Mortality in the Democratic Republic of Congo: a nationwide survey

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Summary

Background Commencing in 1998, the war in the Democratic Republic of Congo has been a humanitarian disaster, but has drawn little response from the international community. To document rates and trends in mortality and provide recommendations for political and humanitarian interventions, we did a nationwide mortality survey during April–July, 2004.

Methods We used a stratified three-stage, household-based cluster sampling technique. Of 511 health zones, 49 were excluded because of insecurity, and four were purposely selected to allow historical comparisons. From the remainder, probability of selection was proportional to population size. Geographical distribution and size of cluster determined how households were selected: systematic random or classic proximity sampling. Heads of households were asked about all deaths of household members during January, 2003, to April, 2004.

Findings 19 500 households were visited. The national crude mortality rate of 2·1 deaths per 1000 per month (95% CI 1·6–2·6) was 40% higher than the sub-Saharan regional level (1·5), corresponding to 600 000 more deaths than would be expected during the recall period and 38 000 excess deaths per month. Total death toll from the conflict (1998–2004) was estimated to be 3·9 million. Mortality rate was higher in unstable eastern provinces, showing the effect of insecurity. Most deaths were from easily preventable and treatable illnesses rather than violence. Regression analysis suggested that if the effects of violence were removed, all-cause mortality could fall to almost normal rates.

Interpretation The conflict in the Democratic Republic of Congo remains the world's deadliest humanitarian crisis. To save lives, improvements in security and increased humanitarian assistance are urgently needed.

Introduction

The Democratic Republic of Congo (DR Congo) is struggling to recover from a devastating 6-year conflict that continues to destabilise Central Africa and cause immense suffering to the country's civilian population. Known as "Africa's first world war"[1] because of the involvement of at least six nations in the region, the war began in August, 1998, and quickly engulfed the country in a conflict characterised by extreme violence, mass population displacements, widespread rape, and a collapse of public health services. The outcome has been a humanitarian disaster unmatched by any other in recent decades, but one that has drawn little response from the international community.

The broader health consequences of the war have been similar in nature but much greater in scale compared with those of other conflicts over the past two decades. In a series of three mortality surveys, the International Rescue Committee (IRC) documented that between 1998 and 2002, an estimated 3·3 million people died as a consequence of the war.[2–5] These data show that the Congolese conflict has been the world's most deadly since the end of World War 2[6] and that the death toll far exceeds those of other recent crises, including those in Bosnia (estimated 250 000 dead),[7] Rwanda (800 000),[8] Kosovo (12 000),[9] and Darfur in Sudan (70 000).[10]

Since 2002, however, there had been some encouraging political and diplomatic developments involving local, regional, and international participants. A

series of peace accords signed by the various factions, the deployment of about 10 000 UN peace-keeping troops, and the formation of an interim Government of National Unity and Transition in July, 2003, had earlier held out the hope for greater peace and stability in DR Congo. Additionally, plans were drawn for nationwide democratic elections in 2005 that would be open to all major political parties.

Against this backdrop, the IRC decided to undertake its fourth mortality survey in DR Congo from April to July, 2004. This was the second nationwide survey in the series, the first two surveys having concentrated only on the eastern provinces. The specific objectives of the survey were to determine both the rate and causes of mortality throughout DR Congo, to identify trends in mortality through comparisons with recent historical data, to ascertain whether there were regional differences in mortality rates, and to estimate the total number of excess deaths since the previous survey. However, the survey does not include mortality data for the period since the beginning of June 2004, during which there has been a resurgence of violence, including a brief occupation of Bukavu by rebel forces, an attempted coup in Kinshasa, the massacre of over 150 Congolese Tutsi refugees in neighbouring Burundi, and major population displacements in Ituri Province. The relevance of the findings has, therefore, increased in the wider context of the deteriorating social, political, and economic situation now confronting DR Congo.

Methods

Study design

We divided DR Congo into two strata along the 2001 line of military control: an east stratum of territory formerly held by rebel groups and a west stratum of territory formerly held by government forces. We surveyed each stratum with a three-stage, household-based cluster sampling technique. We calculated sample size to detect a difference of 0·8 deaths per 1000 population per month from the crude mortality rate in pre-war DR Congo (1·2 per 1000 population per month). The crude mortality rate in each stratum was taken to be the point estimate from the 2002 IRC survey: 3·5 per 1000 population per month in the east and 2·0 per 1000 population per month in the west. A design effect of four for a recall period of 16 months was assumed. Written approval for the study was provided by the DR Congo Ministry of Health.

In the first stage, four east health zones surveyed by the IRC on at least two previous occasions (Kalemie, Kalima, Katana, and Kisangani-Ville) were purposely selected to allow for historical comparisons. We excluded these zones from the sampling frame. 46 of the remaining 245 health zones in the east (about 5·4 million people) were excluded because of security problems, and three of 262 health zones in the west were excluded due to inaccessibility. These three zones contained large military bases; population figures were withheld and access was restricted by the Congolese government. From the remaining population, ten health zones were randomly selected from 259 western zones and 11 health zones were randomly selected from 199 eastern health zones for study. Probability of selection was proportional to population size from 2004 government census data. Total population for DR Congo was estimated at 63·7 million (east stratum 22·9 million; west stratum 35·4 million; inaccessible 5·4 million).

In the second stage, clusters were assigned to the smallest population units within each health zone (villages or avenues). Thirty clusters were selected in each health zone, with a probability of selection proportional to population size. Where populations were unknown, the relative size of smallest units was crudely weighted by visual assessments or estimates by local leaders.

In the third stage, we surveyed 20 households in each cluster in the west and 30 in the east. The different number of households sampled in each stratum reflects the different point estimates of crude mortality used in the calculations for the sample size. A household was defined as a group of people eating and sleeping together. The type of sampling depended on the size and geographical distribution of the village or avenue. For well ordered or small units, systematic random sampling was used: all households in the cluster were counted (N), a sampling interval (x) was calculated by dividing N by the number of households required in the sample, and the starting household selected by choosing a random number between 1 and x. The sampling interval was then added to

this random number to select the next household and the process repeated until completion of the cluster. For widely distributed or larger units, households were selected according to the standard WHO Extended Program on Immunization (WHO/EPI) cluster sampling proximity method.[11] Interviewers walked in a randomly chosen direction from the centre of the unit to its edge, counting the number of houses (n) along the route. The first household surveyed was selected by randomly choosing a number between 1 and n. Subsequent households were selected by proximity until the cluster was finished.

Procedures

Neighbours were asked to assist in tracing the occupants of empty households. If occupants could not be found or if they refused to participate, or if no household member older than 14 years was at home, that household was skipped and the next nearest visited. Logistical, security, and time constraints prevented a re-visiting of empty households.

The survey questionnaire was standardised, written in French, and consisted of three questions taken from the 2002 IRC survey. The purpose of the study was explained to all heads of households and oral consent was obtained. The age and sex of people sleeping in the household on the night before the interview was recorded. Any pregnancies, births, or deaths in the household since January 1, 2003, were recorded. Decedents needed to have normally slept in the interviewed household or have resided with the interviewed family at the time of their death. The age, sex, and date and cause of death were recorded in French for each decedent. No independent confirmation of death or verbal autopsy was done. For the purposes of analysis, the recall period was taken to be the 16-month period from January 1, 2003, to 30 April, 2004.

Interviewers were experienced local nursing staff from IRC programmes and health zone staff assigned to the survey by Ministry of Health offices. All spoke French and the local language and dialects, and all had excellent literacy and numeracy skills. Many of IRC's local staff members were already experienced in the conduct of similar surveys. The interviewers received standardised training that included field exercises. At a minimum, each interviewer was supervised by a senior IRC staff member or Burnet Institute consultant for the data collection of at least one entire health zone. Questionnaires were checked at the end of each cluster for completeness and accuracy.

Statistical analysis

Data were entered into EpiData 3·0 with 5% cross-checking. R 2.0, STATA 8.0 and EpiInfo 6 were used for analysis. The data were weighted according to the probability of selecting each individual in the sample, as well as a post-stratification of the weights to account for the age and sex distribution of the sample. All mortality

rates were expressed as deaths per 1000 population per month. The equation for the under-5 mortality rate assumes that the total number of children being born is equal to the number of children turning 5 years old during the recall period. The panel lists the key equations used in this report.

For 2003–04, rates and rate ratios were estimated with Poisson regression, taking account of the survey design. The regression included a log link and an offset for the log of the population per month. The negative population per month for the births were included in the regression by aggregation of the data by death status, 5-year age group, sex, cluster, and health zone. To model for mortality attributable to violence, a binary indicator for violent deaths in a health zone was included as a covariate in a Poisson regression for the crude mortality

rate. Mortality attributed to violence was estimated by the proportion of deaths in health zones with violence multiplied by one less the inverse of the rate ratio for the binary indicator; confidence intervals were estimated taking account of variation in the rate ratio. For rate comparisons with 2002, the log-rates were assumed to be independent and normally distributed.

We identified two subdivisions in the east stratum to allow analysis of mortality on the basis of changes in the security situation over time and within specific geographic areas (figure). The divisions of the east have been classified according to regions of ongoing unrest as investigated in the 2002 IRC survey (designated "east 2002") and according to areas with minimal current security concerns (called "transition east"). The western division investigated this year was termed "west."
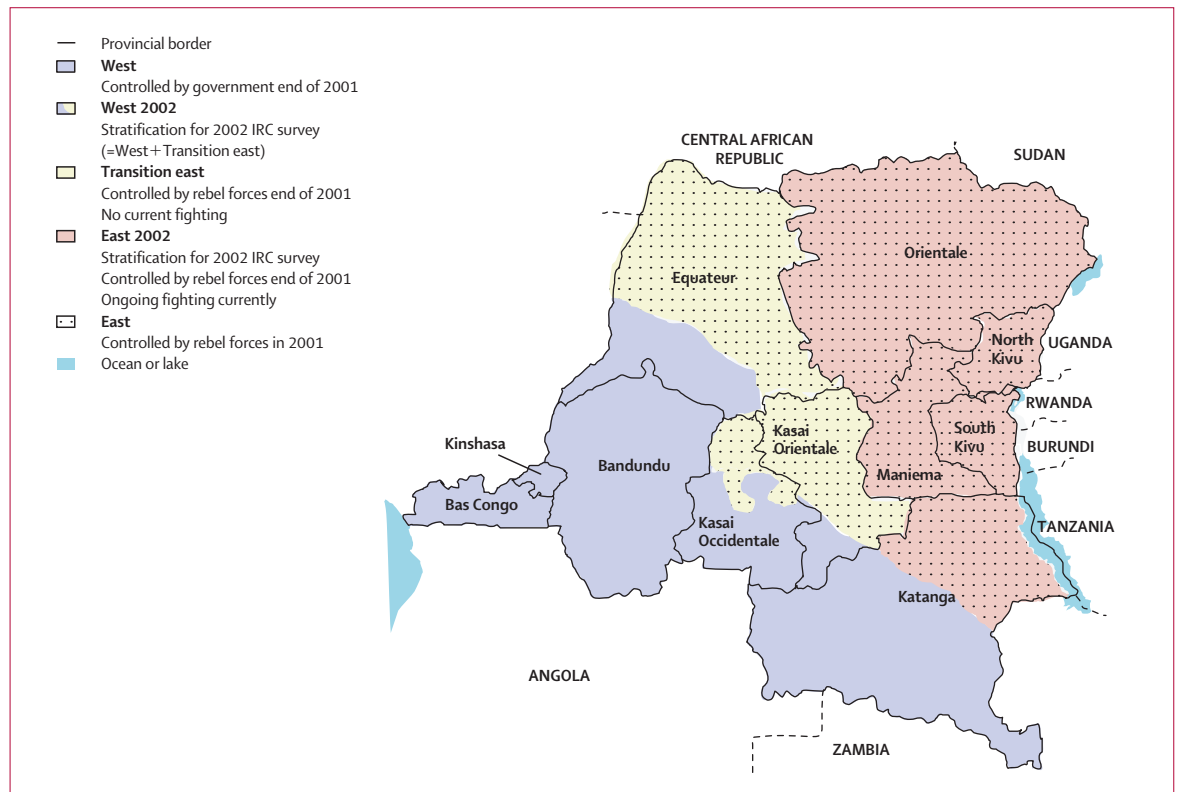

Figure: Stratification of DR Congo for the 2003–04 survey

	East stratum			West stratum	
	East*	East 2002*	Transition east	West	West 2002†
CMR					
Total	2·4 (2·2–2·7)	2·9 (2·6–3·2)	1·5 (1·3–1·7)	1·8 (1·7–2·0)	1·8 (1·6–1·9)
Male	2·4 (2·2–2·7)	2·9 (2·6–3·2)	1·5 (1·3–1·7)	2·0 (1·8–2·2)	1·9 (1·7–2·1)
Female	2·4 (2·2–2·7)	2·8 (2·5–3·2)	1·5 (1·3–1·8)	1·7 (1·5–1·9)	1·6 (1·5–1·8)
Under-5					
Total	4·9 (4·4–5·4)	5·9 (5·3–6·6)	3·1 (2·7–3·6)	4·3 (3·8–4·8)	4·1 (3·7–4·5)
Male	5·1 (4·6–5·7)	6·2 (5·4–7·0)	3·4 (2·8–4·0)	4·6 (3·9–5·3)	4·3 (3·8–4·9)
Female	4·6 (4·1–5·2)	5·6 (4·9–6·5)	2·9 (2·4–3·5)	4·0 (3·4–4·6)	3·8 (3·3–4·3)
Violent death					
Total	0·031 (0·020–0·050)	0·045 (0·028–0·072)	0·002 (0·000–0·013)	0·002 (0·000–0·016)	0·002 (0·000–0·012)
Infectious diseases					
Total	1·3 (1·2–1·5)	1·5 (1·3–1·7)	1·0 (0·8–1·1)	1·2 (1·1–1·3)	1·2 (1·0–1·3)

Mortality rates expressed as deaths per 1000 per month (95% CI). *East and east 2002 are aggregates of randomly and purposely selected zones. †West 2002 is equal to (west+transition east).

Table 1: **Mortality rates**

However, the western Congo investigated in the 2002 IRC survey also included the transitional east, for the purposes of this report it has been called "west 2002."

Results

Surveys were done from late April to July 2004, although fighting in South Kivu during May and June resulted in a suspension of the study for 3 weeks. One health zone and two villages in the east could not be visited because of security concerns. They were replaced with the nearest unit of a similar size. 19 500 households were visited: 13 500 in the east and 6000 in the west, accounting for a total population of 119 378 people. Of the total 750 clusters surveyed, 186 (24·8%) were sampled by systematic random sampling and 564 (75·2%) by the WHO/EPI proximity method. Few households declined to participate in the survey: 22 (0·16%) in the east and only three (0·05%) in the west.

The demographic profile of the population was consistent with national data.[12] The average household size in the east (7·2 people per household) was 29% larger (95% CI 27–31) than the average household size in the west (5·6).

From January, 2003, to April, 2004, the crude mortality rate (CMR) was 60% greater in the east and 20% greater in the west than the reported baseline for sub-Saharan Africa (1·5 deaths per 1000 per month;[13] table 1). Over this period, the CMR for eastern Congo was significantly higher than for western Congo (rate ratio=1·3, 95% CI 1·2–1·5), whereas there was limited evidence that the under-5 mortality rate was higher in eastern Congo than in western Congo (1·1, 1·0–1·3, p=0·08; table 1). Comparisons of CMRs between the east and west were not significantly different whether the four health zones that were purposely selected were included or not. Presented values therefore include randomly and purposely selected health zones. For the 2002 subdivisions, rates were higher in the east than the west for both CMR (rate ratio=1·7, 95% CI 1·5–1·9) and

	CMR	Under-5 mortality rate
Health zones reporting violence*	3·0 (2·6–3·4)	6·4 (5·7–7·2)
Health zones not reporting violence†	1·7 (1·5–1·9)	3·1 (2·7–3·5)

Mortality rates expressed as deaths per 1000 per month (95% CI). *Adi, Tshofa, Kalemie, Kalima, Katana, Moba, Oicha, Rwanguba, Shabunda Centre. †Mushenge, Bosomondanda, Lisala, Kisangani-Ville, Isangi, Titule.

Table 2: **Comparison of east health zones with and without violent deaths**

under-5 mortality rate (1·5, 1·3–1·7; table 1). Seven of 15 (47%) eastern health zones and five of ten (50%) western health zones had a CMR higher than the sub-Saharan regional norm.

These findings indicate a national mortality rate of 2·1 deaths (95% CI 1·6–2·6) per 1000 per population per month. Thus, from January, 2003, to April, 2004, mortality in DR Congo as a whole was still about 75% greater (95% CI 36–118) than before the onset of war in 1998 (1·2 deaths per 1000 population per month).[14]

Four eastern zones—Shabunda Centre, Kalemie, Kalima, and Moba—had death rates that, at minimum,

	Mortality rates		
	Crude	Under-5	Cause-specific (violence)
East*			
2002	3·5 (2·2–4·9)	9·0 (4·0–14·0)	0·06
2003–04	2·9 (2·6–3·2)	5·9 (5·3–6·6)	0·045 (0·028–0·072)
West†			
2002	2·0 (1·5–2·6)	4·4 (3·2–5·7)	0
2003–04	1·8 (1·6–1·9)	4·06 (3·7–4·5)	0·002 (0·000–0·012)

Mortality rates expressed as deaths per 1000 per month (for cause-specific mortality, 95% CIs available for 2003–04). *For 2003–04, east 2002 is equivalent to the areas in the east that were surveyed in 2002. †For 2003–04, west 2002 is equivalent to the areas in the west that were surveyed in 2002. This is equal to west 2003–04+transition east.

Table 3: **Comparison of 2002 and 2003–04 survey findings**

were more than double DR Congo's pre-war rate. The average CMRs in these four zones surpassed even the emergency threshold of 0·9 deaths per 10 000 per day[15] for the entire 16 months.

Deaths due to violent injury were concentrated in the east, where nine of 15 health zones reported at least one war-related violent death. The CMR in these zones was 1·7 times higher (95% CI 1·5–2·0) than the rate in eastern zones that did not report violent deaths (table 2). In the east, 57% of deaths were in health zones reporting violent deaths, suggesting that up to 30% of deaths (95% CI 23–36%) could be attributed to violence. Areas with ongoing conflict and insecurity (east 2002) also had death rates that were almost double those of the former rebel territories where fighting was minimal (transition east; table 1). Only one violent death was recorded in the west for 2003–04, in a zone bordering former rebel-held territory (Kalonda East).

For the east, men aged 15 years and older were at greater risk of being killed, constituting 71% of all violent deaths, although women (18%) and children younger than 15 years (10%) were not exempt. Relative risk of violent death for women was 3·4 (95% CI 1·2–9·6) and for men was 16·2 (95% CI 5·1–51·8), compared with children younger than 15 years. Interviewees recounted military forces killing their relatives by shooting or beating them, cutting their throats, and, in one case, torturing a family member to death.

In the east, the disease-specific mortality rate attributed to violence (0·045 deaths per 1000 population per month) and the percentage of all deaths due to violence (1·5%) had not changed significantly since the 2002 survey (0·06 per 1000 population per month and 1·6%, respectively; table 3). On the other hand, the number of violent deaths decreased significantly over the 16-month survey period in eastern health zones reporting war-related deaths (rate ratio=0·91 per month,

95% CI 0·85–0·97). The proportion of violent deaths also declined over the 16 months (logistic regression odds ratio=0·88 per month, 95% CI 0·84–0·92). Similarly, a much smaller but significant reduction in non-violent mortality of 1% per month occurred over the same period.

A Poisson regression analysis of all eastern health zones suggested that the CMR would be 1·7 per 1000 population per month (95% CI 1·6–1·9) in the absence of all violence. This value was identical to the average CMR in eastern zones in which no violent deaths were reported during the recall period (table 2). These associations suggest a strong link between insecurity and deaths from both violent and non-violent causes. The situation was less clear in the west. The number of deaths in the first 4 months of 2004 was well above that recorded during the same period the year before. The reasons for this increase were unclear, but do not seem to be directly linked to increases in either insecurity or violence.

Most deaths in the east and west strata were due to preventable and easily treatable diseases. Fever and malaria, diarrhoea, respiratory infections, and malnutrition were the principal causes of death, together accounting for more than 50% of deaths in both east and west. Under-5s are at particular risk from these diseases and accounted for 45·4% of all deaths, even though they made up only 18·7% of the sample population (relative risk of dying compared with people aged 5 years and older was 3·9, 95% CI 3·5–4·3).

Malnutrition was cited as a primary or contributing cause in 10·9% of all deaths in the east and 8·1% in the west. Maternal deaths were also more common in the east (maternal mortality ratio 1174 deaths per 100 000 livebirths) than the west (811 deaths per 100 000 livebirths). Deaths from meningitis and deaths in the neonatal period were higher in the east than in the west, whereas measles-related deaths were higher in the

	Duration of recall period for survey				
	1998–99	1999–2000	2000–01	2002	Jan, 2003–April, 2004
Kalemie					
CMR	Not surveyed	Not surveyed	10·8 (9·5–12·1)	4·2 (2·8–5·6)	4·0 (3·4–4·5)
Under-5 mortality rate	Not surveyed	Not surveyed	23·8 (19·8–27·8)	14·9	9·8 (8·1–11·8)
Kalima					
Crude	Not surveyed	Not surveyed	7·5 (6·3–8·7)	3·0 (2·2–3·9)	4·1 (3·3–5·1)
Under-5 mortality rate	Not surveyed	Not surveyed	17·1 (13·2–21·0)	8·9	8·4 (6·4–11·0)
Katana					
Crude	3·8	3·0	4·9 (3·8–6·0)	1·9	2·5 (2·0–3·3)
Under-5 mortality rate	10·1	6·9	12·9 (9·3–16·5)	2·9	5·8 (4·6–7·4)
Kisangani-Ville					
Crude	Not surveyed	2·9	Not surveyed	6·2	1·4 (1·1–1·7)
Under-5 mortality rate	Not surveyed	4·8	Not surveyed	10·4	2·2 (1·6–3·0)
Moba*					
Crude	Not surveyed	12·1	Not surveyed	Not surveyed	3·7 (3·0–4·4)
Under-5 mortality rate	Not surveyed	24·5	Not surveyed	Not surveyed	11·4 (9·4–14·0)

Mortality rates expressed as deaths per 1000 per month (95% CI if available). *Moba was selected randomly in 2003–04.

Table 4: **Comparison of 2003–04 survey findings for individual health zones with surveys from previous years**

west, a finding that is consistent with a large epidemic reported by local health authorities and staff of non-governmental organisations within two surveyed zones in Kasai Occidental during 2003–04. In the west, there were almost three times as many deaths from measles in 2003–04 (4·6% of all deaths at rate of 0·09 deaths per 1000 population per month) as in 2002 (1·6% at rate of 0·03 deaths per 1000 population per month).

The national CMR for 2003–04 (2·1) had not changed significantly since 2002 (2·2; rate ratio=0·9, 95% CI 0·7–1·1). Although the point estimates for crude mortality decreased by 17% in the east and by 10% in the west, these changes were not significant (table 3).

Comparisons of mortality data for 2002 and 2003–04 in the four eastern zones that were purposely selected (table 4) showed mixed findings: both CMR and under-5 mortality rate decreased in Kalemie and Kisangani-Ville, whereas CMR increased non-significantly in Kalima and Katana, with a non-significant increase in under-5 mortality in Katana. The only zone to show a significant improvement, Kisangani-Ville, was the scene of heavy fighting before the 2002 IRC survey but has had a strong UN military presence since.

We estimate that about 607 000 excess deaths above the regional baseline occurred across all health zones of DR Congo between January, 2003, and April, 2004—almost 38 000 excess deaths per month. 71% of these deaths occurred in the east 2002 health zones.

Discussion

Our main finding was that a significant and sustained increase in mortality occurred in DR Congo from January, 2003, to April, 2004, compared with the point-estimates for pre-war DR Congo in 1998 and the accepted norm for sub-Saharan Africa in 2004. The crude mortality rate for DR Congo over that period was estimated to be 2·1 deaths per 1000 population per month, a rate that was 40% higher than the reported baseline for sub-Saharan Africa. This translates into an excess of more than 600 000 deaths in total, or more than 1200 people dying per day, compared with what would usually be expected over this time.

However, this death toll was not uniformly distributed throughout the country: mortality rates in the insecure eastern part of the country remained significantly higher than those in the west. In the five most insecure provinces (east 2002), the crude mortality rate was 93% higher than the regional sub-Saharan norm, and the under-5 mortality rate was 97% higher, 6 years after the commencement of the war. 71% of the excess mortality occurred in these provinces. Of particular concern was that four eastern health zones recorded an average crude mortality rate that exceeded the emergency threshold of 0·9 deaths per 10 000 per day[15] for the entire 16 months covered by the survey.

These findings show that DR Congo remains in the grip of a major humanitarian crisis that continues to be most severe in the eastern provinces. When combined with the results of the three previous IRC surveys, we estimate that about 3·9 million people have died as a result of the conflict between August, 1998, and April, 2004. This estimate makes three assumptions: first, that the previous estimate by the IRC of 3·3 million deaths until the end of 2002 was reasonable (limitations of previous surveys have been discussed elsewhere; all past estimates only considered excess mortality in the five eastern zones undergoing conflict and are believed to be conservative[2–5]); second, that the baseline mortality rate for DR Congo is equal to the sub-Saharan norm of 1·5 deaths per 1000 population per month; and third, that the zones excluded in the east because of security problems had the same CMR as the east 2002 subdivision, which was the most insecure region to which the researchers had access.

These assumptions can be adjusted to estimate a minimum and a maximum death toll. If the baseline CMR is equal to the 2003–04 rate for the west, and the excluded zones have a rate equal to this baseline, then the minimum number of deaths due to this conflict is about 3·5 million. If the baseline is the same as the pre-war mortality rate as reported by UNICEF (1·2 deaths per 1000 per month), and the excluded zones experience the same death rate as the worst eastern zone recorded in 2003–04, then the maximum reasonable estimate is 4·4 million deaths due to the conflict.

The persistently high mortality in DR Congo is deeply disturbing and indicates that both national and international efforts to address the crisis remain grossly inadequate. IRC's earlier studies had shown a decrease in mortality in eastern DR Congo from 2001 to 2002. For the most recent survey, the point estimates for CMR and under-5 mortality rate have improved since 2002 at the national level and in both eastern and western DR Congo. Although these trends are encouraging, none of these decreases reached statistical significance. Comparisons for the four eastern zones that were purposely selected showed mixed findings between 2002 and 2004. Despite the troubling results of this survey, however, some of our findings suggest a more positive way forward.

Analysis of the data suggests that the reductions in crude mortality are closely associated with reductions in violence and, by extension, improvements in security. The average CMR of health zones where a violent death was documented was more than 76% higher than that of health zones where no violent deaths were recorded. Additionally, when the effects of violence are removed for all eastern health zones, the CMR for the east would reduce from 2·4 to 1·7 deaths per 1000 per month, thereby almost eliminating excess mortality. Importantly, the overall CMR in health zones formerly held by rebels where there is no current fighting (ie, transition east) is now similar to those in western DR Congo. Finally, in Kisangani-Ville, the CMR has

declined by 77% and excess mortality has almost been eliminated since fighting in the city stopped in 2002.

All these trends underscore the association between violence and mortality due to all causes in DR Congo. They also provide compelling evidence that improvements in security represent perhaps the most effective means to reduce excess mortality in DR Congo. The most obvious inference to be drawn is that a larger, more robust peacekeeping force than the current MONUC (UN Mission in DR Congo) contingent of 16 700 is urgently needed to effectively address the security concerns and associated humanitarian needs in DR Congo. In fact, the African Union indicated in a recent report that up to 45 000 troops might be needed to stabilise the region and disarm the militias.[16] But any additional troops must be better trained, better equipped, have better leadership, and be willing to exercise their mandate to engage more forcefully than MONUC personnel to date.[17]

Another key finding of the survey was that most deaths were due to preventable causes such as malnutrition and infectious diseases. Some epidemic diseases, like measles, even seem to be on the increase. Moreover, young children were disproportionately affected by these illnesses. Improving food security and increasing access to essential health services, such as immunisations, clean water, insecticide-treated bednets, and case management of common diseases, have the potential to contribute greatly to reductions in excess mortality. The international humanitarian response should emphasise established, cost-effective strategies and interventions related to infectious disease control, child survival, and environmental health.

In interpreting the results, it is important to recognise the limitations of the survey. First, five million people were inaccessible because of security issues and so were excluded from the sampling frame. Second, during the survey, security concerns led to the substitution of one health zone and two villages with the nearest accessible unit of a similar population size. Third, the sample does not capture households where all occupants have died (survival bias). Fourth, under-reporting of infant deaths is a known issue in rural Africa.[18,19] All these factors serve to underestimate the mortality rates.

On the other hand, the seasonal variations in mortality seen in previous IRC studies—with peaks at the end of the rainy season between November and January—might have resulted in a slight overestimation of mortality for the 16-month recall period. The regression analysis for mortality attributed to violence assumes that there was no confounding, so that any differences between areas with and without violence would be caused, indirectly or directly, by violence. If areas with higher pre-war mortality rates were more likely to have had violence, then we will have overstated mortality due to violence.

Recall bias is likely to affect the results, although the extent and direction of bias are difficult to measure. Long recall periods can lead to an underestimate of less recent deaths, while traumatic events may be remembered as having occurred more recently than is actually the case.[20] Households in which all family members were absent were not sampled and could be interpreted as survivor bias[9] in the east. This assumption is less valid in the west where there is no conflict and the direction of bias is difficult to estimate. Inaccurate government census data might have resulted in selection bias, and UNICEF and World Bank mortality rates used for comparison are subject to limitations of their own.[13,14]

Formal verbal autopsies were not done, although information about the cause of death was sought. Although responses were probably valid for traumatic deaths and common diseases with obvious clinical manifestations, such as measles, other cause-of-death data must be interpreted with caution. Additionally, no independent confirmation of cause of death from health facilities or other sources was sought.

Lastly, the WHO/EPI method was not designed to measure mortality. Mortality surveys that use this method, including the 2002 IRC survey in DR Congo,[4] often report higher design effects than the assumed standard of two, particularly when examining violent deaths. Mortality surveys may thus need to either assume design effects of many times greater than two or greatly increase the number of clusters surveyed, although these decisions have to be balanced against the consequent increases in costs, time, and logistical requirements, not to mention security risks, when studying populations in such contexts. Our choice of a design effect of four and our decision to sample 30 clusters per health zone (and not more) reflects such a balance, and was an increase compared with the 2002 IRC survey of 15 clusters per health zone. Furthermore, we believe that our use of systematic sampling for almost a quarter of all clusters is likely to have improved the precision of the study, although we cannot quantify the level of improvement.

We believe that this survey of DR Congo is the largest of its kind to be done in a country experiencing ongoing conflict. Surveying was suspended for 3 weeks during June because of major security concerns. During this time, one of the main IRC offices was attacked and burnt, and staff were threatened. Nonetheless, the survey was representative of almost the entire national population and a method similar to that of the 2002 IRC survey was used to allow a discussion of the key trends in mortality over this time.

Notwithstanding these constraints, we believe that periodic surveys are an invaluable tool for mapping the trends in mortality in a conflict situation where regular sources of data are limited. Lack of security has been clearly linked to increased mortality rates and, consequently, DR Congo still has a rate among the highest in the world. The limits of the current "peace"—

geographically restricted, unaccepted by key factions, and undermined by economic and political interests—is reflected in the great number of excess deaths found in this survey and points to the inadequacy of national and international efforts. In spite of the critical need to complement increased humanitarian assistance with scaled-up security and diplomatic measures, the response of the international community to date remains inadequate. During 2004, only 42% of funding sought by the UN for its activities in DR Congo through the Consolidated Appeals Process had been raised by August.[21] Contributions by the US Agency for International Development to DR Congo for 2004 have fallen by more than 25% compared with 2003.[22,23] Additionally, although the UN recently agreed to deploy an additional 5900 peacekeepers in October (bringing the total to 16700), this number was less than half the troops requested by the Secretary General of the UN and below the "minimum required to meet the current challenges in DR Congo".[24]

According to the International Crisis Group, the "collapse of the Congo peace process and return to war are real prospects"[25] unless the needs of the country are addressed through the supply of sufficient resources backed by a resolute will. Yet even if this worst-case scenario is averted, maintenance of the status quo is unacceptable: the east remains in conflict and hundreds of thousands of civilians continue to die unnecessarily as a result.

References
1 Talbot C, Mason M. US intervenes to shape settlement in Congo. World socialist website. Feb 3, 2000. http://www.wsws.org/articles/2000/feb2000/cong-f03.shtml (accessed June 15, 2005).
2 Roberts L. Mortality in eastern DRC: results from five mortality surveys. New York: International Rescue Committee, 2000.
3 Roberts L, Belyakdoumi F, Cobey L, Ondeko R, Despines M, Keys J. Mortality in eastern Democratic Republic of Congo: results from 11 mortality surveys. New York: International Rescue Committee, 2001.
4 Roberts L, Ngoy P, Mone C, et al. Mortality in the Democratic Republic of Congo: results from a nationwide survey. New York: International Rescue Committee, 2003.
5 Roberts L, Zantop M. Elevated mortality associated with armed conflict—Democratic Republic of Congo, 2002. *MMWR Morb Mortal Wkly Rep* 2003; **52:** 469–71.
6 Twentieth Century Atlas. Death tolls for the major wars and atrocities of the twentieth century. http://users.erols.com/mwhite28/warstat2.htm (accessed Sept 10, 2004).
7 US Department of State. Bosnia and Herzegovina country report on human rights abuses for 1996. http://www.state.gov/www/global/human_rights/1996_hrp_report/bosniahe.html (accessed July 10, 2004).
8 Steering Committee of the Joint Evaluation of the Emergency Assistance to Rwanda. The international response to conflict and genocide: lessons from the Rwanda experience. Odense: Strandberg Grafisk, 1996.
9 Spiegel PB, Salama P. War and mortality in Kosovo, 1998–1999: an epidemiological testimony. *Lancet* 2000; **355:** 2204–09.
10 WHO. Sudan: mortality projections for Darfur. Geneva: World Health Organization, 2004. http://www.who.int/mediacentre/news/briefings/2004/mb5/en/ (accessed Oct 22, 2004).
11 WHO Expanded Programme of Immunization. Training for mid-level managers: the EPI coverage survey WHO/EPI/MLM/91·10. Geneva: World Health Organization, 1991.
12 US Bureau of the Census. International data base population pyramids. Sep 30, 2004. http://www.census.gov/ipc/www/idbpyr.html (Nov 1, 2004).
13 World Bank Group. World development indicators 2004. http://www.worldbank.org/data/wdi2004/tables/table2–1.pdf (accessed Aug 4, 2004).
14 UNICEF. The state of the world's children report 1999. Oxford: Oxford University Press, 1999.
15 Sphere Project. Humanitarian charter and minimum standards in disaster response. Oxford: Oxfam Publishing, 2004.
16 IRIN OCHA. AU may need 45000 troops to disarm militias. June 26, 2005. http://www.irinnews.org/report.asp?ReportID=47834 (accessed June 27, 2005).
17 The International Crisis Group. Letter to UN Secretary General Kofi Annan. March 21, 2005. http://www.crisisgroup.org/library/documents/miscellaneous_docs/drcongo_letter_annan_21march2005.pdf (June 21, 2005).
18 Taylor WR, Chahnazarian A, Weinman J, et al. Mortality and use of health services surveys in rural Zaire. *Int J Epidemiol* 1993; **22** (suppl 1): S15–19.
19 Becker SR, Diop F, Thornton JN. Infant and child mortality in two counties of Liberia: results of a survey in 1988 and trends since 1984. *Int J Epidemiol* 1993; 22 (suppl 1): S56–63.
20 Depoortere E, Checchi F, Broillet F, et al. Violence and mortality in West Darfur, Sudan (2003–04): epidemiological evidence from four surveys. *Lancet* 2004; **364:** 1315–20.
21 UNOCHA. Humanitarian situation in DRC monthly update, July 2004. http://www.reliefweb.int/rw/RWB.NSF/db900SID/JMAN-63TDP6?OpenDocument&rc=1&emid=SKAR-64FB9M (accessed Nov 27, 2005).
22 UNOCHA. Total humanitarian assistance for Democratic Republic of Congo 2003. http://ocha.unog.ch/fts/reports/pdf/OCHA_24_593.pdf (accessed Nov 15, 2004).
23 UNOCHA. Total humanitarian assistance for Democratic Republic of Congo 2004. http://ocha.unog.ch/fts/reports/pdf/OCHA_24_628.pdf (accessed Nov 15, 2004).
24 BBC World news. UN to boost DR Congo peace force. Oct 1, 2004. http://news.bbc.co.uk/1/hi/world/africa/3707496.stm (accessed Oct 3, 2004).
25 International Crisis Group. Maintaining momentum in the Congo: the Ituri problem. Africa report no 84, Aug 26, 2004. Kinshasa/Nairobi/Brussels: International Crisis Group, 2004 . http://www.crisisweb.org/home/index.cfm?id=2927&l=1 (accessed Sept 10, 2004).