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**Rainfall variations and child mortality in Sahelian region.
Results from a comparative analysis in Burkina Faso and Mali**

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In sub-Saharan Africa, health conditions continue to be the worst of all developing regions and child mortality rates are running at an average rate of 174 deaths per 1000 babies born, compared with 121 per 1000 in low income regions as a whole (World Bank, 2004). Beyond the effects of the classical determinants of child survival (mothers' and fathers' education, birth interval, economic status of the household, etc.), ecological factors (such as drought or land degradation) can have a strong influence on child survival in rural subsistence societies, particularly through their impact on malnutrition and on income reduction. More precisely, ecological factors affect the quantity and variety of food crops produced and the quantity and quality of water. They also influence the availability of income-generating work, the access to and use of medical facilities, and the time mothers can spend at home in child care. However, even if the importance of the ecological factors have already been emphasized in the well-known article written by Mosley and Chen (1984) on the determinants of child survival, there is little empirical evidence on this topic.

In the early 1970s, in sub-Saharan Africa 70 million people were affected by chronic food shortages, and this number attained 100 million by 1985 (Kiros, et al., 2000). Famine induced by drought has almost certainly contributed to continued high African mortality levels (Caldwell, et al., 1992). Persistence of unfavourable climatic conditions could lead to not only a sharp reduction of the food production but also to the disorganisation of food distribution. The consequence for population is a deterioration of alimentation (Palloni, 1988) and the availability of a basic minimum food supply of sufficient variety is critical to ensure adequate amounts of all nutrients. The most vulnerable groups to excess famine deaths are the young and the old (Kiros, et al., 2000). In Niakhar (Senegal), 60 percent of deaths among children aged 1 to 60 months have been attributed to malnutrition (Garenne, et al., 2000). The infant survival is expected to decrease because the malnutrition, by reducing birth weight, influences the neo-natal and post-neonatal mortality (Palloni, 1988). Maternal diet and nutrition during pregnancy also affect birth weight and, during lactation, influence the quantity and nutrient quality of breast milk (Mosley, et al., 1984). In case of breastfeeding, babies are less vulnerable of strong food reduction, except if breastfeeding is not exclusive or if malnutrition also concerns the mothers. Besides, the survival of children aged 1 to 5 is very sensitive to the food shortage because of the needs of solid food of young children and because their immune system is not completely developed (Palloni, 1988). Moreover, famines help the rapid spread of disease through the weakening of immune systems,

through resulting migrations, through the breakdown of sanitary services, and through the readiness of famine victims to eat whatever they can get (Kiros, et al., 2000).

In addition to malnutrition, ecological factors may have influence on child survival by the reduction of income. In period of drought, rural families experience many difficulties such as the reduction of food production, abnormal increases in food grain prices and the non-availability of jobs (Paul, 1998). In poor societies in particular, families may spend 80 percent or more of their disposable income on food; thus variations in income or food prices may be translated directly into rising rates of malnutrition mortality. In rural subsistence economies, even seasonal variability in income and/or food availability may lead to seasonal swings in mortality.

Finally, rainfall seasonality has effects on pathogens by increasing the development of water-related insect vectors and the development of water-based diseases (such as diarrhoea).

Objective of the study

In Burkina Faso, a first case study has already highlighted how child survival depends on rainfall conditions. More precisely, there are specific patterns of rainfall variations and children's mortality relationships in each burkinabè agro-climatic region (Dos Santos and Henry, 2007). This communication aims to understand how rainfall variations may influence child survival in a larger zone in the Sahel. The first objective is to examine the influence of climatic variations on child survival in rural Mali. The second objective aims to compare results obtained in Burkina Faso with those obtained in Mali. Throughout the Sahel and other regions affected by rainfall variability, there is a widespread understanding of the connection between climate variability and family well-being. This study could be the first step to understand the complex ways in which rainfall variability affect the mortality during the childhood period.

Context

Burkina and Mali experience high levels of child mortality compared to their west-African neighbourhoods (WHO, 2004), with large geographic disparities within each countries. In Burkina Faso, the childhood mortality rate is 150 per thousand in the Central region while it is more than 250 per thousand in the Sahel and the North regions (INSD and ORC Macro, 2004). Marked regional differentials in under-five mortality are also observed in Mali. For example, under-five mortality ranges from a low of 219 per

thousand live births in Koulikoro Region³ to a high of 291 per thousand live births in the Mopti Region (CPS/MS, DNSI and ORC Macro, 2002).

In terms of environmental context, there is a long history of droughts and related famine in the Sahel. Three distinctive farming systems are largely determined by rainfall patterns: (1) Pastoral Systems with a high incidence of severe poverty and low potential for poverty reduction; (2) Agro-Pastoral Millet-Sorghum System with a high incidence of severe poverty but with a high potential for poverty reduction and (3) Cereal-Root Crop Mixed System with a lower incidence of poverty but also with a high potential for agricultural growth. Most agricultural production is concentrated in the short rainy season, and climate events affecting the distribution or quantity of rain during the rainy season have historically had a significant impact on food production.

In terms of rainfall, these two Sahelian countries are characterized by a strong south-north decreasing gradient of average annual rainfall.

Data

An original aspect of this work is the use of exceptionally reliable and comparable multi-source data for the study of how climatic variations influence child survival in Burkina Faso and in Mali.

1. Individual and household data are provided by two nationally-representative detailed retrospective surveys (life-history type). The first one, *Enquête sur les Dynamiques Familiales et l'Education des Enfants au Mali (EDFEEM)*, was conducted in 2000 in Mali (Marcoux, et al, 2002). In all, 3,152 women were surveyed among others on the birth and death history of their children.

The second one, *Enquête Migration, Insertion Urbaine et Environnement au Burkina Faso (EMIUB)*, was conducted in 2000 in Burkina Faso by the ISSP of the University of Ouagadougou, the Demography Department of the University of Montreal and the CERPOD (Poirier, et al., 2001). In all, 3,751 women were surveyed, with 17,544 births and 3,268 deaths among these children.

These two surveys have followed the same methodology and are thus highly comparable. Household questionnaires included questions on the individual characteristics of the different members and on their housing conditions. Detailed

³ Except for the urban region of the Greater Bamako (134 per thousand live births).

biographic questionnaires covered family origins, migration, employment, matrimonial and fertility histories.

2. Rainfall data covering the 1960-1998 period have already been obtained from the global monthly precipitation data set produced by the Climatic Research Unit at the University of East Anglia (New, et al., 2000). These data have been interpolated from a network of stations at a spatial resolution of 0.5 degree latitude and longitude, and have been linked to the survey data above.

In the literature, season at birth is often used as proxy for climatic influence (Blacker, 1991). In this study, **the mean annual precipitation over the 1960-1998 period and the percent of normal precipitation over the three preceding years** are used in addition to the season of birth. The first variable is considered to be a good indicator of agricultural productivity and of vulnerability to drought. The second variable is a time-varying variable indicating the extent to which rainfall in the department over the three preceding years differed from the long-term rainfall conditions in the department. It is measured as the ratio of the mean rainfall over the three preceding years to the mean rainfall over the 1960-1998 period.

Methods and expected results

Multilevel event-history methods are used to estimate the impact of various characteristics of the environment on child survival, controlling for relevant variables related to the child (sex, rank, generation) and his mother (education, age at the child's birth, migratory status, standard of living). The event history approach allows us to take into account time-varying explanatory variables. Multilevel models are used to model and correct for the correlation of observations at multiple levels. In terms of expected results, child survival is expected to be higher in semi-urban areas in case of adverse climatic events than in the villages, because semi-urban households have probably more means to cope in period of drought. As found in Balk et al. (2003), the unweaned infants are expected to be less vulnerable to climatic variations than children aged 1-5, thanks to the protection by breastfeeding (Palloni, 1988).

Although many researchers are convinced of the benefits of multi-disciplinary studies, practical issues have often limited their number. In terms of ecological factors, population scientists content themselves with available data (often coarse classifications of rainfall or environmental vulnerability). In this study, rainfall variables are measured with accuracy at fine spatial and temporal resolutions. In addition, the event-history

approach allows us to take into account the conditions of the child environment during his first five years and not only at the time of the survey, as has generally been done by previous studies. The likelihood of child survival could be different if for example a child moved during his first five years from a village with unfavourable climatic conditions to a village with favourable climatic conditions. Our approach takes this residential change into account, by using the mother's migratory history collected by the survey.

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