How does climate contribute to intra-annual variability and abnormal peaks of acute respiratory infections among children in rural Benin?

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Introduction

Today, no doubt remains on the existence of effects – mostly negative – of natural environment on human health (Kalkstein et al., 1993; McMichael et al., 2001). The resurgence and redistribution of diseases mirror changes in ecological and climatic conditions (Craig et al, 1999) and it is estimated that 25 to 30% of the global disease burden can be attributed to environmental factors (Smith et al., 1999). In the literature, malaria (Craig et al., 1999; Kazembe *et al*. 2006), other vector-borne diseases (Thomson et al., 2004) and meningitis (eg. Sultan et al., 2004; Mueller et al., 2008) are the most encountered infections diseases in the studies about the impacts of environmental factors on human health in Africa. Seasonality is a fact frequently reported in such studies. Sauerborn and al. (1996) asserted that in Burkina Faso the frequency of the most diseases increases during the rainy season. In Gambia, Jaffar and al. (1997, 2000) also showed that the all-causes mortality presented peaks during the rainy seasons. Tall and al. (1997) showed that the peaks of meningitis and measles occurring in 1996 in Bobo - Dioulasso (Burkina Faso) took place in March. Vaahtera and al. (2000) showed that in rural Malawi the diarrheic diseases and the malaria are especially observed in rainy season. In central Mali, malaria transmission starts two months after the beginning of the wet season and culminates two months after the rainfall peaks (Findley et al., 2005).

Acute respiratory infections (ARI) alone account for more than 20% of the causes of child mortality (Morris et al., 2003; Bryce et al., 2005). In the scientific literature, the most studies focusing on causes of ARI mention the pollution inside houses (Smith and al., 2000; Mishra, 2003), the relation with the number of persons by room in house, the gender and the age (Cunha, on 2000), or the air quality degradation caused by population growth, use of fuel wood, development of the industries, or traffic intensification. Recently, some authors highlighted the effects of annual rainfall, wet/dry seasons, temperature, air humidity, altitude (Lanata et al., 2004) and air pollution (Ozer et al., 2007) on ARI. Shek and Lee (2003) and, more recently, Hart and Cuevas (2007) revealed results showing that the viral respiratory infections are mainly observed during rainy season in the tropical zones. In central Mali, ARI incidences peak at the end of the rainy season, as well the cold and dry season, probably

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reflecting the existence of multiple pathogens (Findley et al., 2005). Scientific studies are often limited to quote factors, without estimating them quantitatively and are mainly localised in a small study zone. Anyway, such studies are very scarce in West Africa.

Objectives

This study is a part of a PhD research that aims to contribute to the understanding of the spatial and temporal distributions of lower ARI to children (0-5 years olds) according to a north-south gradient in rural zones of West Africa. We are particularly interested in the impact of the environmental factors and we choose a spatial approach, rarely found in literature. Such an approach is useful as a support of communication between scientists, healthcare professionals, decision-makers and citizens and can serve as a base to define populations of interest and to make relevant choices in the later.

Specifically, this communication aims first to highlight the intra-annual variability of lower ARI affecting children in Benin according to a north-south gradient. Compared to existing studies, the advantage is a study area crossed by different climatic zones with an unique harmonized system of collect of health data. The second objective is to detect abnormal peaks of lower ARI in time or/and in space and to assess the potential contribution of extreme weather conditions on the extreme ARI rates. To our knowledge, this aspect is not addressed in the literature.

Hypotheses

Hypothesis 1: The intra-annual variability of lower ARI is linked to the distribution of dry/wet seasons during a calendar year in Benin.

Hypothesis 2: Some abnormal peaks are associated with extreme weather conditions. In particular, exceptionally raised dust and rainfall events have impacts on ARI, respectively in dry and wet season. Other abnormal ARI rates can be explained by abnormal duration of weather conditions.

Context

Benin constitutes an interesting case study for several reasons. Firstly, this country is characterised by a north-south increasing gradient of rainfall. The North records on average 800 mm of annual rainfall during the single wet season (from April to October). In comparison, the South mean annual rainfall exceeds 1200 mm and two wet seasons alternate with two dry seasons. Intermediate situations are encountered in the central parts of the country. Secondly, Benin is located in the trajectory of the Saharan dust particles (Ozer, 2005). Tanaka and Chiba (2006) calculated that the Sahara Desert could account for 58% (or almost 1100 $Tg.yr^{-1}$) of the total global dust emission. Overall 60% of the total Saharan particles are transported to the Gulf of Guinea (D’Almeida, 1986) in a south-westerly direction. Airborne dust particles affect human health, through their impact on local and regional air quality (Sassen et al., 2003; Anuforom et al., 2007).

Besides, as in other countries of West Africa, ARI are the second cause of child consultation in Benin (Ministère de la Santé/République du Bénin, 2006). Children are to be particularly vulnerable to ARI.

Data and methodology

Epidemiological databases from Ministry of Health are analysed from 1998 to 2006. Benin is divided in 34 health zones. We kept the 18 most northern to avoid the densely populated regions and concentrate present analyses on 4 health zones - distributed in a north-south way - each including a synoptic station (Figure 1). Taking into account population size and age distribution, monthly numbers of lower ARI cases by age are converted in ARI rates. Then, two extreme events indicators are calculated. The first consists in comparing each recorded monthly value of ARI rate with mean monthly ARI rates calculated on the study period (1998-2006) in each health zone. The second is based on the percentile 90 calculated for each health zone on the whole study period. Both indicators have a binary form taking the value 1 when extreme value is effective and 0 otherwise.

Daily minimum and maximum temperature, air humidity, rainfall from 1998 to 2006 for 4 synoptic stations and hourly horizontal visibility – a proxy of air quality - from 2003 to 2006 for 2 stations were provided by the national meteorological agency of Benin. Several indicators highlighting the intensity and the duration of weather conditions are derived from these meteorological data.

In a first step, spectral analysis is implemented to detect intra-annual variability of lower IRA. The second step focuses on specific statistical methods (Khi-Square test, logistic regression) in order to check associations between extreme ARI and extreme climate events.

Results and expected results

In Benin, the intra-annual variability of lower ARI depends on latitude and seems to be in narrow relation with the climatic zone (Figure 1). The annual average distributions of the lower ARI are represented are calculated to highlight the months of the year in which occur the characteristic peaks for the studied health zones. In the North, ARI incidences peak two times a year, at first in March during the dry season and secondly, at the end of the rainy season (between September and October). It is summarized in the spectral analysis bringing out a half-yearly frequency, contrary to the rest of the study area where a yearly frequency is reported. In the central region, we can observe a significant increase of ARI rates in October at the end of the rainy season. In the southern part, where a bimodal rainfall system occurs, two peaks of ARI appear successively in July and October-November at the end of the two rainy seasons. The dry season seems to have only a weak impact on ARI incidences outside the northern part of the study area.

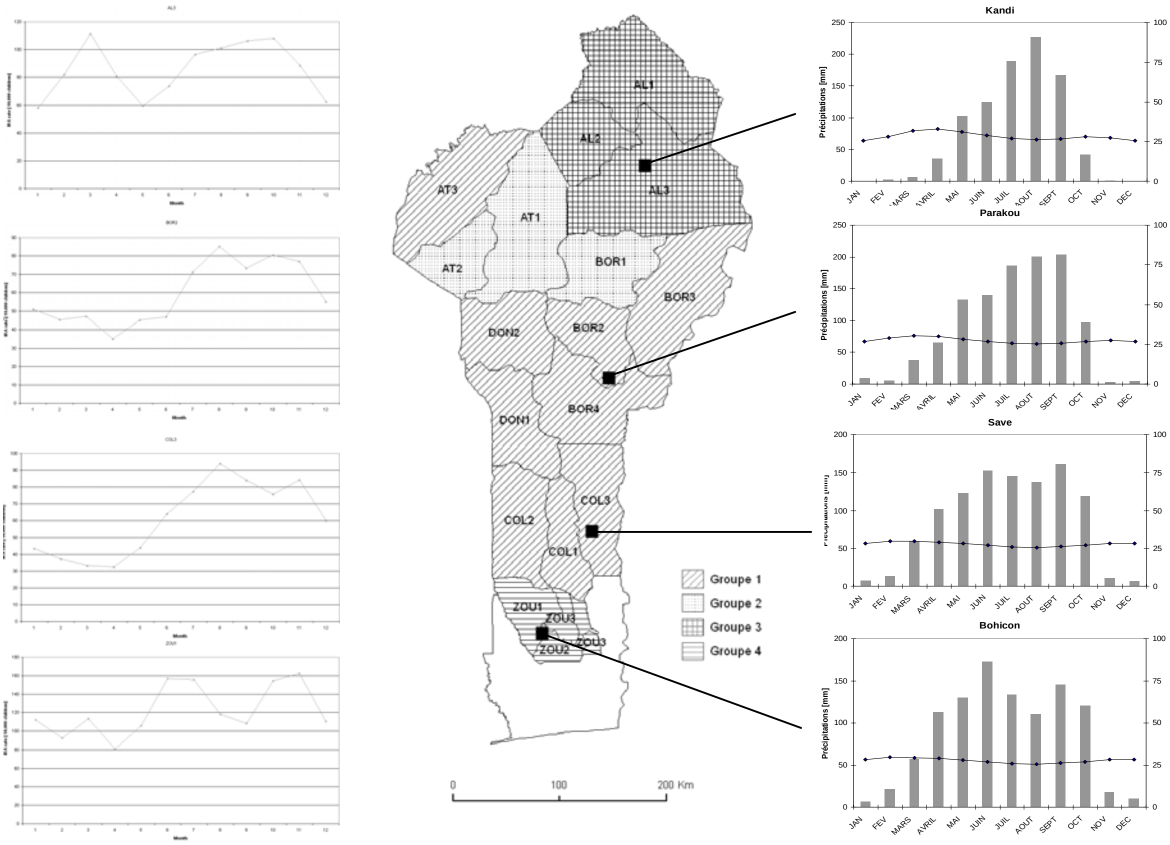

Figure 1 – Relationships between intra-annual variability of ARI and rainfall structure

The first extreme ARI indicator - based on deviation from the monthly mean value – is positive on average 17 times on 108 months studied from January 1998 to December 2006. Extreme ARI values are mostly, but not exclusively, observed between 1998 and 2001. They occur both in the dry season than wet season. The second extreme ARI indicator - based on percentile 90 and calculated for each health zone separately – is positive on average 10 times on 108 months during the study period. With some exceptions, it happens in the dry season in the zone located in the north of Benin and in the wet season elsewhere. It is expected that, for instance, an extreme daily dust concentration or a persistent dust event over a more or less long period will have impacts on ARI incidences, particularly in the north part of the study area. Effects will be either immediate or with a lag. In a same way, abnormal high rain values on a short period of time or a rainfall anomaly can directly influence ARI incidences in the North as in the South of the country. It is possible that other climatic variables, like a particular weak air humidity in dry season, have also an effect.

Conclusion

It is acknowledged that seasonal variation is a part of infectious diseases in West Africa. ARI, one of the first child mortality causes, does not escape from this rule. In this study, we show that in Benin, intra-annual variability of ARI changes with latitude, in a narrow relation with rainfall structure. On the other hand, the dry season has clearly an impact on the ARI incidences in the northern part of the study area, its role is less and less important by going southward. During some months over the study period, ARI rate values deviate from the average and we suppose that these abnormal peaks can be explained by climate influences.

Nowadays, in the context of climate changes, it is expected that more extreme climatic events will happen in the future. Thus, it is important to evaluate the effects of extreme weather conditions on ARI incidences for the planning of public health activities. Focus on the children is particularly relevant in order to be in agreement with the Millenium Development Goals (MDG's). Anyway, this study could help for better understanding of the impacts of environmental factors on health in West Africa, where such studies are very scarce.

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