

Seasonal patterns of cardiovascular disease mortality of adults in Burkina Faso, West Africa

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Summary

OBJECTIVE To evaluate seasonal patterns of cardiovascular death in adults, which are possibly influenced by hot and dry climate, in a rural setting of Burkina Faso.

METHODS Cause of death was ascertained by verbal autopsy. Age-specific death rates (cardiovascular death and all-cause) by month of death were calculated. Seasonal trends and temperature effects were modelled with Poisson regression.

RESULTS In 11 174 adults (40+), 1238 deaths were recorded for the period 1999–2003. All-cause mortality in adults (40–64 years) and the elderly (65+ years) was 1269 per 100 000 (95% CI 1156–1382) and 7074 (95% CI 6569–7579), respectively. Cardiovascular death was the fourth most frequent cause of death in adults (40+), with a mortality of 109.9 (95% CI 76.6–143.1) for ages 40–64 and 544.9 (95% CI 404.6–685.1) for ages 65+. For all-causes, the mortality was highest in March and for cardiovascular death highest in April, the hot dry season (March–May). Mean monthly temperature was significantly related to mortality in old ages.

CONCLUSIONS Cardiovascular mortality varies by season, with higher mortality rates in the hot dry season. The pattern seems to be consistent with other studies suggesting association between hot weather and cardiovascular disease. A ‘heat-wave’ effect appears to be observable also in areas with hot average temperatures.

keywords adult mortality, Burkina Faso, cardiovascular disease, demographic surveillance, hot dry season, verbal autopsy

Introduction

Mortality in sub-Saharan Africa

Population health has improved remarkably over the last 50 years. Average life expectancy at birth has increased substantially in sub-Saharan Africa (SSA) since the 1950s (WHO/UNICEF 2003). Because of the decrease in childhood mortality, a larger proportion of the population reaches old age (Lopez *et al.* 2006; Mathers & Loncar 2006). In adults, HIV/AIDS is the most frequent cause of death in many parts of SSA, but non-communicable diseases (NCD) and non-natural causes of death are also playing a major role now (Murray & Lopez 1997). Recent projections of mortality from 2002 to 2030 show that the proportion of NCDs will rise (Mathers & Loncar 2006). There is a dramatic shift in the distribution of deaths from younger to older ages and from communicable, maternal, perinatal and nutritional causes to NCD.

Reliable data on age-, sex- and cause-specific mortality are lacking in more than half of all countries or are of poor quality (Mathers *et al.* 2005). Coverage of death registration varies from close to 100% in the WHO European region to <10% in the African region. In such areas, health demographic surveillance systems (HDSS) provide the data to construct all-cause and cause-specific mortality patterns (INDEPTH 2002), which have been used to report cause-specific mortality rates in SSA countries (Adjuik *et al.* 2006). Uncertainty in all-cause mortality estimates ranged from around 1% in high-income countries to 15–20% in SSA (Lopez *et al.* 2006).

Adults and cause-specific mortality in SSA

Little is known about the level and causes of adult mortality in SSA, and mortality rates are high throughout adulthood (Kitange *et al.* 1996; Murray & Lopez 1997).

Mortality rates are not as extreme as for infants and children, but in SSA, they are higher in all age groups than in developed countries (MMWR 2000). Several studies in West Africa showed an increase in prevalence rates for cardiovascular disease (CVD) (Quigley *et al.* 1999; Lawoyin *et al.* 2004; Mufunda *et al.* 2006; Amuna & Zotor 2008). Prevalence rates of NCD risk factors in Africa showed an increase in the prevalence of hypertension (Unwin *et al.* 2001; Mufunda *et al.* 2006). In Burkina Faso, smoking prevalence as one strong risk factor for CVD showed prevalence rates close to zero in women and up to 35% in men depending on age (Winkler *et al.* 2006).

Seasonal patterns of mortality

An association between hot weather and CVD mortality has been suggested by two studies in Italy (Mastrangelo *et al.* 2006), but little is known for countries with a hot climate. There are few studies from SSA in which seasonal patterns of mortality in adults are reported, and the results are inconsistent. Slightly higher mortality rates in adults were observed during the rainy than the dry season in a study from The Gambia (Rayco-Solon *et al.* 2004). Seasonal patterns of overall mortality in the Nouna HDSS in the period 1993–2001 for all age groups showed an excess of mortality in young children at or around the end of the rainy season in contrast to an excess mortality in older children and adults during the early dry season (Kynast-Wolf *et al.* 2006). Becher *et al.* (2008) found the highest mortality rates in dry season.

We evaluated mortality rates for adults (40 years and above) by cause of death. Seasonal and temporal patterns of CVD were investigated in a typical rural African population with a Sahelian climate (Yé 2005).

Materials and methods

Study area

The database for this study is based on a HDSS run by the *Centre de Recherche en Santé de Nouna* (CRSN) in Nouna Health District (Becher & Kouyaté 2004). It covers a large part of Kossi province in northwestern Burkina Faso. The study area had about 62 000 inhabitants in 2003. The first baseline census took place in 1992 and collected demographic information on all individuals in the study area. Two control censuses were held in 1994 and 1998 to check and add information to previous censuses. The data collection and vital event registration now follows a 3-month cycle. Health services in the HDSS area comprise the District Hospital in Nouna town and six local health centres in the surrounding villages. The predominantly rural and – considering the town of Nouna itself – semi-urban area is a dry orchard savanna, populated almost exclusively by subsistence and cattle farmers.

Climate and temperature data

The region has a sub-Saharan climate with a mean annual rainfall of 796 mm (range 483–1083) over the past five decades. In Burkina Faso, it is hottest from March until May with a peak in April; the lowest temperatures occur in December and January (TuTiempo.net 2010). The rainy season usually lasts from June until October with malaria peak during and shortly after the rainy season. The period November until February is considered the cool dry season, while the period March until May is called the hot dry season. Temperature measurements by day for the study period 1999–2003 are available for Dedougou, about 50 km away from Nouna town (TuTiempo.net 2010). We used the monthly provided mean temperature and rainfall from Dedougou for extended monthly analysis (Figure 1).

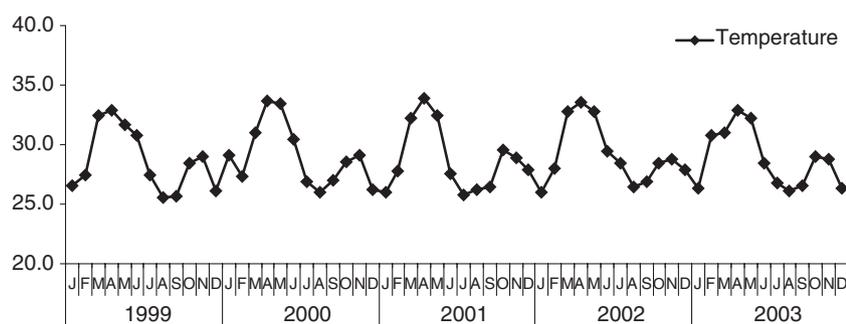


Figure 1 Average monthly temperature, Dedougou, Burkina Faso, 1999–2003.

Study population and cause of death assessment

Data of adults (40+) were analysed for the period January 1st 1999 to December 31st 2003. Data for the rural area cover the entire period; data from the Nouna town population were added from January 1st 2000. The population increased from 10 782 in 2000 to 11 174 in 2003 [(8406 aged 40–64 years, 2376 aged 65+) to (8782 aged 40–64 years, 2392 aged 65+)].

Ascertaining the cause of death is based on the verbal autopsy (VA) questionnaire method. Verbal autopsy data are collected by trained field staff who systematically visit the households of deceased persons in the CRSN study area. A standardized questionnaire developed at CRSN is applied 1–6 months after the death and after having obtained oral informed consent. The questionnaire covers demographic data and the clinical history before the death occurred. Some 5–10% of these questionnaires are systematically checked by the supervisors of field staff through field visits and repeated interviews. These questionnaires are then read by two experienced local physicians of a pool of locally available and specifically trained physicians who assign a definite cause of death. In case of discordance, a third physician is involved. At least two physicians have to agree on the final diagnosis (Anker 1997).

Statistical methods

All individuals with a residence period in the study area within the study period were included in the analysis. For modelling seasonal trends, mortality rates per month of death were estimated. For each month within the study period, the monthly person-years of observation PY_{ijlm} by sex ($i = 0,1$), age group ($j = 1,2$), year ($l = 1999, \dots, 2003$) and month ($m = 1, \dots, 12$) were approximated as the arithmetic mean of the population at the beginning and the end of a given month divided by 12. The following age groups were considered: adults (40–64 years; $j = 1$) and elderly (65+ years; $j = 2$). Likewise, total numbers of deaths in these categories are calculated and denoted by D_{ijlm} . Mortality rates were estimated as

$$\hat{\lambda}_{ijlm} = D_{ijlm} / PY_{ijlm}$$

For further analysis, cause-specific mortality rates for CVD were calculated.

Regression analysis

The relative effect of each month on overall or cause-specific mortality was estimated with Poisson regression

using the floating absolute risk method (Greenland *et al.* 1999). The following models were used separately for both age groups:

$$\log(D_{ilm}) = \log(PY_{ilm}) + \beta_{1i}\text{sex} + \beta_{2l}\text{year} + \beta_{3m}\text{month} \quad (1)$$

$$\log(D_{il}) = \log(PY_{il}) + \beta_0 + \beta_{1i}\text{sex} + \beta_{2l}\text{year} \quad (2)$$

The effect of each month on mortality relative to the yearly average is then given as $\beta_{3m(1)} - \beta_{0(2)}$, the difference of the monthly effect of model (1) and the overall effect of model (2).

Modelling seasonal trends and temperature effects

For continuous modelling of the seasonal or temperature effect on mortality rates by age groups, we used two methods: (i) A Poisson model with a sine function of the form $g(\text{month}) = \sin[(\text{month} + k) \times \pi/6]$, assuming a period of 12 months, where k can take a value between 1 and 6. This analysis parallels an earlier analysis on childhood mortality (Becher *et al.* 2008).

$$\log(D_{ilm}) = \log(PY_{ilm}) + \beta_0 + \beta_{1i}\text{sex} + \beta_{2l}\text{year} + \beta_{3m}g(\text{month}) \quad (3)$$

(ii) A model in which the monthly mean temperature is included as a covariable.

$$\log(D_{ilm}) = \log(PY_{ilm}) + \beta_0 + \beta_{1i}\text{sex} + \beta_{2l}\text{year} + \beta_{4lm}\text{temperature}_{lm} \quad (4)$$

The indices are i for sex (binary), l for year (entered as continuous variable from 0 (1999) to 4 (2003) and m for month (1–12).

In model (i), the effect of month on the mortality rates is described by the parameter β_4 , the amplitude, and the value k , the shift of the sine function. To find the best combination of (β_4^*, k^*) , model (3) is also fitted without $g(\text{month})$. The difference of deviances between these two models is asymptotically χ^2 -distributed with two degrees of freedom, because two parameters (β_4, k) are estimated. A numerical search for the set of parameters (β_4, k) , for which the differences of the deviances gives the maximum, is the best combination (β_4^*, k^*) and therefore the best fit of the model. Effects are given as logarithmic rate ratios (RR).

To construct the confidence band, a numerical search was carried out for a set of parameters $(\beta_{4\text{conf}}, k_{\text{conf}})$ for which

$$(\text{deviance}[\text{model}(\beta_4, k)] - \text{deviance}[\text{model}(\beta_4^*, k^*)]) < \chi_{2,0.95}^2 \quad (5)$$

With this set of combinations ($\beta_{4 \text{ conf}}$, k_{conf}), the 95% confidence was constructed (Preuß 2007).

Regression diagnostics

Overdispersion in the Poisson models was tested with a likelihood ratio test according to Cameron and Trivedi (1998). All analyses were carried out with SAS (SAS Institute Inc. 2003) using SAS 9.1 software, the Poisson regression using SAS-procedure PROC GENMOD.

Results

A total of 11 174 adults (40+) were observed, of whom 1238 had died by the end of the study period in December 2003. Table 1 shows that with 98 deaths, CVD was the fourth most frequent cause of death in adults (40+), comprising 10.7% of all known causes (11.3% for men, 10.1 for women). A verbal autopsy questionnaire had been completed for 75.5% of all deceased. CVD was the most frequent NCD in both age groups and for both sexes. For adults aged 40–64 years, acute respiratory infections (ARI) and HIV/AIDS were the most frequent causes of death, followed by malaria and CVD. For the elderly (65+ years), malaria was the most frequent cause of death followed by ARI, acute gastrointestinal infections (AGI) and CVD. The

category ‘ill-defined’ covers unspecified diagnoses, whereas the category ‘others’ groups all diagnoses with very small numbers. Thirty-seven per cent of all causes of death were missing or ‘ill-defined’.

Mortality rates were expressed per 100 000 PY. For all adults (40+), the all-cause mortality rate was 2534 (95% CI 2396–2679); in adults (40–64 years), it was 1269 (95% CI 1156–1382) and in the elderly (65+ years), it was 7074 (95% CI 6569–7579).

Cardiovascular disease mortality was 205 per 100 000 (95% CI 168–249) in all adults, 110 (95% CI 81–149) for people aged 40–64 years and 545 (95% CI 421–704) for people aged 65+. The mortality rates for men were higher than for women [230 (95% CI 176–303) for men and 183 (95% CI 138–242) for women] (Figure 2).

For analysing mortality rates by month of death, four of the 1238 deceased persons with missing month of death were omitted. The relative effect of month of death (two adjacent months were combined to get more stable estimates) for all-cause mortality is shown, by age group, in Figure 3. The RRs are illustrated for each month using the floating absolute risk method. While a peak for people aged over 65 is very pronounced in March–April, adults aged 40–65 years did not show a seasonal pattern. Table 2 shows the number of deaths and respective death rates by months for CVD in the age group 65+, using the same grouping of months. As for all causes of death, the highest rates occurred in March and April.

Seasonal patterns and temperature effects for all cause and CVD mortality were then modelled by age group as a

Table 1 Most frequent cause of death (CoD) ranked by age groups, Nouna health demographic surveillance systems, 1999–2003

Adults (40–64)			Older people (65+)			All adults (40+)		
CoD	N	%	CoD	N	%	CoD	N	%
ARI	53	10.9	Malaria	146	19.4	Malaria	189	15.4
HIV/AIDS	52	10.7	ARI	107	14.2	ARI	160	12.9
Malaria	43	8.9	AGI	76	10.1	AGI	107	8.4
CVD	42	8.7	CVD	56	7.4	CVD	98	7.9
AGI	31	6.4	Non-natural	18	2.4	HIV/AIDS	56	4.6
Tuberculosis	13	2.7	Tuberculosis	11	1.5	Non-natural	32	2.6
Non-natural	14	2.9	Stroke	10	1.3	Tuberculosis	24	1.9
Cancer	12	2.5	Cirrhosis	6	0.8	Cancer	16	1.3
Illeus	10	2.0	Illeus	6	0.8	Illeus	16	1.3
Cirrhosis	7	1.4	Cancer	4	0.5	Stroke	15	1.2
Stroke	5	1.0	HIV/AIDS	4	0.5	Cirrhosis	13	1.0
Others	28	5.8	Others	30	4.0	Others	58	4.7
Ill-defined	58	12.0	Ill-defined	90	12.0	Ill-defined	148	12.0
Missing	117	24.1	Missing	189	25.1	Missing	306	24.8
Total	485	100.0	Total	753	100.0	Total	1238	100.0

CVD, cardiovascular diseases; ARI, acute respiratory infections; AGI, acute gastrointestinal infections.

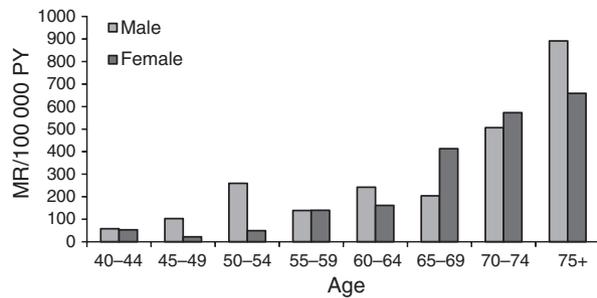
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Figure 2 Age-specific mortality rate (MR) per 100 000 for cardiovascular disease by sex, Nouna health demographic surveillance systems, 1999–2003.

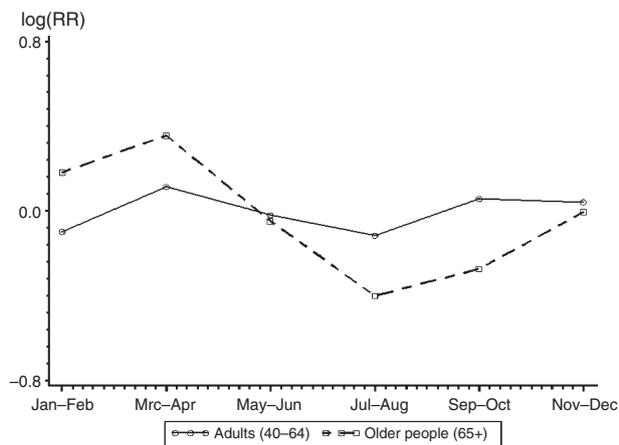


Figure 3 Relative effect of month of death using the ‘floating risk method’ for all-cause mortality (adjusted for sex, area, calendar year) by age group, Nouna health demographic surveillance systems, 1999–2003.

continuous function of month using Poisson regression. The results are given in Figure 4 as RRs with 95% confidence band. The estimated sine functions support a highly

significant ($P < 0.001$) seasonal variation for all-cause mortality and a significant ($P < 0.05$) seasonal variation for CVD mortality in the elderly. Table 3 summarizes the functions describing the best fit of the RRs. In the analysis, the seasonal effect was not only indicated by month but by mean temperature. For all-cause mortality, the mean temperature for the 65+ age group was highly significant ($P < 0.0001$). Also, for the 40–64 age group, an effect could be ascertained for the mean temperature ($P = 0.09$). The analysis with the maximum temperature provided no higher significance than the analysis with mean temperature. For CVD, these effects were not significant, but estimates were on the same order of magnitude, $P = 0.2$ for mean temperature in the 65+ age group and $P = 0.3$ for mean temperature in the 40–64 age group. Although we found no seasonal effect in the younger age group, we did see a clear and significant pattern for people aged over 65 years both for all causes and CVD with similar dates for the highest and lowest rates (Figure 4).

All Poisson models were tested for overdispersion. Results presented in Table 3 show that the Poisson assumption was appropriate. For two models (CVD, younger age group), a slight underdispersion was observed, so that the true P -values for the temperature/seasonal effect may be smaller than reported.

Discussion

As age is a known risk factor for CVD mortality increased with age, higher proportions of deaths were found among the elderly people. A clear seasonal effect on all-cause mortality has been detected in adults (40+), with highest rates in the dry season (November–May). This pattern is mainly dominated by CVD and by the higher age group 65+. CVD in adults (40+) peaked in April, the hottest month in the middle of the hot dry season (March–May). The effect was stronger for CVD in people older than 65 years ($P = 0.05$), peaking at the beginning of May. This

Table 2 Mortality rates (MR) by month for cardiovascular diseases, age 40–65 and 65+, Nouna health demographic surveillance systems, 1999–2003

Months	40–65 years			65+ years		
	Deaths	MR	95% CI (exact)	Deaths	MR	95% CI (exact)
January–February	6	96.8	35.5–211.1	13	748.3	398.1–1279.6
March–April	9	141.5	64.8–268.9	14	787.8	430.2–1323.5
May–June	5	78.4	25.4–182.7	8	451.8	194.7–890.0
July–August	4	62.5	17.0–160.0	13	731.5	150.7–2135.9
September–October	10	155.5	74.6–286.1	4	223.7	60.8–572.7
November–December	8	123.9	53.4–244.1	6	334.4	122.7–728.9
Total	42	109.9	81.2–148.7	58	544.9	419.6–708.4

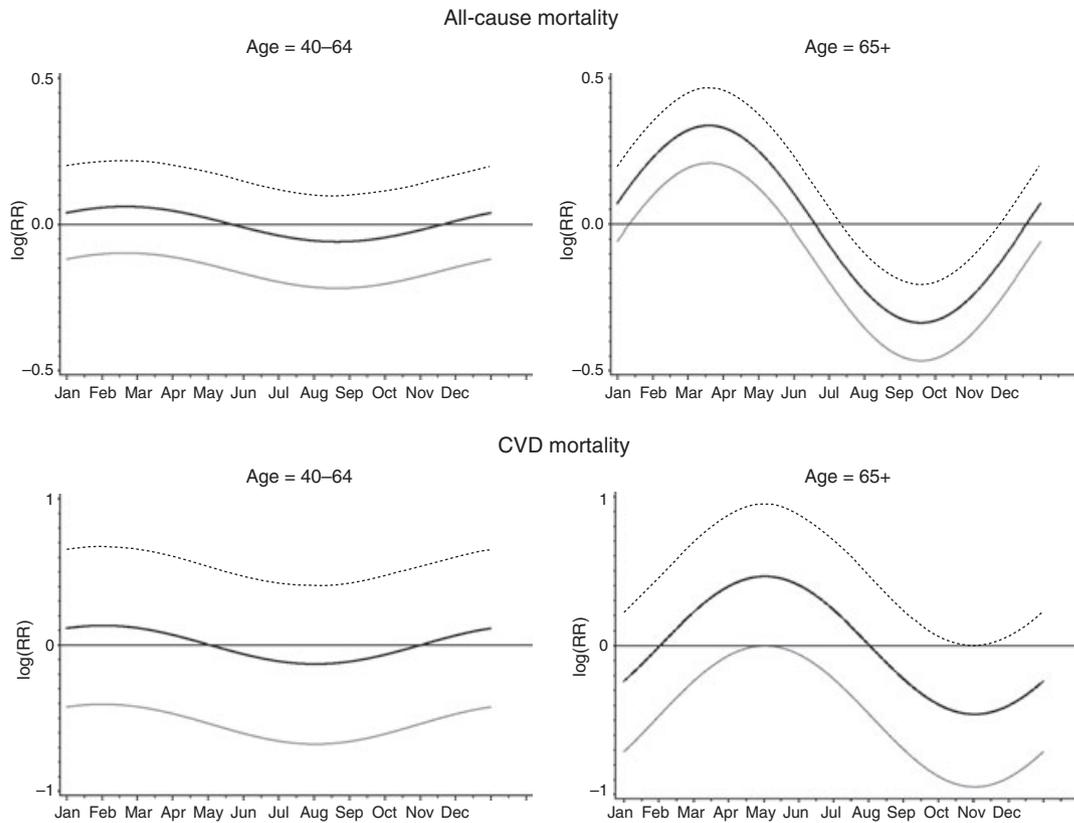


Figure 4 log(Rate Ratios) by month of death relative to yearly average with 95% confidence band for all-cause and cardiovascular disease mortality, by age group, Nouna health demographic surveillance systems, 1999–2003.

Table 3 Effect of month and temperature on all-cause and cardiovascular disease (CVD) mortality by age group, Nouna health demographic surveillance systems, 1999–2003 (continuous modelling)

Age group	Month (<i>m</i>)			Temperature (<i>t</i>)		
	log RR(<i>m</i>)	<i>P</i>	<i>P</i> *	β	<i>P</i>	<i>P</i> *
All-cause						
40–64	$0.06 \times \sin[(m + 1.3) \times \pi/6]$	0.6	0.9	0.030 <i>t</i>	0.09	0.9
65+	$0.34 \times \sin[(m + 0.4) \times \pi/6]$	<0.0001	0.7	0.069 <i>t</i>	0.0001	0.2
CVD						
40–64	$0.13 \times \sin[(m + 2.0) \times \pi/6]$	0.8	0.65†	0.060 <i>t</i>	0.3	0.83†
65+	$-0.46 \times \sin[(m + 5.0) \times \pi/6]$	0.05	0.6	0.056 <i>t</i>	0.2	0.5

*Test for overdispersion.

†Deviance/(degrees of freedom) (underdispersion).

is consistent with other studies suggesting an association between hot weather and CVD (Mastrangelo *et al.* 2006). We also found a direct link between temperature and mortality using temperature measurements available near the study region.

Our results are in line with previous findings. Earlier studies focussed on the effect of short heat waves. In London, mortality excess during heat waves was of short duration and followed by mortality deficits which summed up to zero, whereas in Delhi the excess was larger than the

following deficit (Hajat *et al.* 2005). An investigation of the effect of high temperatures on daily mortality in three cities in Europe revealed that the risk of heat-related death increased with age (Ishigami *et al.* 2008). In Spain during the hot season, its heat which most clearly manifests an effect with mortality rate variations according to age and cause of death: the effect of temperature was greater in persons aged over 70 years, and it was also greater in people with circulatory and respiratory diseases (Ballester *et al.* 1997).

Because of global warming, seasonality is becoming increasingly relevant for mortality patterns in developing countries, and there is a necessity to show the linkage between climate and disease (Moore 2006). Recent changes in the occurrence of infectious diseases (tick-borne encephalitis in Sweden, cholera outbreaks in Bangladesh, malaria in the east African highlands) may in part reflect regional climatic changes (Hales & Woodward 2003, 2005; McMichael *et al.* 2003). Because CVD is sensitive to climate conditions, an understanding of the current pattern of seasonal variations will assist in estimating the impact of future climate change (McMichael *et al.* 2006).

In SSA alone, the number of persons aged 65 years and older is expected to increase by 50% from 2000 to 2015, from 19.3 to 28.9 million (Smith & Mensah 2003). As age is the most powerful independent predictor of cardiovascular mortality, the impact of these demographic changes on CVD and stroke will be substantial.

This study has a number of limitations. The first, well-known limitation relates to the validity of the causes of death. However, verbal autopsies are at present the best possible method to obtain information on cause-specific deaths in poor countries (Quigley 2005), and although new survey instruments for VA collection (Setel *et al.* 2005; Murray *et al.* 2007) have recently been proposed, which might improve the availability of data in future, there will always remain a limited sensitivity and specificity. To our knowledge, this has not been estimated specifically for CVD. Heart attacks may be easier to classify, but this is mere speculation. It is unlikely, however, that the misclassification of cause of death by any chronic disease depends on season. Therefore, the true seasonal patterns may be even stronger than observed, because non-differential misclassification would then dilute the true effect.

Another limitation in this database is the large percentage of deaths with unknown or ill-defined cause, resulting either from completely missing or insufficient information, which either leads to conflicting evaluations from the physicians or to assignment to the 'ill-defined' category. This is a problem of most similar studies from SSA. A

further limitation is the relatively small number of CVD deaths in this study despite the relatively large population. Further analyses jointly analysing data from different HDSS sites in Africa would be useful.

Overall, this study confirms the rising impact of CVD on mortality in SSA and highlights the seasonality of this disease. Further investigations of high temperature and an excess of death from CVD are warranted.

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