RESEARCH

Update on Mortality in the Democratic Republic of Congo: Results From a Third Nationwide Survey

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ABSTRACT

Background: The humanitarian crisis in the Democratic Republic of Congo (DRC) has been among the world's deadliest in recent decades. We conducted our third nationwide survey to examine trends in mortality rates during a period of changing political, security, and humanitarian conditions.

Methods: We used a 3-stage, household-based cluster sampling technique to compare east and west DRC. Sixteen east health zones and 15 west zones were selected with a probability proportional to population size. Four east zones were purposely selected to allow historical comparisons. The 20 smallest population units were sampled in each zone, 20 households in each unit. The number and distribution of households determined whether they were selected using systematic random or random walk sampling. Respondents were asked about deaths of household members during the recall period: January 2006–April 2007.

Findings: In all, 14,000 households were visited. The national crude mortality rate of 2.2 deaths per 1000 population per month (95% confidence interval [CI] 2.1–2.3) is almost 70% higher than that documented for DRC in the 1984 census (1.3) and is unchanged since 2004. A small but significant decrease in mortality since 2004 in the insecure east (rate ratio: 0.96, $P = .026$) was offset by increases in the western provinces and a transition area in the center of the country. Nonetheless, the crude mortality rate in the insecure east (2.6) remains significantly higher than in the other regions (2.0 and 2.1, respectively). Deaths from violence have declined since 2004 (rate ratio 0.7, $P = .02$).

Conclusions: More than 4 years after the official end of war, the crude mortality rate remains elevated across DRC. Slight but significant improvements in mortality in the insecure east coincided temporally with recent progress on security, humanitarian, and political fronts. (*Disaster Med Public Health Preparedness.* 2009;3:88–96)

Key Words: cluster surveys, Democratic Republic of Congo, mortality, conflict, postconflict

For more than a decade, the Democratic Republic of Congo (DRC) has been the scene of one of the most complex, deadly, and prolonged humanitarian crises ever documented. The all-out wars of 1996 and 1998 resulted in massive disruption to the social, political, and economic fabric of the country. The second war officially ended in December 2002 but has since given way to an ongoing low-intensity conflict in the eastern provinces that continues to extract an enormous toll on the lives and livelihoods of the Congolese people.

Between 2000 and 2004, the International Rescue Committee (IRC), an international nongovernmental organization, conducted a series of 4 mortality surveys to evaluate the humanitarian impact of conflict in DRC.[1–5] The first 2 surveys (2000 and 2001) were confined to the 5 eastern provinces; the later 2 (2002 and 2004) were nationwide. The 2004 study recorded a national crude mortality rate (CMR) of 2.1 deaths per 1000 population per month, a rate more than 60% above that documented in the 1984 national census (1.3).[6] Mortality was again highest in the eastern provinces, where the CMR averaged 2.9 deaths per 1000 population per month.

Less than 10% of deaths documented in the earlier studies were directly attributable to violence. Most were due to the indirect public health effects of conflict, including higher rates of infectious diseases, increased prevalence of malnutrition, and neonatal conditions.

Recent gains on political, security, and humanitarian fronts have raised expectations that DRC may soon break free of its cycles of conflict and crisis.[7] To evaluate the prevailing humanitarian situation, IRC conducted its third nationwide mortality survey be-

https://doi.org/10.1097/DMP.0b013e3181a6ee32 Published online by Cambridge University Press

tween May and July 2007. The key objectives of the study were to estimate national and regional mortality rates and to evaluate mortality trends through comparisons with recent historical data.

The authors note that violence increased in North Kivu province between December 2006 and January 2009, largely owing to clashes involving Laurent Nkunda's National Congress for the Defence of the People. The present report includes mortality data only for the first 5 months of this period.

METHODS

Sampling Design

DRC was divided into 2 strata along the 2001 military front line: an east stratum of territory formerly held by rebel groups and a west stratum formerly held by government forces. We surveyed each stratum using a 3-stage, household-based cluster sampling technique.

Sample size was calculated to detect a difference between east and west assuming the west had reverted to the sub-Saharan baseline rate for 2005 (1.4 deaths per 1000 population per month)[8] and the east had reduced to the 2003–2004 survey result for the west (1.8).[5] We used design effects from the 2004 IRC survey for the east (5.3) and west (3.4). We used Optimal Design for Multi-level and Longitudinal Research version 1.77 (University of Michigan, Ann Arbor) to then determine the optimal number of health zones, clusters per health zone, and households per cluster, following consideration of the survey budget, logistical issues, the intraclass correlations, and average household sizes from our 2004 survey. In the east, the intraclass correlation at the health zone level was 0.51 and the average household size was 7.2. These figures were 0.18 and 5.2, respectively, in the west. Ethical approval for the study was provided by the ethics committee of the School of Public Health, Kinshasa University.

In the first stage, 4 east health zones (Kalemie, Kalima, Katana, and Kisangani-Ville) surveyed by the IRC on at least 3 prior occasions were purposely selected to allow for historical comparisons. These were excluded from the sampling frame. A single health zone in the west was excluded because it contained a military base and access was not granted by the Congolese government. From the remaining population, 15 health zones were randomly selected from 261 western zones and 16 health zones were randomly selected from 248 eastern health zones for the study. The probability of selection for an individual health zone was proportional to its population size, using 2006 data from the Congolese Ministry of Health (MOH).[9] For example, a health zone with a population of 200,000 had twice the chance of selection as a health zone with a population of 100,000. Total population for DRC was estimated by the MOH at 69.9 million (east stratum 32.6 million; west stratum 37.3 million; inaccessible 44,000).

In the second stage, we selected 20 of the smallest population units within each health zone (villages in rural settings or avenues in urban settings) with a probability of selection proportional to population size. Where populations were unknown, the relative size of smallest units was crudely weighted using estimates of local leaders.

In the third stage, 20 households in each of these smallest units were surveyed. For well-ordered (grid pattern or along a single road) and/or small units (<100 houses), we used systematic random sampling to select households. For widely distributed and/or larger units (>100 houses), households were selected according to the standard World Health Organization Expanded Program on Immunization (WHO/EPI) cluster sampling random walk method. This method entails randomly selecting a direction from the center of the cluster by spinning a pen; counting the houses along that direction to the boundary of the cluster; choosing the first household at random from among those counted; and choosing subsequent households by a rule of proximity (ie, the next closest household). This method was initially developed for estimating vaccination coverage, but it has been used widely to estimate other indicators, including mortality. It is described in more detail elsewhere.[10]

If occupants could not be found or if they refused to participate, or if no household member older than 16 years was home, then that household was skipped and the next nearest visited. Logistical, security, and time constraints prevented a revisiting of empty households.

Household Data Collection

The survey questionnaire consisted of 3 questions used in the 2002 and 2004 surveys. It was back-translated into French and the 4 most common local languages (Lingala, Kikongo, Tshiluba, and Swahili). The purpose of the study was explained to all heads of households and oral consent was obtained. Wherever possible, the questionnaire was conducted with a senior female member of the household, because our previous experience had indicated that they provided more rapid and accurate answers.

The current household census method was used[11] to limit time in remote and insecure sites. The age and sex of people sleeping in the household on the night preceding the interview were documented. All pregnancies, births, or deaths occurring in the household during the recall period (January 1, 2006–April 30, 2007) were recorded. Decedents needed to have resided with the interviewed family at the time of their death or else normally slept in the interviewed household if they died in a health care facility. The age, sex, date of death, and cause of death were recorded for each decedent. We used a predefined list for cause of death that was based on previous IRC mortality survey results and a knowledge of the local epidemiology, with the option of specifying the cause if it did not meet any of our classifications. No independent confirmation of death or verbal autopsy was conducted.

Interviewers were experienced local nursing staff drawn from IRC programs and health zone personnel assigned to the

https://doi.org/10.1097/DMP.0b013e3181fdeed2 Published online by Cambridge University Press

TABLE 1

Summary of Key Equations

Crude mortality rate (CMR) = No. of deaths in the sample/(no. living in sample + ½ deaths in the sample – ½ live births in the sample)† × 1000/recall period*

Under 5 mortality rate (U5MR) = No. of deaths among those <5 years of age in the sample/(no. living <5 years of age + ½ deaths among those <5 years)† × 1000/recall period*

*Recall period is 16 months.

†The denominator is an estimate of the sample population at the midpoint of the recall period.

survey by MOH offices. The interviewers received standardized training that included field exercises. Data collection in all health zones was supervised by a senior staff member. When possible, data entry was done in the field. We used personal digital assistants (Dell Axim X30) with Pocket PC Creations version 4.0. All of the data were double entered.

Statistical Analysis

EpiData 3.0 was used to cross-check duplicate entries and errors were compared against original paper questionnaires. STATA 9.2 (StataCorp, College Station, TX) was used for data analysis. The first stage of sampling defined the analysis and the multistage sampling design was accounted for by STATA in the calculation of design effects. Data were weighted according to the probability of selecting each individual in the sample. Mortality rates have been expressed as deaths per 1000 population per month using the equations listed in Table 1. No adjustment is made for live births in the denominator for the under-5 mortality rate (U5MR) because we assumed that the total number of children born during the recall period was equal to the number of children turning 5 during the recall period. Rate ratios were estimated using Poisson regression. We accounted for the survey cluster design in the calculation of all rates and rate ratios.

As originally investigated in the 2002 IRC survey, we also analyzed 2 subdivisions within the east stratum reflecting areas with ongoing unrest (designated "East 2002" with 15 health zones) and areas with minimal security concerns since the cessation of conflict (called "Transition East" with 5 health zones). The western division investigated this year is termed "west." However, the western Congo investigated in the 2002 IRC survey also included the Transition East and for the purposes of this report has been called "West 2002." Figure 1 illustrates these subdivisions. Figure 2 shows the location of all 35 selected health zones.

RESULTS

Respondents from 14,000 households were interviewed; we counted 51,205 people in 8000 households in the east and 34,260 people in 6000 households in the west, for a total population of 85,465. The average household size was 6.4 in the east and 5.7 in the west. For both strata, 47% of the sample was male and 53% female. Compared with MOH data from 2004, which are adjusted from the 1984 census, our sample had fewer young men ages 10 to 29 years and girls ages 5 to 14 years, but more men older than 35 years and more women between 20 and 55 years old (Fig. 3).

Of 700 clusters visited, 112 (16%) were sampled using systematic random sampling and 588 (84%) by the WHO/EPI random walk method. In the east, about half of the population of 88,008 in Itebero health zone could not be surveyed because of security concerns and were excluded from selection. Another 2 villages—1 in the east and 1 in the west—could not be accessed and were replaced with alternate randomly selected sites. Few households declined to participate in the survey: 58 (0.7%) in the east and 50 (0.8%) in the west. Empty households or households in which no family member older than 16 years could be found were more common: 2300 (22%) in the east and 1838 (23%) in the west.

From January 2006 to April 2007, the CMR for the country was 2.2 deaths per 1000 population per month. The CMR in the east stratum was higher than for the west stratum (rate ratio 1.2; 95% confidence interval [CI] 1.1–1.4; Table 2). The U5MR, however, was not statistically significantly different between the strata (rate ratio 1.1; 95% CI 1.0–1.3; $P = .12$; Table 2). The CMR was statistically significantly higher than the sub-Saharan regional norm in 16 of 35 health zones (46%); 5 zones were in the west (33% of western zones) and 11 were in the east (55%). Three eastern zones—Ankoro, Kalemie, and Kunda—and 1 western zone—Ngandanjika—had a CMR that was statistically significantly above the emergency threshold of 0.9 deaths per 10,000 per day[12] (or 2.7 deaths per 1000 per month) for the 16-month recall period (range 2.8–8.2).

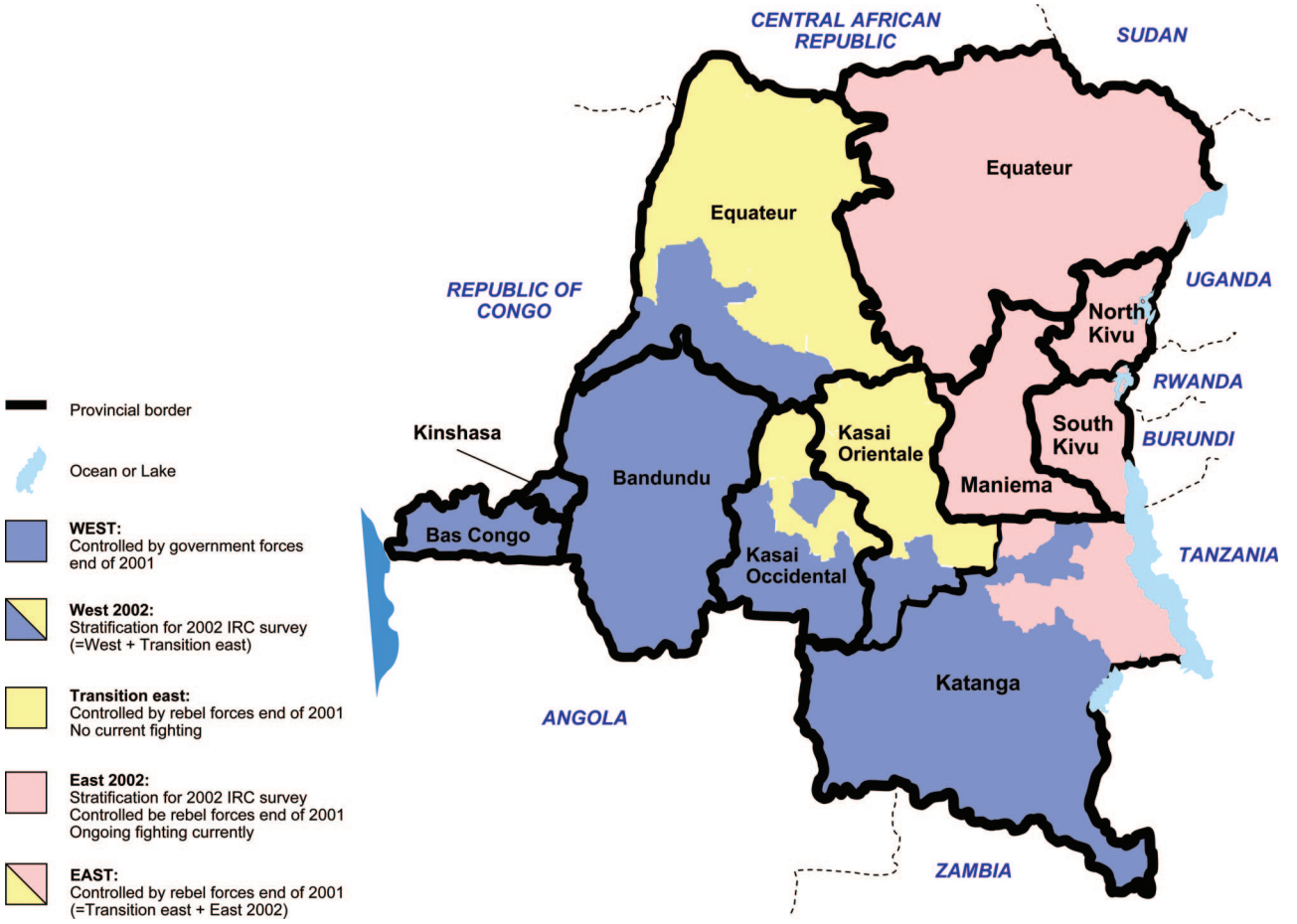
The 5 principal causes of death in the east and west were fever/malaria, diarrhea, respiratory infections, tuberculosis, and neonatal deaths, together accounting for more than 55% of deaths (Table 3). Measles was reported to have caused 9.9% of deaths in children younger than 5 years in the east and 15.1% (95% CI 8.9–24.6) of all deaths in Ankoro health zone in northern Katanga. Young children are especially vulnerable to communicable diseases and malnutrition (Table 3): 47% of all deaths were in children younger than 5 years who make up 19.4% of the sample population (relative risk of dying compared with people ages 5 or older: 3.5; 95% CI 3.2–3.8).

Deaths from violence accounted for just 0.4% of deaths nationally. Two of 3 deaths in the west appeared to be associated with the crackdown on opposition supporters in Kinshasa and Bas-Congo during March 2007. Of 11 violent deaths in the east, 7 were in North Kivu. Unlike the last IRC survey in 2004, violent deaths are no longer indicative of zonewide insecurity and health zones reporting a death from violence did not have a higher CMR than those without violent deaths. The risk of death from violence declined by almost 30% in east 2002 since the 2004 survey (rate ratio 0.7;

https://doi.org/10.1097/DMP.0b013e3181666e32 Published online by Cambridge University Press

FIGURE 1

Stratification of Democratic Republic of Congo for 2007 survey.



95% CI 0.6–0.9). This result occurs against a background of a steadily declining proportion of violent deaths in east 2002 over the course of IRC's survey series: war period 11.1% of all deaths (1999 survey); 9.4% (2000); 1.6% (2002); postwar period 1.5% (2004); 0.6% (2007).

Despite these positive trends, the crude mortality rate in the east stratum has not changed significantly since 2004 (Table 2). Similarly, there has been no change for the west stratum or the national CMR. The East 2002 division, which comprises the 5 most unstable provinces, had a small significant decrease in CMR (rate ratio 0.96; 95% CI 0.93–1.00; $P = .026$), continuing the downward trend in mortality across all 4 surveys since 2000 (Table 2). In contrast, the CMR for Transition East was significantly higher for this survey than the last (rate ratio 1.10; 95% CI 1.04–1.17; $P = .001$).

Mortality data in the 4 eastern zones purposely selected show different trends over time (Table 4). Kalima and Katana had significant reductions in CMR since 2004. Kisangani has been calm since our last survey, and this zone experienced a further nonsignificant reduction in CMR and U5MR. Mortality rates in Kalemie have not changed and were again statistically significantly above the emergency threshold.

DISCUSSION

Mortality Rates

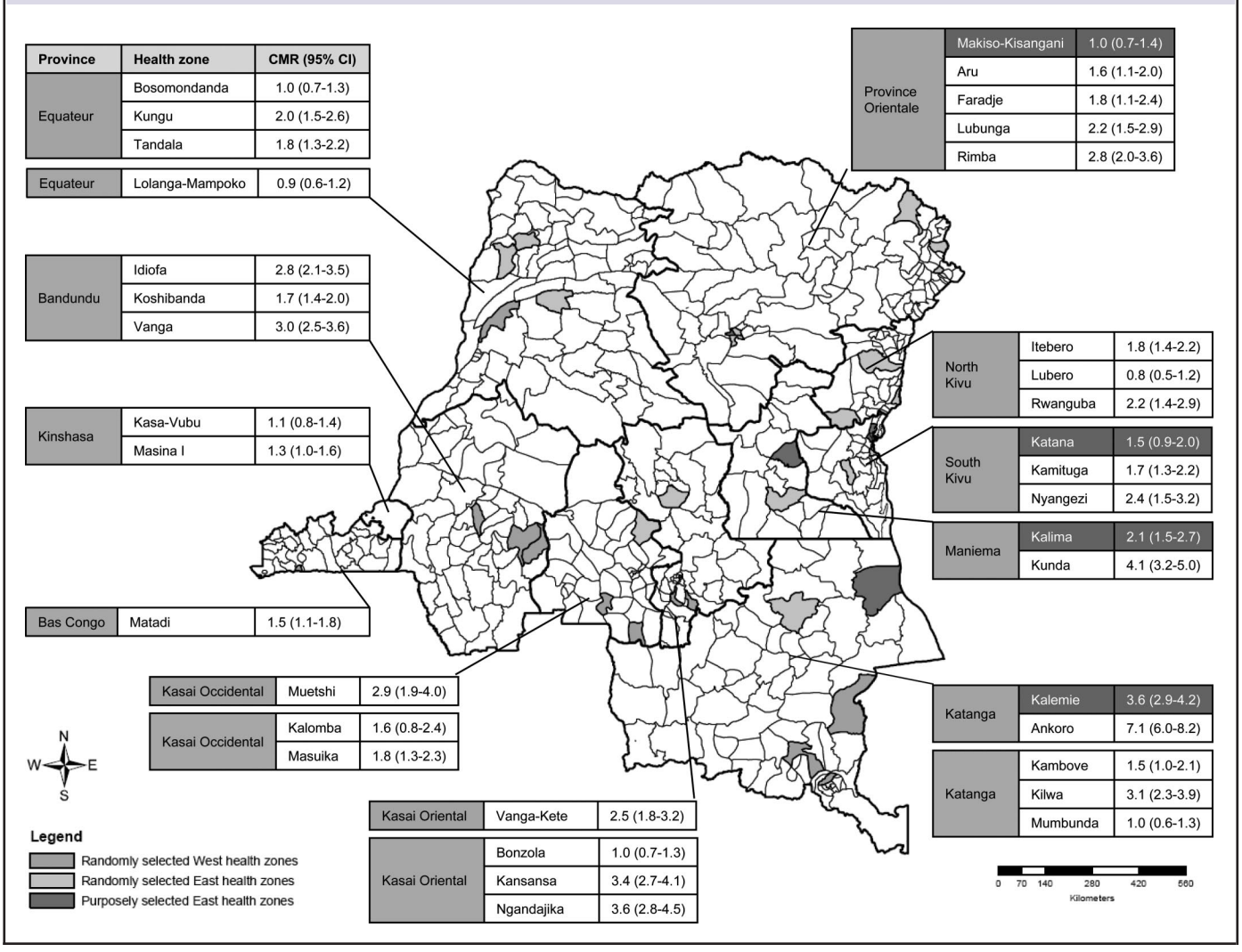
The crude mortality rate in DRC remains elevated at a level that is almost 70% higher than that reported in the 1984 national census[6] and more than 55% higher than the reported baseline for sub-Saharan Africa (1.4).[8] There has been no reduction in the national crude mortality rate since 2004. As with our previous studies, most deaths have been attributed to the so-called indirect consequences of conflict, especially increased rates of infectious diseases and malnutrition. Children continue to bear a disproportionate burden of the humanitarian crisis in DRC, accounting for almost half of all deaths.

As documented in previous IRC surveys, mortality rates remain significantly higher in the east than in the west.[1–5] Nonetheless, we found rates that exceeded important inter-

https://doi.org/10.1097/DMP.0b013e3181fdee92 Published online by Cambridge University Press

FIGURE 2

Location of surveyed health zones with crude mortality rates for 2006–2007.



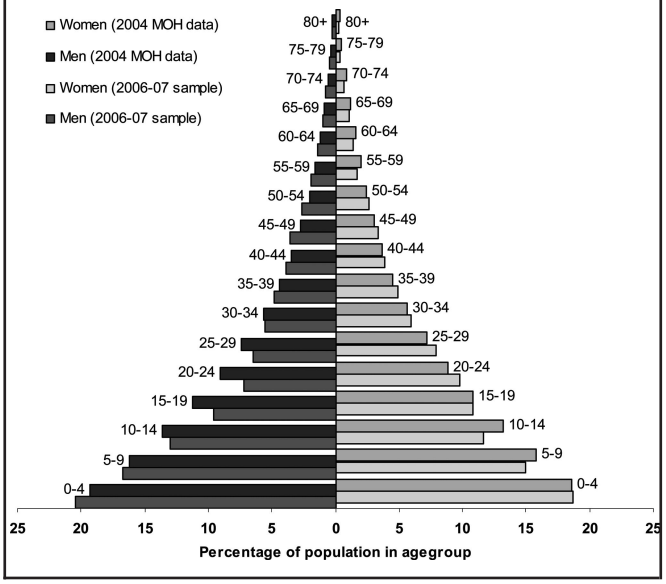
national benchmarks on both sides of the former front line. Ngandanjika health zone of Kasai Oriental Province in the west recorded a CMR that was, at best, above the threshold that defines a humanitarian emergency of 0.9 deaths per 10,000 per day (2.7 deaths per 1000 per month; Fig. 2).[12] In the east, northern Katanga, known as "Congo's forgotten crisis,"[13] is of particular concern: the CMR in Ankoro health zone was statistically significantly higher than the threshold for a severe emergency of 2.0 deaths per 10,000 per day (6.0 deaths per 1000 per month)[14]; and Kalemie has had an average death rate above the emergency threshold for every period measured by IRC back to 2000.

Although the national CMR has remained unchanged since 2004, the CMR in the unstable East 2002 region has decreased since the last survey. Security has improved during this period, through a combination of political, diplomatic, and peacekeeping efforts.[7,15] When considered in light of the documented reduction in violent deaths in the present survey and the demonstrated association between insecurity and all-cause mortality from our 2004 study,[5] it is plausible that these improvements have contributed to the decline in CMR in East 2002. Before this survey, all IRC surveys excluded large numbers of eastern health zones due to insecurity,[1–5] which may have led to past underestimates of the true CMR in East 2002. Consequently, the overall level of decline between our surveys of 2004 and 2007 may have been greater than we have been able to demonstrate.

Perhaps surprisingly, the Transition East recorded significantly increased mortality rates since the last survey. Although this increase in CMR was unexpected, a recent review of mortality surveys in DRC provides some supportive evidence. Two surveys in Equateur in 2006 indicated an emergency situation based on crude mortality, under-5 mortality, and the prevalence of acute malnutrition, and the average CMR in Equateur had worsened since 2004.[16]

FIGURE 3

Demographic profile of survey sample compared with 2004 data from Democratic Republic of Congo Ministry of Health.



The demographic profile of our sample compared with national records is difficult to interpret because the latter is an adjustment of much earlier census data. Assuming the national data are reasonable, the population deficits we recorded in 2007 are consistent with earlier IRC studies showing markedly elevated mortality among vulnerable children and young males during the intense early years of the conflict.[1–4]

Comparisons With Conflicts in Other Countries

Given that there are few comprehensive, longitudinal examinations of the "natural history" of mortality rates following conflict, it is difficult to make confident projections about likely mortality trends in DRC. Nonetheless, other African conflicts may offer relevant comparisons. In 2002, 3 years after the end of the decade-long civil war in Sierra Leone, the average CMR in 4 rural districts—representing one third of the population—was almost 4 times higher than the sub-Saharan baseline.[17] In Angola, some provinces documented mortality rates above the emergency threshold 2 years after the end of the war.[18] Similarly, Liberia and southern Sudan had sustained increases in mortality years after official peace processes and successful political transitions.[19] Finally, a retrospective study of 51 countries demonstrated that civil wars greatly increased the subsequent risk of death and disability for years after the end of conflict.[20]

On the one hand, DRC's experience of sustained increases in mortality is neither unusual compared with other conflicts nor out of keeping with its own history of years of conflict superimposed on decades of socioeconomic and political decline. Indeed, improvements in health indicators in DRC are further constrained by the lowest per capita health expenditures for any country in the world.[21] On the other hand, it would be inappropriate to dismiss such sustained elevations of mortality 4 years after the official end of the war as being simply inevitable. For example, a reduction in mortality was achieved in the East 2002 region since 2004, although its CMR is still 85% higher than the regional norm. This is the region of the country that has received the bulk of international peacekeeping support and humanitarian assistance, but at a level that is reported to be out of proportion to the documented need.[22,23] Arguably a more robust and equitable engagement by the Congolese government, peacekeepers, and international agencies would have contributed to even greater reductions in mortality.

Survey Limitations

As with all surveys, our study has limitations. Several of these relate to the problems of applying cluster sampling methodology, a tool originally designed for vaccination coverage surveys, to the collection of mortality data. These limitations have been described well elsewhere.[11,24,25]

TABLE 2

Mortality Rates for Each Stratum and Subdivision of Democratic Republic of Congo 1999–2007

	Year	National	East*	Transition	West	East 2002*	West 2002
Crude mortality rate†	1999–2001	—	—	—	—	5.4 (—)	—
	2002	2.4	—	—	—	3.5 (2.2–4.9)	2.0 (1.5–2.6)
	2003–04	2.1 (1.6–2.6)	2.4 (2.2–2.7)	1.5 (1.3–1.7)	1.8 (1.7–2.0)	2.9 (2.6–3.2)	1.8 (1.6–1.9)
	2006–07	2.2 (2.1–2.3)	2.4 (2.3–2.6)	2.1 (1.8–2.3)	2.0 (1.8–2.1)	2.6 (2.4–2.7)	2.0 (1.9–2.1)
Under-5 mortality rate†	1999–2001	—	—	—	—	Range 4.8–24.5	—
	2002	—	—	—	—	9.0 (4.0–14.0)	4.4 (3.2–5.7)
	2003–04	4.5 (3.6–5.4)	4.9 (4.4–5.4)	3.1 (2.7–3.6)	4.3 (3.8–4.8)	5.9 (5.3–6.6)	4.1 (3.7–4.5)
	2006–07	5.0 (4.6–5.3)	5.2 (4.8–5.7)	4.2 (3.5–4.9)	4.7 (4.3–5.1)	5.7 (5.1–6.3)	4.6 (4.2–5.0)

*Reported rates for east and East 2002 include the 4 purposely selected zones. Rates were not different whether these zones were included or excluded.
†Mortality rates are expressed as deaths per 1000 per month (95% confidence intervals).
2006–2007 design effects for crude mortality rate: east = 2.2, west = 1.4.
2006–2007 design effects for under-5 mortality rate: east = 2.2; west = 1.3.
2006–2007 intraclass correlations: east = 0.48 (zone), 0.09 (cluster); west = 0.33 (zone), 0.03 (cluster).

TABLE 3

Deaths in East and West Democratic Republic of Congo by Age and Sex

Stratum	Cause of Death	No. Reported	Weighted Percentage	5 Years and Older		Young Children 0–59 Mo (%)
				Male (%)	Female (%)	
East	Fever/malaria	498	26.3	116 (21.0)	83 (18.2)	299 (34.2)
	Other/unknown	395	21.4	187 (34.2)	144 (31.1)	64 (7.9)
	Diarrhea	174	9.1	59 (10.3)	35 (6.6)	80 (9.7)
	Acute respiratory tract infection	136	7.5	37 (6.7)	35 (7.5)	64 (8.1)
	Neonatal death	142	7.1	N/A	N/A	142 (15.5)
	Tuberculosis	129	6.6	69 (11.5)	54 (11.4)	6 (0.7)
	Measles	115	5.5	11 (1.7)	10 (2.1)	94 (9.9)
	Malnutrition	75	4.0	11 (2.1)	10 (2.3)	54 (6.3)
	Anemia	71	3.2	8 (1.4)	11 (2.4)	52 (4.8)
	Meningitis	55	2.8	18 (3.2)	15 (3.1)	22 (2.3)
	Accident/injury	45	2.4	30 (5.2)	11 (2.5)	4 (0.6)
	Maternal	42	2.3	N/A	42 (9.1)	N/A
	AIDS	27	1.2	9 (1.1)	18 (3.5)	0 (0)
	Violence	11	0.6	10 (1.8)	1 (0.2)	0 (0)
	Total	1915	100.0	565 (100.0)	469 (100.0)	881 (100.0)
West	Fever/malaria	268	27.7	51 (19.5)	47 (21.2)	170 (35.0)
	Other/unknown	231	22.8	111 (39.9)	79 (34.1)	41 (8.5)
	Diarrhea	86	8.9	14 (5.3)	10 (4.6)	62 (12.8)
	Tuberculosis	68	6.8	37 (13.4)	23 (10.5)	8 (1.6)
	Neonatal death	62	6.5	N/A	N/A	62 (12.9)
	Acute respiratory tract infection	55	5.5	11 (4.2)	11 (4.6)	33 (6.6)
	Anemia	41	4.3	5 (2.1)	1 (0.4)	35 (7.2)
	Malnutrition	41	4.3	8 (2.9)	10 (5.3)	23 (4.5)
	Accident/injury	35	3.4	22 (8.1)	6 (2.5)	7 (1.3)
	Meningitis	30	3.2	6 (2.1)	2 (0.9)	22 (4.7)
	Measles	29	2.9	1 (0.4)	3 (1.6)	25 (4.8)
	Maternal death	26	2.8	N/A	26 (12.7)	N/A
	AIDS	8	0.8	4 (1.4)	4 (1.6)	0 (0)
	Violence	3	0.3	2 (0.6)	0 (0)	1 (0.2)
	Total	982	100.0	272 (100.0)	222 (100.0)	488 (100.0)

TABLE 4

Comparison of 2006–2007 Survey Findings for Individual Health Zones With IRC Surveys From Previous Years

Health Zone	Mortality Rate*	Duration of Recall Period for Survey					
		1998–1999	1999–2000	2000–2001 (CI)	2002 (CI)	January 2003–April 2004 (CI)	January 2006–April 2007 (CI)
Kalemie	CMR	—	—	10.8 (9.5–12.1)	4.2 (2.8–5.6)	4.0 (3.4–4.5)	3.6 (2.9–4.2)
	U5MR	—	—	23.8 (19.8–27.8)	14.9	9.8 (8.1–11.8)	8.9 (6.9–10.9)
Kalima	CMR	—	—	7.5 (6.3–8.7)	3 (2.2–3.9)	4.1 (3.3–5.1)	2.1 (1.5–2.7)†
	U5MR	—	—	17.1 (13.2–21.)	8.9	8.4 (6.4–11.0)	5.2 (3.1–7.3)
Katana	CMR	3.8	3.0	4.9 (3.8–6.0)	1.9	2.5 (2.0–3.3)	1.5 (0.9–2.0)†
	U5MR	10.1	6.9	12.9 (9.3–16.5)	2.9	5.8 (4.6–7.4)	4.5 (2.1–6.9)
Kisangani–Ville	CMR	—	2.9	—	6.2	1.4 (1.1–1.7)	1.0 (0.7–1.4)
	U5MR	—	4.8	—	10.4	2.2 (1.6–3.0)	1.6 (0.6–2.5)

CMR = crude mortality rate; U5MR = under-5 mortality rate.
*Mortality rates expressed as deaths per 1000 per month.
†CMRs for 2006–2007 are significantly different from 2003–2004 (Kalima rate ratio 0.8; $P < .000$; Katana rate ratio 0.8, $P = .001$).
Where no rates are reported, no survey was done in the health zone during that year. Range of design effects for 4 health zones: CMR (1.2–1.8); U5MR (1.0–2.1).

We relied on MOH population data for the random selection of health zones. Wherever possible, we also used MOH data for the selection of individual clusters. When such data were not available, the relative size of smallest units was crudely weighted using estimates of local leaders. No independent confirmation of these estimates was conducted due to time constraints. It is unclear whether inaccuracies in MOH data or in the estimates of local leaders could have biased our

results, but we have no reason to believe that these would have led to significant systematic errors.

Our choice of a method to select households was bound by time, logistical, and resource constraints. Systematic random sampling was our preferred method of household selection, but this was only feasible in 16% of the smallest sampling units because most were dispersed, rural communities. In such settings, we used the WHO/EPI random walk method, which has been used widely in other mortality surveys.[26,27] Articles published since our fieldwork have suggested amendments and alternatives to this method, although each have their own limitations and biases.[24,28]

We used the current household census method for the ascertainment of events and the population at risk during the recall period. Although the past household census method is preferred, our own experience indicated that it significantly increased the time at each household, posing problems for staff in remote and insecure areas. The current household census remains a valid but not ideal method of household data collection.[11,24]

There was a high proportion of empty households in both strata. A limited assessment during the 2002 survey found that mortality was 43% higher in empty households than in households in which occupants were home at the time of the initial household visit.[4] Logistical issues prevented a similar assessment during the most recent study; therefore, we do not know whether this pattern holds true in DRC today. We tried to reduce exclusions by surveying early morning or late afternoon, and avoided interviewing on public holidays and on Sundays in Christian communities. Ideally, all surveys should return to empty households at a later date and avoid replacement with a neighboring household. If this is impractical, then a subset of empty households should be revisited to gauge the likely direction and magnitude of this bias. It is a clear limitation of our survey that we did not use these measures.

Fever/malaria was reported to be the number one killer in DRC and our inclusion of 2 wet seasons in the recall period could overestimate mortality rates. This should not, however, influence comparisons between our 2004 and 2007 surveys because recall periods for both surveys covered exactly the same months. Cause of death data were as reported by interviewees and must be interpreted with caution. Deaths due to trauma (violent and accidental) and measles and deaths during the neonatal period are likely to be accurate, although the latter may be underreported. Our cause of death data should only be used in a general sense to alert planners to possible health priorities, and should be followed by more accurate local assessments to determine cause-specific mortality rates.

This is the first IRC survey in DRC in which zones were not omitted from the sampling frame in advance due to insecurity. Except for 1 small, militarized zone in the west, all of the health zones were eligible for selection. Nonetheless, as with every survey in conflict settings, our results could have underestimated mortality because of survival bias, underreporting of infant deaths, and exclusions of segments of the population from the survey; large areas in 1 zone in North Kivu became unsafe to visit after surveying began, and a military camp and a remote, rural village could not be accessed.

CONCLUSIONS

Sustained elevations of mortality more than 4 years after the official end of war indicate that serious humanitarian concerns persist in DRC, with children disproportionately affected. Our findings provide additional evidence that improvements in key health outcomes can take years following protracted conflicts, even after the signing of formal peace accords and successful political transitions. Nonetheless, slight but significant reductions in mortality were documented in the eastern provinces, coinciding temporally with improvements in security.

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Received for publication February 19, 2009; accepted March 24, 2009.

An earlier version of this article entitled "Mortality in the Democratic Republic of Congo: An Ongoing Crisis" was released by the International Rescue Committee in January 2008.

Authors' Disclosures

As an operational humanitarian agency in Democratic Republic of Congo, the International Rescue Committee can benefit from increased foreign assistance funds that may result from the publication of this report. The other authors report no conflicts of interest.

Acknowledgments

The authors thank all of the International Rescue Committee national staff from Democratic Republic of Congo who worked tirelessly during the data collection phase, as well as contributed to the data entry. The authors also wish to acknowledge colleagues from all 35 health zone offices who helped survey households. The dedication, courage, and good humor of the field teams were invaluable as they dealt with many logistic and other challenges, often in remote and potentially insecure areas. Thanks also to Susan Bartels of the Harvard Humanitarian Initiative and to Franklin Broadhurst and Charles Lubula Muganda, both of the International Rescue Committee, who helped to supervise field teams. Damian Jolley of Monash University made valuable contributions to the statistical analysis, and the Joint Military Analysis Cell of Mission des Nations Unies en République Démocratique du Congo provided useful information concerning threat assessments.

Funding for this study was provided through a grant from the United Kingdom's Department for International Development.

ISSN: 1935-7893 © 2009 by the American Medical Association and Lippincott Williams & Wilkins.

DOI: 10.1097/DMP.0b013e3181a6e952

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