Risk mapping of animal movements standardized rates using two GIS grids (irregular and regular lattice). An application to a farmer census dataset in Ethiopian highlands in the context of Contagious Bovine Pleuropneumonia control.

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a) Summary

Movements of animals occurring between farmers in a rural area of Highlands of Ethiopia are studied and represented by application of standardized (direct method) and raw rates of movements per zone. Rates with confidence intervals were mapped & compared using irregular administrative boundaries-based lattice and regular lattice, with use of GIS. Local and global autocorrelation were studied using GeoDA© [Anselin L., 2003] to assess the accuracy and level of possible regionalisation within lattice maps. Discussion is focusing on appropriate use of such maps towards appropriate health planning. They highlight contiguous clusters of high level movements as compared to classic chloropleth maps.

b) Introduction

Study of animal movement patterns & mapping with regionalisation of movements rates may serve to better target preventive tasks and disease surveillance in particular areas. In order to avoid confounding factors such as animal population size and herd functional structure, movements rates should be calculated in raw figures and with direct standardization so that comparison of zones is facilitated.

c) Objectives

The study is part of a larger research protocol to study determinants of re-emergence of CBPP in Africa with particular focus in western Ethiopian highlands [Lesnoff M., 2001]. In order to better target vaccination in a context where health service budget is scarce one needs to optimize interventions at district level. Therefore risk mapping was an attempt to localize geographical regions with differential risk of CBPP spread at local scale. Movement of animals was therefore studied to represent the risk.

d) Materials & Methods

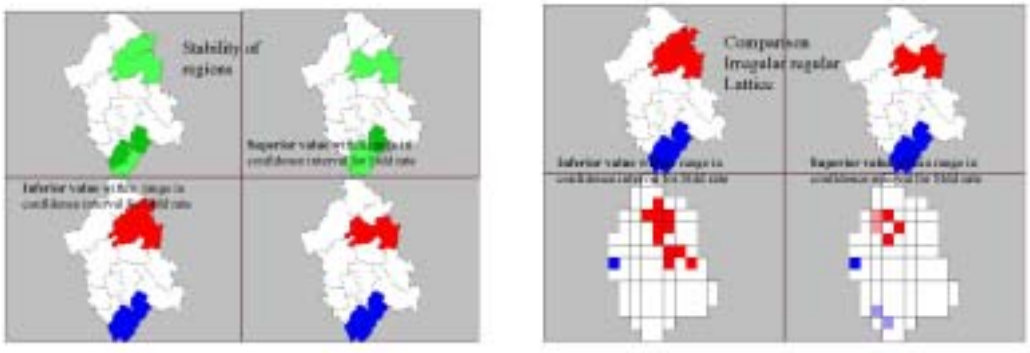
The data originated from a comprehensive cross sectional geo-referenced census of 6246 farmers out of which 2390 animal breeders were used for the analysis of movements between neighbors [Bonnet P., 2002]. A number of 13351 animal exchanges described were categorized and have served for movement rate computation. Rates were calculated as number of animals moving (incoming plus outgoing from farm as observed during the 3 month census period) divided by average number of animals at risk being farmer's ownership or neighboring animals daily kept in same shelter. Aggregation of data and computation of polygon based rates was carried out by spatial cell in lattice representing the spatial domain. Then

mapping with chloropleth maps was performed using quantile and Jenks discrete categorization of raw and standardized rates with use of direct method and a reference population structure as observed in the sub region where structure of the cattle population per functional category is known [Rumeau-Rouquette, 1988]. Mapping was applied in irregular lattice maps based on administrative boundaries (Peasant association PA's being subdistricts) and regular lattice applied with cells of 2 km edge. This measure was a result issued from a preliminary study on distribution of between farms distance when farmers exchange animals. Confidence intervals of standardized movement rates were computed and have given superior and inferior measure of rates [Bouyer J., 1993]. Then global and local spatial autocorrelation indices (Moran I) were computed using Rook contiguity first order method and values tested against null hypothesis (I Moran = 0 no autocorrelation) with permutation procedures. We have used global and local indices for autocorrelation based on standardized movements rate variable. Then use of Moran significance and LISA maps has helped to better design regions. Finally we discussed validity of regionalisation of contiguous cells and the identification of cluster at risk for high movement rates within maps. Additionally in order to compare movement rates between 2 regions, an indication on use of rates ratio = CMF Comparative Movements Figure was provided [Bouyer J., 1993].

e) Results

Mapping rates in regular and irregular lattice with similar dataset and various indices provides a set of maps with different patterns and some common traits. The regionalisation has been possible because global and local autocorrelation were positive (Global Moran = 0,3999 irregular lattice M=0,1839 in regular lattice and M>0 with p-value <0,01). Both lattice maps provide evidence on assumption for high movement rate clusters. Maps suggest a spatial structure inherent to the domain. and additional examination of local autocorrelation has highlighted some clusters of high movements rates that we think are targets for preventative interventions in health.

Figure 1: Stability of region delineation given confidence interval of movement rates



and given use of irregular versus regular lattice (direct standardization and raw)

Differences in movement rates between delineated regions can been tested using CMF (Comparative Movement Figure) derived from CMF (Comparative Morbidity Figure) used

in Epidemiology where two standardized movements rates in two different regions are compared building a ratio (CMF) compared to 1.

f) Discussion

Mapping of standardized rates has been useful in medical geography to help generating hypothesis on disease risk factors associated with particular areas. Additionally regionalisation of a particular spatial domain given a particular risk marker is an interesting process to redesign health planning maps and better target health interventions. In Economic evaluation of health intervention, targeting may help to decrease cost of programmes having similar effectiveness and therefore giving advantage to some options when a global approach would have failed [Contandriopoulos A.P., 2001]. Since movements and introduction of animals are major factors for contagious disease spread the mapping of movement rates will help to better delineate spatial clusters & aggregate regions at risk. It also helps to eventually better allocate budget and resources to health services given such regions when few disease-based data are available. Nevertheless how stable are maps designed from such studies is debatable when only cross sectional studies are carried out. With additional retrospective surveys on variability of the movements along year one may study the stability of such maps at different period of the cycle of farming systems before we eventually use them for health planning. In the particular example of Boji district in Ethiopia, when looking at particular socio-economic characteristics of clusters, with use of other geographical information layers, the influence of both remoteness and urban centres have been identified as factors associated with movements of animals. The spatial cells with such features contribute more than other to the global autocorrelation. The conjoint use of maps based on raw and standardized rates, the study of local and global autocorrelation indices, and additional mapping of extensive data such as crude movements number are therefore recommended to elaborate a portfolio of maps which will serve for decision making.

g) References

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