Meningococcal meningitis (MM) presents its highest activity and toll on populations in Sub-Saharan Africa, in an area determined by its environmental conditions and designated as the “meningitis belt” stretching from Senegal in the west to Ethiopia in the east. It affects close to 400 million people, and annual incidence rates can reach 1,000 cases per 100,000 people.

The disease has a tremendous economic impact, the burden estimated to be more than $11 million/year in diagnostic, tests and case treatment costs.

Climate, Seasonality, Distribution and Density

Outbreaks of Meningococcal epidemics have been reported to environmental conditions such as dry and dusty environment (Lapeyssonie 1963) (Fig. 1).

However, it has been suggested that other factors need to be incorporated in the modeling of meningitis occurrence (Yaka et al. 2008), such as as demography (population size, density, age structure) and immunological state of the population.

The particular spatial distribution and concentration of large-size epidemics suggests that “demographic risk factors are important in the development of larger disease outbreaks” (Pollard and Madsen 2003).

Population density is likely related to the spread of the disease, while a rural or urban residence generally marks differences in terms of access to health care, information and resources (Balk et al. 2003).

Finally, population surfaces displaying total population counts, density or both provided the denominators for calculating the incidence of the disease (Thomson et al. 2006).

Data and Methods

Niger was selected as case study because of the availability of time series of epidemiological data recording cases of meningitis at the district level since 1986.

We integrated climate, demographic and epidemiological data in a single, pooled, district-level database.

Then, we fit a multiple linear regression model using demographic, geographic and atmospheric independent variables, and an epidemiological dependent variable at district level.

Dependent variable: weekly number of cases at district level

Overall climate conditions in Niger are adequate for the development of meningitis outbreaks. These environmental conditions interact with demographic conditions as population density, size and age distribution (Pollard and Madsen 2003). The disease is present throughout the year, and across districts (Fig. 5).

Data and Methods

In initial examination of relationships between the frequency of epidemics and each independent variable was done via scatterplots and linear correlation analysis.

Best relationship was found to be with log10(popdensity)

2 districts were left out in subsequent analysis:

N’amey: totally urban, better access to health care, potentially different reporting system

Bilma: very rural, low population density, some issues in the time series.

Stepwise selection of best multiple regression model using all 11 predictors was performed.

Best model obtained using log10(popdensity), meridional wind at 925 and log10(total population) (Fig. 7).

Epidemic frequency = 26.5+2.35 log10(pop_den)+1.72 mer wind 4.26 log10(dist_pop)

Fig. 7: Results of multivariate linear regression

Predictor Coef Std err p

Visit pop den 2.3452 0.5158 0.0001

Visit pop 4.2528 1.6350 0.0199

Mer wind925 1.7516 0.4774 0.0010