UNIVERSITE CATHOLIQUE DE LOUVAIN

Mortality in the Darfur Conflict

A study of large-scale patterns based on a meta-analysis of small-scale surveys

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Chapter 1

Introduction

Mortality in conflicts has been an important subject of research and debate during the past decade. Recent crises — eg in the Democratic Republic of Congo, Iraq, and Darfur, have generated substantive discussions about numbers and rates of death as a result of wars [15, 22, 71, 49, 12, 13, 37, 43, 70, 75, 54, 44, 59].

Although interest in the study of conflict mortality has undoubtedly increased over recent years, the interest for the topic is not new. In the nineteenth century, several reports were published in which the characteristics of soldiers' death were thoroughly studied. Some famous examples are Minard's flow map of Napoleon's march in Russia depicting survival throughout the campaign [36], Bortkiewicz's analysis of horse-kick deaths in the Prussian army [9], and Nightingale's mortality study of the British army in the Crimean War [55]. In one of her letters, Nightingale asserts

> "...it is as criminal to have a mortality of 17, 19, and 20 per thousand in the Line, Artillery and Guards, when that in civil life is only 11 per 1,000, as it would be to take 1,100 men out upon Salisbury Plain and shoot them."

Her writing, in other words, referred to concepts like expected[1] and excess mortality[2] avant la lettre. However, since wars were mainly fought on battlefields, civilians accounted for a relatively low percentage of the casualties, and as a consequence, most of the research on conflict deaths from that period was focused on reducing the mortality among military and combatants.

Throughout the twentieth century though, the share of non-combatants in conflict casualties increased considerably [38]. While it is estimated that civilians accounted for nineteen percent of the World War I victims, they represented almost half of the deaths of World War II. Nonetheless, it wasn't until the late 1960s and early 1970s, before civilian deaths in conflicts became a topic of interest, and even a research area on its own.

During those years, the devastating effects of armed conflicts, like the Biafra secession, were for the first time watched by everyone on television. In the aftermath of these humanitarian crises, many of today's major non-governmental organizations (NGOs) were created, with the purpose to improve the effectiveness of relief operations and to alleviate the suffering of the civilian population [1]. However, this was still the middle of the Cold War, and humanitarian aid during those years remained mainly justified on the basis of geopolitical strategies and its charitable nature, rather than its effectiveness [33]. It's only following the end of the Cold War, and following conflicts in the early nineties like the Rwanda genocide and the civil conflict in Yugoslavia, that the field of humanitarian action was subject to important changes, which would ultimately trigger the development of better data collection tools in humanitarian situations [34].

First, the humanitarian budget grew spectacularly over the last two decades, going from US$ 1.1 billion in 1990 to US$ 10.8 billion in 2008 [63]. Similarly, its share in the international aid budget increased from 1.5% of total ODA in 1990, to 6.8% in 2008.

[1] Expected mortality: the mortality that we expect during peacetime, ie. the counterfactual mortality rate.

[2] Excess mortality: the difference between the observed mortality and the expected mortality. It represents the level of mortality attributable to the conflict.

However, as the budgets increased, donor countries requested a higher effectiveness and better transparency of allocation of these funds.

A second evolution, occurring concurrently with this growth in budget, was the significant increase in the numbers and the influence of the NGOs. From 1,600 development NGOs in 1980 registered within the thirty OECD industrialized countries, the number had almost doubled to 2,970 in 1993 [10].

Due to the absence of national mechanisms to deliver aid, and due to a global disenchantment with the public sector in favor of private initiative, these NGOs became a major recipient of the increasing humanitarian budgets [32]. However, the rise in the popularity of NGOs for aid delivery also drew criticisms of poor performance, and of NGOs as competitive corporate entities driven more by funding than humanitarian imperatives [10]. The NGOs themselves realized that their capacity to attract support and their legitimacy as actors in humanitarian aid would depend on their ability to demonstrate that they can perform effectively and are accountable for their actions. This pushed them to step up their data collection activities.

A first major achievement towards this improved accountability, was the establishment, through the Sphere project, of minimum standards for humanitarian assistance. This project, launched in 1997, regrouped several NGOs such as MSF, Oxfam and Save the Children, as well as the Red Cross and Red Crescent Movement, in an attempt to develop clear targets for relief operations. A Sphere manual was published in 2000 [77], covering four sections of humanitarian action: water, sanitation and hygiene promotion; food security, nutrition and food aid; shelter, settlement and non-food items; and health services. More than a decade later, the Sphere standards are used by most of the actors in the field.

With regards to the assessment of mortality, the Sphere project established a set of regional reference mortality rates. These rates correspond to the expected level of mortality in each region of the world. For example, it estimated a "normal" level of mortality in Sub-Saharan Africa at 0.44 deaths per 10,000 people per day. At the same time, it defined an emergency as a situation where mortality rates were exceeding twice the reference value. In the case of Sub-Saharan Africa, this corresponds to situations where mortality rates exceed 0.88/10,000/day.

However, while cut-off and threshold values for many indicators had been developed, a gap remained regarding guidance on how to actually collect this information. In an attempt to fill this gap, the United States Agency for International Development (USAID) started the SMART initiative in 2002 [65]. This initiative gathered professionals from NGOs, UN organizations, research institutes and donor agencies, with the purpose of developing a common methodology for the assessment of nutrition and mortality in emergencies. A first version of this standardized methodology was released in 2006 and it has been increasingly used by relief organizations since then [74].

From this point of view, the study of conflict mortality should be seen as some sort of operational research, with the purpose of providing an evidence base for actions aiming at reducing the number of conflict casualties. For this, patterns in conflict related mortality are identified, including causes of deaths, vulnerable groups and spatio-temporal trends. This is the essence of conflict epidemiology.

The research presented in this thesis, aims at providing a new methodology to analyze risk factors for mortality in conflict situations, by combining data from numerous health surveys. In chapter 2, we will review the current knowledge of the impact of conflicts on public health, and its ensuing impact on mortality. We will further discuss the current methods used to assess mortality in humanitarian crises. Next, we will focus on the case of Darfur. In chapter 3, an overview of the origins of the conflict will be given, as well as a brief chronology of the first five years of the crisis. In the following chapters, our analysis of mortality patterns in Darfur will be presented. In chapter 4, we will focus on the material and methods used; in chapters 5 and 6, we will present and discuss the results; and we will end in chapter 7 with some concluding remarks.

Chapter 2

Mortality in armed conflicts

2.1 Impact of armed conflicts on public health

Violence related deaths

The first and most direct impacts of conflict related violence on health are injuries, whether they are due to bullets, shrapnel, mines, or others. Conflicts affect the patterns of injuries both in a quantitative and qualitative way. There is a higher incidence and severity of injuries and the characteristics of traumas differ significantly from the burden of injury in times of peace [60]. These vary according to the kind and use of the weapons involved [25, 24].

A specific subset of injuries are rape related as sexual violence increases during conflict [80, 83]. Nowrojee [61] shows the higher incidence of sexual crimes and their consequences on health in the case of Sierra Leone. Over 50% of Sierra Leonean women and girls were victim of sexual abuses from rebel forces or government soldiers, resulting in deaths or lifelong health disabilities.

Non-violence related deaths

In developping countries, injuries as direct effects of conflicts are only the tip of the iceberg, as they account for a relatively small proportion of the total adverse health outcomes due to conflicts. In fact, previous research has shown that non-violence related causes can account for up to ninety-eight percent of all deaths [39].

Armed conflicts often cause health problems, by aggravating the population's health status and by negatively affecting the health system. Besides a compromised access to health infrastructures or their destruction, there is often a decrease of financial and human resources within the health care system, resulting in a lack of equipment, supplies and qualified health professionals [23, 40, 80, 96].

Life-long disabilities are more frequent and fatality rates higher in conflict situation [56]. The time to reach professional health care in case of injury largely determines the long-term outcome, and the probability of fatal outcomes depends on a functioning curative health care system [46].

Appropriate curative programs are also essential for the disease affected population to recover [82] and are of importance for the number of people who recover completely from illness and/or malnutrition. Especially among children case fatality largely depends upon a sound provision of health care in case of illness.

A briefing note on the potential impacts of the conflict on health in Iraq prepared by the World Health Organization before the 2003 invasion stated that on a monthly basis, if 10,000 people would be unable to access health care, around 2% of the children suffering from an infection (gastro-intestinal or respiratory) would remain untreated. Diarrheal diseases and acute respiratory infections are known to be the main cause of death among children in developing countries and an increase in untreated cases would result in an increased mortality.

In addition to these infectious diseases, people with chronic conditions will be affected by the breakdown of health infrastructure too. For example, the prevalence of diabetes in a normal population is around 3%, a number that is expected to increase in the next decades due to aging and growing obesity. A collapse of the health system could result in a reduced accessibility to antidiabetic drugs, aggravating the conditions of the patient.

Furthermore, a majority of the countries affected by conflict have a relatively high birth rate; on average, women in conflict affected countries have given birth to one more child than women in non affected countries. Since conflicts, through the destruction of the health infrastructure, seriously hamper antenatal care, professional birth attendance and post-natal care, the survival of both the mother and the child are compromised during conflicts [105, 23, 58, 82]. As a consequence, maternal mortality, neonatal mortality and infant mortality are twice as high in conflict countries as opposed to non conflict countries.

Associated to these relatively higher mortality rates is the finding that in countries affected by conflict, the prevalence of low birth weight is higher. However, this weight disparity is not limited to newborns alone. The proportion of underweight children in the 6 to 59 months age group is twice as high in conflicts as opposed to non conflict settings, partly because of the collapse of the healthcare system. Indeed, the destruction or inaccessibility to feeding centers is a major obstacle to the maintenance of nutritional programs, which are crucial to prevent and cure malnutrition.

Finally, health system breakdown during conflict further increases the risk of serious infectious diseases. Apart from the destruction of infrastructures and the lack of qualified health staff, prevention through vaccination and health education decreases [73]. It also induces a lack of proper surveillance and rapid outbreak response capacities. Control programs are missing, resulting in a spread of vector-borne diseases [23, 100].

Displacement

In order to avoid the consequences of conflict violence, many people are forced to flee, either within the borders of their own country, i.e. the internally displaced people (IDP – 26 million worldwide) or outside, i.e. the refugees (13 million). In some cases, displaced people end up in camps, but sometimes they remain far away from specific structures intended to support them.

A first way through which displacement affects the health of populations is the exposure to new pathogens. Indeed, displaced populations might settle in areas prone to particular diseases that were not present in the area of origin and for which they have not developed immunity. On the other hand, displaced persons might carry pathogens that are unknown to host populations and in this way accelerate the spread of diseases. Connolly et al. [23] highlight this process in the case of malarial transmission in Burundi between 2000 and 2001, as did a WHO report on the potential impact of conflict on health in Iraq [105].

However, the impact of camp conditions on people's health status is ambiguous. On the one hand, camp settings often provide several services to support the living conditions of the displaced such as health facilities, food distributions, shelter, access to safe water, sanitation, education services, etc. For example, the Standards and Indicators Report project (SIR) of the UNHCR sets clear targets for service coverage in refugee camps such as: less than 10,000 people per primary health care facility, less than 5% global acute malnutrition (GAM), over 50% of life births attended by skilled personnel, on average at least 2100 kcal and 20 liters of water available per person per day, 100% of children from 6 to 11 years old enrolled in schools etc [87].

On the other hand, camp situations can have pervasive effects on the health of the displaced [8]. Indeed, if too many people simultaneously flee to the same camp, the camp population might exceed its capacity, resulting in overcrowding. An increase in population density holds an increased risk of disease transmission because of a higher probability of encountering an infectious person. Therefore, in order to minimize the risk of emergence of epidemics, the average camp area per person should not get below 45 m^2.

Beside increased population density, high numbers of displaced might result in a lack of appropriate shelter, clean water and hygiene, leading to a higher risk of diarrhea, one of the major causes of child morbidity and mortality in complex emergencies [23] and other hygiene related infectious diseases.

Finally, living in camps might jeopardize the security of displaced people. Several cases have been reported where rebels lived among the displaced population, increasing the risk of exposure to counter insurgency attacks and resulting in deaths and injured among the displaced.

Food security and malnutrition

Closely related to the incidence of diseases is the nutritional status of a population. In times of conflicts, several factors could influence the food availability and accessibility. Broadly speaking, there are two ways through which food is available to people: local production and imported goods. The former will suffer from destruction of crops and killing of cattle whereas the latter will be affected by a total collapse of trade as a result of insecurity, governance failure and redirection of funds. In addition, hunger is often used as a weapon according to the World Hunger Education Service, as food stocks are seized or destroyed on purpose, agricultural land is mined and food supplies are cut off. Besides reduced food availability, lack of access to food is a major factor influencing the emergence of malnutrition. An increase in food prices or reduction in household income can turn into a major difficulty for poor households.

Interactions between low nutritional levels and disease have been extensively described in the literature. A lack of nutrients results in a decreased immune response of the body and thus in an increased vulnerability to infectious diseases. However, the immunological consequences of malnutrition differ depending upon specific nutrients, or combinations of nutrients, that are lacking [7].

Similarly, the risk of malnutrition related mortality varies per disease. Studies have documented a strong association between malnutrition and an increased risk of death from diarrhoea and acute respiratory infections. For measles and malaria, on the other hand, results are less conclusive as risk factors such as overcrowding and patterns of disease transmission are more important than nutritional status [69].

Infections affect nutritional status by reducing food intake trough loss of appetite or vomiting and leading to malnutrition. Additionally, people suffering from infectious diseases are in a state of an increased energy expenditure and requirement of nutrients which will not be met and will cause the disease to linger on [72, 81].

Long-term health outcomes

In the end, injured or ill people will evolve to one of the following three outcomes: totally recovered, chronically impaired or dead. In order for injured or ill people to recover, appropriate curative programs are essential [82]. Recovery will obviously depend on the accessibility of health services since the time to reach professional health care largely determines the long-term outcome. Besides accessibility, quality of care is crucial in reducing the adverse long-term consequences on health. Without professional care, even harmless wounds can have fatal effects. Both accessibility and quality are badly affected by conflict as discussed above. This decreases the number of people who recover completely from injuries, illness and/or malnutrition and results in higher case fatality rates and more life-long disabilities due to conflict [56].

2.2 Measuring mortality in conflict situations

Since the turn of the 21^{st} century, an increasing number of mortality studies in armed conflicts has been conducted. Each one of these studies was conducted with a specific purpose, going from forensics to the monitoring and evaluation of programs. Since different purposes may require different types of data, and different methods used to collect it, the results of these studies are not necessarily comparable between each other [66].

In the following section, I present two brief examples of conflicts for which discrepant mortality studies have been published. Subsequently, I will discuss the major differences between two approaches used to collect mortality data, and the implications of it for conflict epidemiology.

Bosnia-Herzegovina

The disintegration of the federal republic of Yugoslavia consisted of a series of wars of independence throughout the 1990s. Of these internal conflicts, the war in Bosnia-Herzegovina was one of the deadliest. The conflict lasted from April 1992 to November 1995 and involved Serbian, Croatian and Bosnian forces. Almost twenty years after the onset of the fighting, the death toll remains disputed. Estimates range from 25,000 to 329,000 [79]. Discrepancies are partly due to different periods covered as well as different inclusion criteria, but also due to different sources and methodologies used.

In recent years, two of these mortality studies were published in the scientific literature. The first one, produced by Tabeau and Bijak [79], is based on a compilation of individual mortality records obtained from multiple different sources. Zwierzchowski and Tabeau presented an updated version of this analysis in 2010 [109]. The original paper collected death records from ten independent sources; the updated version used the same 10 sources with 2 additional ones. Using an approach based on the capture-recapture technique, the authors have estimated the Bosnian death toll at 102,622 in the original paper and 104,732 individuals in the 2010 update. The number of individual death records validated by the authors is 89,186. However, the authors point out that this number should be considered as a minimum estimate.

The second estimate was produced by Obermeyer et al [62]. The authors used national survey data from the WHO's 2002-2003 World Health Surveys (WHS) to estimate the percentage of total deaths in the survey sample that was due to war injuries. This proportion was then applied to the UN Population Division estimate of the total number of deaths in Bosnia, in order to obtain a death toll attributable to war injuries. The Bosnian sample consisted of 4,095 records with 619 deaths of which 111 were attributed to war. Based on these figures, the authors estimated the number of war related deaths to be 176,000 with a 95% confidence interval ranging from 67,000 to 305,000.

Iraq

Iraq is another example of a conflict where casualty figures have initiated a fierce debate on reliability of existing methods to assess mortality. Even though controversy still exists about the mortality following the 1991 Gulf War and ensuing sanctions, we will limit this overview to the debate around mortality since the 2003 invasion.

In early 2003, the project called Iraq Body Count (IBC) [?] was set up, with the aim of maintaining a database of casualties resulting from the military operations in Iraq. The project collects data on civilian deaths mainly from media sources, but also from hospitals and morgues. As of August 25^{th} 2010, civilian casualties were estimated between 97,994 and 106,954. Although IBC's objective is to provide a comprehensive list of civilian war deaths, the authors have acknowledged that the true death toll could be approximately twice as high as the number included in their database. Critics however, believe the project underestimates the true death toll to a much larger extent [12].

Secondly, in two papers published in the Lancet in 2004 and 2006, Roberts, Burnham and others estimated the death toll following the 2003 invasion at 98,000 for the period March 2003-September 2004 [70], and 654,965 for March 2003-June 2006 [12], numbers that were considerably higher than the IBC estimates at that time. Both estimates were accompanied by large confidence intervals: 8,000 to 194,000 for the 2004 estimate, and 392,979 to 942,636 for the 2006 one. The two death tolls were obtained through a nation-wide retrospective mortality survey, in which information on deaths since January 2002 were collected in a sample of 988 households in the 2004 survey, and 1849 households in the 2006 survey. The calculated mortality rates were subsequently extrapolated to the entire Iraqi population, and this resulted in the death tolls given above. However, the studies have been heavily criticized as being biased and overestimating the true mortality level during the conflict [75, 43, 99, 57, 11, 31, 47, 53].

Three additional surveys provided mortality data for the conflict in Iraq. First, UNDP/ COSIT/FAFO jointly conducted a survey in early 2004, called the Iraq Living Conditions Survey (ILCS) [86]. The survey used a stratified, cluster design with more than 21,000 households in their sample. The estimation of mortality was not the main objective of the study, but a question regarding conflict deaths was included in the questionnaire. The study estimated the number of conflict deaths at 24,000 between March 2003 and May 2004.

The next study, called the Iraq Family Health Survey (IFHS), was done by the WHO and the Iraqi authorities in 2006, and published by Alkhuzai et al in the New England Journal of Medicine [3]. A stratified, cluster sampling was used with 971 clusters accounting for 9,345 households. The study did not focus exclusively on deaths, but mortality was an important component of the questionnaire. Based on the results, WHO estimated the number of violent deaths at 151,000 between March 2003 and June 2006.

The last analysis is based on a survey jointly undertaken by two polling companies, namely Opinion Research Business (ORB) and the Independent Institute for Administration and Civil Society Studies (IIACSS) [64]. Their mortality estimate was based on extrapolating the average number of deaths per household from a representative, national sample to all households across the country. The sample, consisting of 2,414 households, was obtained through multi-stage random probability sampling and covered 112 unique sampling points. The death toll according to this study was little over one million for the period March 2003 to August 2007, but this figure has been criticized as being not credible [76].

Passive surveillance versus mortality surveys

The huge discrepancy between the different mortality estimates has casted doubt on the reliability of the methods used in collecting this type of data [20]. It has further highlighted differences between two major approaches used in analyzing mortality data. A first approach is based on passive surveillance methods. It is basically, the compilation of different sources of mortality data that were often not collected for the purpose of analyzing mortality. This can include media reports, witness accounts, death registries, etc. With this method, the researcher enumerates each death, without making any extrapolation. Since a complete enumeration is rarely realistic, figures resulting from this method are typically undercounts or lower limits of the death toll. This passive surveillance approach is the one used by Tabeau, Bijak and Zwierzchowski in the case of Bosnia-Herzegovina, and by IBC in the case of Iraq.

As opposed to this first approach, the second method does not require a full listing of war fatalities. Using random sampling techniques, mortality data is collected for a representative sample of the affected population. The ensuing results are then considered to be valid for the larger population, although some margin of error is included. As a consequence, these retrospective mortality surveys do not typically undercount the number of deaths like passive surveillance does, but on the other hand, survey results are surrounded by a - sometimes - large degree of uncertainty. This is, for instance, the case for Obermeyer's estimate of Bosnian conflict deaths, as well as the survey-based mortality estimates for Iraq.

Use of retrospective mortality surveys in conflict epidemiology

Conflict epidemiologists typically follow the second approach and collect data through retrospective mortality surveys. Apart from Iraq and Bosnia-Herzegovina, large retrospective mortality surveys have been conducted recently in many other conflict affected countries, including the Democratic Republic of Congo [22] and Darfur [107]. However, these large-scale surveys are subject to some important limitations.

First, large-scale surveys have typically long recall periods, i.e. the period for which mortality data is collected, and as such, they do not allow for a detailed time trend analysis. This is due to the fact that the results are averages for the entire period, and thus variations over time are leveled out. In other words, periods with high mortality can't be differentiated from those with low mortality. In Iraq, for example, recall periods were sometimes more than 3 years, and although rates were reported for sub-periods, the precision of those rates is often insufficient [12].

Second, large-scale surveys do not provide useful information for a geographical analysis of mortality. These surveys report mortality rates for entire countries or provinces, ignoring significant differences in space. Therefore, national figures do not make any distinction between those areas with very high mortality and areas with lower levels of mortality.

Finally, highly clustered phenomena, such as the one faced in civil conflict situations, present a major challenge in sampling techniques that ensure reliable estimates. The 2004

Iraq mortality survey by Roberts et al. showed a very high clustering of deaths in and around the city of Fallujah, several times higher than the rest of the country [70]. Therefore, the authors decided to exclude a cluster from their final analysis.

Besides these large-scale mortality surveys, many small-scale surveys are conducted in conflict situations. These surveys are characterized by a limited geographical scope, often the district or subdistrict level, and typically, a shorter recall period than the large-scale surveys. As a result, they provide a more detailed picture of the mortality at a specific point in time and in space.

This type of surveys is typically conducted by non-governmental organizations [29], in order to measure baseline mortality levels prior to the start of health programs, or to assess improvement or deterioration as part of monitoring and evaluation activities. As discussed in chapter 1, the high number of NGO surveys being conducted, results from the increasing pressure that was put on many NGOs during the last two decades, to improve their efficiency and increase their transparency.

Notwithstanding the large amount of this type of surveys, they are rarely used in mortality analyses. In this research, I will show how an innovative approach, in which these small-scale surveys are aggregated, provides new information on conflict mortality, that cannot be obtained from each survey separately.

Chapter 3

The Darfur conflict

3.1 Seeds of the conflict

The Darfur conflict is commonly said to have started in February 2003, when rebels attacked a garrison in Gulu, West Darfur. However, although this can indeed be considered the beginning of the current phase of the conflict, tensions and fighting were already widespread for a long time [35].

Made up of three states, The Sudanese region of Darfur lies on the fringe of the Sahara desert, in the so-called Sahelo-Saharan belt, neighboring Chad and Libya. It covers an area comparable to Spain, and has an estimated population of six to seven million [103]. The inhabitants are often divided in two main groups: Arabs and Africans. Scholars have argued that the distinction between the two is more of a cultural nature than purely ethnic. Indeed, tribes of African descent that have been arabized, are considered Arab today [28].

Arab tribes are mainly pastoral (semi-)nomads, while African tribes are mostly sedentary farmers. Although they managed to live relatively peacefully together for centuries, recent phenomena such as overgrazing, climate change and desertification, have put an increased burden on both pastoralists and farmers, struggling with each other for fertile lands. However, tensions between the African tribes and nomads, are also the result of a specific system of attribution of land rights, called *hakura*. At the time of the Darfur Sultanate, each tribe was granted a homeland, a *dar*, in which they had jurisdiction. Nomads, however, had by definition no well-defined homeland. As a consequence, the camel-herding nomad tribe of the Abbala Rizeigat did not receive such a *hakura*; yet, some sort of gentleman's agreement existed among the tribes to grant them free access to grazing lands in the different dars. However, in the last two decades, especially following the 1984-85 famine, non-nomadic tribes started to fence their fields, blocking passage for the nomads' livestock. This shift in mentality can be considered a turning point in the inter-tribal relations [27].

Concomitantly, the Sudanese regime was fighting a civil war in South Sudan against the rebels of the Sudan People's Liberation Movement/Army (SPLM/A). In 1991, an attempt was made by the rebels to export the conflict to Darfur under the command of Daud Bolad. This military expedition, however, was crushed by the Murahaleen, a militia of horse-men from the Arab Baggara tribe. The tactic of using militias instead of regular army soldiers, had proven to be very efficient, and was further used throughout the 1990s. Many of these militias were composed of young men of the Arab nomadic tribes in Darfur, who were trained and armed by the governments of Sudan and of Libya. Indeed, during the eighties, Libyan leader Ghaddafi fancied the idea of using these militias to conquer Chad. However, following the cease-fire between Libya and Chad, these armed young men were left without a cause [35].

During the nineties, non-Arab tribes in Darfur, like the Zaghawa, Fur and Masalit, felt increasingly marginalized by the central government in Khartoum. A system of discrimination, favoring Arabs above non-Arabs, was indeed present at different levels of the society. At the turn of the century, members of these tribes gathered together to found a rebel group named the Darfur Liberation Front, which would be renamed in 2003 as the Sudan's Liberation Movement/Army (SLM/A - not to be confused with the Sudan's People Liberation Movement/Army). At the same time, another rebel movement was established called the Justice and Equality Movement (JEM). JEM's origin is a manuscript titled the *Black Book*, in which the inequality between the Khartoum area and the rest of Sudan is highlighted. Although the authors of the book remain unknown, they are presumably the same as the founders of the JEM rebel group. In addition, many of JEM's leaders are considered Islamists, and one of Sudan's foremost religious Islamist leaders, Hassan al-Turabi, has been linked to the organization by the Sudanese regime [50].

In early 2003, the SLM/A and JEM joined forces in their fight against the central government in Khartoum. After the attack on Gulu in February 2003, their major military achievement was the attack in April 2003 on the airport of El Fasher, North Darfur's capital city, destroying seven airplanes and killing seventy troops. As a reaction, the Arab militias, now called Janajaweed, were reinforced and fought alongside the army against the rebels [27, 35, 50].

3.2 Six phases of the Darfur conflict

For the purpose of this analysis, I have divided the time span of the conflict between February 2003 and December 2008, in six periods. The distinction between these different periods, is based on patterns in violence and insecurity, displacement trends and the level of humanitarian aid. The main data source for these parameters were the Darfur Humanitarian Profile (DHP) reports released by UN OCHA (see section 4.2.3) [84].

Based on these statistics, I identified five distinct phases of the conflict between September 2003 and December 2008 (Periods 2 to 6 - see below). An additional phase (Period 1 - see below), from February to August 2003, corresponds to months for which no data is available and as a consequence, this period could not be included in the main analysis. Figure 3.1 shows the different trends and corresponding periods described below.

Period 1 - February to August 2003 The first seven months of the conflict are characterized by a scarcity of data. I was not able to find any survey that provided a crude mortality rate for that period, nor is there systematic data available on the number of people affected. Nonetheless, violence was widespread, mainly in North and West Darfur [52]. In neighboring Chad, the number of Darfuri refugees reached 65,000 by the end of August 2003 [51]. Due to the lack of reliable data, this period was excluded from the following analysis.

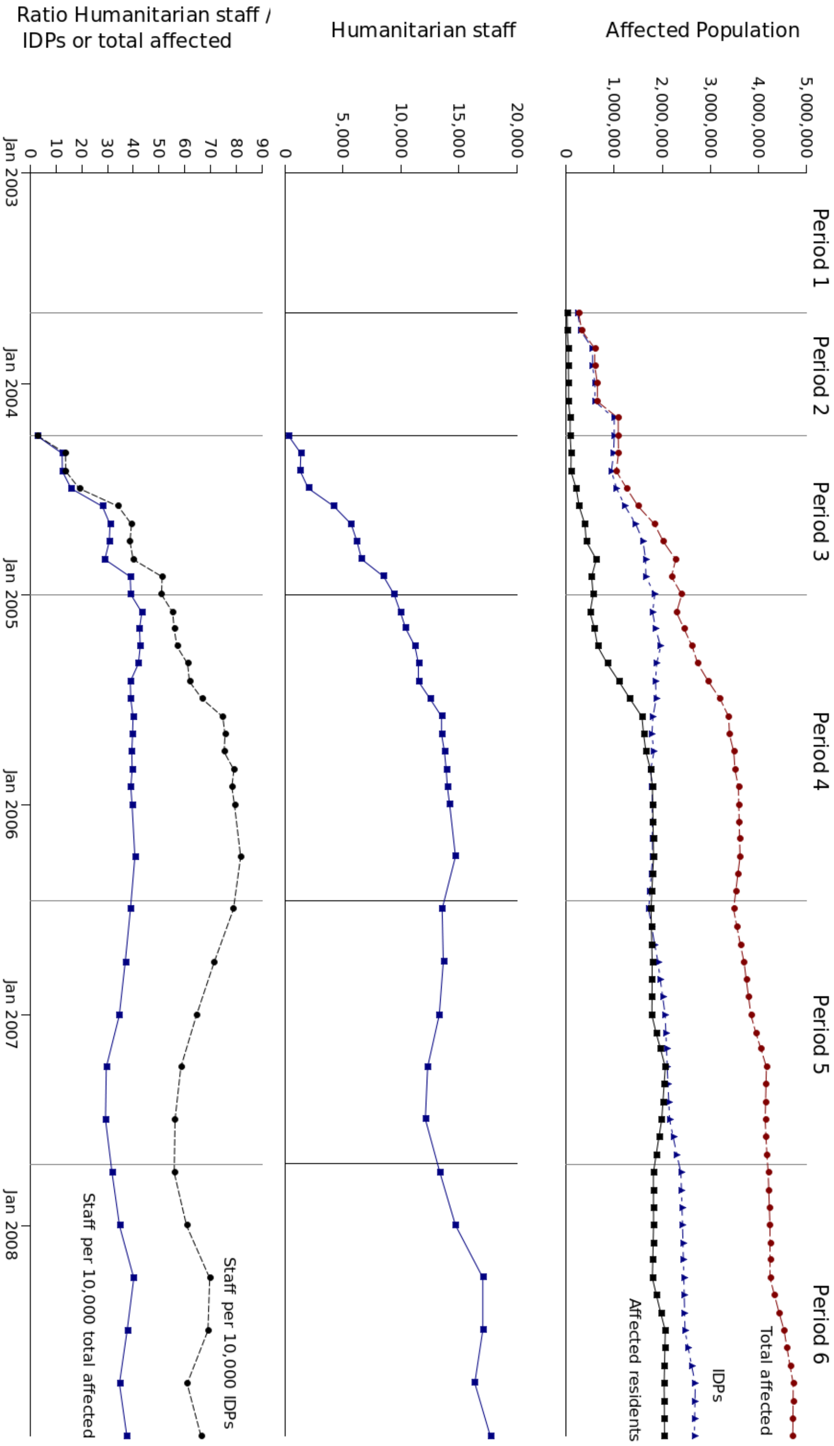


Figure 3.1: Six periods of the conflict in Darfur and trends in affected populations and humanitarian staff.

Period 2 - September 2003 to March 2004 This period is generally considered to have been the most violent of the entire conflict [35]. During these months, major counter-offensives were conducted by the government together with the Janjaweed. By March 2004, the number of displaced exceeded one million [84]. Similarly, the refugee load in Chad increased during that period from 65,000 to around 110,000 [51]. However, humanitarian assistance was still extremely limited [84].

Period 3 - April to December 2004 April 2004 marks the beginning of a large humanitarian deployment. Over the course of the nine months from April to December 2004, the number of humanitarians present in Darfur increased from 200 to 8,500. As fighting still prevailed in most of the region, often in combination with food insecurity, the number of displaced also raised from 1 million to 1,659,000 during the same period. This means that the number of humanitarians for every 10,000 displaced increased from 2 in April to 51 in December 2004

Period 4 - January 2005 to June 2006 After 2004, displacement figures stabilized between 1,750,000 and 2 million, but the number of affected non-displaced residents increased sharply from 500,000 in January 2005 to 1.8 million twelve months later. As a consequence, the share of IDPs in the total affected population decreased from 75% at the beginning of 2005 to 50% by the end of the year. Humanitarian staff continued to increase, resulting in a humanitarian-displaced ratio reaching as high as 80 per 10,000. The number of humanitarians per total affected population however remained constant around 40 per 10,000 during this entire period.

Period 5 - July 2006 to September 2007 From mid 2006 onwards and following the May 2006 Darfur Peace Agreement, the conflict was characterized by a new wave of displacement, primarily due to intensified fighting in South Darfur. Between July 2006 and October 2007, the number of IDPs in South Darfur raised from 734,000 to 1,172,000, a 60% increase. At the same time, persisting insecurity as well as funding shortages lead to a decrease in humanitarian presence dropping from almost 15,000 in July 2006 to 12,000 in July 2007. The ratio humanitarian staff to displaced fell from around 80 per 10,000 to

56 per 10,000 by mid 2007 .

Period 6 - October 2007 to December 2008 By late 2007, the number of aid workers increased again for the first time since April 2006. At the same time, the number of displaced continued to raise by some 25,000 new IDPs per month, mainly in South Darfur. The ratio humanitarian staff to displaced increased slightly and remained above 60 per 10,000 during the entire period.

3.3 Estimates of conflict deaths conducted prior to May 2005

3.3.1 Non-Governmental Organizations

In the first months following the exacerbation of violence and insecurity in Darfur in 2003, several documents, mainly from Amnesty International, reported that hundreds of civilians - mostly the Fur, Masalit and Zaghawa, the same ethnic groups that constituted the Sudan Liberation Army - were being killed [5, 4, 6]. These reports however, were of an anecdotal nature and meant for advocacy purposes. Only little comprehensive information on the magnitude and patterns of mortality was available.

Towards the second half of 2003, humanitarian NGOs like Médecins Sans Frontières (MSF) started warning against the risk of infectious diseases in some refugee settings in Chad. At that point, violence related wounds were only a marginal problem which was overshadowed by the alarmingly high levels of malnutrition among children. Still, little international attention was given to the unfolding crisis.

It was again MSF that provided, as one of the first organizations, more reliable and scientifically sound mortality figures. In April-May 2004, the NGO conducted, in collaboration with its sister-organization Epicentre , two mortality surveys in the IDP camps of Zalingei and Murnei [30]. The results showed mortality rates that were two to three times higher than emergency thresholds, with up to seventy-five percent of the deaths attributable to violence. These high rates suggested that five percent of the surveyed population had died in the preceding six months. In addition, over twenty percent of the children under five that were still alive were severely malnourished. Although these surveys provided a reliable picture of the situation of the IDPs in Zalingei and Murnei, the results could not be extrapolated to other IDPs in Darfur.

3.3.2 United Nations agencies

During the summer of 2004, the World Health Organization (WHO) conducted a region-wide mortality survey covering all IDP populations in Darfur [106]. Due to security problems, the sample for South Darfur had to be limited to Kalma camp, which hosted at that time around 70,000 of the more than 500,000 displaced in that state. The survey reported mortality rates that were in line with the MSF findings from some months earlier, but a major difference was the distribution of the causes of death. While the MSF survey reported half or more of the deaths attributable to violence, the WHO survey reported twenty-one and twelve percent violent deaths in North and West Darfur respectively, thus suggesting that by mid 2004, diseases had replaced violence as the main cause of death. On September 14^{th}, a WHO statement declared that up to 10,000 people were dying every month in Darfur mainly from diseases and malnutrition; a month later, David Nabarro, head of WHO's department Health Action in Crisis, stated that 70,000 people had died in the conflict from March to October 2004.

Parallelly to the WHO survey, the World Food Program (WFP) and the US Centers for Disease Control and Prevention (CDC) conducted a similar survey across the three Darfur states [16]. Surprisingly, the results where inconsistent with the figures released by WHO one month earlier; mortality rates appeared not to exceed the emergency thresholds. Some differences in methodology between the two surveys could partially explain these seemingly contradicting results. While WHO only included displaced populations in its sample, the WFP/CDC sample also consisted of residents that where considered affected by the conflict [1]. It seems reasonable to assume that IDPs would have been worse off than the residents and thus focusing only on displaced would result in a higher estimate. However, although in

[1] Residents affected by the conflict where defined as those living in villages where the displaced exceeded the host population.

the WFP/CDC survey mortality among IDPs was almost twice as high as among residents (0.88 vs 0.46 /10,000/day), it was still substantially lower than the figures published by WHO.

Another factor that might partially explain the differences between the two surveys is the recall period. WHO covered a period from June 15^{th} to August 15^{th}, while WFP/CDC included all deaths from February 10^{th} to September 12^{th}. In Darfur, the months from June to September are typically known as the hunger season, the period before the main harvest, when food stocks are running low. Since WHO's recall period lies entirely in that period, one could interpret their high mortality rates as an effect of this hunger season. WFP/CDC however focussed on a longer period, which means that high rates during the summer months could have been averaged out. This however would imply that mortality rates in the months preceding the hunger season were substantially lower. This seems unlikely since several other small-scale surveys conducted by NGOs throughout Darfur during those months, reported values that were well above the emergency threshold.

In its survey report, WFP/CDC mentions some limitations of the study which according to the authors *"are particularly relevant for mortality"*. Besides the recall period that we discussed above, they identify the extremely large and heterogeneous sampling frame, and inaccessible areas as potentially problematic. Although heterogeneity in a large sampling frame can result in large confidence intervals, it does not affect the accuracy of the results. In other words, the point estimate would not be affected by this factor. The inaccessible areas on the other hand, are very likely to affect the point estimate, as survey results can only be extrapolated to the areas that were included in the sampling frame. Since SLA-held areas as well as parts of North Darfur were not included in the WFP/CDC sample, the survey results are not valid for those areas. Similarly, the WHO survey did not include most of South Darfur. However, the decision was taken to drop the South Darfur stratum of the survey and to replace it by a survey covering only Kalma camp; a more appropriate approach.

3.3.3 High end mortality figures

The discrepancy between the WHO and the WFP/CDC surveys laid the basis for a fierce debate on the death toll of the Darfur conflict. Besides NGOs and UN agencies, scholars outside the humanitarian world started analyzing mortality figures to come up with their own estimates.

Eric Reeves

One of the first contributors to the Darfur death toll debate was Eric Reeves, a professor in English Language and Literature, with a special interest in Sudan. In July 2004, about four months before WHO's 70,000 deaths figure was released, Reeves published his first estimate which was based on two main sources: the MSF study in Murnei and a USAID projection of mortality rates in Darfur. He estimated the number of deaths from February 2003 to June 2004 at 120,000 [68].

However, I believe Reeves's calculation contains two major flaws. First, he assumed that mortality rates after February 2004 remained unchanged. The MSF survey however reported that crude mortality rates after February 1^{st} were approximately three times lower than the period before (1.7 vs 5.1/10,000/day respectively). Furthermore, the same MSF mortality rates were applied to the months preceding the start of the recall period, i.e. before September 2003. There is however no evidence that justifies the use of the same rate for that period. In fact, end 2003-beginning 2004 is generally considered to be the worst period of the conflict and as a consequence mortality rates for that period are likely to be the highest of the entire conflict. For these reasons, applying the crude mortality rates reported for September 2003-February 2004 to the total fifteen months from February 2003 to April 2004 should be considered invalid and is likely to result in an overestimation.

A second problem relates to the unconditional use of USAID projection data. In April 2004, USAID/OFDA predicted the evolution of mortality rates and malnutrition levels until the end of 2005. This prediction was computed based on two assumptions: 1) the government of Sudan would continue to block most Darfur relief deliveries, and 2) violence would not stop. However, subsequent data has shown that both assumptions were not valid. First, large humanitarian relief operations were set up throughout Darfur from April 2004 onwards (see 3). Second, as discussed above, the WHO mortality survey conducted during the summer of 2004, reported already a much lower rate of violence related mortality, suggesting that violence, although still present, had decreased. Therefore, the USAID projections should be considered to have been proven wrong and as a consequence, any analysis relying on them cannot be considered reliable.

Throughout the weeks following this first estimate, Reeves released several updates to the original figure, adapting it as other data sources became available.

The *Documenting Atrocities in Darfur* study

In July and August 2004, the US government commissioned a team of experts[2] to investigate the allegations of genocidal crimes committed in Darfur. For that purpose, a survey was carried out in refugee camps in eastern Chad, collecting testimonies from Darfuri refugees - mainly Zaghawa and Masalit - on the nature of violent events that had occurred in Darfur. Based on 1,136 interviews the researchers concluded that clear patterns of systematic attacks on villages from non-Arab tribes (Zaghawa, Masalit, Fur) including killings and rape, were identified. They noted however that although the results should be representative for the Darfurian refugees in Chad, they may not be representative for the IDPs that had remained in Darfur [94].

Although the data collected through this survey was not intended for mortality calculations and was not used in that way in the study report, it was the basis for a 2005 mortality analysis by Hagan, Rymond-Richmond and Parker in which the estimated number of deaths from February 2003 to April 2005 was 396,563. The authors calculated mortality rates for violent deaths and non-violent deaths separately. The former was based on the 1,136 interviews conducted among the refugees in Chad, the latter was the non-weighted average of the CMRs reported in the 2004 WHO mortality survey (see page 23). The aggregated

[2] The consortium, called the Atrocities Documentation Team, consisted of experts from the Coalition for International Justice (CIJ), the American Bar Association, the US Department of State and USAID.

CMR amounted to 3.343/10,000/day - sixty-four percent due to non-violent causes - and it was then extrapolated to an average affected population of 1.5 million, resulting in the final estimate of 396,563 [45].

The analysis however is subject to some limitations. First, the authors have aggregated two un related mortality rates under the assumptions that both measured different types of mortality: violence related from the first source and non-violence related from the second. While deaths reported in the Documenting Atrocities survey are in all probability indeed violence related, it is incorrect to state that the mortality figures of the WHO survey consist of non-violent deaths alone. While the majority of the deaths was indeed due to diseases, twelve to twenty-one percent was still due to violence. As a consequence, any aggregation of both rates should at least exclude the violent deaths of the WHO mortality rate that was used. However, since the share of violent deaths was quite small in the WHO survey, the true impact of this inaccuracy is limited: the non-violent mortality rate decreases from 2.138 to 1.8685/10,000/day.

Of bigger concern is the fact that the authors extrapolated mortality rates to a period of time and a geographical area that are not adequately covered by the data. The Documenting Atrocities survey investigated crimes committed between February 2003 and August 2004; the WHO survey covered deaths during the period June to August 2004. Any extrapolation of the results should therefore be limited to those periods. The authors however applied the mortality rates to a twenty-six month period ranging from February 2003 to April 2005. In addition, the results of the Documenting Atrocities survey that included only refugees in Chad were applied to IDPs in Darfur and the WHO survey that principally covered IDPs in North and West Darfur was also extrapolated to displaced in South Darfur and the refugees in Chad. These inferences can only be made if one assumes that there were no differences in mortality rates between the periods and areas covered by the two surveys and those not covered by the surveys. However, evidence suggests that this is an incorrect assumption.

For these reasons, I believe that the analysis by Hagan et al based on the Documenting Atrocities survey data, overestimated the true level of mortality, as it was doublecounting violence related deaths, and extrapolating the results beyond what was justifiable.

Jan Coebergh

In February 2005, Jan Coebergh, a Dutch neurologist who had worked in Darfur, provided three estimations of the conflict death toll [21]. A first figure estimates the excess number of deaths between February 2003 and December 2004 at 306,130, with 172,542 due to violence. The approach used to obtain this number is similar to that used by Hagan et al, but the period covered by this estimate is four months shorter. Coebergh however assumed a smaller average load of IDPs, resulting in less deaths due to diseases and malnutrition. Since this methodology is in line with Hagan's, my concerns about this estimate are the same.

Coebergh's second figure is based on Epicentre's surveys in IDP camps (see 3.3.1) and the WHO survey. The estimated death toll is 218,449, but the calculation used to obtain this number is utterly unclear. Finally, Coebergh also provides a third possible estimate based on a combination of UN data and the WHO survey data. Again, the description of the calculation is confusing, and as a consequence, I believe Coebergh's analysis is of questionable scientific quality.

3.3.4 Low end mortality figures

United States Department of State

In April 2005, the US Department of State published a brief in which they reported that a total of 98,000 to 181,000 people had died between March 2003 and January 2005, of which 63,000 to 146,000 were considered excess deaths [95]. This estimate, computed by the Department's Bureau of Intelligence and Research, was based on thirty epidemiological surveys triangulated with displacement trends and patterns of village destruction, which was obtained through satellite imagery of the villages in Darfur. For each month, a high and low crude mortality rate was calculated and these rates were subsequently applied to UN population figures, resulting in the total death tolls.

This estimate was heavily criticized as it contradicted the high end estimates that circulated at that time. A Washington Post editorial stated that

> "The Bush administration's challenge on Darfur is to persuade the world to wake up to the severity of the crisis. On his recent visit to Sudan, Deputy Secretary of State Robert B. Zoellick took a step in the opposite direction. He said that the State Department's estimate of deaths in Darfur was 60,000 to 160,000, a range that dramatically understates the true scale of the killing. If Mr. Zoellick wants to galvanize action on Darfur, he must take a fresh look at the numbers..." [101]

This statement is characteristic for the contention of many activist groups at that time, that publishing lower mortality numbers may compromise humanitarian action. It was the beginning of a polemic surrounding the exact death toll in Darfur. It is in that context that this study was initiated.

Chapter 4

Materials and methods

4.1 Scope of the analysis

Many of the analyses described in section 3.3 focused mainly on the number of deaths, and little on the causes or patterns. In several of these studies, a constant death rate was extrapolated to the entire duration of the conflict and affected population. With this approach, conflict related mortality was assumed to be constant with time, and geographically, which was not the case. Furthermore, the affected population varied with time.

From a public health perspective, however, the estimation of death tolls is of limited value since it provides little information on vulnerable groups, causes of death and mortality patterns. The objective of the following analysis is to fill this gap and to provide answers to the following four questions:

1. What were the temporal and geographical trends of mortality in Darfur?
2. What were the trends in causes of death, more specifically violence and diarrhea related deaths?
3. To what extent were children under 5 more vulnerable than the rest of the population?
4. Was there a difference in mortality pattern between displaced and non-displaced populations?

4.2 Material

This study is based on two main data sources. The first is a set of mortality surveys collected from the Complex Emergency Database (CE-DAT). It is the basis for the regression analysis performed in this study. The second data source I've used is the population data from the Darfur Humanitarian Profile (DHP) series. This allowed me to calculate absolute numbers of deaths.

This section consists of three parts. First, I will give a brief description of how mortality surveys are conducted. Then I will discuss the Complex Emergency Database project. Finally, I will address the Darfur Humanitarian Profile series.

4.2.1 Mortality surveys

The estimation of the death toll in armed conflicts is a very complex task because death records, if existing at all, are often incomplete. Therefore, epidemiologists typically rely on retrospective mortality surveys and statistical methods to estimate casualties.

Conducting surveys consists of identifying a representative subset of a population, obtaining data on that subset and analyzing this in order to reach conclusions that are valid for the entire population. It is a complex process and is prone to errors at different levels. Recently however, the development of a standardized survey methodology within the SMART initiative has greatly improved the quality of many surveys (see section 1 p. 4). The initiative's manual [74] provides a detailed explanation of the different steps that should be followed when organizing and implementing a survey. In addition, a free software (ENA[1]) has been developped which guides the surveyors through the entire process of sample size calculation, sampling and analysis. In the following paragraphs, I will summarize the mortality module of the SMART methodology.

The objective of a mortality survey is to assess the mortality in a population over a predetermined period of time called the "recall period". The choice of the length of the

[1] http://www.nutrisurvey.de/ena/ena.exe

recall period has important implications on the survey results. Too short recall periods bear the risk of capturing too few cases of decease. Indeed, the number of cases collected is related to the length of the recall period. However, too long recall periods also carry a certain risk. The collection of demographic data in mortality surveys is based on people's recollection of events in the past. The longer ago something happened, the less reliable the recollection may be. SMART recommends recall periods between three and six months. This being said, in specific cases of acute high levels of mortality, e.g. epidemics, a shorter recall period may be appropriate. Due to the high mortality rates in situations like these, we can still expect to collect enough cases of decease for periods less than three months.

Based on the level of mortality we expect to find, the precision we want and the length of the recall period, we can calculate an adequate sample size. We then need to choose a method to select this sample in a way that makes it representative of the total population. Statistically, the best method is the simple random methodology, in which the sample is drawn completely at random, out of a long list enumerating all individuals living in the population. Such a list, however, is often unavailable in conflict settings. For that reason, the design that is most widely used for mortality studies in complex emergencies is the cluster sampling method. It typically consists of two stages. First, a list of population statistics is generated. It can enumerate the population size of sectors, villages, cities or administrative units in the studied area. All these entities are then regrouped in distinct geographical areas, called clusters. Depending on the magnitude of the study these clusters can vary from a set of sectors to entire districts.

Next, a predetermined number of clusters is selected from the total list of clusters. This selection is done randomly, but proportionately to the population size. This means that a cluster with few people will have less chance to be selected than a cluster with many. The number of clusters to select can vary. It is typically at least 30, but the more there are, the higher the precision of the results.

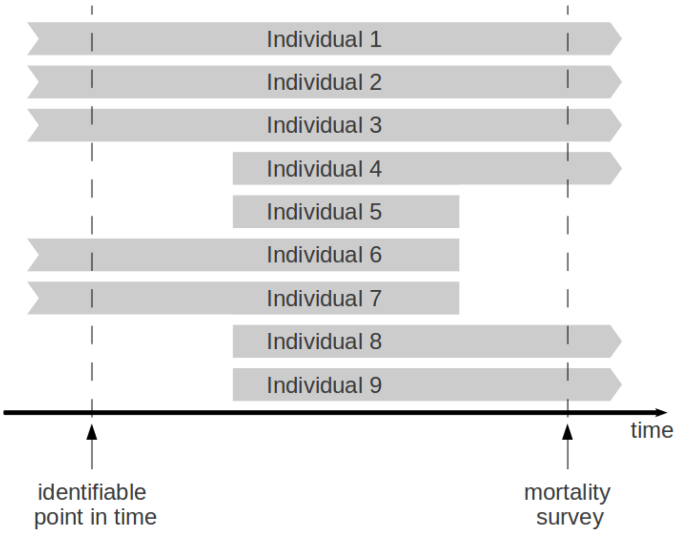
After identifying the clusters, the first household of each cluster is randomly chosen and the remainder will be selected by proximity, usually by picking the household closest to the one just surveyed. Surveyors repeat this procedure until the necessary number of households, typically thirty, has been collected. Using this method, one assumes that a representative sample of the total population is selected.

Subsequently, a household census is conducted by interviewing one person in each selected household about demographic changes in that household. Two lists are generated: one enumerating people living in the household at the time of the survey and another one with the people living there at a specific point in the past, typically three to six months before. Further inquiries are then made into the differences, categorizing these either as births or arrivals, or deaths or departures. For every death, a tentative cause of death is registered by means of verbal autopsy. This method consists of asking specific questions regarding the circumstances of the death, based on which the cause can be presumed. The reliability of this method is questionable for diseases, but the distinction between violence related and non-violence related causes is usually obvious. The whole procedure is repeated for every household. This way the surveyors obtain the number of deaths and the average population size.

Example *Figure 4.1 shows a hypothetical household included in a mortality survey. Six individuals are living in the household at the time of the survey (individuals 1-4, 8 and 9), while at a specific, predetermined point in time, the household consisted of only five people (individuals 1-3, 6 and 7). The average household size is thus 5.5.*

The household census shows that:

- *Individuals 1-3 are assumed to have lived in the household during the entire recall period.*
- *Individuals 4, 8 and 9 are living in the household at the time of the survey, but were not there at the time point in the past. Further inquiry reveals that individual 4 is a new birth while individuals 8 and 9 are new arrivals.*
- *Individuals 6 and 7 were living in the household in the past, but no longer at the time of the survey. Individual 6 has reportedly died and individual 7 left.*



N°	present at survey	present in past	birth/joined	died/left
1	YES	YES	-	-
2	YES	YES	-	-
3	YES	YES	-	-
4	YES	**NO**	birth	-
5	**NO**	**NO**	birth	died
6	**NO**	YES	-	died
7	**NO**	YES	-	left
8	YES	**NO**	joined	-
9	YES	**NO**	joined	-

Figure 4.1: Hypothetical enumeration of household members

- *Individual 5 was born after the reference point in time and died before the survey was conducted. As a result, he was not in the household at any of the two points in time, and will therefore not even be reported during the interview.*

We can thus conclude that during the recall period, there were two deaths in the household, on an average population of 5.5. Through verbal autopsy techniques, more details could be obtained on the causes of death.

Based on the number of deaths, the average population size and the recall period, epidemiologists calculate a mortality rate for the sample. This indicator represents the number of deaths per population unit per time unit. It is typically expressed as "number of deaths per 10,000 individuals per day". The probability that the obtained figure for the representative sample corresponds exactly to the figure of the entire population is small. Therefore, using statistical methods, one estimates the so-called 95% confidence interval, which is the range of values that has a 95% probability of containing the true rate of the entire population.

Typically, two different mortality indicators are calculated. The first one, called crude mortality rate (CMR), represents the mortality in all age groups. It takes all deaths into consideration and all individuals are included in calculations of the average population size. The second indicator, the under 5 mortality rate (U5MR), is an age-specific mortality rate. It is calculated using the number of children under five years of age who have died and the total number of children under five in the population for respectively the number of deaths and average population size.

4.2.2 Complex Emergency Database (CE-DAT)

The source for survey data that I've used in this research was the Complex Emergency Database (CE-DAT) [17]. This publicly available database contains statistics from over 2,500 health surveys conducted over the last ten years among conflict-affected populations in more than fifty countries. Although over twenty different indicators are included in the database, the five predominant ones are CMR, U5MR, global acute malnutrition (GAM), severe acute malnutrition (SAM) and the coverage of measles vaccination (MCV).

Data entered in CE-DAT is collected through randomized population-based field surveys, typically anthropometric surveys, retrospective mortality surveys or very often a combination of both. The rationale for conducting health assessments can vary: e.g. organizations may require baseline data prior to implementing a health program, intermediary data in order to redirect activities, or data collected after an intervention in order to evaluate its impact; in only very few cases, health surveys are conducted for research purposes. As a consequence, CE-DAT's main data providers do not have an academic or scholar profile, but are mainly NGOs and UN agencies. Since their main objectives are essentially of an operational nature, the assessments they conduct should not be seen as rigorous scientific studies. Nonetheless, the quality of these surveys has improved since the early nineties, to a large extent as a result of increased awareness of the importance of reliable data for evidence-based decision making [78]. In this context, projects such as SPHERE or the SMART initiative (see section 1 p. 4) have been of great value.

The CE-DAT team compiles survey data in two ways which we could label as direct and indirect. First, CE-DAT's data manager maintains direct contact with relevant staff of partner NGOs or UN agencies. In nine cases these contacts are formalized through a Memorandum of Understanding (MoU)[2] which stipulates that the partner organization will provide the CE-DAT project with the survey reports as soon as these have been validated. The majority of the surveys entered in the database are obtained through this channel. Secondly, the CE-DAT staff performs regular internet searches looking for new surveys that have been published online or that are mentioned on relevant webpages.

Survey reports that are made available to CE-DAT are assessed for their completeness and quality. For this purpose, a completeness checklist has been developed by the project's team in collaboration with a panel of expert epidemiologists (see Annex 5 p.129) [18]. This checklist comprises seventy items categorized in four sections (survey preparation, methods, results, discussion). These items are deemed essential in a survey report in order to be considered complete. In addition, every calculation given in the report is redone, and the sampling approach as well as the questionnaire are checked for their adequacy. Based on this completeness and quality assessment, the CE-DAT team decides then on whether a survey is considered acceptable or not to be entered in the database. If it is deemed not to meet the criteria, it can still be entered in the database, but will be labeled as *"pending"*, which makes it invisible to the public as long as the errors or gaps have not been resolved.

[2] MoUs have been signed with the following NGOs: Action Against Hunger-USA, Acción Contra el Hambre, Action Contre la Faim - France, Concern, Goal Ireland, International Rescue Committee, International Medical Corps, Merlin and Tearfund

Survey information extracted from the report and entered in CE-DAT includes the name of the organization in charge, the exact dates and location[3] of the study, the sampling design used, the population type and the different indicators available in the report. For each indicator, the exact definition and methodology are recorded as well as the point estimate, the 95% confidence interval and the sample size. As much as possible, fields in the database have been standardized in order to make comparison between different surveys possible.

Although CE-DAT is the largest publicly available source of health survey data of conflict-affected populations, it relies for 100% on other humanitarian organizations for data collection. As such, areas with limited humanitarian presence or access are likely to be underrepresented in the database, while surveys from countries with a large humanitarian deployment constitute an important share of the data. Concretely, the two countries with the most surveys included in CE-DAT, Sudan and the Democratic Republic of Congo, are the exact same countries as those who received the most humanitarian funding since 1998 [85]. The abundance of survey data available in CE-DAT for Sudan and in particular for Darfur, makes it a very suitable data source for the analysis of mortality in the Darfur conflict.

Surveys from Darfur available in CE-DAT

I queried the CE-DAT database in search of all surveys conducted across Darfur between 2003 and 2008 that included a mortality component. Overall, 106 surveys could be retrieved. While only five surveys were found for 2003, the first year of the conflict, the number of available surveys increased to reach a peak of forty surveys in 2005. After that, the level of surveying dropped rapidly, down to an average of thirteen surveys per year between 2006 and 2008.

Although the geographical distribution of the surveys is more or less equal across the three states, some geographical differences over time are found. North and West Darfur

[3] Geographic information is georeferenced up to the third administrative level using FAO's Global Administrative Unit Layers (GAUL) dataset.

each represented 40% of the surveys conducted during the period 2003-2005, whereas South Darfur was the area with most of the surveys (49%) for 2006-2008. This trend corresponds to the shift of the area with most affected people from North and West to South Darfur after 2005.

The proportion of IDPs in the sample was reported in 98 surveys. Of these, twenty surveys (20%) covered populations that consisted for more than eighty percent of non-displaced people. In comparison, forty-six surveys (47%) had samples consisting of more than 80% IDPs.

Finally, non-governmental organizations were involved in eighty-eight surveys (83%), UN agencies in twenty-three (22%) and the Sudanese government in twenty-one (20%).

State	2003	2004	2005	2006	2007	2008	Total
North Darfur	5	8	14	6	5	3	41
South Darfur	0	6	8	5	9	5	33
West Darfur	0	8	18	2	1	3	32
Total	5	22	40	13	15	11	106

Table 4.1: Distribution of surveys by year and state

State	Period 1 7 mths	Period 2 7 mths	Period 3 9 mths	Period 4 18 mths	Period 5 15 mths	Period 6 15 mths
North Darfur	4	7	10	15	7	5
South Darfur	0	0	8	10	11	6
West Darfur	0	5	14	16	2	3
Total	4	12	32	41	20	14

Table 4.2: Distribution of surveys by period and state

Note: One survey can be included in two succeeding periods if it covers months of both periods respectively. As such, the total of the table exceeds the number of surveys.

Eligibility of surveys

As described above, all surveys made available to the CE-DAT team undergo a thorough validation before being added to the database. Nonetheless, twenty-five of the 106 (23.6%)

identified surveys had to be excluded from the analysis as one or more of the explanatory variables used in the model were not reported. First, ten surveys did not provide adequately the number of days that was covered by the mortality estimate. For five surveys, a recall period was available, but instead of being reported in days, it was reported in months: twice 2 months, twice 3 months and once 4 months. I converted the number of months to days by multiplying it by 30.4, the average number of days per month. Although it might not correspond exactly to the number of days covered by the recall period, I consider it a satisfactory approximation for the purpose of this analysis. For the remaining five (4.7%), no recall period was provided at all and consequently, these surveys could not be used in the analysis.

A second required variable that was not reported in all surveys was the proportion of IDPs in the population. Eight (7.5%) surveys lacked this information and thus did not meet this eligibility criteria.

Finally, the models used in the analysis require death counts rather than death rates. These death counts were recalculated by multiplying the mortality rates by the number of people included in the survey and the number of days covered by the recall period. For U5MR, the number of people was further multiplied by the proportion of children in the population. For twenty-three (21.7%) surveys however either the exact number of individuals included in the survey or the number of children under the age of five were missing. As I was therefore unable to calculate the number of deaths, these surveys were excluded from the analysis.

Although the eighty-one retained surveys provided all information required to analyze CMRs, additional data on U5MR, violence related deaths and diarrhea related deaths was available in only sixty-four surveys. To proceed, I had the choice between two approaches. First, I could analyze each of the four indicators individually using all surveys in which the required data for that indicator is available. This means that for the analysis of CMR, U5MR, violence related deaths and diarrhea related deaths, indicator-specific datasets would be used consisting of 81, 78, 72 and 68 surveys respectively. Alternatively, I could

	Available	Missing
recall period	101	5
percentage of IDPs	98	8
individuals included in sample	83	23
all explanatory variables	81	25

	Available	Missing
CMR	81	25
U5MR	77	29
% violence related deaths	72	34
% diarrhea related deaths	68	38
all variables	64	42

Table 4.3: Availability of explanatory and dependent variables in the surveys (N=106)

opt for a conservative approach and use only those sixty-four surveys that provided all necessary data for the four indicators in a so-called basic dataset.

As the number of surveys included in the analysis is higher with the first approach, I expected these results to be more precise than with the basic dataset. Then again, the first approach might compromise a comparison across indicators as the analyzed datasets are inconsistent. I have therefore chosen to perform the analysis using both approaches and to discuss the differences if noteworthy.

4.2.3 Darfur Humanitarian Profile series (DHP)

The Darfur Humanitarian Profile is a report published by UN OCHA-Khartoum, which started off in April 2004. It provides on a monthly - since January 2006 quarterly - basis statistics on the number of displaced and affected people, the humanitarian coverage of their needs and the number of aid workers present in Darfur. Each issue consists of three documents: a narrative describing the major findings and trends over the most recent period, a set of tables with aggregated population figures and coverage data, and thirdly, a detailed list of each site where affected people have been reported.

The data collection procedure works as follows. At field-level, one-page forms are filled in for each site included in the report. This is done in collaboration with humanitarian agencies and the state authorities. Within each state, the individual forms are aggregated in an overview table, which is then forwarded to OCHA's country office in Khartoum. There, Darfur-wide tables are generated and the narrative document is compiled. In a next step, the draft results are shared for comments with all humanitarian agencies present in Khartoum, after which a revised version is made available online.

The data I have used in this analysis was obtained from the aggregated tables. I extracted the number of IDPs and affected residents[4] for each one of the three states separately, and compiled a dataset consisting of these monthly (or quarterly) population figures. Although I deemed the quality of these figures acceptable, there are still some limitations related to it (see section 6.1.1).

4.3 Methods

4.3.1 Poisson models

Although mortality rates can be considered continuous variables, they are basically a standardized representation of the number of deaths per time-unit and population-unit. As such, mortality data is in fact count data, characterized by the fact that it can only take a finite number of non-negative integer values from $\{0, 1, 2, \ldots, N\}$ with N the total size of the population. It is thus a discrete variable that should be analyzed using discrete probability distributions instead of continuous ones [41]. The most commonly used distribution for this type of event count data is the Poisson distribution.

[4]residents in towns hosting IDPs. The three state capitals are not included, since their population compared to the number of IDPs that they host is relatively large - they are thus generally not judged to be in need of emergency assistance.

Although the distribution was first described by Siméon-Denis Poisson in 1838, one of the best known examples of its use is given by Ladislaus Bortkiewicz in his work *"Das Gesetz der kleinen Zahlen"* published in 1898 [9]. Bortkiewicz showed how a Poisson distribution approximated very well the annual number of cavalrymen in the Prussian army that had died as a result of horse-kicks. The title of his treatise, translated to *"The Law of Small Numbers"*, summarizes in one sentence when Poisson distributions are particularly valuable, i.e. rare events [14].

Indeed, if we consider a binomial distribution represented by

$$B(N,n) = \frac{N!}{(N-n)!n!}p^n(1-p)^{N-n}$$

with n the number of successes, N the number of trials and p the probability of success, we can show that in the case of rare events, i.e. for small n's and large N's, the equation can be approximated by

$$B(N,n) \approx \frac{(Np)^n e^{-Np}}{n!}.$$

Replacing Np by λ gives

$$B(N,n) = \frac{(\lambda)^n e^{-\lambda}}{n!}.$$

or

$$Pois(\lambda) = \frac{(\lambda)^n e^{-\lambda}}{n!}.$$

which corresponds to the Poisson distribution. In this form, λ represents the expected number of successes or, translated to mortality data, λ is the number of expected deaths.

Poisson distributions are generalized linear models characterized by a unique parameter, λ, which corresponds to both the mean and the variance of the distribution. The probability function has an asymmetric shape and is, especially for small values of λ, skewed towards infinity (see Figure 4.2). The distribution has the advantages of requiring only one known parameter and of being easier to calculate than a binomial distribution. For these reasons, it is very suitable for the analysis of rare event count data [14].

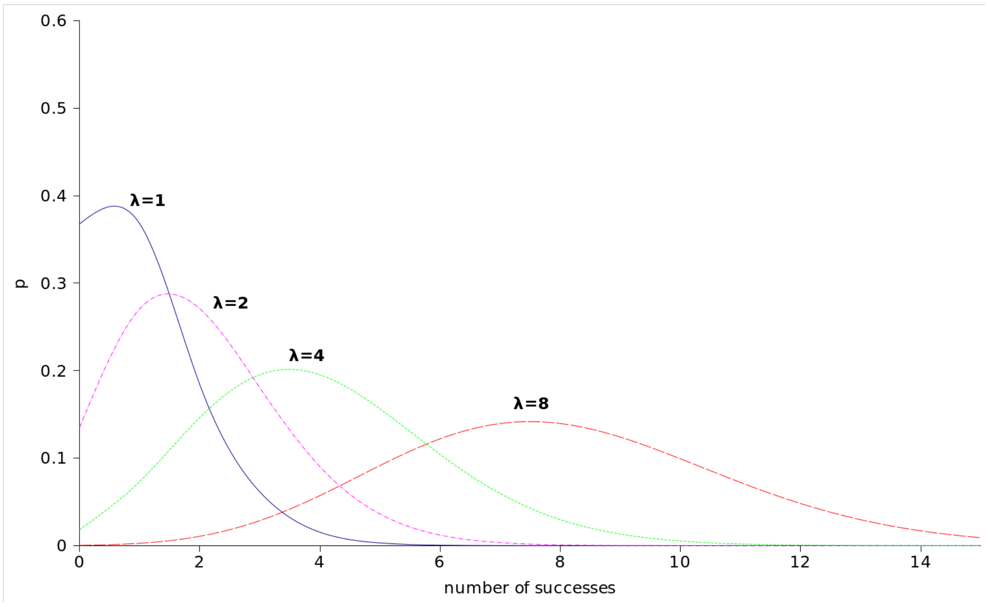


Figure 4.2: Probability function of a Poisson distribution for four values of λ

The distribution's simplicity however, is at the same time its major limitation. Indeed, the so-called Poisson nominal variance assumption, i.e. the requirement that mean and variance are equal, makes the distribution very restrictive. If this assumption is violated and the variance is smaller than the mean, the data is said to be underdispersed. For many biological phenomena however, the variance is larger than the mean and we refer to the data as overdispersed. This can be the case when events are not totally independent or occur in clusters. Analyzing this type of data with classic Poisson regression models leads to spuriously high levels of precision and significance, and is thus incorrect [108].

4.3.2 Variants of Poisson models that allow for overdispersion

To account for overdispersion of count data, two different approaches are commonly used. The first is the quasi-Poisson model and the second is the negative binomial distribution [97].

Quasi-Poisson models

Quasi-models are based on the quasi-likelihood method described by Wedderburn in 1974, and are included in the generalized linear models [102]. The fundamental idea behind these models is that a full knowledge of the probability distribution of the data is not necessary to estimate the model's parameters. We only need to know the relationship between the mean and the explanatory variables, also called the link function, as well as the relationship between the variance and the mean, called the variance function. Both Poisson and quasi-Poisson models have a log link function, which means that the dependent variable is converted to logarithms while the explanatory variables remain linear. The models' variance function is

$$V(\mu) = \phi \times \mu$$

with ϕ called the dispersion parameter. In the case of Poisson models, the value of ϕ is restricted to 1. For quasi-Poisson models, however, ϕ can take any strictly positive value, which allows for a varying variance.

Since the link function remains the same as that of the Poisson model, the estimated coefficients for the parameters included in a quasi-Poisson model will be the same as those of the corresponding Poisson model. The standard errors however will be inflated with a factor corresponding to $\sqrt{\phi}$, and as a consequence, p-values will change accordingly.

Negative binomial models

The second alternative for Poisson models when data is overdispersed, is the negative binomial model. Similarly to the Poisson and quasi-Poisson models, negative binomial models belong to the generalized linear models and, as such, are specified by a link and variance function [97, 102]. The link function of negative binomial models is the same as that of Poisson and quasi-Poisson models, namely the log link. The variance function however is defined as

$$V(\mu) = \mu + \frac{\mu^2}{\theta}$$

or

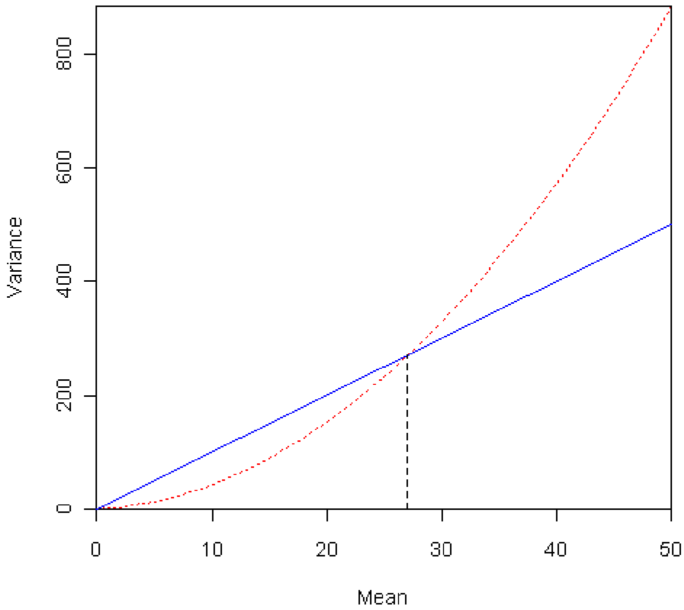
$$V(\mu) = \mu \times (1 + \frac{\mu}{\theta})$$

with θ, the shape parameter. Note that in the case of the negative binomial model, the variance function is quadratic in μ, as opposed to the quasi-Poisson model, where it is linear [97]. In other words, for small expected mean values, the variance based on a negative binomial model will be smaller than the variance based on a quasi-Poisson model, whereas the opposite is true for larger values (see figure 4.3(a)).

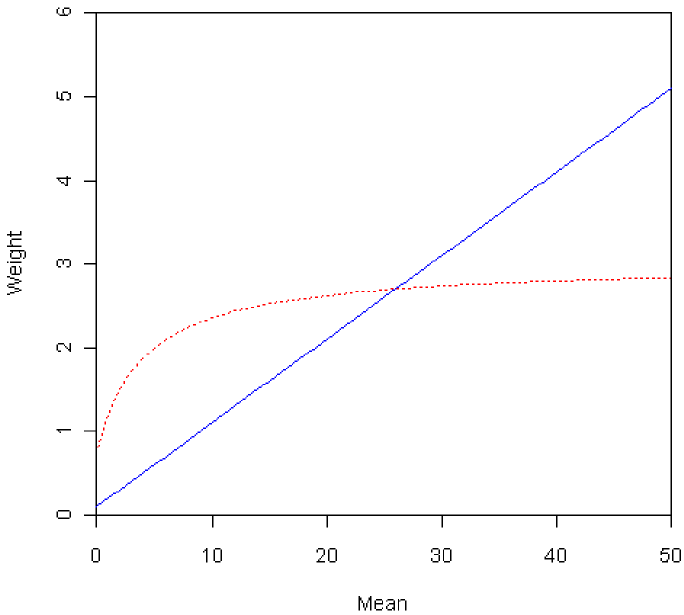
Difference between quasi-Poisson and negative binomial models

Besides affecting the standard errors of the estimated parameter coefficients, the difference between linear and quadratic variance function has some implications on the weights applied to each observation included in the analysis. Indeed, both the quasi-Poisson and the negative binomial models are estimated using iteratively weighted least squares. This means that an algorithm performs iterations, until the sum of the squared residuals has reached the smallest possible value. However, it is a weighted approach, which means that each observation is given a weight, in function of the reciprocal of the expected variance for that value ($\frac{1}{V(\mu)}$). As we can see in figure 4.3(b), for a same expected mean value, the weights calculated by the quasi-Poisson and negative binomial models differ. Indeed, weights based on a quasi-Poisson model increase arithmetically, whereas those based on a negative binomial model are asymptotic, converging to θ. As a consequence, quasi-Poisson models give less weight to small observations, but more to larger observations in comparison to negative binomial models [97].

The practical implication of this difference can be explained with the following example. We take the models used in figure 4.3, and assume two observations for which the explanatory variables (time, place, conditions, etc) have the same values; in the first observation we counted ten deaths and in the second, fifty. In a negative binomial model, the two observations will have rather similar weight, i.e. 2.3 and 2.8 respectively. In a quasi-Poisson model however, the weights will be considerably different, namely 1 and 5 respectively. In an analysis with a quasi-Poisson model, the larger observation will thus weigh five times more than the smaller observation, whereas in an analysis with a negative binomial model,



(a) Variance functions ($V(\mu)$)



(b) Weight functions ($W(\mu)$)

quasi-Poisson (solid blue): $V(\mu) = 10 \times \mu$, $W(\mu) = \frac{\mu}{10}$; negative binomial (dashed red): $V(\mu) = \mu + \frac{\mu^2}{3}$, $W(\mu) = \frac{\mu}{(1+\frac{\mu}{3})}$.

Figure 4.3: Variance and weight functions for quasi-Poisson and negative binomial models

it will only weight 1.2 times more.

This particularity does not mean that one model is better than the other though. If one is mainly interested in larger observations, then the quasi-Poisson model might be more appropriate as it gives those more weight. However, if one prefers less difference in weights, then the negative binomial model might be better [97].

4.3.3 Regression models

Dependent variable

The dependent variable of the models is the number of deaths reported during the survey and is defined as

$$n_i = r_i \times N_i \times t_i$$

with i the index of the survey, n the number of deaths, r the mortality rate, N the number of individuals and t the recall period of the survey. For crude and under five mortality, r equals CMR and U5MR; for violence and diarrhea related deaths, r was calculated as the product of CMR with respectively the percentage of deaths attributable to violence and to diarrhea. The number of individuals N corresponds to the total number of people who were living in the sampled households, either at the beginning or at the end of the recall period. For under five mortality however, N includes only children aged less than five. Finally, n was rounded to the nearest integer if necessary.

Independent variables

Time A set of five continuous variables $P_2 - P_6$, represents the temporal component of the model. The five variables correspond to the second up to sixth period described in section 3.2. No variable was computed for the first period, as it was not covered by any survey included in the analysis. The value for each P_i was calculated as the proportion of the recall period that lied within the time span of period i. For example, a survey with a ninety day recall period from 1^{st} November 2004 to 30^{th} January 2005 would have sixty-one and twenty-nine days of its recall period in respectively Period 3 and Period 4.

Therefore, the values for P_2, P_5 and P_6 would equal 0, whereas P_3 would be 0.68 and P_4 0.32.

Location Three dummy variables were introduced in the model as geographic covariates. ND, WD and SD stand for North, West and South Darfur respectively, and take the value 1 if the survey was conducted in areas located in the corresponding state.

Population status The model takes into account the type of population that was included in the survey. A continuous variable IDP, with values in $[0, 1]$, corresponds to the proportion of internally displaced in the sampled population, with 0 being a population of local residents only.

Interaction terms

Several interaction terms are introduced in the models. First, I considered an interaction between the location of the survey and the period within the conflict. This would account for differences in time trends across the three states. Second, an interaction between the location of the survey and the population status. This corresponds to differences between the states regarding the impact of displacement. Finally, interaction between the period of the survey and the population status relates to the changes over time as far as the displacement effect is concerned.

Offset term

An offset term differs from other covariates in that its coefficient is not estimated by the regression model, but instead, is considered to be 1. It is often used in regression models to standardize data from different sample sizes or unequal lengths of observation period.

In the case of mortality surveys, the number of deaths captured in a mortality survey is directly related to the length of the recall period and the number of people included in it. Provided that the mortality rates remain the same, doubling the recall period or the number of people included in the survey would result in a doubling of the expected number deaths. As these two components were indeed different across the surveys used in this analysis, an offset term needed to be introduced in the model to account for this effect. The term was defined as

$$ln(t_i \times N_i)$$

with t_i the recall period and N_i the number of people included in survey i.

4.3.4 Model selection

First, I investigated the data for overdispersion. This was done by building a full regression model, i.e. including all possible interaction terms, and assuming an ordinary Poisson distribution. The dispersion coefficient can then be approximated by dividing the residual deviance by its number of degrees of freedom. If this is larger than one, then the data is overdispersed, and analysis should be pursued with quasi-Poisson and/or negative binomial regression models [108]. This turned out to be the case for the four indicators.

Next, I proceeded by identifying the best fitted quasi-Poisson and negative binomial models. A commonly used technique for this purpose, is the approach based on Akaike's information criterion (AIC), which is defined as

$$AIC = -2ln(L) + 2k$$

with L the maximum likelihood of the model and k the number of parameters introduced in the model [2]. When comparing different models, the model having the lowest AIC is considered the best. The fundamental idea behind this approach is that a trade-off should be made between improving a model's maximum likelihood and increasing its complexity. As such, adding parameters in a model will typically increase its maximum likelihood, the $-2ln(L)$ term, but in AIC this addition is penalized with the $2k$ term. In other words, AIC identifies the model with maximum likelihood yet minimum parameters.

However, quasi-models such as quasi-Poisson, do not have a likelihood function, and as a consequence, an AIC value can not be calculated. Therefore, the best quasi-Poisson model was selected starting with the full model, and running an iterative procedure based on hypothesis testing. At each step, p-values were computed testing the hypothesis that the exclusion of a term, would alter the model significantly. The term with the highest p-value, greater then 0.05, was identified as the term to be dropped from the model. The procedure was stopped when a model was obtained for which the hypothesis test yielded only p-values smaller than 0.05 [108].

In the end, two models were selected: a best-fit quasi-Poisson model and a best-fit negative binomial model. These two models could be different, but this is not always the case.

4.3.5 Calculation of mortality rates

Mortality rates were calculated using the estimates of the best quasi-Poisson model, as well as those of the best model for the negative binomial distribution. For each one of the five periods included in the analysis, rates were computed by state and by population status. As such, period-specific mortality rates were available for six strata.

In a next step, average mortality rates for the entire Darfur region were estimated, considering the distribution of the affected population across the three states and the proportion of displaced. For this, data from the Darfur Humanitarian Profile series [84] was used to calculate values, which correspond to the proportion of the affected population living in West and South Darfur, as well as the proportion of IDPs in the total affected population. These values were calculated for each period separately, in order to account for changing trends throughout the conflict.

4.3.6 Estimation of total and excess number of deaths

By applying the obtained mortality rates to the number of people affected by the conflict, I estimated the total number of deaths that had occurred during the studied period. For the months from September 2003 to December 2005, monthly population data is available in the Darfur Humanitarian Profile. I simply added these reported figures to obtain cumulative numbers of person-months of exposure to the conflict. For the following three years however, DHP was only published on a quarterly basis. Therefore, I had to estimate the missing data by extrapolating numbers from the previous and the next quarters' reports.

Finally, I calculated the number of deaths in excess to what could be considered an expected death toll should the conflict not have occurred. For that purpose, I used two different baseline mortality rates. The first one is the commonly used baseline CMR for Sub-Saharan Africa, namely 0.44 deaths per 10,000 people per day. Its use has been disseminated through the SPHERE Project [77], but the value is based on UNICEF's State of the World's Children 2003 [88], which provided reference mortality rates for 2001. It is in other words, simply the level of mortality that was estimated for the Sub-Saharan Africa region in 2001, notwithstanding the fact that, at that moment, conflicts were ongoing on the African continent.

A second possible value for the baseline mortality comes from de Waal who conducted a mortality survey in Darfur after the 1984-85 famine. His study showed that, prior to the famine, mortality rates were approximately 0.3/10,000/day [26]. Although this figure predates the conflict by almost twenty years, the continuous hostilities during the decades following the famine, in conjunction with the poor development of the Darfur region during the 1990s, make me believe that this CMR can still be considered appropriate as baseline value. In fact, the World Bank used almost the exact same rate for Darfur (11-11.4/1,000/year, which equals 0.30-0.31/10,000/day), in a 2003 report on the reconstruction of Sudan [103].

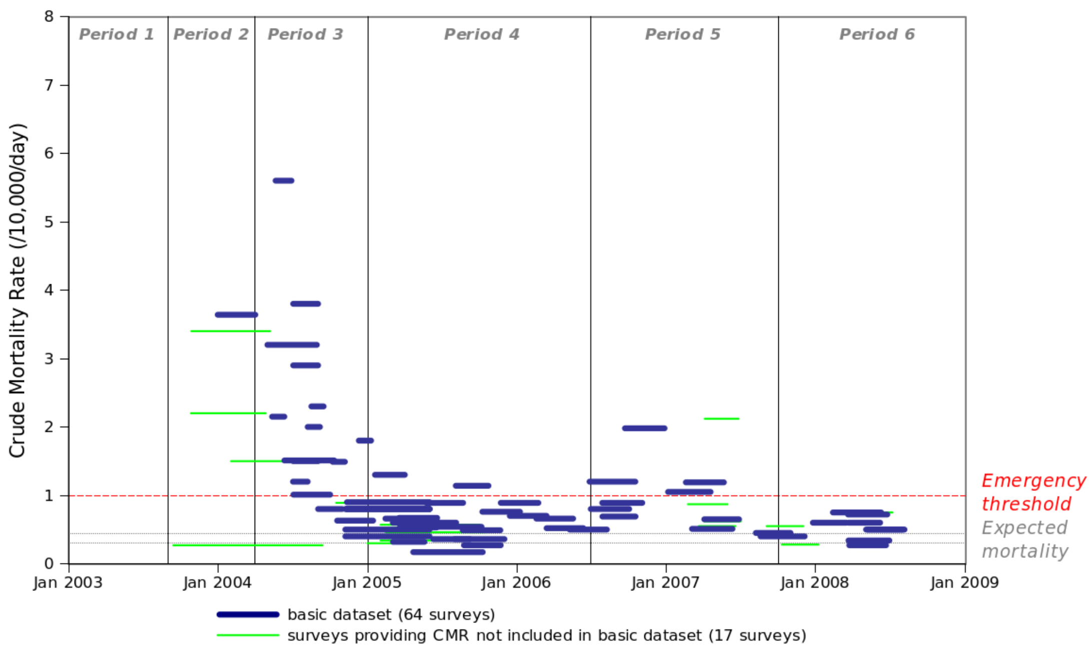
Chapter 5

Results

5.1 Descriptive analysis

As described in section 4.2.2, I have compiled two sets of surveys for the analysis of each mortality indicator. The first one, which I will refer to as basic dataset, consists of the sixty-four surveys for which all required information on the four indicators was available. It is thus a common dataset that can be used for the analysis of each of the four mortality rates. In addition, some surveys included information on one or more indicators, yet lacked data on at least one of them. They were therefore excluded from the basic dataset, but retained in larger, indicator-specific datasets.

Figure 5.1 shows a time trend of the CMRs included in the basic dataset (thick blue lines) as well as those excluded from the basic dataset but retained in the larger one (thin green lines). The main difference between the two datasets is the limited number of surveys during Period 2 in the basic dataset. In fact, the only survey in the basic dataset that covered a part of Period 2, was the survey reporting the highest CMR (3.64/10,000/day). In the extended dataset, which consists of eighty-one surveys, the three surveys that had more than 80% of their recall period lying in Period 2, had an average CMR of 3.1/10,000/day. This difference of 17% is likely to have some implications on the estimated mortality rates for that period (see below).

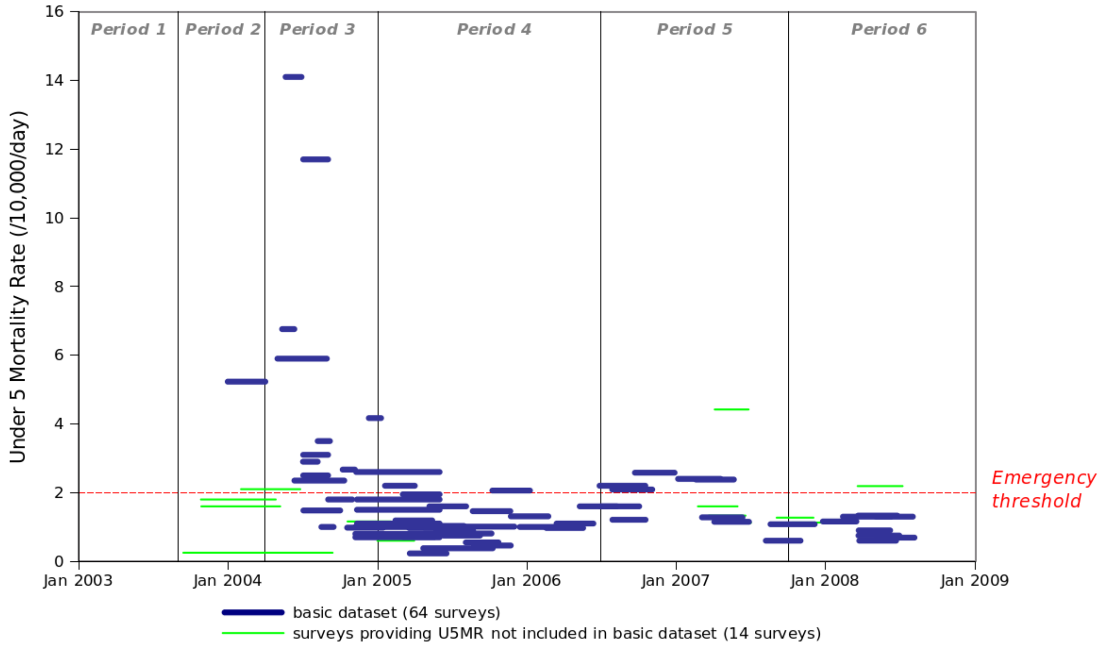


Note: The length of each line corresponds to the recall period covered by the survey.

Figure 5.1: Crude Mortality Rates as reported in 81 surveys

Visually, one notes a mortality peak during the second and the third period, yet decreasing towards the end of 2004. Of the eighteen surveys conducted during 2004, sixteen (89%) reported a CMR that exceeded the emergency threshold of 1/10,000/day. After 2004, CMRs remained mostly below the emergency threshold, although some increase can be noticed during Period 5, when five of the seventeen (29%) surveys had CMRs exceeding 1/10,000/day.

A more or less similar trend is seen for under 5 mortality rates (Figure 5.2), including the difference between the basic and extended datasets during Period 2. In the case of U5MR, this discrepancy is even more pronounced, with the only survey included in the basic dataset (5.2/10,000/day) being approximately twice as high as the mean U5MR for the three surveys lying mainly in Period 2 (2.9/10,000/day). The results for U5MR for that period using the basic dataset should therefore be considered cautiously.

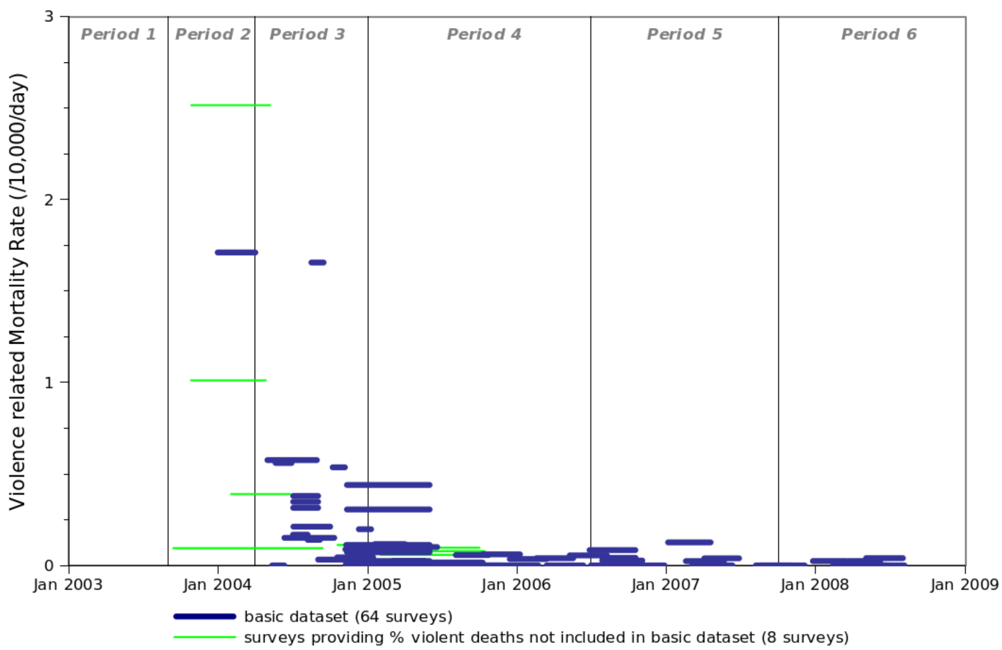


Note: The length of each line corresponds to the recall period covered by the survey.

Figure 5.2: Under 5 Mortality Rates as reported in 78 surveys

Although very high U5MRs can be seen during Periods 2 and 3, overall, the severity of child mortality for those periods is lower than what was the case for CMR. Indeed, twelve (67%) of the eighteen surveys conducted in 2004 reported U5MRs that were above the emergency threshold of 2/10,000/day, compared to the sixteen (89%) for CMR.

Figure 5.3 shows the trend for violence related mortality. A peak during Period 2 is noticeable, as well as a decrease throughout Period 3 and a steady state from 2005 onwards. Contrarily to CMR and U5MR, the rate reported in the only survey for Period 2 included in the basic dataset (1.7/10,000/day), was not the highest for that period in the extended dataset. Indeed, the average violence related mortality rate of the three surveys that had a recall period of 80% or more in Period 2, was precisely 1.7/10,000/day. Consequently, the results for Period 2 are not likely to differ greatly between the basic dataset and the dataset consisting of the seventy-two surveys reporting violent deaths.



Note: The length of each line corresponds to the recall period covered by the survey.

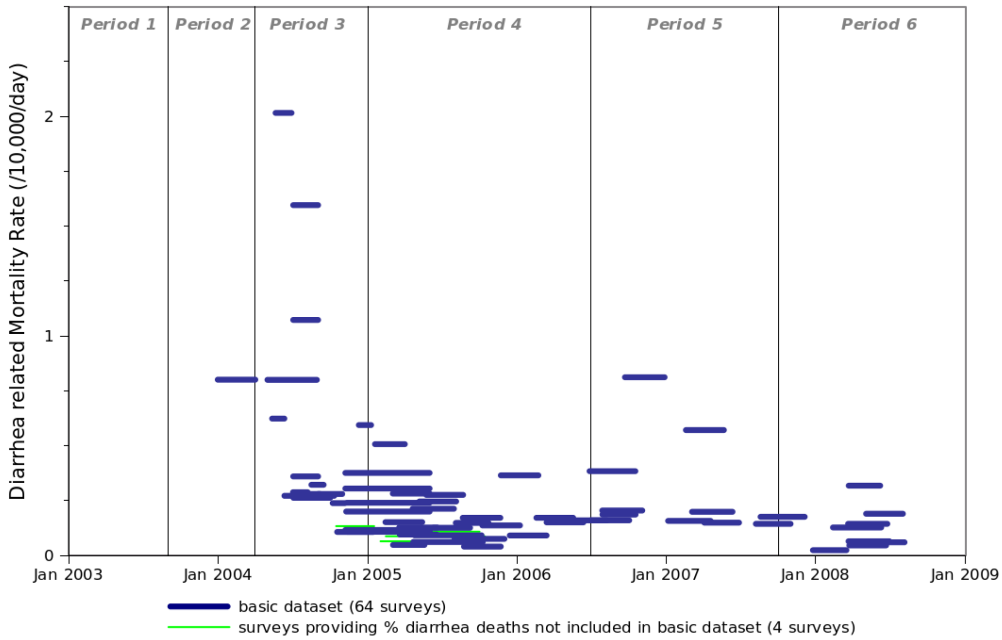
Figure 5.3: Violence related Mortality Rates as reported in 72 surveys

Finally, diarrhea related mortality rates (figure 5.4) were hardly available for Period 2. Since only one survey provided this data for that period, any extrapolation should be done with extreme caution.

Mortality attributable to diarrheal diseases peaked during Period 3, corresponding to mid 2004, with a maximum of 2/10,000/day. After this peak, most rates remained below 0.4/10,000/day, with the exception of 2 surveys during Period 5 that reported diarrhea related deaths reaching levels of 0.6 and 0.8/10,000/day .

5.2 Regression model

Four sets of covariates were build for each of the four indicators studied in this analysis (see section 4.3.4). The first (M_1) corresponds to a model with all covariates as well as all possible interaction terms. Depending on the dataset that was used, this model contains either nineteen or twenty terms (including the intercept). Model two (M_2) is a



Note: The length of each line corresponds to the recall period covered by the survey.

Figure 5.4: Diarrhea related Mortality Rates as reported in 68 surveys

basic restricted model comprising only covariates and consisting of eight terms. Finally, models three and four (M_3, M_4) are models selected based on their best fit. M_3 is the model with the best fit for a quasi-Poisson distribution; M_4 had the lowest AIC value for negative binomial models. The comparison of the different models was first done using the basic dataset of 64 surveys that reported all four studied indicators. In a second stage, the analysis was repeated using the extended, indicator-specific datasets.

5.2.1 Crude mortality rate

Analysis of basic dataset

First, I built a regression model considering a normal Poisson distribution. This resulted in a residual deviance of 271.33 on 45 degrees of freedom, which means that the dispersion parameter, ϕ, is estimated at 6.0. Consequently, I decided to discard pure Poisson models, and to pursue the analysis with quasi-Poisson and negative binomial models.

		Parameters	df	Log Likelihood	AIC
Basic dataset					
	Model 1 (M_1)	19	20	-249.481	538.962
	Model 2 (M_2)	8	9	-264.919	547.837
	Model 3 (M_3)	14	15	-250.395	530.791
Extended dataset					
	Model 1 (M_1)	20	21	-331.971	705.944
	Model 2 (M_2)	8	9	-344.479	706.957
	Model 4 (M_4)	14	15	-332.970	695.941

Likelihood-ratio Test (LRT)

		d	df	p-value
Basic dataset				
	M_1 vs. M_2	30.8756	11	0.001
	M_1 vs. M_3	1.8291	5	0.8723
Extended dataset				
	M_1 vs. M_2	25.0137	12	0.0148
	M_1 vs. M_4	1.9971	6	0.9200
	M_2 vs. M_4	-23.0166	6	0.0008

Table 5.1: Goodness-of-fit of negative binomial regression models for CMR

Using the approach described in section 4.3.4, I identified the best-fitted quasi-Poisson model which consists of the seven main covariates, as well as six interaction terms, ie. WD×Period3, WD×Period5, SD×Period4, IDP×Period3, IDP×Period5 and WD×IDP. It turned out that this model was also the best fit for a negative binomial distribution. Table 5.1 summarizes the goodness-of-fit of the different negative binomial models. Comparing models 1 and 2, we see that the LL for the model with interaction terms, M_1, is higher than that for the basic model, M_2. This means that including interaction terms fits the data better than leaving them out. Furthermore, although M_1 has the highest LL of the three models, the difference with M_3 (or M_4) is small, and this small difference does not justify the higher complexity of M_1. As a result, M_1's AIC value is greater than that of M_3, and I thus decided to reject the former in favor of the latter.

Table 5.2 shows the regression coefficients and their standard errors. Although the results across the quasi-Poisson and the negative binomial models are in general comparable, some differences can be seen. First, standard errors are almost consistently larger in the quasi-Poisson models than in the negative binomial ones. As a consequence, parameters for the latter have a higher level of significance than those for the former. Second, the largest difference in coefficients between the quasi-Poisson and negative binomial models is found for the terms Period3 and IDP×Period3 (0.358 and −0.386). Hence, the negative binomial model estimates lower mortality rates for residents during Period 3 than the quasi-Poisson model, but on the other hand it assumes a bigger difference in rates between IDPs and residents.

Both models show negative coefficients for WD, although in three cases, this effect is modified by interaction terms. In other words, the models suggest that surveys in West Darfur reported lower mortality rates than North Darfur, except those conducted among displaced populations, for which no difference with North Darfur was found, and surveys done during Periods 3 and 5, when mortality rates in West Darfur are estimated to have been higher than North Darfur.

The coefficient for the SD term, on the other hand, is positive, implying higher rates in South Darfur in comparison to the other states. Similarly to WD however, the model contains an interaction term SD×Period4, that cancels out the effect of SD in Period 4. Mortality rates were thus generally higher in South Darfur than in North Darfur, except during Period 4.

Coefficients for the IDP term were negative and comparable across the models. One exception however, is the previously discussed difference in the IDP×Period3 interaction term between quasi-Poisson and negative binomial models. Overall, both models indicate lower mortality rates for surveys conducted among displaced people in comparison to surveys among affected residents. Exceptions however are West Darfur, where no difference between the two population types was found, and periods 3 and 5, when mortality was higher among IDPs.

	Basic dataset (N=64)		Extended dataset (N=81)	
	quasi-Poisson	neg. binom.	quasi-Poisson	neg. binom.
	(M_3)	(M_4)	(M_3)	(M_4)
(Intercept)	-9.816	-9.782	-9.889	-10.030
	(0.269)	(0.212)	(0.317)	(0.212)
WD†	-0.672	-0.549	-0.482	-0.170
	(0.253)	(0.211)	(0.308)	(0.153)
SD†	0.740	0.691	0.669	0.647
	(0.139)	(0.121)	(0.162)	(0.136)
IDP	-0.466	-0.456	-0.402	-0.207
	(0.231)	(0.196)	(0.290)	(0.196)
Period2‡	2.426	2.358	0.065	-0.735
	(0.313)	(0.346)	(0.953)	(1.084)
Period3‡	0.304	-0.054	0.418	-0.037
	(0.432)	(0.393)	(0.513)	(0.426)
Period4‡	0.490	0.441	0.345	0.453
	(0.221)	(0.160)	(0.247)	(0.174)
Period5‡	-0.351	-0.367	-0.240	-0.109
	(0.389)	(0.341)	(0.448)	(0.345)
WD:Period3	0.836	0.816		0.623
	(0.305)	(0.282)		(0.286)
WD:Period5	1.372	1.243	1.133	0.919
	(0.520)	(0.444)	(0.630)	(0.485)
SD:Period4	-0.815	-0.703	-0.662	-0.670
	(0.263)	(0.211)	(0.288)	(0.231)
IDP:Period2			2.012	3.351
			(1.023)	(1.241)
IDP:Period3	1.140	1.526	1.134	1.589
	(0.458)	(0.423)	(0.566)	(0.460)
IDP:Period5	1.052	1.048	0.947	0.753
	(0.407)	(0.380)	(0.477)	(0.386)
WD:IDP	0.664	0.534	0.796	
	(0.350)	(0.305)	(0.396)	
logLik	-	-134.206	-	-167.234
AIC	-	290.413	-	356.468
ϕ	5.719	-	9.162	-
θ	-	13.009	-	8.153

ϕ = dispersion parameter

†: reference is North Darfur; ‡: reference is Period 6

Note: LL or AIC cannot be calculated for quasi-Poisson models.

Table 5.2: Coefficients for M_3 and M_4 for CMR

Coefficients for Period2 were almost identical in both models, and highly positive. For Period3 however, the results are inconsistent, which I already pointed out. Furthermore, two interaction terms must be taken into account. Indeed, WD×Period3 and IDP×Period3 greatly increase the effect, due to their large coefficients. We further note positive values with small standard errors for Period4, yet the interaction term SD×Period4 is highly negative. In other words, the model estimates for Period 4 a slightly higher mortality in North and West Darfur in comparison to Period 6, yet a lower mortality in South Darfur. Finally, Period5 coefficients have large standard errors and as such a low degree of significance. Then again, the interaction terms WD×Period5 and IDP×Period5 have high, significant values, which means that, while no difference was found between Period 5 and 6 among affected residents in North and South Darfur, for the IDPs and people in West Darfur mortality was higher during Period 5 in comparison to the last period.

Comparison between basic (N=64) and extended dataset (N=81)

The seventeen surveys that were included in the extended dataset but not in the basic dataset, were excluded from the latter because they were missing information on under five mortality, violence related mortality or diarrhea related mortality; the exclusion was thus not done based on quality related criteria. Therefore, the extended dataset should not be regarded as being of a lesser quality, but on the contrary, as a more complete compilation of surveys reporting CMR data.

A similar approach as outlined above was used to analyze the extended dataset. The quasi-Poisson model that fits the data best, consists of almost the same terms as the model that was developed for the basic dataset. The only difference is that the WD×Period3 term was dropped and replaced by the interaction term IDP×Period2. Similarly, the negative binomial model introduced the term IDP×Period2 too, but it dropped WD×IDP. The statistics of the selection process for the best-fitted negative binomial model are given in table 5.1. The model with interaction terms (M_1) was preferred above the basic model with only main covariates (M_2) as the LRT resulted in a small $p-$value, and the AIC value for M_1 was lower than that for M_2. However, the AIC value for M_4 was even lower than that for M_1, and thus M_4 was selected as best negative binomial model.

Overall, the coefficient estimates are comparable to those obtained using the basic dataset. One important difference however, is the introduction of the IDP×Period2 interaction term in the models based on the eighty-four surveys. This is a consequence of the fact that five surveys, which cover parts of Period 2, are included in the extended dataset, as opposed to only one in the basic set. These five have different proportions of displaced in the sample and thus, a more refined disaggregation between the two population types for that period is possible. As a result, coefficients for the Period2 term are much lower in the extended dataset models, but large values for the interaction term IDP×Period2 modify that effect in the case of displaced populations. Hence, predictions for IDPs will be comparable between basic and extended dataset models, but as far as residents are concerned, values will be lower and more reliable in the extended dataset's results.

Calculation of predicted crude mortality rates

Based on the regression coefficients of the models 3 and 4 described in the previous sections, I calculated predicted CMRs with their 95% confidence interval for periods 2 to 5, disaggregated by state and population type. This resulted in a set of thirty rates for each model used. Furthermore, predicted values were calculated using both the basic and the extended dataset (see Table 5.3).

The four series of CMRs show few, yet important differences across the models and datasets. Most obvious is the discrepancy between the basic and extended dataset, with regards to affected residents in Period 2. The results based on the basic dataset show high mortality rates for that group and period, even exceeding, in South and North Darfur, the values for IDPs during the corresponding period. Using the extended dataset however, values that are twenty to thirty times lower were obtained. While the former values are above the emergency threshold, the latter ones are almost all below. This inconsistency is due to the higher number of surveys covering Period 2 in the extended dataset, and the resulting introduction of the IDP×Period2 interaction term in models based on that

	Basic dataset (64 surveys)		Extended dataset (81 surveys)	
	$\text{Model}_{3,quasi-Poisson}$	$= \text{Model}_{4,NegBinom}$	$\text{Model}_{3,quasi-Poisson}$	$\text{Model}_{4,NegBinom}$
Residents in West Darfur				
Period 2	3.15 (1.74;5.73)	3.45 (1.72;6.93)	0.33 (0.06;1.83)	0.18 (0.02;1.44)
Period 3	0.87 (0.41;1.87)	0.70 (0.35;1.41)	0.48 (0.20;1.12)	0.67 (0.35;1.29)
Period 4	0.45 (0.30;0.69)	0.51 (0.37;0.70)	0.44 (0.26;0.75)	0.58 (0.44;0.78)
Period 5	0.77 (0.36;1.65)	0.78 (0.42;1.48)	0.77 (0.29;1.99)	0.84 (0.39;1.78)
Period 6	0.28 (0.16;0.49)	0.33 (0.22;0.49)	0.31 (0.16;0.62)	0.37 (0.24;0.57)
IDPs in West Darfur				
Period 2	3.84 (2.61;5.65)	3.73 (2.08;6.69)	3.71 (2.65;5.20)	4.13 (2.34;7.28)
Period 3	3.32 (2.46;4.48)	3.48 (2.39;5.07)	2.19 (1.57;3.06)	2.66 (1.77;4.00)
Period 4	0.55 (0.36;0.85)	0.55 (0.38;0.78)	0.66 (0.45;0.96)	0.47 (0.35;0.65)
Period 5	2.70 (0.88;8.31)	2.42 (0.89;6.53)	2.93 (0.76;11.22)	1.44 (0.56;3.68)
Period 6	0.34 (0.19;0.61)	0.35 (0.23;0.55)	0.46 (0.28;0.76)	0.30 (0.20;0.45)
Residents in South Darfur				
Period 2	12.94 (6.48;25.84)	11.91 (5.58;25.45)	1.06 (0.16;7.09)	0.40 (0.05;3.36)
Period 3	1.55 (0.79;3.03)	1.07 (0.54;2.11)	1.50 (0.66;3.43)	0.81 (0.41;1.62)
Period 4	0.83 (0.52;1.30)	0.87 (0.59;1.26)	0.72 (0.42;1.24)	0.68 (0.46;1.01)
Period 5	0.80 (0.48;1.36)	0.78 (0.48;1.26)	0.78 (0.43;1.42)	0.75 (0.45;1.25)
Period 6	1.14 (0.67;1.95)	1.13 (0.72;1.75)	0.99 (0.53;1.85)	0.84 (0.54;1.30)
IDPs in South Darfur				
Period 2	8.12 (4.48;14.74)	7.55 (3.81;14.97)	5.29 (3.02;9.26)	9.35 (4.72;18.53)
Period 3	3.04 (2.37;3.90)	3.11 (2.44;3.98)	3.13 (2.30;4.26)	3.23 (2.43;4.29)
Period 4	0.52 (0.35;0.76)	0.55 (0.41;0.74)	0.48 (0.31;0.76)	0.55 (0.40;0.76)
Period 5	1.45 (1.09;1.92)	1.41 (1.05;1.89)	1.34 (1.00;1.80)	1.30 (0.99;1.72)
Period 6	0.72 (0.52;1.00)	0.71 (0.55;0.93)	0.66 (0.46;0.96)	0.68 (0.52;0.90)
Residents in North Darfur				
Period 2	6.17 (3.33;11.44)	5.97 (2.93;12.16)	0.54 (0.08;3.49)	0.21 (0.03;1.73)
Period 3	0.74 (0.36;1.50)	0.54 (0.27;1.06)	0.77 (0.33;1.79)	0.42 (0.21;0.86)
Period 4	0.89 (0.61;1.29)	0.88 (0.64;1.21)	0.72 (0.47;1.09)	0.69 (0.50;0.95)
Period 5	0.38 (0.22;0.67)	0.39 (0.24;0.65)	0.40 (0.21;0.77)	0.39 (0.23;0.68)
Period 6	0.55 (0.32;0.92)	0.56 (0.37;0.86)	0.51 (0.27;0.94)	0.44 (0.29;0.67)
IDPs in North Darfur				
Period 2	3.87 (2.26;6.63)	3.79 (1.97;7.27)	2.71 (1.58;4.64)	4.89 (2.59;9.26)
Period 3	1.45 (1.11;1.90)	1.56 (1.23;1.98)	1.60 (1.17;2.19)	1.69 (1.29;2.22)
Period 4	0.56 (0.42;0.75)	0.56 (0.44;0.70)	0.48 (0.34;0.68)	0.56 (0.44;0.73)
Period 5	0.69 (0.49;0.97)	0.71 (0.52;0.96)	0.69 (0.47;1.01)	0.68 (0.49;0.94)
Period 6	0.34 (0.24;0.49)	0.36 (0.27;0.47)	0.34 (0.22;0.52)	0.36 (0.27;0.48)

Table 5.3: Predicted crude mortality rates by state and population status

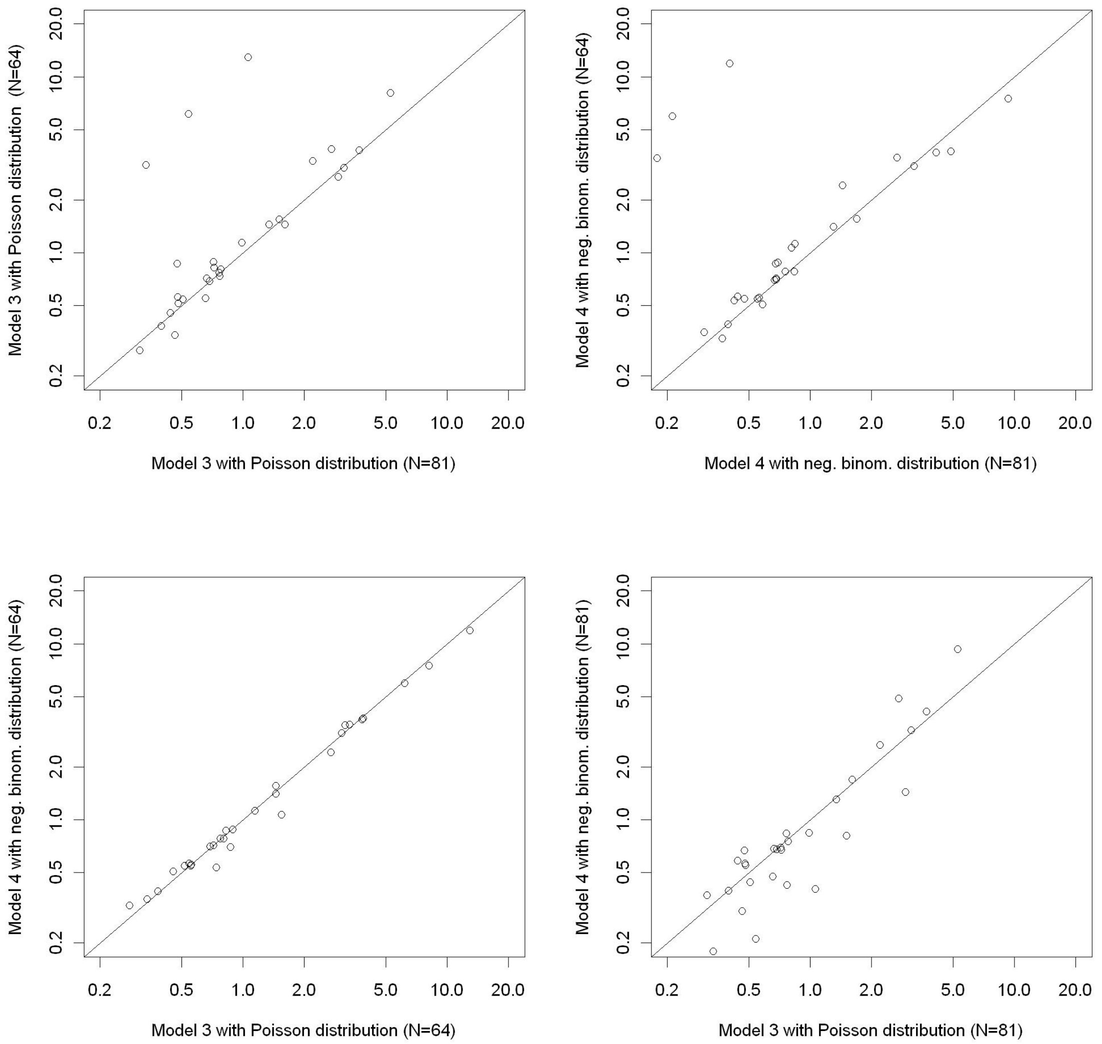
dataset. This term allows for a differentiated estimation of mortality for Period 2, i.e. one rate for residents, and a second one for IDPs.

This discrepancy between the datasets also appears in the top charts of Figure 5.5. In general, the charts, which represent the predicted mortality rates, show that most of the points lie along the first bisectrix ($y = x$), and thus the results are similar across models and datasets. However, in the top charts, there is an obvious deviation from this trend for the three points corresponding to the Period 2 mortality rates for residents in each of the three states.

I have described in section 5.1 how, for Period 2, the basic dataset differs from the extended one. I believe that the unique survey that was included in the basic dataset for that period, is not representative enough to allow for an extrapolation to all population types across Darfur. Hence, with regards to Period 2, the values obtained using the larger dataset are preferred above those using the more limited one, and I thus proceeded with the interpretation of the results using the extended dataset.

The bottom right chart of Figure 5.5 (models based on the extended dataset) shows several points for which the M_4 predictions are lower than those under M_3. These points correspond again to the three Period 2 mortality rates for residents, as well as CMR for IDPs in West Darfur during Period 5 (M_3: 2.93 vs M_4: 1.44) and for residents in South Darfur during Period 3 (M_3: 1.50 vs M_4: 0.81). Due to large standard errors however, none of these discrepancies shows p-values below 0.05.

For the Darfur region as a whole, predicted crude mortality rates are shown in Figure 5.6. The chart confirms the decreasing trend during Periods 2 and 3 that appeared in Figure 5.1, as well as the relative constancy during Periods 4 to 6. We further note the accordance between the two sets of estimations, i.e. between M_3 with a quasi-Poisson model and M_4 with a negative binomial one. Finally, most confidence intervals are small, with the exception however of those for Period 2. As I discussed above, the shortage of surveys covering that period resulted in large standard errors for the estimated coefficients,

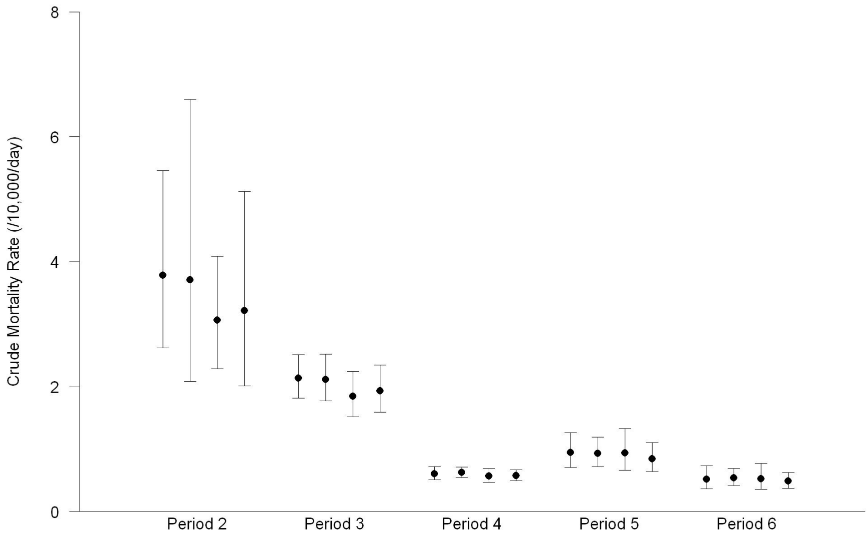


Note: the scale of the axes is logarithmic

Figure 5.5: Correlation between different models and datasets

and thus for the predicted mortality rates too.

Mortality rates during Periods 2 and 3 are several times higher than the emergency threshold of 1/10,000/day. This testifies to the severity of the crisis at that time. For the last three periods however, all point estimates are below that level. Nonetheless, both models report 95% confidence intervals for Period 5 that overlap with this threshold. This



Note: first bars correspond to quasi-Poisson model (basic), second bars to negative binomial model (basic), third bars correspond to quasi-Poisson model (extended), fourth bars to negative binomial model (extended).

Figure 5.6: Estimated crude mortality rates with 95% confidence intervals for the entire Darfur region

finding reflects a deterioration of the situation during that period.

In summary, notwithstanding a high degree of uncertainty for Period 2, a clear decrease in crude mortality rates during 2004 is apparent. After that, rates remained below the emergency threshold, although some worsening during 2006-2007 can not be excluded.

Application of the rates to the affected population

The mortality rates obtained in the previous section allow for the calculation of the total number of conflict affected people who have died in Darfur during the studied period. Due to the absence of survey data from South and North Darfur for Period2, I decided to base the estimation for that period only on the rates calculated for West Darfur.

Using the number of person-months of exposure to the conflict, I obtained period-specific death tolls presented in Table 5.4. The table also provides estimates for the number of excess deaths, assuming baseline mortality rates of 0.3 and 0.44/10,000/day.

	Model 3 (quasi-Poisson)		Model 4 (negative binomial)	
	CMR	95% confidence interval	CMR	95% confidence interval
Total deaths				
Basic dataset				
Period 2	47,864	33,152; 69,104	46,910	26,371; 83,446
Period 3	92,792	78,903; 109,125	91,837	76,921; 109,645
Period 4	105,697	88,956; 125,588	108,796	94,836; 124,810
Period 5	168,505	126,232; 224,935	165,325	128,871; 212,091
Period 6	104,762	73,955; 148,400	108,385	84,076; 139,724
Total	519,620	401,198; 677,152	521,253	411,075; 669,716
Extended dataset				
Period 2	38,718	28,969; 51,748	40,646	25,495; 64,802
Period 3	80,219	65,956; 97,565	84,077	69,217; 102,129
Period 4	98,899	81,240; 120,396	100,974	87,081; 117,084
Period 5	167,778	118,539; 237,470	149,854	114,113; 196,789
Period 6	105,472	71,630; 155,301	97,619	75,317; 126,524
Total	491,086	366,334; 662,480	473,170	371,223; 607,328
Excess deaths with baseline = 0.3/10,000/day (extended dataset)				
Period 2	34,922	25,173; 47,952	36,850	21,698; 61,006
Period 3	67,172	52,910; 84,519	71,031	56,170; 89,082
Period 4	46,412	28,753; 67,909	48,488	34,595; 64,597
Period 5	114,245	65,006; 183,937	96,321	60,581; 143,256
Period 6	44,983	11,142; 94,812	37,131	14,829; 66,036
Total	307,734	182,984; 479,129	289,821	187,873; 423,977
Excess deaths with baseline = 0.44/10,000/day (extended dataset)				
Period 2	33,151	23,402; 46,180	35,078	19,927; 59,234
Period 3	61,084	46,822; 78,430	64,943	50,082; 82,994
Period 4	21,918	4,259; 43,416	23,994	10,101; 40,103
Period 5	89,263	40,024; 158,955	71,339	35,599; 118,274
Period 6	16,755	-17,086; 66,584	8,903	-13,399; 37,808
Total	222,171	97,421; 393,565	204,257	102,310; 338,413

Table 5.4: Estimated death tolls among the conflict affected population

The results suggest that about half a million conflict affected people have died in Darfur between September 2003 and December 2008. Of these, two to three hundred thousand can be considered deaths that would not have occurred if the conflict had not erupted. Still, confidence intervals are large, which confirms the high level of uncertainty surrounding the death toll attributable to the conflict.

5.2.2 Under five mortality rate

Analysis of basic and extended dataset

Similarly to the CMR analysis, the results obtained for U5MR suggest that the data is overdispersed. Indeed, we see that the residual deviance for a model with all interaction terms and assuming a Poisson distribution, is 170.25 for 45 degrees of freedom. This means that the dispersion parameter is approximately 3.8, and as a consequence, the analysis must be done using quasi-Poisson or negative binomial models.

The quasi-Poisson model for which the best fit was obtained (M_3), consists of the seven main covariates and four interaction terms, i.e. WD×Period3, WD×Period5, SD×Period4 and IDP×Period3 (see table 5.5). Although the term IDP yields a high p-value, it was kept in the model since the IDP×Period3 interaction, on the other hand, has a small p-value. Similarly, Period3 remained in the model due to the high significance level of WD×Period3 and IDP×Period3.

As far as negative binomial models are concerned, I noted a much better likelihood for the full model in comparison to the model with no interaction terms (see table 5.6). Nonetheless its AIC value remains higher than that of a reduced model consisting of only five interaction terms. This best fitted negative binomial model (M_4) consists of almost the same terms as the quasi-Poisson model, except that WD×Period5 is replaced by WD×Period4 and SD×IDP is added. These differences are reflected in the estimation of the coefficients. First, the switch between WD×Period4 and WD×Period5 results in a more negative coefficient for WD in M_3 compared to M_4, and a more positive one for WD×Period3. Second, as M_3 does not contain the SD×IDP term, it yields a higher value for SD and a less negative coefficient for IDP. Finally, a considerable difference for the terms Period3 and IDP×Period3 is seen between the two.

	Basic dataset (N=64)		Extended dataset (N=78)	
	quasi-Poisson (M_3)	neg. binom. (M_4)	quasi-Poisson (M_3)	neg. binom. (M_4)
(Intercept)	-9.359	-9.198	-9.358	-9.227
	(0.299)	(0.258)	(0.336)	(0.254)
WD†	-0.708	-0.043	-0.655	-0.362
	(0.248)	(0.307)	(0.305)	(0.286)
SD†	0.676	0.110	0.673	0.584
	(0.174)	(0.308)	(0.210)	(0.166)
IDP	-0.185	-0.536	-0.104	-0.159
	(0.221)	(0.219)	(0.257)	(0.216)
Period2‡	2.658	2.095	1.427	1.875
	(0.427)	(0.440)	(0.477)	(0.401)
Period3‡	-0.054	-0.621	-0.295	-1.051
	(0.530)	(0.477)	(0.643)	(0.553)
Period4‡	0.587	0.690	0.491	0.395
	(0.277)	(0.234)	(0.321)	(0.224)
Period5‡	0.422	0.607	0.333	0.316
	(0.256)	(0.207)	(0.267)	(0.214)
WD:Period3	1.314	0.754	0.858	1.332
	(0.375)	(0.383)	(0.466)	(0.398)
WD:Period4		-0.819		
		(0.357)		
WD:Period5	1.189		1.216	0.889
	(0.515)		(0.640)	(0.542)
SD:Period4	-0.853	-0.820	-0.816	-0.759
	(0.328)	(0.274)	(0.403)	(0.303)
IDP:Period3	1.560	2.406	1.763	2.625
	(0.553)	(0.499)	(0.682)	(0.593)
SD:IDP		0.658		
		(0.328)		
WD:IDP				-0.675
				(0.426)
logLik	-	-198.476	-	-258.897
AIC	-	424.952	-	545.793
ϕ	5.719	-	9.162	-
θ	-	11.0531	-	6.1679

ϕ = dispersion parameter

†: reference is North Darfur; ‡: reference is Period 6

Note: LL or AIC cannot be calculated for quasi-Poisson models.

Table 5.5: Coefficients for M_3 and M_4 for U5MR

		Parameters	df	Log Likelihood	AIC
Basic dataset					
	Model 1 (M_1)	19	20	-197.431	434.862
	Model 2 (M_2)	8	9	-217.722	453.445
	Model 4 (M_4)	13	14	-198.476	424.952
Extended dataset					
	Model 1 (M_1)	20	21	-257.472	556.944
	Model 2 (M_2)	8	9	-272.676	563.353
	Model 4 (M_4)	13	14	-258.897	545.793

Likelihood-ratio Test (LRT)

		d	df	p-value
Basic dataset				
	M_1 vs. M_2	40.5829	11	<0.001
	M_1 vs. M_4	2.0908	6	0.9112
	M_2 vs. M_4	-38.4921	5	<0.001
Extended dataset				
	M_1 vs. M_2	30.4088	12	0.002
	M_1 vs. M_4	2.8491	7	0.8986
	M_2 vs. M_4	-27.5597	5	<0.001

Table 5.6: Goodness-of-fit of negative binomial regression models for U5MR

For the extended dataset, similar models were constructed. The best fitted quasi-Poisson model consisted of the same terms as the quasi-Poisson model for the basic dataset. The negative binomial model however, differs more from the one based on the sixty-four surveys, but it is more similar to the quasi-Poisson model than was the case for the basic dataset. As a consequence, few differences are seen between M_3 and M_4, with the exception of Period3 and its interaction terms.

Across the different models, the coefficients for WD are negative, suggesting lower mortality in West Darfur. However, considering interaction terms, I obtain for West Darfur positive values for Periods 3 and 5 (except in $M_{4,\, basic\, dataset}$), and negative values for Period 4. For SD on the other hand, values are positive, and have in general standard errors that are smaller than those for WD's coefficients. Two interaction terms modify this effect though. First, all models have large negative values for SD×Period4. This implies that, although rates in South Darfur were in general higher than in North Darfur, almost no difference between the two states was seen during period 4. However, the negative binomial model for the basic dataset suggests a slightly different interpretation, as the SD×IDP term must be considered too. According to that model, the higher rates in South Darfur were mainly among IDPs, while residents showed rates that were similar to those in North Darfur. During Period 4 however, this inter-state difference among IDPs disappeared, but then again, residents in South Darfur showed lower rates than those in North Darfur.

In three of the four models, the IDP term is slightly negative, but close to zero. Nevertheless, the interaction term IDP×Period3 changes this effect and results in a very high positive value, especially in the negative binomial models. The models thus suggest slightly lower rates among IDPs in comparison to affected residents, except during Period 3, when they were much higher than among residents. Note however, that due to the introduction of the SD×IDP term in $M_{4, basic\,dataset}$, the coefficient for IDP has become more negative. Consequently, the aforementioned interpretation is slightly changed, in the sense that the overall absence of a difference between the two population groups is only true for South Darfur. For the other states, under five mortality among IDPs was lower than among residents. The high mortality among IDPs during Period 3, however, remains present in this model too.

As far as the temporal aspect is concerned, all models report very high coefficients for the Period2 term, suggesting high child mortality during that period. However, in section 5.1 (page 54), I pointed out that the only survey for Period 2 included in the basic dataset, reported a U5MR that was about twice as high as the average of the three main surveys included in the extended dataset, that covered that period. Therefore, the coefficients for Period 2 using the extended dataset are considerably lower than those using the basic one. For the other periods, results are more consistent. In the case of Period 3, an additional distinction must be made between the quasi-Poisson and negative binomial models. While results show less negative values for Period3 in the quasi-Poisson model, the value for IDP×Period3 is equally smaller. This means that, although both models suggest rather similar results for displaced populations during Period 3, the negative binomial model implies lower values for the residents than the quasi-Poisson model. For Period 4, three of the four models suggest mortality in North and West Darfur was higher compared to South Darfur, but again the reults of $M_{4,\,basic\,dataset}$ are slightly different, as, according to this model, mortality in West Darfur was lower too. Finally, Period 5 is positive across the models, yet some difference is seen as three models include the interaction term WD×Period5.

Calculation of predicted crude mortality rates

Table 5.7 shows the predicted U5MRs with their 95% confidence interval for periods 2 to 5, disaggregated by state and population type. The most striking results are the very high rates for Period 2, especially in South Darfur. However, the estimation for Period 2 is based on the extrapolation from data originating from West Darfur only, and I therefore decided it is judicious to discard the predicted U5MR for North and South Darfur for Period 2 due to lack of data. Furthermore, as mentioned above, the unique survey included in the basic dataset that covers that period, is not representative for the other surveys from Period 2. Therefore, I believe the Period 2 estimates based in the basic dataset are overestimating the true under five mortality rate for that period.

Apart from that, rates for IDPs in South and North Darfur are consistent across the different models and datasets. For the displaced in South Darfur, I note high rates during Period 3, followed by lower rates during Period 4, an upsurge during Period 5, and again lower values for Period 6. As far as the IDPs in North Darfur are concerned, the results show a consistent decrease throughout the different periods.

The results for the affected residents in North and South Darfur, as well as the results for West Darfur, show more discrepancies across the different models and datasets. For West Darfur, the rate for residents for Period 2 is considerably higher in $M_{4,\,extended\,dataset}$ in comparison to $M_{3,\,extended\,dataset}$. This difference is not present among IDPs. For the other periods, U5MRs among residents are in general low, with the exception of Period

	Basic dataset (64 surveys)		Extended dataset (78 surveys)	
	$\text{Model}_{3,quasi-Poisson}$	$\text{Model}_{4,NegBinom}$	$\text{Model}_{3,quasi-Poisson}$	$\text{Model}_{4,NegBinom}$
Residents in West Darfur				
Period 2	6.06 (3.17;11.61)	7.88 (3.76;16.51)	1.87 (0.90;3.85)	4.47 (1.91;10.44)
Period 3	1.50 (0.59;3.80)	1.11 (0.48;2.56)	0.79 (0.27;2.33)	0.91 (0.39;2.13)
Period 4	0.76 (0.50;1.18)	0.85 (0.60;1.21)	0.73 (0.43;1.25)	1.02 (0.64;1.62)
Period 5	2.13 (0.96;4.73)	1.78 (1.03;3.08)	2.11 (0.78;5.73)	2.29 (0.93;5.61)
Period 6	0.42 (0.21;0.84)	0.97 (0.57;1.66)	0.45 (0.20;1.01)	0.68 (0.38;1.25)
IDPs in West Darfur				
Period 2	5.04 (2.84;8.94)	4.61 (2.35;9.05)	1.68 (0.93;3.05)	1.94 (1.12;3.38)
Period 3	5.93 (3.86;9.09)	7.19 (4.62;11.17)	4.14 (2.41;7.11)	5.44 (3.31;8.96)
Period 4	0.64 (0.40;1.00)	0.50 (0.34;0.73)	0.66 (0.38;1.15)	0.44 (0.25;0.77)
Period 5	1.77 (0.73;4.28)	1.04 (0.55;1.97)	1.90 (0.64;5.68)	0.99 (0.32;3.10)
Period 6	0.35 (0.19;0.67)	0.57 (0.31;1.03)	0.40 (0.19;0.86)	0.30 (0.15;0.58)
Residents in South Darfur				
Period 2	24.19 (9.63;60.77)	9.19 (3.36;25.16)	7.04 (2.44;20.30)	11.51 (4.82;27.44)
Period 3	1.61 (0.70;3.69)	0.61 (0.25;1.48)	1.26 (0.45;3.55)	0.62 (0.22;1.70)
Period 4	1.30 (0.77;2.21)	0.99 (0.59;1.68)	1.22 (0.64;2.34)	1.23 (0.74;2.03)
Period 5	2.58 (1.71;3.91)	2.07 (1.28;3.36)	2.36 (1.48;3.76)	2.42 (1.60;3.65)
Period 6	1.69 (0.96;3.00)	1.13 (0.62;2.07)	1.69 (0.90;3.17)	1.76 (1.06;2.93)
IDPs in South Darfur				
Period 2	20.11 (8.96;45.11)	10.39 (4.30;25.09)	6.35 (2.56;15.75)	9.82 (4.44;21.73)
Period 3	6.36 (4.69;8.61)	7.62 (5.66;10.25)	6.62 (4.57;9.60)	7.27 (5.13;10.29)
Period 4	1.08 (0.69;1.69)	1.12 (0.78;1.62)	1.10 (0.63;1.93)	1.05 (0.68;1.60)
Period 5	2.15 (1.55;2.98)	2.34 (1.73;3.18)	2.13 (1.53;2.96)	2.06 (1.54;2.76)
Period 6	1.41 (0.94;2.11)	1.28 (0.92;1.77)	1.52 (0.99;2.34)	1.51 (1.07;2.11)
Residents in North Darfur				
Period 2	12.3 (5.28;28.69)	8.23 (2.96;22.87)	3.59 (1.37;9.39)	6.42 (2.88;14.28)
Period 3	0.82 (0.34;1.96)	0.54 (0.24;1.22)	0.64 (0.22;1.90)	0.34 (0.12;0.95)
Period 4	1.55 (1.02;2.36)	2.02 (1.40;2.91)	1.41 (0.86;2.30)	1.46 (1.00;2.14)
Period 5	1.31 (0.83;2.08)	1.86 (1.20;2.87)	1.20 (0.69;2.09)	1.35 (0.87;2.10)
Period 6	0.86 (0.48;1.55)	1.01 (0.61;1.68)	0.86 (0.45;1.67)	0.98 (0.60;1.62)
IDPs in North Darfur				
Period 2	10.23 (4.89;21.39)	4.82 (2.00;11.59)	3.24 (1.43;7.33)	5.48 (2.62;11.46)
Period 3	3.23 (2.33;4.49)	3.53 (2.65;4.71)	3.38 (2.26;5.04)	4.05 (2.88;5.70)
Period 4	1.29 (0.92;1.82)	1.18 (0.88;1.59)	1.27 (0.83;1.93)	1.25 (0.90;1.72)
Period 5	1.09 (0.72;1.65)	1.09 (0.78;1.52)	1.09 (0.67;1.76)	1.15 (0.79;1.68)
Period 6	0.72 (0.46;1.12)	0.59 (0.41;0.86)	0.78 (0.47;1.30)	0.84 (0.58;1.21)

Table 5.7: Predicted under five mortality rates by state and population status

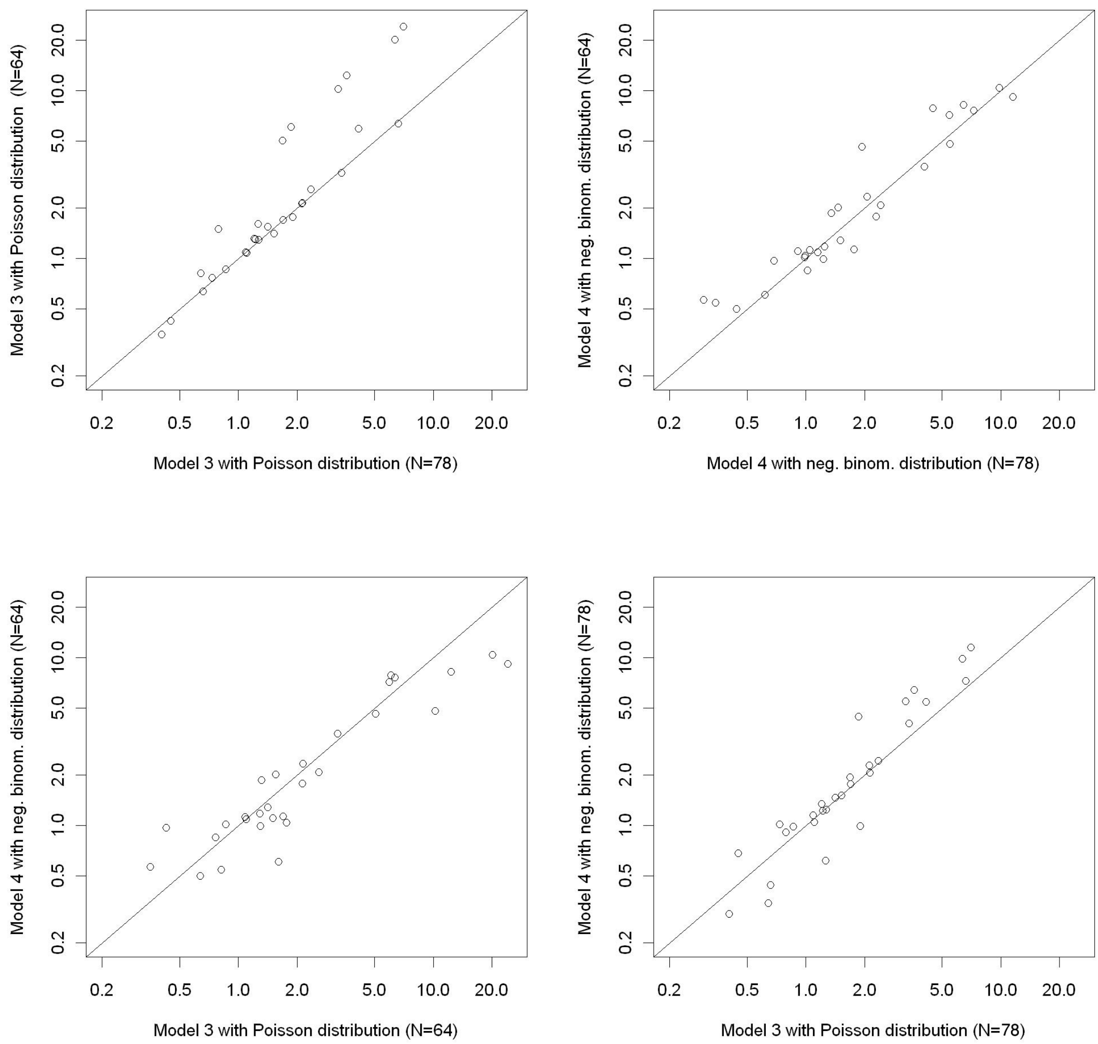
5, when values increased, reaching the emergency threshold. For the IDPs however, the highest mortality rates are reported for Period 3. Following this peak, U5MR remained low during Period 4, increased again during Period 5, to end low during Period 6.

As far as residents in South Darfur are concerned, the results show some inconsistencies for Period 3: U5MRs predicted using the quasi-Poisson model, are over twice as high as those predicted based on a negative binomial distribution. For the other periods, differences between the models are smaller. Overall, mortality remained stable, with the exception of Period 5, when rates exceeded the emergency threshold.

Finally, for residents in North Darfur, mortality rates during Period 3 remain low, yet showing some difference between the models. During the subsequent three periods, rates increase again but remain mostly below the emergency threhsold.

The top left chart in Figure 5.7 illustrates the discrepant results between the quasi-Poisson models of the different datasets. Six datapoints can be considered obvious outliers, as they have very high values for the basic dataset, but low rates for the extended one. These values correspond to the six U5MRs for Period 2. In the top right chart, on the other hand, these outliers are less obvious, but then again, points lie further away from the bisectrix, suggesting that the match between the two models is not as high. Similar conclusions can be made based on the bottom plots.

The average under five mortality rates for the entire Darfur region are shown in figure 5.8. Note again the important discrepancy between the basic and the extended dataset, as far as rates for Period 2 are concerned. As explained above, the figures based on the extended dataset are considered the most representative of the two. I also believe that the predicted rates for North and South Darfur are unreasonably high. As a result, I decided to take the predicted U5MR for West Darfur for Period 2 as the best estimate for the entire region for that period. As such, U5MR for Period 2 is estimated at 2/10,000/day. Subsequently, mortality rates increased and reached approximately 4/10,000/day during Period 3. After 2004, however, rates remained low, though a clear increase is seen during



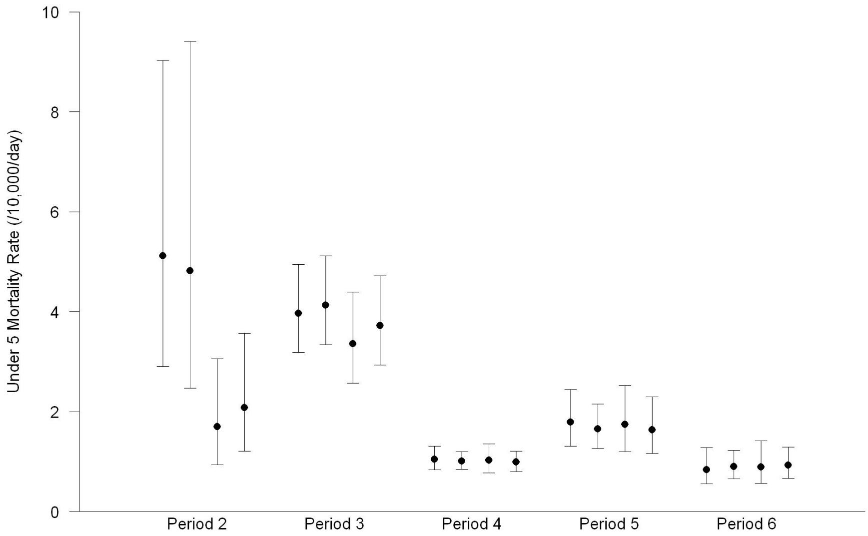
Note: the scale of the axes is logarithmic

Figure 5.7: Correlation between different models and datasets

Period 5.

Application of the rates to the affected population

Table 5.8 shows the calculated number of children under five that have died between September 2003 and December 2008. Since I believe the results of the extended dataset are more reliable, I conclude that overall, around 175,000 children died during the studied



Note: first bars correspond to quasi-Poisson model (basic), second bars to negative binomial model (basic), third bars correspond to quasi-Poisson model (extended), fourth bars to negative binomial model (extended).

Figure 5.8: Estimated under five mortality rates with 95% confidence intervals for the entire Darfur region

period. Less than one quarter of these deaths occurred during the deadliest years 2003 and 2004.

According to Sudan's MICS 2000 survey [90], the probability of dying before the age of five for the Darfur region, was approximately 100 per 1,000 live births. Assuming that Darfur's birth rate was equal to that of Sudan, which was estimated by UNPD at 34.5 births per 1,000 people per year, I estimate for the six million people in Darfur, a counterfactual number of under five deaths for the analyzed period equal to 120,000. This means that the excess number of deaths among children under five is estimated at 55,000−70,000, suggesting a 50% increase in child mortality throughout the conflict.

	Model 3 (quasi-Poisson)		Model 4 (negative binomial)	
	CMR	95% confidence interval	CMR	95% confidence interval
Basic dataset				
Period 2	13,594	7,705; 23,983	12,796	6,553; 24,988
Period 3	36,242	29,100; 45,136	37,734	30,494; 46,694
Period 4	38,452	30,794; 48,015	36,898	30,986; 43,938
Period 5	66,851	48,862; 91,463	61,757	47,394; 80,474
Period 6	35,573	23,357; 54,180	37,920	27,706; 51,901
Total	190,712	139,818; 262,777	187,105	143,133; 247,995
Extended dataset				
Period 2	4,508	2,498; 8,136	5,513	3,206; 9,481
Period 3	30,670	23,476; 40,068	33,960	26,777; 43,070
Period 4	37,669	28,548; 49,703	36,231	29,540; 44,437
Period 5	65,302	45,057; 94,642	61,269	43,581; 86,135
Period 6	37,757	23,799; 59,902	39,285	28,232; 54,665
Total	175,906	123,378; 252,451	176,258	131,336; 237,788

Table 5.8: Estimated death tolls among conflict affected children younger than five years of age

5.2.3 Violence related mortality rate

Regression models

The residual deviance for the Poisson model with no interaction terms was 276.31 for 56 degrees of freedom. As a results, ϕ is estimated at 4.9, which confirms the presence of overdispersion in the data. Similarly, the ϕ based on the full-model, i.e. with all interaction terms, was approximately 4.3.

The best-fit for the quasi-Poisson model consists of the main variables with the exception of Period5, and two interaction variables, SD$\times$Period4 and WD$\times$IDP; the dispersion parameter of this model is 4.0 (see table 5.9). The coefficients of all terms have p-values inferior to 0.05, with the exception of SD, for which the p-value was 0.097. The model suggests that violence related mortality was lower for residents in West Darfur in comparison to North Darfur, although for the displaced, no difference existed between the two states. In South Darfur, on the other hand, violent mortality was slightly higher than in North Darfur, except for Period 4, when it was lower. The results further show that surveys conducted among IDPs in North and South Darfur reported lower rates of violent mortality than surveys conducted among affected residents. For West Darfur, however, results show the opposite. Finally, a clear time trend is seen in the coefficients. Values for Period2 are very high, but are smaller for Period3 and even more for Period4.

As far as the negative binomial model is concerned, the full-model yields an AIC value (AIC=306.130) that is higher than the value for the model without interaction (AIC=294.964) (see table 5.10). In other words, the model's gain in likelihood does not compensate for the complexity added to the model by increasing the number of parameters. Still, by introducing the same two interaction terms as in the quasi-Poisson model, the likelihood improves significantly, yet keeping the number of parameters low. Hence, the AIC value for that model (AIC=290.413) is smaller than the AIC for the model consisting only of the main variables. Since the parameters included in this model are almost exactly the same as those in the quasi-Poisson model, the results of both models are very similar.

The extended dataset for violence related mortality consists of eight additional surveys compared to the basic dataset. These additional surveys cover parts of Period 2, 3 and 4. Contrarily to crude and under five mortality however, few differences were found between the two datasets. While for the former indicators, considerable differences were seen between the datasets as far as rates for Period 2 are concerned, the data for violent deaths is consistent across the different datasets. Indeed, the only survey for Period 2 included in the basic dataset reported a violence related mortality rate of 1.71/10,000/day. This is very similar to the 1.74/10,000/day, corresponding to the mean of the two additional surveys included in the extended dataset, that had recall periods lying mainly in Period 2. As a consequence, little discrepancy is seen between the results of both datasets. First, the terms included in M_3 and M_4, respectively the best-fitted quasi-Poisson and negative binomial model, are the same across both datasets (see table 5.9). Second, the coefficients for the extended dataset's models are very similar to those of the basic dataset. Nonetheless, some differences can still be noted. The coefficient for WD in the quasi-Poisson model for the extended dataset, is smaller than that of the same term in the basic dataset's model; the opposite is seen for the interaction term WD$\times$IDP. In other words, in comparison to

	Basic dataset (N=64)		Extended dataset (N=72)	
	quasi-Poisson (M_3)	neg. binom. (M_4)	quasi-Poisson (M_3)	neg. binom. (M_4)
(Intercept)	-12.157	-13.270	-12.285	-13.334
	(0.520)	(0.782)	(0.571)	(0.748)
WD†	-2.718	-1.962	-3.573	-2.141
	(0.790)	(0.679)	(0.650)	(0.612)
SD†	0.532	0.603	0.637	0.668
	(0.315)	(0.412)	(0.348)	(0.387)
IDP	-1.544	-1.050	-1.424	-1.021
	(0.399)	(0.497)	(0.426)	(0.454)
Period2‡	5.119	5.814	5.192	5.607
	(0.585)	(1.149)	(0.600)	(0.877)
Period3‡	2.983	3.785	2.906	3.687
	(0.458)	(0.662)	(0.500)	(0.643)
Period4‡	1.322	1.824	1.452	1.990
	(0.550)	(0.715)	(0.582)	(0.687)
Period5‡		1.133		1.134
		(0.748)		(0.726)
SD:Period4	-1.760	-1.755	-1.588	-1.530
	(0.850)	(0.776)	(0.743)	(0.648)
WD:IDP	3.019	2.072	3.989	2.426
	(0.935)	(0.901)	(0.735)	(0.790)
logLik	-	-134.206	-	-167.234
AIC	-	290.413	-	356.468
ϕ	4.020	-	4.814	-
θ	-	1.297	-	1.547

ϕ = dispersion parameter

†: reference is North Darfur; ‡: reference is Period 6

Note: LL or AIC cannot be calculated for quasi-Poisson models.

Table 5.9: Coefficients for M_3 and M_4 for vMR

		Parameters	df	Log Likelihood	AIC
Basic dataset					
	Model 1 (M_1)	19	20	-133.065	306.130
	Model 2 (M_2)	8	9	-138.482	294.964
	Model 4 (M_4)	10	11	-134.206	290.413
Extended dataset					
	Model 1 (M_1)	20	21	-165.490	372.980
	Model 2 (M_2)	8	9	-173.192	364.384
	Model 4 (M_4)	10	11	-167.234	356.468

Likelihood-ratio Test (LRT)

		d	df	p-value
Basic dataset				
	M_1 vs. M_2	10.8341	11	0.4573
	M_1 vs. M_4	2.2832	9	0.9862
	M_2 vs. M_4	-8.551	2	0.0139
Extended dataset				
	M_1 vs. M_2	15.4033	12	0.2201
	M_1 vs. M_4	3.4872	10	0.9675
	M_2 vs. M_4	-11.916	2	0.0026

Table 5.10: Goodness-of-fit of negative binomial regression models for vMR

the basic dataset, the extended dataset results in a bigger difference in violent mortality rates between displaced and affected residents in West Darfur, in favor of the latter. The same finding is observed in the negative binomial models.

Note: Since many surveys reported no violent related deaths, the proportion of zeros in the dataset is high. For that reason, a zero-inflated negative binomial model was also considered in the model selection [108]. The smallest AIC obtained by any of these models with the extended dataset was 381.93. Since this value was still greater than the AIC value obtained for the negative binomial model, i.e. 356.47, I concluded that a zero-inflated negative binomial model would not fit the data better than regular negative binomial model.

Predicted violence related mortality rates and estimated deaths

With the exception of Periods 2 and 3, violence related mortality rates are low, with values that are in general inferior to 0.1/10,000/day. Periods 2 and 3, on the other hand, are in sharp contrast to this general trend, as rates for these periods, i.e. during 2003 and 2004, were significantly higher. This is especially the case for the Period 2 estimates among residents in South and North Darfur. As discussed previously, these values are marked by a high degree of uncertainty due to the shortage of surveys and, as a consequence, I believe these figures overestimate the true level of violent mortality. Nonetheless, the predicted rates for Period 2 in West Darfur are consistent with the survey results that are available, and are therefore considered a better reflection of the reality. I thus conclude that violence related mortality rates peaked during Period 2, with values around 2.5/10,000/day among displaced and 0.5/10,000/day among residents. It decreased during Period 3, remaining elevated among residents in North and South Darfur, and as of 2005, reached levels that were generally inferior to 0.1/10,000/day.

Figure 5.9 shows the estimated violence related mortality rates with 95% confidence interval for the entire Darfur region. However, as the obtained results for Period 2 in South and North Darfur were deemed not to reflect reality well enough, the values in the chart for Period 2 are based on the results for West Darfur only.

Finally, I estimated the number of violent deaths from September 2003 to December 2008 between 50 and 60,000, with approximately seventy-five percent of these deaths having occurred prior to 2005 (table 5.12).

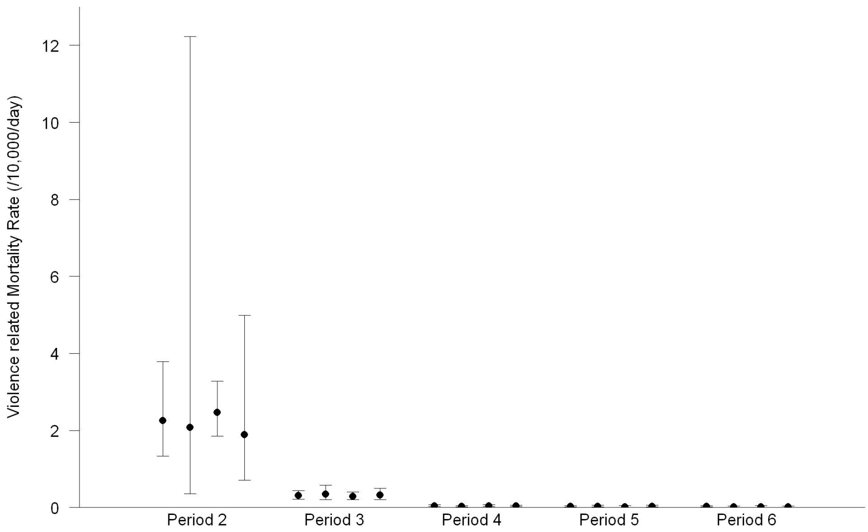
5.2.4 Diarrhea related mortality rate

Regression models

For the basic dataset, the Poisson model yields a residual deviance of 158.18 with 45 degrees of freedom. On this basis, the dispersion parameter is estimated at 3.5, and hence, I conclude that the data is overdispersed. The same analysis using the extended dataset results in a residual deviance of 173.77 on 49 degrees of freedom, again a ϕ of 3.5.

	Basic dataset (64 surveys)		Extended dataset (72 surveys)	
	$\text{Model}_{3,quasi-Poisson}$	$\text{Model}_{4,NegBinom}$	$\text{Model}_{3,quasi-Poisson}$	$\text{Model}_{4,NegBinom}$
Residents in West Darfur				
Period 2	0.58 (0.15;2.26)	0.81 (0.10;6.58)	0.23 (0.08;0.72)	0.52 (0.12;2.26)
Period 3	0.07 (0.01;0.33)	0.11 (0.03;0.38)	0.02 (0.01;0.08)	0.08 (0.02;0.23)
Period 4	0.01 (0.00;0.06)	0.02 (0.01;0.04)	0.01 (0.00;0.02)	0.01 (0.01;0.04)
Period 5	0.00 (0.00;0.02)	0.01 (0.00;0.03)	0.00 (0.00;0.01)	0.01 (0.00;0.02)
Period 6	0.00 (0.00;0.02)	0.00 (0.00;0.01)	0.00 (0.00;0.01)	0.00 (0.00;0.01)
IDPs in West Darfur				
Period 2	2.53 (1.38;4.65)	2.26 (0.38;13.56)	3.03 (2.25;4.09)	2.11 (0.79;5.67)
Period 3	0.30 (0.15;0.61)	0.30 (0.12;0.76)	0.31 (0.17;0.56)	0.31 (0.14;0.67)
Period 4	0.06 (0.02;0.13)	0.04 (0.02;0.11)	0.07 (0.03;0.15)	0.06 (0.03;0.12)
Period 5	0.02 (0.00;0.05)	0.02 (0.01;0.07)	0.02 (0.01;0.05)	0.02 (0.01;0.07)
Period 6	0.02 (0.00;0.05)	0.01 (0.00;0.03)	0.02 (0.01;0.05)	0.01 (0.00;0.03)
Residents in South Darfur				
Period 2	14.94 (5.59;39.92)	10.57 (1.25;89.54)	15.70 (5.89;41.88)	8.60 (1.86;39.63)
Period 3	1.76 (0.87;3.58)	1.39 (0.47;4.08)	1.60 (0.74;3.44)	1.26 (0.47;3.39)
Period 4	0.06 (0.01;0.26)	0.03 (0.01;0.12)	0.08 (0.02;0.27)	0.05 (0.02;0.14)
Period 5	0.09 (0.03;0.23)	0.10 (0.04;0.27)	0.09 (0.03;0.25)	0.10 (0.04;0.27)
Period 6	0.09 (0.03;0.23)	0.03 (0.01;0.15)	0.09 (0.03;0.25)	0.03 (0.01;0.14)
IDPs in South Darfur				
Period 2	3.19 (1.23;8.27)	3.70 (0.49;28.02)	3.78 (1.52;9.38)	3.10 (0.75;12.72)
Period 3	0.38 (0.24;0.60)	0.49 (0.24;0.98)	0.38 (0.23;0.64)	0.45 (0.24;0.87)
Period 4	0.01 (0.00;0.05)	0.01 (0.00;0.04)	0.02 (0.01;0.06)	0.02 (0.01;0.05)
Period 5	0.02 (0.01;0.05)	0.03 (0.01;0.08)	0.02 (0.01;0.06)	0.04 (0.02;0.08)
Period 6	0.02 (0.01;0.05)	0.01 (0.00;0.04)	0.02 (0.01;0.06)	0.01 (0.00;0.04)
Residents in North Darfur				
Period 2	8.78 (3.54;21.77)	5.78 (0.76;44.19)	8.3 (3.39;20.33)	4.41 (1.11;17.48)
Period 3	1.04 (0.49;2.20)	0.76 (0.28;2.08)	0.84 (0.38;1.88)	0.65 (0.26;1.61)
Period 4	0.20 (0.11;0.35)	0.11 (0.05;0.25)	0.20 (0.11;0.35)	0.12 (0.06;0.25)
Period 5	0.05 (0.02;0.15)	0.05 (0.02;0.16)	0.05 (0.02;0.14)	0.05 (0.02;0.14)
Period 6	0.05 (0.02;0.15)	0.02 (0.00;0.08)	0.05 (0.02;0.14)	0.02 (0.00;0.07)
IDPs in North Darfur				
Period 2	1.87 (0.78;4.48)	2.02 (0.29;14.04)	2.00 (0.87;4.60)	1.59 (0.44;5.72)
Period 3	0.22 (0.13;0.37)	0.27 (0.14;0.51)	0.20 (0.11;0.37)	0.23 (0.13;0.42)
Period 4	0.04 (0.02;0.09)	0.04 (0.02;0.08)	0.05 (0.02;0.10)	0.04 (0.02;0.08)
Period 5	0.01 (0.00;0.03)	0.02 (0.01;0.05)	0.01 (0.00;0.03)	0.02 (0.01;0.05)
Period 6	0.01 (0.00;0.03)	0.01 (0.00;0.02)	0.01 (0.00;0.03)	0.01 (0.00;0.02)

Table 5.11: Predicted violence related mortality rates by state and population status



Note: first bars correspond to quasi-Poisson model (basic), second bars to negative binomial model (basic), third bars correspond to quasi-Poisson model (extended), fourth bars to negative binomial model (extended).

Figure 5.9: Estimated violence related mortality rates with 95% confidence intervals for the entire Darfur region

The best-fitted model based on a quasi-Poisson approach consists of six main covariates and seven interaction terms (sse table 5.14). WD is negative with a small p-value, suggesting lower diarrhea related mortality in West Darfur in comparison to North Darfur. However, the interaction terms WD×Period3 and WD×IDP cancel out this negative coefficient, while the WD×Period5 term turns it into a positive one. SD, on the other hand, has a large p-value and thus a low degree of significance. Nonetheless, the term remained in the model, since the interaction terms SD×Period3 and SD×Period5 were found significant. This means that no difference is apparent between South and North Darfur, except for Periods 3 and 5, when rates were higher in South Darfur. Similarly, the coefficient for the main IDP term does not have a small p-value, but due to the inclusion of the more significant interaction terms IDP×Period3 and IDP×Period5, the covariate was nonetheless kept in the model. The main conclusion here, is that diarrhea related mortality was especially a problem among IDPs during Period 5. Finally, the time variables show an

	Estimated death toll	95% CI		Estimated death toll	95% CI	
Basic dataset						
Period 2	28,095	16,703	47,257	25,981	4,419	152,758
Period 3	13,237	9,213	19,018	14,743	8,800	24,701
Period 4	6,713	3,658	12,320	5,317	3,191	8,861
Period 5	3,593	1,515	8,520	5,268	2,391	11,605
Period 6	4,095	1,745	9,613	1,945	568	6,665
Total	55,733	32,834	96,728	53,254	19,369	204,590
Extended dataset						
Period 2	30,805	23,192	40,917	23,547	8,902	62,281
Period 3	12,041	8,483	17,091	13,695	8,705	21,545
Period 4	7,213	4,218	12,334	6,665	4,394	10,109
Period 5	3,152	1,239	8,016	5,156	2,430	10,938
Period 6	3,708	1,467	9,368	1,915	575	6,378
Total	56,919	38,599	87,726	50,978	25,006	111,251

Table 5.12: Estimated violence related death tolls

overall decreasing trend, although the many interaction terms result into a high degree of variation for Periods 3 and 5.

For the negative binomial distribution, the full model yields a lower AIC value than the model without any interaction (see table 5.13). However, another model, with less interaction terms resulted in an even lower AIC value. The difference between this model and the full model had a p-value of 0.0014, and I thus preferred this model above the full model. It introduces three additional terms in comparison to the quasi-Poisson model: Period4, WD$\times$Period4 and IDP$\times$Period4. Nonetheless, the findings are in general very similar. WD has a large, negative coefficient, but interacts with several other covariates. WD$\times$Period4 and WD$\times$IDP attenuate the effect of WD, yet keeping the resulting values negative. With WD$\times$Period3 and WD$\times$Period5, on the other hand, the value becomes positive. The coefficient for SD is almost equal to zero, suggesting no difference in diarrhea related mortality rates between South and North Darfur, but here too, interactions have to be considered. SD$\times$Period3 and SD$\times$Period5 have large, positive coefficients, which

		Parameters	df	Log Likelihood	AIC
Basic dataset					
	Model 1 (M_1)	19	20	-190.749	421.499
	Model 2 (M_2)	8	9	-205.951	429.903
	Model 4 (M_4)	17	18	-191.139	418.279
Extended dataset					
	Model 1 (M_1)	19	20	-203.235	446.470
	Model 2 (M_2)	8	9	-218.485	454.971
	Model 4 (M_4)	16	17	-204.559	443.119

Likelihood-ratio Test (LRT)

		d	df	p-value
Basic dataset				
	M_1 vs. M_2	30.4041	11	0.0014
	M_1 vs. M_4	0.7798	2	0.6771
	M_2 vs. M_4	-29.6242	9	0.0005
Extended dataset				
	M_1 vs. M_2	30.5009	11	0.0013
	M_1 vs. M_4	2.6489	3	0.4490
	M_2 vs. M_4	-27.8520	8	0.0005

Table 5.13: Goodness-of-fit of negative binomial regression models for dMR

means that during those periods, mortality was higher in South than in North Darfur. As for the impact of population status, the coefficient for IDP suggests lower rates among IDPs. However, taking the interaction terms into account, no difference is seen for Period 4, while during Periods 3 and 5, rates among displaced were higher than among the affected residents. Lastly, the coefficients for the Period covariates show decreasing values over time, but similarly to the quasi-Poisson model, much variation results from the many interaction terms.

As far as the quasi-Poisson model is concerned, there is a high similarity between the results obtained with the basic dataset and those with the extended one. For the negative binomial model, however, more difference is seen. Overall, the coefficients of the main

	Basic dataset (N=64)		Extended dataset (N=68)	
	quasi-Poisson (M_3)	neg. binom. (M_4)	quasi-Poisson (M_3)	neg. binom. (M_4)
(Intercept)	-10.735	-9.361	-10.903	-10.778
	(0.286)	(1.010)	(0.277)	(0.360)
WD	-0.904	-2.254	-0.824	-1.535
	(0.398)	(0.802)	(0.398)	(0.642)
SD	-0.134	-0.010	-0.149	-0.151
	(0.279)	(0.230)	(0.274)	(0.218)
IDP	-0.309	-1.969	-0.194	-0.305
	(0.342)	(1.124)	(0.352)	(0.301)
Period2	1.636	3.114	1.658	2.554
	(0.369)	(0.770)	(0.367)	(0.682)
Period3	-0.343	-1.989	-0.259	-0.766
	(0.653)	(1.128)	(0.641)	(0.630)
Period4		-1.365		0.030
		(1.045)		(0.259)
Period5	-1.300	-2.693	-1.099	-1.173
	(0.615)	(1.179)	(0.616)	(0.615)
WD:Period3	1.197	2.818	1.095	2.008
	(0.465)	(0.859)	(0.454)	(0.690)
WD:Period4		1.587		0.865
		(0.811)		(0.608)
WD:Period5	1.877	3.282	1.769	2.467
	(0.869)	(1.062)	(0.881)	(0.922)
SD:Period3	1.132	1.032	1.141	1.200
	(0.423)	(0.367)	(0.421)	(0.366)
SD:Period5	1.038	0.898	1.036	0.998
	(0.474)	(0.404)	(0.475)	(0.409)
IDP:Period3	1.079	3.094	1.078	1.660
	(0.676)	(1.241)	(0.667)	(0.612)
IDP:Period4		1.686		
		(1.153)		
IDP:Period5	1.664	3.349	1.530	1.602
	(0.623)	(1.266)	(0.635)	(0.575)
WD:IDP	1.061	0.718	1.035	0.733
	(0.522)	(0.451)	(0.527)	(0.457)
logLik	-	-191.139	-	-204.559
AIC	-	418.279	-	443.119
ϕ	3.427	-	3.575	-
θ	-	7.817	-	6.922

ϕ = dispersion parameter; †: reference is North Darfur; ‡: reference is Period 6

Note: LL or AIC cannot be calculated for quasi-Poisson models.

Table 5.14: Coefficients for M_3 and M_4 for dMR

covariates have decreased, while those of the interaction terms have increased. Nonetheless, the patterns identified in the analysis of the basic dataset, remain valid for the extended dataset.

Predicted diarrhea related mortality rates and estimated deaths

Table 5.15 gives an overview of the predicted diarrhea related mortality rates. The most striking numbers are undoubtedly the very high rates in North and South Darfur for Period 2. The underlying cause, the shortage of surveys for that period, has already been raised in the previous sections. Again, I believe that these predicted rates overestimate the true level of mortality for that period, and that the results for West Darfur for Period 2, provide a better estimate.

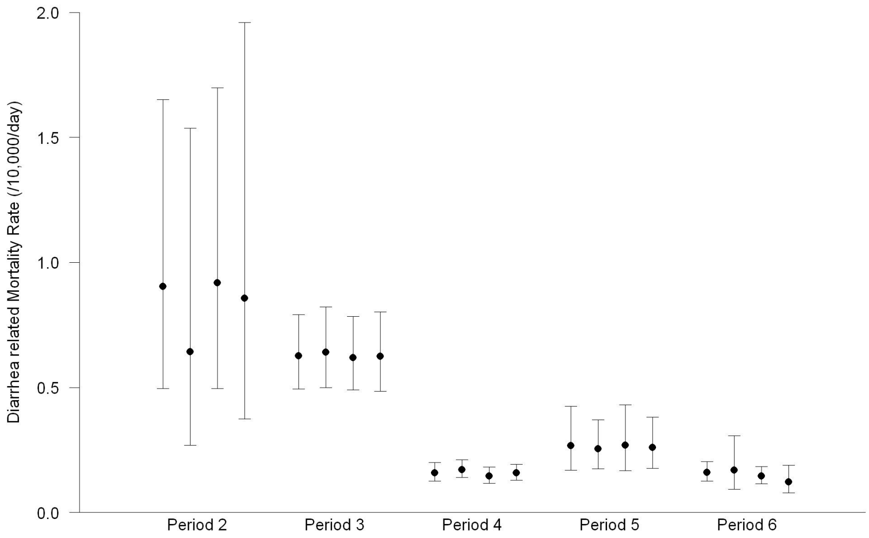
With the exception of the figures for Period 2, the majority of the diarrhea related mortality rates range between 0.1 and 0.3/10,000/day, with, in general, little discrepancy between the different models. Two clear patterns can be identified. First, rates for IDPs are higher than those for residents, especially in West Darfur. In fact, the IDPs in West Darfur were the most affected group as far as diarrheal deaths are concerned. We further see that rates flared up amongst displaced populations during Period 5, after having been low during Period 4. This generally lower level, however, is reached again in Period 6.

This time trend is also observed in the aggregated rates for the entire Darfur region (see figure 5.10). There are high rates during Period 2 and 3, followed by a period of decreased mortality, i.e. Period 4. For Period 5 rates are again higher, and they decrease in Period 6. One must bear in mind however, that the rates for Period 2 only consider the predicted mortality rates for West Darfur, and ignored those for South and North Darfur.

Finally, table 5.16 shows the estimated number of deaths attributable to diarrhea. The different models suggest that between 135,000 and 145,000 people died of diarrhea, with approximately half of those having died between mid 2006 and end 2008.

	Basic dataset (64 surveys)		Extended dataset (68 surveys)	
	$\text{Model}_{3,quasi-Poisson}$	$\text{Model}_{4,NegBinom}$	$\text{Model}_{3,quasi-Poisson}$	$\text{Model}_{4,NegBinom}$
Residents in West Darfur				
Period 2	0.45 (0.18;1.14)	2.03 (0.30;13.81)	0.42 (0.17;1.08)	0.58 (0.21;1.6)
Period 3	0.21 (0.06;0.66)	0.21 (0.08;0.57)	0.19 (0.06;0.54)	0.16 (0.06;0.38)
Period 4	0.09 (0.05;0.17)	0.11 (0.07;0.19)	0.08 (0.04;0.16)	0.11 (0.07;0.19)
Period 5	0.16 (0.05;0.53)	0.16 (0.06;0.43)	0.16 (0.05;0.55)	0.16 (0.06;0.45)
Period 6	0.09 (0.05;0.17)	0.09 (0.02;0.36)	0.08 (0.04;0.16)	0.04 (0.02;0.13)
IDPs in West Darfur				
Period 2	0.96 (0.51;1.80)	0.58 (0.22;1.54)	0.98 (0.52;1.86)	0.89 (0.38;2.06)
Period 3	1.29 (0.89;1.88)	1.31 (0.79;2.17)	1.27 (0.86;1.87)	1.26 (0.74;2.13)
Period 4	0.19 (0.10;0.33)	0.17 (0.10;0.30)	0.19 (0.11;0.32)	0.17 (0.10;0.28)
Period 5	1.76 (0.30;10.21)	1.33 (0.30;5.84)	1.69 (0.28;10.11)	1.25 (0.27;5.73)
Period 6	0.19 (0.10;0.33)	0.03 (0.00;0.14)	0.19 (0.11;0.32)	0.07 (0.02;0.21)
Residents in South Darfur				
Period 2	0.98 (0.36;2.68)	19.17 (0.84;438.81)	0.83 (0.30;2.27)	2.3 (0.49;10.75)
Period 3	0.42 (0.15;1.14)	0.33 (0.12;0.88)	0.38 (0.14;1.05)	0.28 (0.10;0.76)
Period 4	0.19 (0.10;0.38)	0.22 (0.13;0.38)	0.16 (0.08;0.31)	0.18 (0.11;0.32)
Period 5	0.15 (0.06;0.36)	0.14 (0.07;0.30)	0.15 (0.06;0.37)	0.15 (0.07;0.32)
Period 6	0.19 (0.10;0.38)	0.85 (0.10;6.97)	0.16 (0.08;0.31)	0.18 (0.09;0.37)
IDPs in South Darfur				
Period 2	0.72 (0.31;1.66)	2.68 (0.59;12.05)	0.69 (0.30;1.58)	1.7 (0.42;6.94)
Period 3	0.91 (0.61;1.34)	1.01 (0.68;1.50)	0.93 (0.62;1.37)	1.07 (0.71;1.61)
Period 4	0.14 (0.09;0.22)	0.16 (0.11;0.25)	0.13 (0.08;0.20)	0.14 (0.09;0.20)
Period 5	0.57 (0.39;0.83)	0.56 (0.36;0.88)	0.57 (0.39;0.83)	0.55 (0.34;0.88)
Period 6	0.14 (0.09;0.22)	0.12 (0.07;0.19)	0.13 (0.08;0.20)	0.13 (0.08;0.21)
Residents in North Darfur				
Period 2	1.12 (0.44;2.84)	19.36 (0.95;395.81)	0.97 (0.39;2.42)	2.68 (0.58;12.41)
Period 3	0.15 (0.05;0.47)	0.12 (0.04;0.33)	0.14 (0.05;0.44)	0.1 (0.03;0.28)
Period 4	0.22 (0.12;0.38)	0.22 (0.14;0.36)	0.18 (0.11;0.32)	0.21 (0.14;0.34)
Period 5	0.06 (0.02;0.16)	0.06 (0.02;0.14)	0.06 (0.02;0.17)	0.06 (0.03;0.16)
Period 6	0.22 (0.12;0.38)	0.86 (0.12;6.22)	0.18 (0.11;0.32)	0.21 (0.10;0.42)
IDPs in North Darfur				
Period 2	0.82 (0.36;1.87)	2.70 (0.62;11.76)	0.8 (0.35;1.82)	1.98 (0.48;8.19)
Period 3	0.33 (0.20;0.55)	0.36 (0.24;0.55)	0.34 (0.21;0.56)	0.38 (0.25;0.58)
Period 4	0.16 (0.11;0.24)	0.17 (0.12;0.24)	0.15 (0.10;0.23)	0.16 (0.11;0.23)
Period 5	0.23 (0.12;0.45)	0.23 (0.13;0.40)	0.23 (0.12;0.46)	0.24 (0.14;0.41)
Period 6	0.16 (0.11;0.24)	0.12 (0.07;0.21)	0.15 (0.10;0.23)	0.15 (0.09;0.25)

Table 5.15: Predicted diarrhea related mortality rates by state and population status



Note: first bars correspond to quasi-Poisson model (basic), second bars to negative binomial model (basic), third bars correspond to quasi-Poisson model (extended), fourth bars to negative binomial model (extended).

Figure 5.10: Estimated diarrhea related mortality rates with 95% confidence intervals for the entire Darfur region

	Estimated death toll	95% CI		Estimated death toll	95% CI	
Basic dataset						
Period 2	11,288	6,179	20,620	8,030	3,361	19,185
Period 3	26,837	21,210	33,958	27,496	21,447	35,252
Period 4	27,369	21,683	34,545	29,594	24,149	36,268
Period 5	47,091	29,693	74,684	44,798	30,743	65,278
Period 6	31,751	24,919	40,457	33,716	18,572	61,207
Total	144,336	103,684	204,264	143,634	98,272	217,190
Extended dataset						
Period 2	11,465	6,197	21,211	10,695	4,676	24,466
Period 3	26,568	21,003	33,608	26,757	20,817	34,392
Period 4	25,118	20,083	31,414	27,305	22,445	33,218
Period 5	47,290	29,544	75,697	45,612	30,959	67,200
Period 6	28,988	22,963	36,595	24,276	15,738	37,447
Total	139,429	99,790	198,525	134,645	94,635	196,723

Table 5.16: Estimated diarrhea related death tolls

Chapter 6

Discussion

6.1 Methodology of the analysis

6.1.1 Limitations of the analysis

Any scientific analysis is subject to a certain degree of uncertainty and a risk of incorrectness. In this analysis, errors could have been introduced at three different levels:

- random errors;
- errors related to the data used;
- errors related to the analysis's methodology.

Each level of error will be discussed in the next section, as well as the risk for this type of errors in this analysis and their implications on the results.

Random errors

Random errors are a result of unpredictable variations in phenomena and measurements. They are inherent to empirical research and cannot be avoided. Let's, for example, consider a population in which there is an average mortality rate of one death per day. It is very likely that there will be days on which more than one death is being recorded. On the other hand, there will probably be periods during which several days pass without any decease. As a consequence, two researchers may draw contradicting conclusions, depending on the moment of observation. This doesn't mean that one is better than the other. They might both be correct in their analysis, but accidentally, they reach a wrong conclusion because their unique observation is not a good enough reflection of the larger population.

We can reduce this effect of chance by increasing the number of measurements or trials. In other words, the more observations we make, the smaller the random error will be. Using statistical tools, we can then draw a distribution of these measurements, and identify a range in which we believe the true value lies; this is the so-called confidence interval (CI). It is important to note that CIs are only a reflection of the random error component of a measurement, and as such, they do not take systematic biases into account.

All estimates computed in this analysis are accompanied by a 95%CI, which in most of the cases is quite large, reflecting the high level of unpredictable variation of mortality in conflict settings. As a result, without even considering problems related to data sources and methodology, it's complicated to provide a precise estimate of conflict related deaths. This of course contributes substantially to the controversy surrounding the topic.

Errors related to the data used

Since this analysis is based on a compilation of retrospective mortality surveys, all limitations associated to this type of surveys should be considered [19] potential limitations of this study.

The first limitation, a form of selection bias, is related to the access to affected populations. The vast majority of mortality surveys uses a cluster sampling approach. A limited number of geographically well-defined locations is selected at random and surveyed, and the results are then extrapolated to a larger area (see section 4.2.1). In some cases though, some of these areas are inaccessible to the surveyors and therefore not covered by the survey. This could lead to an underestimation of the mortality rate if mortality is higher in the inaccessible areas.

Very few reports provide a detailed description of the areas that were inaccessible during the survey, and that is also true for the survey reports I've used in my analysis. The WHO

Darfur Mortality Surveys from 2004 and 2005 [106, 107] however, are exceptions to that finding. Indeed, in both cases several clusters of the South Darfur arm of the survey could not be accessed due to security issues. In the case of the 2004 survey, this resulted in the South Darfur data being limited to Kalma camp; for the 2005 survey, it was limited to IDPs living in camps, but excluded all IDPs outside camps as well as affected residents. Similar problems are likely to have occurred in other surveys, but are not necessarily reported.

The exact impact of this bias on my results is hard to assess. Nevertheless, it seems reasonable to assume that if the inaccessibility is due to security problems, then higher levels of violence related mortality could be expected in the inaccessible areas in comparison to the accessible ones. As a consequence, the observed mortality rates - especially mortality due to violence - could be underestimates of the real situation. It is however impossible to correct for this bias.

A second limitation is referred to as survival bias. In situations of very high mortality, the possibility exists that entire households have disappeared. These deaths will not be captured by a mortality survey. Although this bias is often mentioned as major problem of mortality surveys in armed conflicts, I believe its impact is quite limited. Based on some analyses I performed on the 2005 WHO Darfur Mortality Survey dataset, I calculated that eight percent of the surveyed households had lost at least one household member. However, no household reported more than three deaths. As a consequence, I think the proportion of households across Darfur where all household members, i.e. on average six people, have died, is quite limited.

Third, in the survey questionnaire, people are asked about events that happened in the past. One can't rule out that some deaths are not recalled by the respondent. This phenomenon is called recall bias. The risk of encountering this type of bias is higher for surveys with long recall periods (more than 1 year). However, the median recall period of the surveys used in this analysis was 90 days and the maximum 365 days. I believe this minimizes to a certain extent the risk of a recall bias.

Finally, information biases due to false statements of the respondent or false reporting by the interviewer should always be considered. During the aforementioned 2005 WHO Mortality Survey in Darfur, pockets with elevated violence related mortality in Kutum area, North Darfur were identified. According to OCHA however, no heavy fighting had occurred in that region during the analyzed period. This lead to some concerns about the reliability of the given answers. One possibility that was emitted was that young men from Kutum area joined fighting groups and were killed in action at some other place. This hypothesis was supported by the finding that no high violencerelated mortality rates were found for the border area between North and South Darfur, notwithstanding the fact that many violent incidents had been reported from that area. It was thus assumed that the deaths had truly occurred, but were not reported at the correct location.

Alternatively, we cannot rule out the possibility that people don't report violent deaths out of fear for retribution. Indeed, the violent death of a household member might suggest that the household is linked to fighting groups and as such the household may become a target for hostile forces. Overall, this means that false statements of the respondents might lead to both an under- or overestimation of the mortality.

In addition to problems related to surveys, the second data source that I used, the Darfur Humanitarian Profile series, can also be subject to errors. Biases in this data will not affect the regressions performed in this analysis, but can affect the estimated death toll. It appears that population figures provided in the documents were not always very accurate. Indeed, areas that had become inaccessible for some period of time, were no longer updated as no information was available. Once the area had become accessible again, a new assessment of the population would be conducted and the figure revised. As a consequence, I noted that some areas remained at exactly the same population size for several months and then abruptly changed. I observed changes in both directions, ie. reductions as well as increases in affected population, and I therefore believe though, that the impact of these inaccuracies will be limited as reductions and increases cancel each other out.

Errors related to the analysis's methodology

Besides limitations inherent to the data sources, other points of limitation should be mentioned. First, there is an additional selection bias, since the surveys used in this analysis might not cover all affected populations evenly. Indeed, mortality surveys are typically conducted in areas that are accessible to the UN or humanitarian NGOs, especially camps. This might result in an overrepresentation of surveys conducted in IDP settings, which have specific characteristics. On the one hand it is obvious that people living in camps have fled violence and can therefore be considered a particularly vulnerable population. They have lost their home, assets, and very often their social network. In addition, the precarious conditions in which they live increase their exposure to pathogens and thus the risk for diseases. Based on this, one could assume that surveys conducted in camps would result in higher levels of mortality both violence and disease related.

However, a camp also provides services to its indwellers. In many cases, there is access to health care, food and shelter. Therefore, one could also consider it a protective factor against violence and against fatal evolution of diseases. One would thus assume that focussing on camps leads to an underestimation of mortality.

Then again, mortality surveys conducted in camps do not necessarily capture camp mortality only. A household that recently arrived in a camp can report a death that occurred prior to the arrival, but still within the recall period. This death wouldn't be a reflection of the mortality level of the camp - as it occurred outside the camp - but it would still be reported within the camp and thus included in the survey-based mortality rates for that camp.

I have tried to account for this selection bias by using the percentage of IDPs in the sample as a covariate in my model and subsequently, when extrapolating the results, by using the share of IDPs as reported in the Darfur Humanitarian Profile to weigh the results, and thus downweighting their importance.

Another constraint is the fact that we couldn't identify any survey that covered the first months of the conflict until September 2003. Other studies however provided some estimates for those months. The US Department of State's report, deemed by the GAO review [42] one of the most reliable studies, estimated mortality for that period between 1,000 and 4,500 deaths [95].

Finally, this analysis only focuses on mortality and deaths in the Darfur region and excludes the refugees living in camps in Chad, who account for 5% of the affected population.

Table 6.1.1 summarizes the different potential errors and biases in my analysis.

6.1.2 The use of quasi-Poisson and negative binomial models to study conflict mortality

The Poisson model and its variants are commonly used in the analysis of count data in fields such as health sciences, biology and ecology [108, 98]. However, it has rarely been used for investigating conflict related deaths, and I could not find a previous study analyzing conflict related mortality rates over time and space, that used this approach.

For all indicators that I've analyzed, the data showed a certain level of overdispersion, and I therefore preferred quasi-Poisson and negative binomial models above the ordinary Poisson model. This overdispersion is probably a consequence of the specific nature of conflict deaths, which is often very heterogeneous. Indeed, mortality rates in an area with heavy fighting, can be very high, while a concomitant survey conducted in an area where fighting was much less, may yield significantly lower mortality rates. I therefore believe that, in general, quasi-Poisson and negative binomial models are more appropriate than ordinary Poisson models in the analysis of conflict deaths.

Type of error	Effect on results	
Random error	results in a large confidence interval and imprecise results	+++
Errors related to the data used		
Selection bias: inaccessible clusters	clusters can be inaccessible due to insecurity and violence, in which case mortality may be underestimated	+
Survival bias: households where everyone died	mortality is underestimated	+
Recall bias: events in the past are misrecalled	if deaths are forgotten, mortality will be underestimated; if former household members are forgotten, the denominator will be underestimated and mortality overestimated	+
Information bias: reported information is inaccurate	mortality can be under- or overestimated	+
Information bias: inaccurate population figures	mortality can be under- or overestimated	++
Errors related to the analysis's methodology		
Selection bias: overrepresentation of IDP settings	mortality can be under- or overestimated, partly corrected by introducing an IDP term in the model	+++
Absence of data prior to September 2003	mortality is underestimated; partly corrected by considering 1,000 to 4,500 deaths for that period (source: US State Dept)	+++
Deaths in Chad are not included	mortality is underestimated	+++

Note: +++ present; ++ probable; + possible

Table 6.1: Overview of potential errors and biases in the analysis

In addition, I also tested the appropriateness of a zero-inflated model for the analysis of violence related deaths [108]. I assumed that violent deaths might have been falsely underreported, which would result in an excess of surveys reporting no violent deaths. The zero-inflated model, however, did not fit the results as well as the negative binomial one. I therefore believe that, although many surveys reported no violent deaths, these zero values should not be seen as a false underreporting of violence related deaths, but on the contrary, they correspond to a true absence of violent kills.

Although the results of the quasi-Poisson and negative binomial models are comparable, some differences can be seen. The Pearson correlation coefficient, which measures the match between two sets of data, was very high when I compared the quasi-Poisson and negative binomial results for CMR, U5MR and violence related mortality rates; it was lower, however, for diarrhea related rates, especially those resulting from the analysis using the basic dataset. This suggest a discrepancy between the results of the quasi-Poisson and negative binomial models. This difference is largely due to a different weighting of the observations [97], which, in this case, is a reflection of an underlying pattern of higher diarrhea related mortality rates in surveys covering shorter periods and smaller sample sizes. For the other indicators, no such pattern could be identified, which explains why there is a good match between the results of the quasi-Poisson and negative binomial models.

6.2 Results of the analysis

6.2.1 Time trend and geographic patterns

The results of my analysis show in the first place an important decrease in mortality since the peak around end 2003-early 2004. This trend matches well previously described general mortality patterns in complex emergencies [67]. After a peak and a sharp decrease in mortality, the conflict typically enters a phase of stabilization. This doesn't imply however that mortality rates are back to normal. My results show that CMRs remained elevated until at least end-2007 and that they probably still were at the end of 2008. However, it is likely that CMR has remained below the emergency level of 1 death per 10,000 people per day since early 2005, with some exceptions however between July 2006 and September 2007.

Nonetheless, the interpretation of the time trend is rendered difficult because of the high level of uncertainty for Period 2. Although all results suggest mortality rates during that period were higher than during any other period of the conflict, this finding is still based on a limited number of surveys that were mainly conducted in IDP settings in West Darfur.

Therefore, as far as the period prior to April 2004 is concerned, little can be concluded for North and South Darfur.

For the other periods, however, state-specific rates can be compared, and this comparison suggests that overall, people in North Darfur were facing lower levels of mortality in comparison to West and South Darfur. Across the different models, this is true for Periods 3 and 5.

As far as this Period 5 is concerned, i.e. the period from July 2006 to September 2007, the results suggest that crude mortality rates in West and South Darfur increased in comparison to Period 4, reaching a level that exceeded the emergency threshold. As described in section 3.2, this period was characterized by a rise in insecurity and banditry which lead to a new wave of displacement; the number of affected people increased from 3.5 million to 4.2 million. At the same time, the humanitarian presence in Darfur, decreased from 14,751 to 12,122, i.e. an eighteen percent reduction. As a result, the ration affected people / humanitarian worker increased from 237 to 346 affected per humanitarian staff, almost a fifty percent increase [84].

I see two explanations for the decrease in humanitarian personnel. First, the above mentioned increase in insecurity meant that more areas became inaccessible, thus directly reducing the need for staff. The second reason is related to a decrease in humanitarian budget allocated to Darfur. In March 2006, UNICEF's representative in Sudan warned that lack of funds could severely affect the humanitarian operations in Darfur [89]. One month later, the World Food Program (WFP) cut the food aid rations by 50% because of funding shortages [104]. By November 2006, 98% of the required 2006 funds for food aid had been pledged, but other sectors still faced major gaps: coverage levels for health, nutrition and water and sanitation were respectively 51%, 45% and 31%. As the humanitarian deployment had decreased throughout 2006, the required budget for 2007 was lower than that of the year before. By July 2007, 85% of needed funds had been covered including 78% of the health and nutrition requirements and 86% of water and sanitation. For 2008, a period with lower mortality rates than 2007, funds were 18% higher than the year before

[91, 92, 93]. As such, the decrease in humanitarian funding would have indirectly triggered an increase in mortality in Darfur.

6.2.2 Causes of death

The findings suggest that over eighty percent of the excess deaths were due to causes other than violence. This is in line with death figures from other conflicts in which initial mortality peaks are often related to a period of intense violence and subsequently high violencerelated deaths, but the main causes of mortality during the stabilization period are due to diseases such as diarrhea [39].

Notwithstanding the limited data available for Period 2, all survey results suggest that violence related mortality rates were significantly higher during 2003 and 2004 in comparison to later years. The almost 25,000 violent deaths calculated for Period 2 using a negative binomial model, represent sixty-four percent of the excess deaths for that period; the results based on the quasi-Poisson model yield an even higher figure, at eighty-eight percent.

However, after April 2004, diarrhea outranked violence as main cause of death, especially in West and South Darfur. Furthermore, the increase in total mortality in West and South Darfur during Period 5, is largely due to an increase in diarrhea related deaths. This means thus, that although insecurity could be considered a driving force in the increase in mortality rates during that period, violence was not the direct cause of this increase. This again supports the hypothesis that it's merely the decreased humanitarian aid due to funding shortages and resulting in more diseaserelated deaths, that explains the rise in mortality between July 2006 to September 2007.

Finally, I point out that, while violence and diarrhea accounted for approximately half of the deaths during Period 3, the two causes combined caused only about thirty percent of the deaths during Period 6. In fact, other, more chronic diseases such as kidney and heart failure, have become increasingly important throughout the course of the conflict, and were often mentioned as cause of death in the more recent mortality surveys.

6.2.3 Child mortality

Trends suggest that under five mortality rates reached a peak during the period from April to December 2004. The months from June to September correspond to the period before the harvest season that is typically known as a period of increased malnutrition, which affects especially young children [26]. This is a general phenomenon seen in many other Sahelian countries. I believe that it is the conjunction of this existing pattern with the effects of the conflict, that has lead to the high level of child mortality observed during the so-called "hunger season" of 2004. At that moment, the humanitarian programs were still in an early phase, and it seems likely that the aid was insufficient to meet the needs of the youngest ones. During later years, the humanitarian deployment reached higher levels of coverage, and no new mortality peak occurred. Nevertheless, in accordance with crude mortality and diarrhea related deaths, the period of decreased humanitarian presence between July 2006 and September 2007, is also characterized by an increase in child mortality, again emphasizing the importance of adequate humanitarian aid.

6.2.4 Effect of displacement

I have identified significant differences between residents and displaced people. Overall, surveys covering populations with large proportions of IDPs have higher mortality rates than those consisting of only non-displaced. However, disaggregated cause-specific mortality rates show a difference between violence related and diarrhea related mortality. The former is in general lower in samples with many displaced, but the latter is significantly higher. This suggests that IDP settings or camps are protected from attacks but on the other hand, overcrowding and precarious conditions in which the displaced live increase the risk of dying from communicable diseases.

Similar findings had already been suggested by the Epicentre survey conducted in Murnei and Zalingei in early 2004 [30]. The survey reported mortality rates that were disaggregated into deaths during the village and flight period, and deaths during the stay in the camp. The results showed that out of the fifty-five deaths outside the camp, forty-six were due to violence. In comparison, out of the forty-five inside the camp, there were only three that were violence related. Comparable patterns were further reported in the WHO 2005 retrospective mortality survey that compared displaced and resident populations.

In brief, this analysis confirms previously observed trends with regard to the differences in mortality patterns between displaced and non displaced in conflicts.

6.2.5 Excess conflict related deaths

I estimate the total number of deaths between September 2003 and December 2008 at approximately half a million, with two to three hundred thousand in excess to the expected level of mortality. In other words, on average, mortality during that period doubled in comparison to peacetime levels.

In recent years, the most widely cited death toll for the conflict is OCHA's estimate of three hundred thousand deaths [48]. This corroborates well with our results, if one assumes a baseline mortality level of 0.3 per 10,000 per day, and I believe this is in line with the previous estimates judged most reliable in the 2006 GAO report. Indeed, my 2005 analysis estimated the number of excess deaths for the period from September 2003 to January 2005 at 120,000 deaths. In this current analysis, excess deaths for Periods 2 and 3, which corresponds to September 2003 to December 2004, were estimated at 102,000 to 108,000. This estimate however does not include deaths during January 2005, nor those in Chadian refugee camps.

Chapter 7

Conclusion

General

When I started this study in 2005, I believed the humanitarian community was too narrowly focusing on the number of killings in Darfur. Very little research was done on mortality trends, risk factors and causes of death. I felt this was an important gap and thought I could address this, using the data of the CE-DAT database, the project I was working on at that moment. I hoped, through my research, to provide evidence on the magnitude, the severity and the preventability of mortality in the Darfur conflict.

There is no doubt that the existence of the CE-DAT project facilitated the collection of research material. Over 100 mortality surveys from Darfur became available in the database during the period of my research. However, the lack of standardization and uniformity in reporting was a barrier in the analysis. Many survey reports, especially the older ones, did not provide enough information to make it practically usable in this study. As a result, I had to exclude one fourth of all available surveys. I think this calls for additional efforts in the development of guidelines and standards on how to report survey results, in addition to the development of standardized field methodologies.

While the analysis progressed, I came up with two clear purposes for my study. First, I wanted to document a new approach in analyzing conflict mortality by aggregating results from small-scale surveys. Most studies on conflict mortality use a limited number of nationwide surveys that often cover long recall periods. I believe a better technique is to use a large number of surveys at higher resolution, and to subsequently apply epidemiological techniques in order to obtain overall results. I see two main reasons for this. First, the availability of a large number of surveys reporting the same results, adds to the credibility of the results. Second, large-scale surveys provide results that are averaged out in time and geographically. As a result, peaks or pockets of high mortality can no longer be identified. By using small-scale surveys, however, a higher resolution of results becomes available.

A second purpose of my thesis was to identify patterns in mortality in Darfur focussing on four factors: spatio-temporal differences, causes of death, children and displacement. The analysis provided insights on each one of these four aspects, but also on their entwinement. Main causes of death, for example, changed over time, but were also different between displaced and non-displaced populations. As mentioned above, this type of findings is less obvious in large, nationwide surveys.

Violence related mortality as severity indicator

My study shows how the vast majority of deaths did not die of violence, a finding that is in line with previous research. As explained in chapter 2, it is a misconception that most of war casualties are a result of killings. In the case of Darfur, for every person who died of violence, four people died of non-violent causes. However, the fact that only twenty percent of the deaths is directly due to violence by no means downscales the severity of the conflict. On the contrary, it confirms how the impact of violence goes far beyond violent deaths. Forced migration, destruction of health services, water and sanitation systems, and collapse of trade are all consequences of the conflict, that are directly related to increases in non-violent mortality. Therefore, I believe it is wrong and even harmful to propagandize the belief that all victims of the Darfur conflict were "killed", as some advocacy groups did. The underlying reason for them doing so, is the belief that higher numbers of violent deaths increase the probability of the conflict being officially recognized as a genocide. However, this is a false supposition, since the definition of genocide does not take the number of deaths into account. [1] As a consequence, I believe that the inflated numbers that were produced by many of these groups were pointless and even counterproductive. In 2006, a group of experts convened by the Government Accountability Office and the National Academy of Sciences, reviewed these studies to assess the quality and reliability of six mortality estimates, including a former version of this analysis [42]. Although none of the estimates was consistently rated to be accurate, in general, the experts had confidence in the studies in which few deaths were reported [2]. Unfortunately, the publication of these findings gave the false impression that the severity of the conflict had been inflated between 2004 and 2006.

I believe a crucial point is that violent mortality is not a good indicator for the intensity of a conflict. It only represents the tip of the iceberg. Many equally detrimental aspects such as fatal infectious diseases, rape and forced displacement, are not covered by this indicator, but nonetheless contribute directly to the severity of a complex emergency.

Humanitarian aid in complex emergencies

Since the beginning of humanitarian operations in 2004, around 200,000 Darfurians have died, often in camps and mainly due to diseases. Does this mean that humanitarian assistance in Darfur was ineffective? I don't think so. In order to answer this question in a truly scientific way, one should design an exposed-unexposed study, in which one cohort of affected people would receive assistance and another not. Clearly, this would never pass any decent ethical board. However, an alternative approach would be to compare periods of adequate assistance, to periods with limited aid. This is precisely what I tried to achieve by comparing results for Period 5 in my analysis, to Periods 4 and 6. The findings do show that mortality, especially due to non-violence related causes, increased during that period. I see in this a strong argument in favor of adequate humanitarian aid. This, however, can only be achieved if enough resources are made available and, as importantly, access

[1] In fact, intentionally sterilizing an entire population can be considered a form of genocide, even though no one is killed.

[2] The review concluded that CRED's analysis was the most reliable and based on the most sound methodology.

to the affected population is ensured. I believe the latter formed the major problem in the Darfur conflict. At the end of 2008, about one third of the affected population lived in areas that were labeled as "no-go" by the UN. Several NGOs did provide assistance in those areas, but the insecurity made it an extremely difficult endeavor. Governments from donor countries provide large amounts of humanitarian funding for crises like Darfur, but unless this goes in pair with diplomatic efforts to ensure full access to affected populations, the effectiveness of humanitarian funding will remain suboptimal.

Meta-analytical analyses to estimate conflict mortality

Following this study, I believe that the further development and improvement of "meta-analytical" techniques to aggregate small-scale mortality surveys, is a research topic that could result in a new way of assessing mortality levels and patterns in conflict settings. Although the gold standard in data collection systems is often considered to be surveillance, I think that a reliable and comprehensive surveillance system is hard to achieve in a humanitarian context. The case of Darfur has shown how fluctuating access to affected populations can be, and it seems unreasonable for many of those areas, to expect a continuous data reporting. As a consequence, data would only be collected routinely from areas that are safe havens, but are unlikely to be representative of the bigger conflict area. In contrast, retrospective surveys can include periods in the past, when an area was inaccessible to the humanitarian community. As such, I would argue that retrospective mortality surveys might provide a more complete picture of the conflict, including areas that were sporadically inaccessible.

Is the approach I've used in this study applicable to other conflict settings? The major requirement of this approach, is the availability of a large number of survey reports. In that perspective, Darfur is different from a situation like, for instance, Iraq. Compared to Darfur, there were twenty times less surveys conducted in Iraq during the period 2003-2007. NGOs who were present in Iraq, did not conduct mortality surveys during the conflict. As a consequence, a study similar to the one I've performed on Darfur, is currently impossible for the Iraq context. For other conflicts like DRC or Angola, major phases of the conflict were already over by the time much data became available. Therefore, I believe that for those countries, the approach I describe could be useful, but only to assess mortality in the post-war phase.

In order to ensure the availability of enough survey data, continuous efforts must be made to train field staff working in conflict situations. In that context, the work done within the Sphere project and the SMART initiative, aiming at providing guidance and standards to humanitarian workers, is invaluable. Although the quality of NGO surveys has been criticized in the past, it has improved greatly over the last decade. However, the high turnover within these organizations is a major problem. Acquiring adequate epidemiological skills requires time, which is in contrast to the typically short careers of NGO staff. Therefore, I believe that a long-term capacity building program regrouping NGO professionals and epidemiological researchers is essential to the maintain a flow of reliable survey data from the field to the policy-makers.

Final Thoughts

To end this dissertation, it might be appropriate to reiterate the two following questions: "Does all this matter?" and "What does it mean?". Personally, I am convinced that the analysis of conflict mortality is important and does matter. It provides us with basic evidence and understanding of dynamics of the conflict, which allows us to better target our health interventions in such contexts. From that perspective, however, I think the exact number of deaths is of subordinate importance. This analysis shows how changing baseline mortality rates and statistical techniques, results in excess death tolls increasing from 200,000 to 300,000. If the confidence intervals are taken into account, the range of possible casualties goes from 100,000 to 500,000, not even including potential biases.

In other words, we don't really know, at least not without a high degree of uncertainty, how many people have died in Darfur. On the other hand, the effect of time, location and displacement, as well as the relations between the different types of mortality rates, remained, in general, the same across different datasets and statistical techniques. As a consequence, I think it is fair to say that we know the dynamics leading to mortality better than we know the exact number of deaths.

Unfortunately, it is the excess death tolls that have been at the centre of the discussion around mortality in Darfur, much in the same way as it has been for Iraq and DRC. The wider public is typically more interested in sensational numbers and statistics, rather than in understanding the complexities of factors leading to someone's death. I am afraid that these - often unproductive - debates, may have a deleterious effect on the analysis of mortality pattern in general. I therefore believe conflict epidemiologists have an important duty in raising awareness amongst the wider public on the importance of the *"WHY"* and *"HOW"*, instead of the *"HOW MANY"*.

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Annex 1

The following pages provide an overview of the surveys that were used in this analysis. The metadata includes:

Organization The organization(s) that carried out or were involved in the survey.

Title The title of the report in which the data was made available.

Survey area The area covered by the survey. **ND**, **SD**, **WD** stand for North, South and West Darfur state respectively. *loc* stands for "locality", ie. the administrative unit below the state. *rur counc* stands "rural council", ie the administrative unit below the locality.

Date The month in which the survey was conducted.

Recall period The length of the recall period in days.

SS The sample size, ie. the number of individuals included in the sample.

U5 The percentage of children aged less than 5 in the sample.

IDP The percentage of Internally Displaced People in the sample. Hundred percent typically reflects an IDP camp.

CMR Crude Mortality Rate

U5MR Under 5 Mortality Rate

Viol The percentage of deaths attributed to violence.

Diar The percentage of deaths attributed to diarrhea.

Surveys included in the analysis

Organization	Title	Survey area	Date	Recall period	SS	U5	IDP	CMR	U5MR	Viol	Diar
Epicentre, MSF	Health Assessment in Emergencies Murnei and Zalingei, West Darfur, Sudan	**WD**, *loc:* Zalingei, *city:* Zalingei, *camp:* Zalingei	Apr 2004	183	2386	20	100	2.2	1.8	46	-
MSF-H	Food and Nutrition Survey - Wade Saleh and Mukjar Provinces (West Darfur - North Sudan) - April 2004	**WD**, *loc:* Wade Saleh **WD**, *loc:* Mukjar	Apr 2004	92	5464	17	75	3.64	5.23	47	22
Epicentre, MSF	Health Assessment in Emergencies Murnei and Zalingei, West Darfur, Sudan	**WD**, *loc:* El Geneina, *city:* Murnei, *camp:* Murnei	May 2004	193	4754	22	100	3.4	1.6	74	-
Epicentre, MSF	A survey of internally displaced persons in El Geneina, Western Darfur	**WD**, *loc:* El Geneina, *city:* El Geneina	Jun 2004	39	5191	18	100	5.6	14.1	10	36
ACF-int	Summary Report - Nutritional anthropometric survey, children under 5 years old - Abu Shok camp, El Fasher, North Darfur State, SUDAN - 7th to 11th of June 2004	**ND**, *loc:* El Fasher, *camp:* Abu Shok	Jun 2004	30	5280	22	100	2.15	6.76	0	29
MSF, Epicentre	Violence and Mortality in West Darfur, Sudan: epidemiological evidence from four surveys	**WD**, *loc:* Jebel Marra, *rur counc:* Niertiti, *city:* Niertiti	Jun 2004	145	5188	20	73	1.5	2.1	26	-
MSF, Epicentre	Health Assessment in emergencies - Kebkabyia, North Darfur, Sudan - August 2004	**ND**, *loc:* Kabkabiya, *city:* Kabkabiya	Aug 2004	36	4989	21	76	1.2	2.9	14	24
Epicentre, MSF	Mortality and Malnutrition Among Populations Living in South Darfur, Sudan: Results of 3 Surveys, September 2004	**SD**, *loc:* Kass, *city:* Kass	Aug 2004	121	5576	22	63	3.2	5.9	18	25
World Relief, CIEDRS	Report of rapid baseline survey Azirni, Sanidadi and Um Tagouk - September 2004	**WD**, *loc:* El Geneina, *city:* Azirni **WD**, *loc:* El Geneina, *city:* Sanidadi **WD**, *loc:* El Geneina, *city:* Um Tagouk	Sep 2004	365	2475	30	45	0.27	0.25	35	-
WHO, Epiet	Retrospective Mortality Survey among the IDP, Greater Darfur, Sudan August 2004	**ND**	Sep 2004	61	8854	16	100	1.5	2.5	21	24
WHO, Epiet	Retrospective Mortality Survey among the IDP, Greater Darfur, Sudan August 2004	**WD**	Sep 2004	61	7659	17	100	2.9	3.1	12	37
WHO, Epiet	Retrospective Mortality Survey among the IDP, Greater Darfur, Sudan August 2004	**SD**, *loc:* Nyala, *camp:* Kalma	Sep 2004	61	3267	17	100	3.8	11.7	10	42
MSF, Epicentre	Mortality and Malnutrition Among Populations Living in South Darfur, Sudan: Results of 3 Surveys, September 2004	**SD**, *loc:* Shareia, *city:* Muhajiria	Sep 2004	30	5256	26	48	2.3	1	72	47
MSF, Epicentre	Mortality and Malnutrition Among Populations Living in South Darfur, Sudan: Results of 3 Surveys, September 2004	**SD**, *loc:* Nyala, *camp:* Kalma	Sep 2004	30	5050	24	100	2	3.5	7	14
Epicentre, MSF-B	Health Assessment. Serif Umra, North Darfur November 2004	**ND**, *loc:* Kabkabiya, *city:* Saraf Omra	Oct 2004	59	5683	20	59	0.8	1.8	4	35
IRC	Nutrition, Vaccination Coverage and Retrospective Mortality Survey Nyala, Otash IDP Camp	**SD**, *loc:* Nyala, *camp:* Otash	Oct 2004	122	2657	20	100	1.51	2.35	10	18
GOAL	Findings of a Nutrition Survey - Kutum Tow, Kassab IDP Camp and Fato Borno IDP Camp, Kutum Province, North Darfur State, Sudan - 16-23rd October 2004	**ND**, *loc:* Kutum, *city:* Kutum **ND**, *loc:* Kutum, *camp:* Fata Borna **ND**, *loc:* Kutum, *camp:* Kasab	Oct 2004	90	5521	22	88	1.01	1.48	21	26
ACF-int	Nutritional Anthropometric Survey children under 5 years old	**ND**, *loc:* El Fasher, *camp:* Abu Shok	Nov 2004	30	5564	25	100	1.49	2.67	36	16
SC-US	Nutrition Assessment Fur Baranga Administrative Unit, Habila Locality, West Darfur, Sudan - January 2005	**WD**, *loc:* Habillah, *rur counc:* Fur Baranga	Jan 2005	93	3256	22	25	0.89	1.8	-	15
ACF-int	Nutritional Anthropometric Survey, Children Under 5 Years Old, Final Report, Gereida Camp, South Darfur State. Sudan - January 2005	**SD**, *loc:* Buram, *rur counc:* Gereida, *camp:* Gereida	Jan 2005	30	4827	30	100	1.8	4.17	11	33
Concern, MoH Sudan	Report of a nutrition survey in Seleia and Kulbus Administrative Units, West Darfur Sudan, January 2005	**WD**, *loc:* Seleia **WD**, *loc:* Kulbus	Jan 2005	88	5421	19	20	0.63	0.98	7	17
Concern, UNICEF, MoH Sudan	Nutritional Survey, Mornei Camp, February 2005, West Darfur, Sudan	**WD**, *loc:* El Geneina, *city:* Murnei, *camp:* Murnei	Feb 2005	106	6816	19	96	0.8	1.16	14	-

UNICEF, ACF-int, WFP	Nutrition and Food Security survey among IDPs and affected residents in El Fasher town and its attachment area	**ND**, *loc:* El Fasher, *city:* El Fasher	Mar 2005	90	5444	20	15	0.3	0.6	-	-
MSF-B, Epi-centre	Rapid Health Assessment in Korma area, North Darfur, Sudan - Final Report - April 2005	**ND**, *loc:* Kutum, *rur counc:* Korma	Apr 2005	73	4982	21	8	1.3	2.2	9	39
GOAL	Findings Of A Nutrition Survey Of Kutum Town, Kasab Camp And Fata Borno, North Darfur - 13th-20th May 2005	**ND**, *loc:* Kutum, *city:* Kutum **ND**, *loc:* Kutum, *camp:* Fata Borna **ND**, *loc:* Kutum, *city:* Fata Borna **ND**, *loc:* Kutum, *camp:* Kasab	May 2005	77	5339	21	74	0.32	0.71	8	15
ACF-int	Preliminary Results Nutrition Anthropometric Survey Children under 5 years old, Kebkabiya, North Darfur State, Sudan	**ND**, *loc:* Kabkabiya, *city:* Kabkabiya	May 2005	90	5231	23	71	0.66	1.19	0	23
ACF-int	Nutrition Anthropometric survey children under 5 years old in Abu Shok Camp - Preliminary Report	**ND**, *loc:* El Fasher, *camp:* Abu Shok	Jun 2005	90	5525	19	100	0.6	1.95	0	47
MoH Sudan, UNICEF, Concern, SC-US	Nutrition and Mortality Survey in Ardamat, Dorti, Riyad and Abu-Zar IDP Camps, West Darfur, Sudan. 14-18 June 2005.	**WD**, *loc:* El Geneina, *camp:* Ardamat **WD**, *loc:* El Geneina, *camp:* Dorti **WD**, *loc:* El Geneina, *camp:* Riyad **WD**, *loc:* El Geneina, *camp:* Abu-Zar	Jun 2005	90	3022	32	100	0.53	0.23	0	18
WHO, MoH Sudan	Mortality survey among Internally Displaced Persons and other affected populations in Greater Darfur, Sudan	**ND**	Jun 2005	202	3961	15	100	0.8	1.5	9	30
WHO, MoH Sudan	Mortality survey among Internally Displaced Persons and other affected populations in Greater Darfur, Sudan	**WD**	Jun 2005	206	3597	16	100	0.8	1	11	47
WHO, MoH Sudan	Mortality survey among Internally Displaced Persons and other affected populations in Greater Darfur, Sudan	**SD**	Jun 2005	204	3188	18	100	0.8	2.6	14	25
WHO, MoH Sudan	Mortality survey among Internally Displaced Persons and other affected populations in Greater Darfur, Sudan	**ND**	Jun 2005	202	3570	16	100	0.9	1.8	34	12
WHO, MoH Sudan	Mortality survey among Internally Displaced Persons and other affected populations in Greater Darfur, Sudan	**WD**	Jun 2005	206	3120	16	100	0.5	0.8	0	61
WHO, MoH Sudan	Mortality survey among Internally Displaced Persons and other affected populations in Greater Darfur, Sudan	**ND**	Jun 2005	202	5024	16	0	0.8	1.1	55	14
WHO, MoH Sudan	Mortality survey among Internally Displaced Persons and other affected populations in Greater Darfur, Sudan	**WD**	Jun 2005	206	3815	16	0	0.4	0.7	6	29
Concern, MoH Sudan	Report of a Nutrition Survey in Seleila and Kulbus Administrative Units, West Darfur, Sudan, July 2005	**WD**, *loc:* Seleia **WD**, *loc:* Kulbus	Jul 2005	101	5063	23	20	0.56	1.03	0	38
ACT, Caritas, NCA	Nutritional surveys in Zalingei IDP Camps and Town - Preliminary results - July/August 2005	**WD**, *loc:* Zalingei, *city:* Zalingei	Aug 2005	90	5595	18	0	0.6	1.6	0	41
ACF-int	Final Report - Nutritional Anthropometric and Mortality Survey, Kalma IDPs Camp, South Darfur State, Sudan - 16th to 22nd of August 2005	**SD**, *loc:* Nyala, *camp:* Kalma	Aug 2005	90	4860	25	100	0.89	0.9	0	31
ACF-int	Nutrition Anthropometric Survey Summary Report, Nyala Town, South Darfur State, Sudan	**SD**, *loc:* Nyala, *city:* Nyala	Sep 2005	90	5249	22	18	0.36	0.75	0	35
SC-US	Report of Nutrition and Mortality in Fur Baranga and Habila Administrative Unit, Habila Locality, West Darfur State, Sudan	**WD**, *loc:* Habillah, *rur counc:* Fur Baranga	Oct 2005	164	4020	29	22	0.54	0.81	3	17
SC-US	Report of Nutrition and Mortality in Fur Baranga and Habila Administrative Unit, Habila Locality, West Darfur State, Sudan	**WD**, *loc:* Habillah, *rur counc:* Habilah	Oct 2005	170	3857	25	41	0.17	0.38	9	36
Concern	Nutrition Survey in El Geneina City and Camp, West Darfur, Sudan, October 2005	**WD**, *loc:* El Geneina, *city:* El Geneina **WD**, *camp:* Geneina	Oct 2005	80	7209	19	50	1.14	0.55	5	13
WFP, UNICEF, CDC, FAO	Emergency food security and nutrition assessment in Darfur, Sudan 2005. Final report. March 2006.	**ND**	Oct 2005	242	5111	18	36	0.46	-	17	19
WFP, UNICEF, CDC, FAO	Emergency food security and nutrition assessment in Darfur, Sudan 2005. Final report. March 2006.	**SD**	Oct 2005	242	3948	16	62	0.4	-	17	19

WFP, UNICEF, CDC, FAO	Emergency food security and nutrition assessment in Darfur, Sudan 2005. Final report. March 2006.	**WD**	Oct 2005	242	4013	16	70	0.57	-	17	19
ACF-int	Preliminary Results Report Nutritional Anthropometric and Retrospective Mortality Survey Children Aged 6 to 59 months, Abu Shok and As Salaam IDPs camps	**ND**, *loc:* El Fasher, *camp:* Abu Shok **ND**, *loc:* El Fasher, *camp:* As Salam	Nov 2005	92	5734	19	100	0.49	1.46	0	35
ACF-int	Nutrition Anthropometric Survey Summary Report, Sanya Afendu and surrounding villages, South Darfur	**SD**, *rur counc:* Sanya Afendu	Nov 2005	90	5258	23	73	0.27	0.46	0	15
Tearfund, Sudan Social Development Organization (SUDO)	Nutrition Survey, IDP population in Abu Matariq, El Firdous, El Neem and Khor Omer, El Daein locality, Sudan	**SD**, *loc:* Ed Daein, *camp:* Abu Matariq **SD**, *loc:* Ed Daein, *camp:* El Firdous **SD**, *loc:* Ed Daein, *camp:* El Neem **SD**, *loc:* Ed Daein, *camp:* Khor Omer	Dec 2005	122	4317	26	100	0.36	1.01	0	21
ACF-int	Nutritional Anthropometric and Retrospective Mortality Survey, Children aged 6 to 59 months, Mellit Town and IDP camp, North Darfur State, Sudan	**ND**, *loc:* Mellit, *city:* Mellit **ND**, *loc:* Mellit, *camp:* Hay Abassy	Jan 2006	92	5426	18	20	0.76	2.06	8	18
ACF-int	Nutritional anthropometric and retrospective mortality survey, Children 6 to 59 months, Kalma IDP Camp, South Darfur State - Sudan - 12-22 February 2006	**SD**, *loc:* Nyala, *camp:* Kalma	Feb 2006	92	4518	24	100	0.89	1.31	0	41
ACF-int	Nutritional anthropometric and retrospective mortality survey, Children aged 6-59 months, Nyala Town and IDP camps, South Darfur State - Sudan	**SD**, *loc:* Nyala, *city:* Nyala **SD**, *loc:* Nyala, *camp:* Otash **SD**, *loc:* Nyala, *camp:* Dereig **SD**, *loc:* Nyala, *camp:* Mosey	Mar 2006	90	5839	19	14	0.7	1	5	13
ACF-int	Nutritional anthropometric and retrospective mortality survey, Children aged 6 to 59 months, Kebkabiya Town, North Darfur State - Sudan.	**ND**, *loc:* Kabkabiya, *city:* Kabkabiya	May 2006	90	5187	22	69	0.66	0.97	6	26
SC-US	Nutritional Anthropometric Survey Sirba Administrative Unit, Kulbus Locality, West Darfur	**WD**, *loc:* Kulbus, *city:* Sirba	Jun 2006	93	4141	24	39	0.67	0.97	15	19
ACF-int	Nutritional anthropometric and retrospective mortality survey, Children aged 6 to 59 months, Abu Shok and As Salaam IDP camps, North Darfur State - Sudan	**ND**, *loc:* El Fasher, *camp:* Abu Shok **ND**, *loc:* El Fasher, *camp:* As Salam	Jun 2006	90	5143	21	100	0.52	1.1	0	29
Concern	Findings of a Nutrition Assessment of Umshaleya, West Darfur.	**WD**, *loc:* Umshaleya	Jun 2006	98	4486	24	11	0.89	2.09	3	23
ACF-int	Final Results Report Nutritional anthropometric and restrospective mortality survey, Children aged 6-59 months: Dar As Salaam, Alowna, Saq Alnaam, Abu Delek, Ed al Beida and Wad Kota rural, North Darfur State - Sudan	**ND**, *loc:* El Fasher, *city:* Dar Es Salaam **ND**, *loc:* El Fasher, *city:* Alowna **ND**, *loc:* El Fasher, *city:* Saq Alnaam **ND**, *loc:* El Fasher, *city:* Abu Delek **ND**, *loc:* El Fasher, *city:* Ed al Beida **ND**, *loc:* El Fasher, *city:* Wad Kota rural	Aug 2006	91	5687	20	0	0.5	1.6	11	32
ACF-int	Preliminary Results Report. Nutritional anthropometric and retrospective mortality surveys, Children aged 6 to 59 months, Nyala Town and IDP Camps, South Darfur State - Sudan.	**SD**, *loc:* Nyala, *city:* Nyala **SD**, *loc:* Nyala, *camp:* Otash **SD**, *loc:* Nyala, *camp:* Dereig **SD**, *loc:* Nyala, *camp:* Mosey **SD**, *loc:* Nyala, *camp:* Sakaly	Oct 2006	94	6034	19	15	0.8	1.6	0	20
ACF-int	Preliminary Results. Nutritional anthropometric and retrospective mortality survey. Children 6 to 59 months. Kakkabiya Town. North Darfur State - Sudan.	**ND**, *loc:* Kabkabiya, *city:* Kabkabiya	Oct 2006	81	5862	21	69	0.69	1.21	6	27
ACF-int	Preliminary Results Report. Nutritional anthropometric and retrospective mortality survey. Children aged 6 to 59 months. Kalma IDP camp, South Darfur State-Sudan.	**SD**, *loc:* Nyala, *camp:* Kalma	Oct 2006	112	5349	24	100	1.2	2.2	7	32
ACF-int	Preliminary results: Nutritional anthropometric and retrospective mortality survey, Otash Camp, Nyala, South Darfur, Sudan	**SD**, *loc:* Nyala, *camp:* Otash	Dec 2006	97	5358	24	100	1.98	2.58	0	41

ACF-int	Nutritional Anthropometric and retrospective mortality survey, Nyala town and surrounding IDP camps, South Darfur State, Sudan, April 2007	**SD**, *loc:* Nyala, *city:* Nyala	Apr 2007	104	5906	19	20	1.05	2.4	12	15
ACF-int	Preliminary Report, Nutritional Anthropometric and retrospective Mortality Survey, Al Salam IDP camp, South Darfur State, Sudan, May 2007	**SD**, *loc:* Nyala, *camp:* Al Salam	May 2007	97	4386	23	100	0.87	1.6	-	-
ACF-int	Final Report - Nutritional Anthropometric and Retrospective Mortality Surveys, Children Aged 6 to 59 Months - Otash IDP Camp, South Darfur State, Sudan - 19-24th of May 2007	**SD**, *loc:* Nyala, *camp:* Otash	May 2007	93	5671	20	100	1.19	2.38	2	48
ACF-int	Preliminary Report, Nutritional Anthropometric and Retrospective Mortality Survey, Kebkabiya Town, North Darfur State, Sudan, June 2007	**ND**, *loc:* Kabkabiya, *city:* Kabkabiya	Jun 2007	99	5491	20	70	0.51	1.28	0	39
ACF-int	Nutritional anthropometric and retrospective mortality survey, preliminary results Kass Town, South Darfur State, Sudan, June 2007	**SD**, *loc:* Kass, *city:* Kass	Jun 2007	83	5790	20	85	2.12	4.42	-	-
ACF-int	Final Report: Nutritional Anthropometric and Retrospective Mortality Survey, Children aged 6 to 59 Months - Abu Shock and As Salaam IDP Camps, North Darfur State, Sudan - 23-28 June 2007	**ND**, *loc:* El Fasher, *camp:* Abu Shok **ND**, *loc:* El Fasher, *camp:* As Salam	Jun 2007	85	5634	20	100	0.65	1.15	6	23
Tearfund, UNICEF, MoH, ECHO	Preliminary nutrition survey result conducted in Adilla locality. 10th-19th June 2007.	**SD**, *loc:* Adayla	Jun 2007	90	4654	25	26	0.55	1.33	-	-
Tearfund, Cordaid, UNICEF, ECHO, MoH, World Relief	Preliminary nutrition survey report conducted in: Abumatariq, El Ferdous, El Neem and Khor Omer IDP camps in Ed Daein and Abu Matariq Locality. 26th June- 2nd July 2007.	**SD**, *loc:* Ed Daein, *camp:* Abu Matariq **SD**, *loc:* Ed Daein, *camp:* El Firdous **SD**, *loc:* Ed Daein, *camp:* El Neem **SD**, *loc:* Ed Daein, *camp:* Khor Omer	Jul 2007	90	4266	30	99	0.62	1.12	-	-
ACF-int	Preliminary Results - Nutritional Anthropometric and Retrospective Mortality Survey, Children Aged 6 to 59 Months - Kass Town, South Darfur State, Sudan - 30th June to 7th July 2008	**SD**, *loc:* Kass, *city:* Kass	Jul 2007	110	6039	19	79	0.75	2.19	-	-
ACF-int	Final Report - Nutritional Anthropometric and Retrospective Mortality Survey, Children Aged 6 to 59 Months - Abu Shok and As Salaam IDP Camps	**ND**, *loc:* El Fasher, *camp:* Abu Shok **ND**, *loc:* El Fasher, *camp:* As Salam	Nov 2007	85	5731	20	100	0.45	0.6	0	32
Tearfund, Cordaid, UNICEF, MoH, World Relief, ECHO	Draft Preliminary nutrition survey report conducted in: Abumatariq, El Ferdous, El Neem and Khor Omer IDP camps in Ed Daein and Baher El Arab Locality.	**SD**, *loc:* Ed Daein, *camp:* Abu Matariq **SD**, *loc:* Ed Daein, *camp:* El Firdous **SD**, *loc:* Ed Daein, *camp:* El Neem **SD**, *loc:* Ed Daein, *camp:* Khor Omer	Dec 2007	90	3804	27	97	0.55	1.27	-	-
ACF-int	Final Report - Nutritional Anthropometric and Retrospective Mortality Surveys, Children aged 6 to 59 Months - Kaguro, Borey and Surrounding Villages, Jebel Si, North Darfur State, Sudan - 27 November to 5 December 2007	**ND**, *loc:* Kebkabiya, *rur counc:* Jebel Si, *city:* Kaguro **ND**, *loc:* Kebkabiya, *rur counc:* Jebel Si, *city:* Borey	Dec 2007	108	4143	27	34	0.4	1.08	0	44
GOAL	Multi-Indicators Clusters Survey Report - Kutum Locality, North Darfur State, North Sudan (Kutum Town, Fata Borno and Kassab camps) - 31st December 2007 - 9th January 2008	**ND**, *loc:* Kutum, *city:* Kutum **ND**, *loc:* Kutum, *camp:* Fata Borna **ND**, *loc:* Kutum, *camp:* Kasab	Jan 2008	90	2347	21	66	0.28	1.13	-	-
ACF-int	Final Report - Nutritional Anthropometric and Retrospective Mortality Surveys, Children Aged 6 to 59 Months - Kalma IDP Camp, South Darfur State, Sudan - 9-16th of March 2008	**SD**, *loc:* Nyala, *camp:* Kalma	Mar 2008	82	5559	21	100	0.6	1.16	4	4
ACF-int	Final report Results - Nutritional Anthropometric and Retrospective Mortality Survey, Children Aged 6 to 59 Months - Kebkabiya Town, North Darfur State, Sudan - 2-7 June 2008	**ND**, *loc:* Kabkabiya, *city:* Kabkabiya	Jun 2008	77	5772	20	72	0.6	0.9	4	53
ACF-int	Final Report - Nutritional Anthropometric and Retrospective Mortality Survey, Children Aged 6 to 59 Months - Abushock and As Salaam IDP Camps, North Darfur State, Sudan - 24-29 June 2008	**ND**, *loc:* El Fasher, *camp:* Abu Shok **ND**, *loc:* El Fasher, *camp:* As Salam	Jun 2008	100	5665	21	100	0.34	0.75	0	19

ACF-int	Final Report - Nutritional Anthropometric and Retrospective Mortality Surveys, Children Aged 6 to 59 Months - Al Salam IDP Camp, South Darfur State, Sudan - 21st May to 09th June 2008	**SD**, *loc:* Nyala, *camp:* Al Salam	Jun 2008	118	5434	24	100	0.75	1.3	0	17
ACF-int	Final Report - Nutritional Anthropometric and Retrospective Mortality Surveys, Children Aged 6 to 59 Months - Otash IDP Camp, South Darfur State, Sudan - 12-24 June 2008	**SD**, *loc:* Nyala, *camp:* Otash	Jun 2008	96	5676	22	100	0.72	1.33	0	20
HAC, MoH, IMC	Nutrition Survey Report - Um Dukhun, West Darfur - 17th-21st June 2008	**WD**, *loc:* Mukjar, *rur counc:* Um Dukhun	Jun 2008	90	4925	23	29	0.27	0.6	0	17
ICRC	Sudan - Gereida: Nutritional Anthropometric Survey, Children 6 to 59 Months Old - 18 September 2008	**SD**, *loc:* Buram, *rur counc:* Gereida, *camp:* Gereida	Aug 2008	90	5283	20	100	0.5	1.3	8	38

Surveys excluded from the analysis

Organization	Title	Survey area	Date	Recall period	SS	U5	IDP	CMR	U5MR	Viol	Diar
Concern	Nutrition Survey in El Geneima Town and Camps, West Darfur, Sudan - August 2008	**WD**, *loc:* El Geneina, *city:* El Geneina **WD**, *camp:* Geneina	Aug 2008	90	5387	21	53	0.5	0.69	0	12
SC-UK	Nutrition survey report EL Fasher and Umm Keddada local councils north Darfur September 2003	**ND**, *loc:* El Fasher, *city:* El Fasher	Sep 2003	90	-	-	0	-	0.97	-	-
SC-UK	Nutrition survey report EL Fasher and Umm Keddada local councils north Darfur September 2003	**ND**, *city:* Um Kedada	Sep 2003	90	-	-	0	-	1.76	-	-
SC-UK	Nutrition survey report pastoral (Malha) and Tombac (Tawila/Korma) Food Economy zone - North Darfur - october-nov 2003	**ND**, *loc:* Mellit, *city:* Al Malha	Nov 2003	90	-	-	0	-	2.5	-	-
SC-UK	Nutrition survey report pastoral (Malha) and Tombac (Tawila/Korma) Food Economy zone - North Darfur - october-nov 2003	**ND**, *loc:* Kutum, *rur counc:* Korma **ND**, *loc:* Tawilla	Nov 2003	90	-	-	0	-	1.76	-	-
SC-UK	Umm Barro - Nutrition Survey Report - November-December 2003	**ND**, *city:* Umm Barro	Dec 2003	90	-	-	0	-	1.36	-	-
SC-UK	Kutum-Nutriton Survey Report	**ND**, *loc:* Kutum, *city:* Kutum	Mar 2004	90	-	-	84	-	2.05	-	-
SC-UK	Save the children UK- Malha (pastoral area) Nutrition Survey Report - May-June 2004	**ND**, *loc:* Mellit, *city:* Al Malha	May 2004	90	-	-	0	-	1	-	-
WHO	Darfur Crisis, Progress Report, 30 May 2004	**SD**, *loc:* Nyala, *camp:* Kalma	May 2004	-	-	-	100	1.85	-	-	-
Epicentre, MSF	NICS 4, November 2004	**WD**, *loc:* Habillah, *city:* Habilah	Aug 2004	61	-	-	69	2.6	6.7	-	-
MSF-H	Nutrition and Health Assessment - Kalma Camp, South Darfur State, Sudan - Final - 29/1-2/2/2005	**SD**, *loc:* Nyala, *camp:* Kalma	Feb 2005	122	-	-	-	0.94	1.52	-	-
ACF-int	Nutrition Anthropometric Survey Children under 5 years old, Nyala Town, South Darfur State, Sudan	**SD**, *loc:* Nyala, *city:* Nyala	Feb 2005	90	5403	22	-	0.26	0.65	0	8
GOAL	Preliminary Findings of a Nutrition Survey - Jebel Mara, West Darfur - 2nd-14th March 2005	**WD**, *loc:* Jebel Marra, *rur counc:* Golo **WD**, *loc:* Jebel Marra, *rur counc:* Rokoro **WD**, *loc:* Jebel Marra, *rur counc:* Galado	Mar 2005	90	5104	20	-	1.12	3.22	14	22
NCA, Caritas, ACT	Nutritional surveys in Zalingei IDP camps and town - Preliminary results - July/August 2005	**WD**, *loc:* El Geneina, *city:* Murnei, *camp:* Hassa Hissa **WD**, *loc:* El Geneina, *city:* Murnei, *camp:* Hamidya **WD**, *loc:* El Geneina, *city:* Murnei, *camp:* Kamsa Dagaic	Jul 2005	90	-	-	100	0.87	1.07	0	71
ACF-int	Preliminary Results Report Nutritional Anthropometric and Retrospective Mortality Survey Children from 6 to 59 months of age, Kebkabiya, North Darfur State, Sudan	**ND**, *loc:* Kabkabiya, *city:* Kabkabiya	Oct 2005	90	5650	20	-	0.73	1.71	0	25
GOAL	NICS 8, January 2006	**WD**, *loc:* Jebel Marra, *rur counc:* Golo **WD**, *loc:* Jebel Marra, *rur counc:* Rokoro **WD**, *loc:* Jebel Marra, *rur counc:* Galado	Oct 2005	91	-	-	-	1.79	2.32	-	-
GOAL	NICS 9, May 2006.	**ND**, *loc:* Kutum	Nov 2005	-	-	-	-	0.75	0.67	-	-

MSF-S	NICS 9, May 2006.	**ND**, *loc:* El Fasher, *camp:* Zamzam	Nov 2005	-	-	-	100	1.7	2	-	-
MSF-S	NICS 9, May 2006.	**ND**, *loc:* El Fasher, *camp:* Shadad **ND**, *loc:* El Fasher, *camp:* Shanguil Tobaya	Dec 2005	-	-	-	100	1.9	1.7	-	-
MSF-B	Health Assessment Surveys - Serif Umra, North Darfur, Sudan - May 2006	**ND**, *loc:* Kabkabiya, *city:* Saraf Omra	May 2006	61	-	-	-	1.3	0.9	-	-
Tearfund	Preliminary Report. Nutrition Survey. Beida Locality. May-June 2006.	**WD**, *loc:* Habillah, *city:* Ararah **WD**, *loc:* Habillah, *city:* Mesteri **WD**, *loc:* Beida, *city:* Beida **WD**, *loc:* Beida, *city:* Kongo Haraza	Jun 2006	91	-	-	-	0.54	0.7	-	-
Tearfund	Preliminary report, Nutrition survey: Ed Daein Locality, february 2007	**SD**, *loc:* Ed Daein, *camp:* Abu Matariq **SD**, *loc:* Ed Daein, *camp:* El Firdous **SD**, *loc:* Ed Daein, *camp:* El Neem **SD**, *loc:* Ed Daein, *camp:* Khor Omer	Feb 2007	-	-	-	100	0.17	0.42	-	-
Concern	Mornei Internally Displaced Persons Camp, West Darfur, Sudan - July 2008	**WD**, *loc:* El Geneina, *city:* Murnei, *camp:* Murnei	Jul 2007	90	-	-	100	0.33	0.74	0	-
FAO, UNICEF, WFP, CDC, MoH, MoA	Food Security and Nutrition Assessment of the conflict-affected population in Darfur, Sudan - Final Report - 2007	**ND**	Sep 2007	248	-	-	34	0.22	0.61	-	-
FAO, UNICEF, WFP, CDC, MoH, MoA	Food Security and Nutrition Assessment of the conflict-affected population in Darfur, Sudan - Final Report - 2007	**SD**	Sep 2007	248	-	-	70	0.3	0.73	-	-
FAO, WFP, UNICEF, CDC, MoH, MoA	Food Security and Nutrition Assessment of the conflict-affected population in Darfur, Sudan - Final Report - 2007	**WD**	Sep 2007	248	-	-	78	0.38	0.95	-	-

Annex 2-4

Annexes are available on request.

Annex 5

Pre-survey preparation and planning

Objective of the survey
1) Nutrition YES NO
2) Mortality YES NO
3) Vaccination YES NO

Population
4) Type of population stated YES NO
5) Total population in area surveyed stated YES NO

Location
6) Geographical area of the survey stated YES NO
7) Area excluded from sampling frame listed YES NO NA

Time period
8) Survey dates are stated ((dd-)mm-yyyy) YES NO

Translation
9) Language of the questionnaire is stated YES NO
10) Language of the interview is stated YES NO

Questionnaire/tool
11) Pre-testing of questionnaire stated YES NO
12) Use of local event calendar stated YES NO

Training
13) Training arrangement stated YES NO

Informed consent
14) Informed consent to participate in the survey mentioned YES NO

Methods

Sampling design
17-19 only if cluster sampling, ☞ 19 for other sampling designs
15) Type of sampling design stated YES NO
16) Rationale for sampling design explained YES NO
17) State if PPS was used YES NO
18) Nr of clusters (cluster x children) *for nutrition* ____ x ____
(cluster x hh) *for mortality* ____ x ____

Final stage
20 only if mortality module included, otherwise ☞ 21
19) State final stage sampling YES NO
20) State if HH without U5 were included YES NO
21) Stated whether sample size was increased to account for non-response? YES NO

Household
23 only if nutrition/vaccination module included, otherwise ☞ 24
22) State definition of HH YES NO
23) State selection of U5 in the HH *for nut/vacc* YES NO
24) HH selection in a compound is explained YES NO NA
25) Procedure for choosing respondent stated YES NO
26) Procedure for re-visiting absent hh stated

Sample size precision
27-29 only if nutrition module included, ☞ 30 ; 30-32 only if mortality module included, otherwise ☞ 33
27) Expected GAM: ____ Stated why? YES NO NA
28) Expected Deff for GAM: ____ Stated why? YES NO NA
29) Desired precision for GAM: ____ Stated why? YES NO NA
30) Expected CMR: ____ Stated why? YES NO NA
31) Expected Deff for CMR: ____ Stated why? YES NO NA
32) Desired precision for CMR: ____ Stated why? YES NO NA

Nutrition survey
33-37 only if nutrition module included, otherwise ☞ 38
33) GAM includes bilateral oedema YES NO
34) Inclusion criteria in terms of age or height described? YES NO
35) Weight and height smallest rounding unit described? YES NO
36) Cut-off for measuring children lying or standing stated? YES NO
37) Questionnaire is provided in Appendix YES NO

Methods (Ctd)

Mortality survey
38-41 only if mortality module included, ☞ otherwise 42
38) Recall period stated YES NO
39) Denominator calculation indicated YES NO
40) Census method indicated YES NO
41) Questionnaire is provided in Appendix YES NO

Results

Analysis
42) Name, version of the software and statistical procedure stated YES NO

Nutritional Indicators
43-50 only if nutrition module included, otherwise ☞ 51
Definition: 43) Prevalence of GAM based on Weight for Height Z-scores reported? YES NO
44) Type of growth ref. used (WHO or NCHS) stated? YES NO
Precision: 45) Confidence interval [____ ; ____]
46) Design effect: ____
47) Plausibility checks mentioned YES NO NA
48) Definition of flags stated YES NO
49) Flags exclusion from analysis described? YES NO
50) Sample size of 6-59 months: ____

Mortality indicators
51-60 only if mortality module included, otherwise ☞ 61
Definition: 51) CMR expressed as death per 10,000/day, 1,000/month or 1,000/year YES NO
Precision: 52) Confidence interval [____ ; ____]
53) Design effect: ____

Demographic indicators
54) Births: ____ 55) Deaths: ____
56) Persons joined: ____ 57) Pers. left: ____
58) Population at the time of the survey: ____
59) Number of households: ____
60) Number of U5 (0-59 months): ____

Vaccination indicators
61 - 64 only if vaccination module included, otherwise ☞ 65
61) Measles-Containing Vaccine (MCV) coverage by card and history YES NO
62) Confidence interval [____ ; ____] YES NO
63) Age range for inclusion in analysis stated?
64) Number of children in the analysis: ____

Discussion

Limitation and bias
66-68 only if cluster sampling, ☞ 68 only if replacement was made, otherwise ☞ 69
65) % non response: ____
66) % inaccessible clusters: ____
67) Final number of clusters: ____
68) Replacement method stated? YES NO NA
69) Potential bias described? YES NO

Comparison of results
70) Results are compared to a reference YES NO

Interpretation of results
71) Recommendations are given YES NO

WHO Collaborating Centre for Research on the Epidemiology of Disasters CRED

CE-DAT Completeness Checklist Version June 2010

Developed in collaboration with the CE-DAT Expert Group: Oleg Bilukha, Alessandro Colombo, Richard Garfield, Colleen Mone Hardy, Jon Pedersen, Paul Spiegel and Michel Van Herp.

Mortality in the Darfur Conflict

A study of large-scale patterns based on a meta-analysis of small-scale surveys

Several mortality estimates for the Darfur conflict have been reported since 2004, but few accounted for conflict dynamics such as changing displacement and causes of deaths. This study analyzes changes over time in crude and cause-specific mortality rates, and assesses the effect of displacement on mortality rates.

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