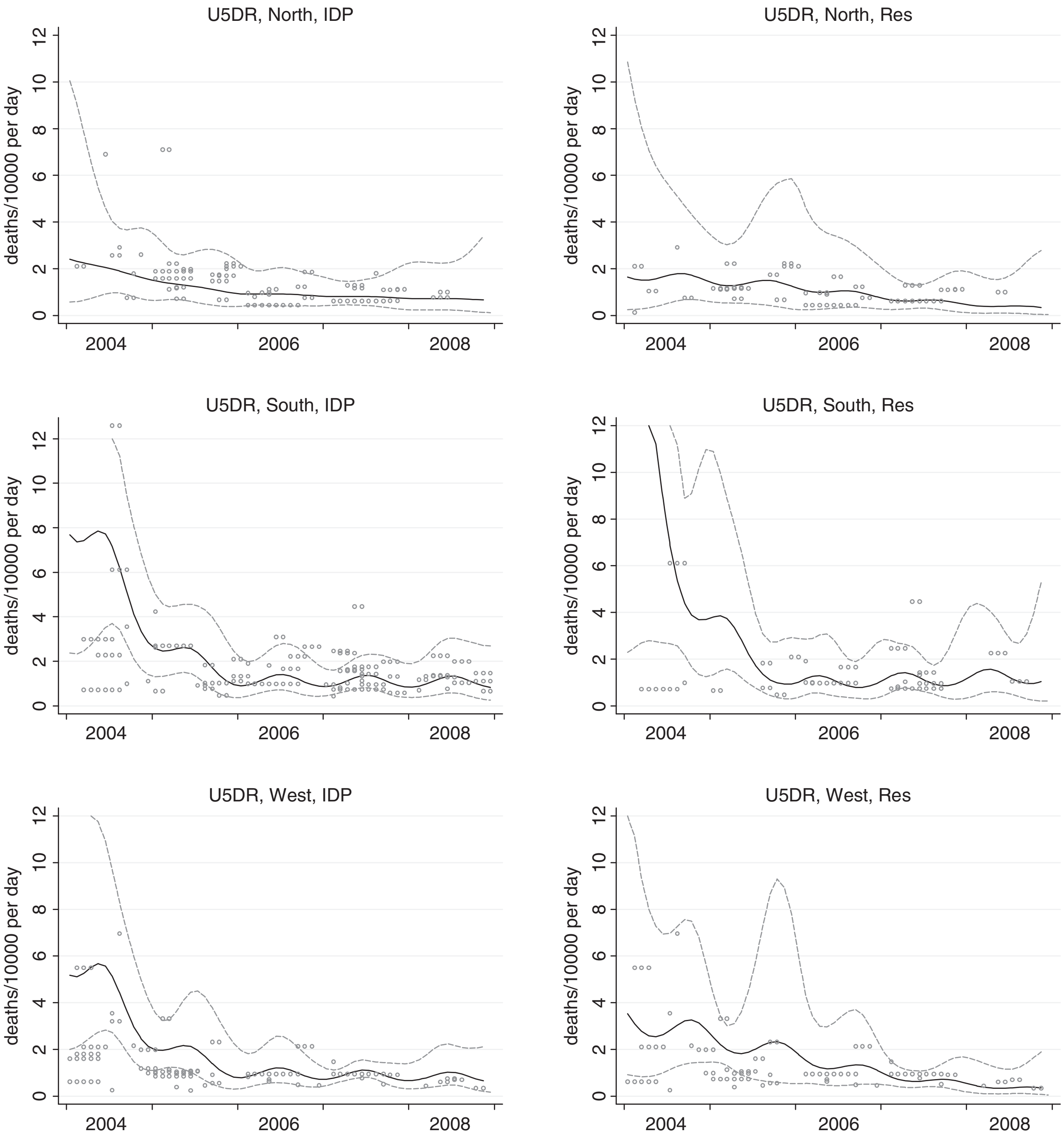

Figure 6 Trend in U5DR by state and type of population. Dots = point estimates; solid line = model mean; faded dotted lines = model CIs

data provided in the survey reports enabled us to determine the survey methodology used and the calculation of the precision of the point estimates, and we included the vast majority of the surveys we first identified. However, there are also some limitations. The analysis was performed according to information available from survey reports. Of the 169 localized surveys, we were able to include 164 having used a random sampling and reporting GAM, SAM, CDR and U5DR in a sufficient way to include them in the study. However, adequate implementation of the surveys at field level, such as the application of the sampling methodology and the quality of measurements could not be verified, nor could primary data analysis be undertaken, as the data sets were unavailable to us. The numbers of surveys conducted in the different states was similar, although slightly more surveys were conducted in South Darfur than in other states in 2007–08, which also corresponds to a higher number of affected populations in this state in the same period. More surveys including IDPs compared with surveys including residents were

Table 3 Effects of periods, proportion of IDPs in the surveyed population and seasonality on CDR

	IDPs Relative effect (95% CI)	**Residents Relative effect (95% CI)**	**Both[a] Relative effect (95% CI)**
North Darfur			
Trend per year			
2004–05	0.66 (0.41–1.06)	0.47 (0.21–1.09)	0.56 (0.38–0.82)
2006–08	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)	October (April–May)	November (July–March)	December (September–February)
South Darfur			
Trend per year			
2004–05	0.37 (0.23–0.61)	0.19 (0.10–0.37)	0.31 (0.21–0.46)
2006–08	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)	March (January–June)	January (September–May)	November (September–January)
West Darfur			
Trend per year			
2004–05	0.24 (0.16–0.36)	0.48 (0.25–0.93)	**0.30 (0.23–0.40)**
2006–08	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)	February (December–April)	October (July–January)	**March (January–April)**
Greater Darfur[b]			
Trend per year			
2004–05	**0.35 (0.28–0.44)**	**0.44 (0.31–0.62)**	**0.35 (0.29–0.42)**
2006–08	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)	March (January–May)	October (August–January)	**October (August–February)**

[a]Controlled for population.
[b]Controlled for state.
Bold estimates indicate that the joined estimate is not statistically proper (test for homogeneity <0.1).

Table 4 Effects of periods, proportion of IDPs in the surveyed population and seasonality on U5DR

	IDPs Relative effect (95% CI)	Residents Relative effect (95% CI)	Both[a] Relative effect (95% CI)
North Darfur			
Trend per year			
2004–05	0.62 (0.26–1.45)	0.84 (0.18–3.88)	0.66 (0.32–1.36)
2006–08	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)	January (February–December)	March (June–December)	February (March–January)
South Darfur			
Trend per year			
2004–05	0.36 (0.16–0.79)	0.25 (0.08–0.77)	0.37 (0.20–0.68)
2006–08	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)	January (August–May)	October (June–February)	December (September–February)
West Darfur			
Trend per year			
2004–05	0.38 (0.18–0.82)	0.72 (0.22–2.36)	0.49 (0.26–0.92)
2006–08	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)	December (October–March)	October (June–March)	January (June–October)
Greater Darfur[b]			
Trend per year			
2004–05	0.48 (0.31–0.74)	0.54 (0.29–1.00)	0.50 (0.35–0.71)
2006–08	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)	January (October–April)	February (March–January)	January (September–May)

[a]Controlled for population.
[b]Controlled for state.

conducted. This might be because the majority of the IDPs lived in or around towns which were more accessible and because humanitarian aid mainly was targeted to them. Furthermore, most of the surveys included in the analysis were conducted by NGOs with the aim of initially assessing or following a situation, and were localized to, for example, one or several IDP camps or towns. Survey locations, therefore, most likely were biased towards areas where access and security were sufficient to allow humanitarian operations and where prevalence of malnutrition and death rates might have been lower than in inaccessible locations. This bias probably was constant over time, so trends were relatively unaffected. Only four surveys in each state were conducted on the entire affected population. For surveys on mixed populations of IDPs and residents, the same point estimates were attributed to both populations, potentially masking differences between the two populations. Retrospective death rates imply a constant rate over the whole recall period and could minimize trend patterns and seasonal variations in death rates. This may, to some extent, be compensated by overlapping recall periods across surveys. We only included two broad periods in the model. More periods of shorter length and different periods tailored to states and types of population might have been identified. However, the two periods seemed to fit data well and including further differentiation would have reduced the statistical power of the analysis. We extrapolated a number of missing primary data from secondary sources and penalized the surveys accordingly. Varying this penalization did not change the results of the analysis, showing that extrapolations had little influence. However, to ensure accuracy of such analyses, it is crucial that survey reports contain detailed information on basic data used to estimate malnutrition prevalence and death rates, including number of malnourished children, number of deaths, number of people surveyed and recall period, as well as on the precision of the estimates, usually expressed as CIs. Stakeholders conducting the surveys should be encouraged to report these figures systematically.

The present study developed a methodology for meta-analyses of general trends in malnutrition and mortality over time based on the survey results and was applied to the situation in Darfur. The methodology can be used in other contexts. It may also be extended to learn more about the humanitarian situation and the humanitarian interventions. This could be attempted in Darfur with, for example, in-depth analyses of the relationship between malnutrition and mortality as well as examination of the influence of specific factors on malnutrition and mortality, such as food security, immunization, morbidity, access to population and level of aid including food distributions, feeding centres and health care.

In conclusion, by the end of 2008 malnutrition and mortality in Darfur had stabilized below emergency thresholds, but the humanitarian situation was very vulnerable. Hence, malnutrition and mortality should continue to be closely monitored to assess the humanitarian situation and the humanitarian aid community must be prepared to respond to changes in needs.

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KEY MESSAGES

- Meta-analyses of survey results can reveal general trends in nutrition and mortality.
- Seasonality in local food supplies should be taken into account in implementation of humanitarian aid.
- The situation in Darfur by the end of 2008 was highly vulnerable.

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