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Surveillance and monitoring of disease outbreaks in rural areas: systematisation of low cost geographic information system techniques

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Summary

The authors describe three recent experiences of epidemiological surveys of zoonotic diseases in Brazil. The role of spatial data acquisition and analysis has been reinforced, considering the intrinsic complexity of environmental and social factors affecting transmission. Health surveillance in Brazil is undergoing a decentralisation process, in accordance with which different responsibilities are attributed to each health institution, from federal level to county health secretaries, including local non-governmental organisations. The availability of data, as well as the skilled use of spatial analysis tools, contributed in this process, allowing rapid and low cost assessments of environmental risks.

Keywords

Brazil, Cluster, Disease, Geographic information system, Health surveillance, Low-cost technologies, Monitoring, Spatial analysis, Zoonosis.

Sorveglianza e monitoraggio di focolai di malattie in aree rurali: sistematizzazione di sistemi informativi geografici a basso costo

Riassunto

Gli autori descrivono tre recenti esperienze di sorveglianza epidemiologica su malattie a carattere zoonosico in Brasile. Il ruolo giocato dalla acquisizione e dall'analisi dei dati spaziali ha assunto un maggiore rilevo in considerazione dell'intrinseca complessità dei fattori ambientali e sociali che influenzano la trasmissione della malattia. La sorveglianza sanitaria in Brasile sta subendo un processo di decentralizzazione; in questo contesto ad ogni istituzione sanitaria sono attribuite responsabilità diverse, dal livello federale ai distretti sanitarie delle contee, includendo le organizzazioni locali non-governative. La disponibilità di dati così come il qualificato uso degli strumenti di analisi spaziale, fornisce un contributo a questo processo permettendo una valutazione rapida e a basso costo del rischio ambientale.

Parole chiave

Analisi spaziale, Brasile, Cluster, Malattia, Monitoraggio, Sistema informativo geografico, Sorveglianza sanitaria, Tecnologie a basso costo, Zoonosi.

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Introduction

The characterisation and location of the places that are vulnerable to enzootic outbreaks is a key element for the control of disease spread as the source of infection is often focused in clusters of cases. The roots of disease ecology are found in the confluence of geography and ecology in the middle of 20th century. On the one hand, ecology is an important contribution of biological sciences that aim to shed light on the relationship between humans and environment, which is evolving constantly. On the other hand, in the field of systematic geography, tools have been developed, such as cartographic overlay, to characterise species habitat. According to Maximilien Sorre, these habitats express a confluence between natural and anthropic elements in a particular place (3). Pavlowski elaborated the nidality theory in which disease is transmitted when a natural niche is invaded by susceptible populations (3, 7).

Emergent diseases are the concern of health authorities. Understanding the social and environmental factors that affect the distribution of diseases can contribute to prevention and control. We describe three experiences of epidemiological surveys of zoonotic diseases, namely: hantavirosis in the southern Brazilian region, cutaneous leishmaniosis in a rural settlement and toxoplasmosis in an urban area. The lessons learned from these experiences involve the development of spatial analytical tools, low-cost technology appropriation by health professionals and the structure of a health surveillance system in a large and diverse country such as Brazil.

Methods

The outbreak surveys were based on survey reports and published papers. The hantavirus pulmonary syndrome (HPS) is a disease of increasing incidence in Rio Grande do Sul State, the most southern state of Brazil. A total of 31 confirmed cases were notified up until the end of 2002. The spatial distribution of cases is apparently scattered across the state. The aim of spatial analysis was to investigate the role of agriculture activities and a changing ecosystem in the virus transmission. This task was accomplished by overlaying case residence points onto vegetation, elevation and land-use maps (2).

A cutaneous leishmaniosis outbreak was reported in a rural area in Paraná State. A comprehensive survey was performed on the settlement, comprising 706 inhabitants in 201 households. Cases of human disease were confirmed by laboratory and clinical examinations. All household locations were obtained using a global positioning system (GPS). A geographic information system (GIS) was employed to characterise local landscape, measure the distances between houses and suspected risk sources, as well as to identify clusters of disease using spatial statistics techniques (4, 5).

The third outbreak survey covered the transmission of acute toxoplasmosis in an urban area. A survey was performed to estimate disease prevalence and associated risk factors. A total of 156 people responded a questionnaire which aimed at identifying exposure pathways. The residence location was obtained by GPS (6).

Results and discussion

The first study enabled a description to be made of the hantavirosis landscape ecology in Rio Grande do Sul State. Individual locations of residence were assigned according to the centroid of county polygon, used as a proxy of the site of infection. The occurrence of cases was superimposed onto vegetation, elevation and land-use maps. The majority of cases occurred during spring, in highland areas dominated by secondary vegetation and agricultural activity. Four case clusters were identified by visual inspection and classified according to the predominant agricultural activity and vegetation. Only one of these groups presented rice cultivation and flat relief as a dominant landscape. The other groups were located along the slopes of plateaux in a combination of intensive agricultural activity and remaining rain forest.

Agricultural activities provided intensive contact with the virus. Men are the most affected because they constitute the majority of rural workers. The degradation of naturally forested areas and the invasion of intensive agriculture practices alter the habitat of rodents, increasing food availability due to grain storage. Rodents seek food and shelter in these areas, leaving excreta and allowing direct contact with their faeces, blood and urine.

The outbreak of American cutaneous leishmaniosis was reported in 2002 in a temporary settlement in which 201 families live, in the southern region of Brazil (Mariluz, Paraná State). Of 38 humans who were examined, four presented healed lesions, ten showed lesions in the healing process, and 24 had active lesions. The local physical geography includes extensive agricultural activities, with well preserved forest areas, riparian vegetation along a creek linking two forest reserves. Dwellings are precarious houses (walls made of cloth, wood or palm leaves) and the presence of domestic animals is common in the house and surrounding areas. Forest and rivers are used for hunting and fishing, as well as for wood, indicating the potential exposure of the entire population to the vector. A survey was performed among all residences to identify people presenting signs of leishmaniosis. A total of 20 cases were confirmed by laboratory examination, representing an attack rate of 3%. All residences were georeferenced through coordinate data acquired by GPS and linked to the epidemiological and socio-demographic data by an index. Figure 1 shows the location of residences in the rural settlement. The point patterns were analysed by kernel density estimation and were calculated for confirmed cases and population as two different layers. The rate between these layers enabled the construction of a risk surface. A Landsat satellite image (Embrapa, www.cdbrasil.cnpm.embrapa.br) was used to compose a visible landscape which was compared with the calculated risk surface. A concentration of risk was observed in two areas near the forests; these were pointed out as the likely vector habitat. Spatial analysis confirmed that environmental alterations and remaining forests facilitated the maintenance of the parasite's enzootic cycle and transmission to humans and domestic animals, thereby maintaining the endemicity of American cutaneous leishmaniosis.

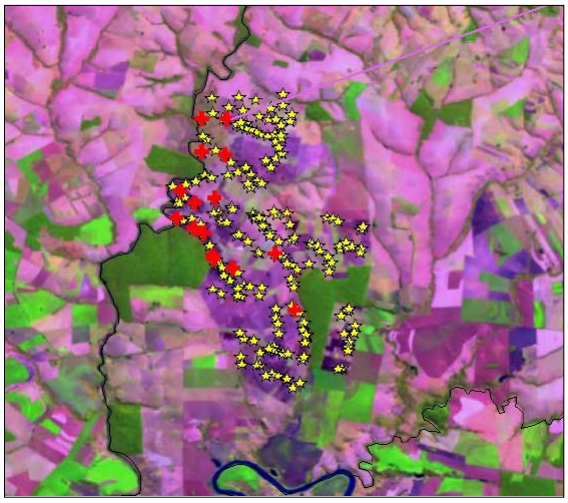

Figure 1
Residences in Mariluz rural settlement
Residences with cases are marked with a red cross

Unusual acute toxoplasmosis cases prompted the third epidemiological survey in the city of Santa Isabel do Ivai. The survey included mapping the city water supply system which is served by two municipal reservoirs (reservoirs A and B) that receive underground water from protected deep wells. Case distribution showed a clustering in the central area served by reservoir A (Fig. 2). Of the 156 survey participants, 138 lived in the area served by reservoir A and 17 individuals lived in the area served by reservoir B. Statistical tests demonstrated that cases were significantly more likely than controls to drink water supplied by municipal reservoir A than reservoir B (6). Further field surveys proved that reservoir A was contaminated by cat faeces. Water is now considered an important vehicle for disseminating human toxoplasmosis during outbreaks (1).

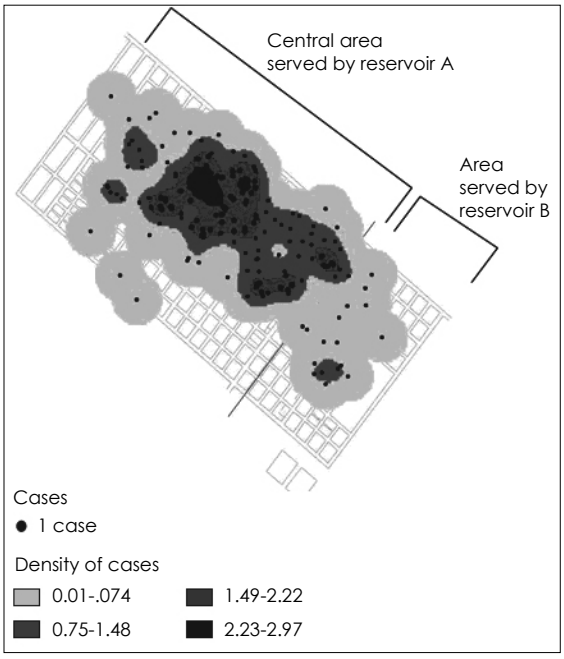

Figure 2
Clusters of toxoplasmosis cases in Santa Isabel do Ivai, Paraná, Brazil (6)

Conclusion

Disease transmission, particularly in outbreak situations, is a consequence of close relations between human and animal populations in the environment, i.e. the ecology of animals involved in the transmission cycle and the humans who work in those areas. Spatial analysis enabled in all cases the characterisation of the ecology landscape in which outbreaks occur (4).

Simple and available spatial analysis tools were used to complement epidemiological field investigations. Spatial data were analysed using Terra software (www.dpi.inpe.br). Transmission hotspots were identified by means of kernel spatial smoothing. The software reads satellite images and shapefiles, providing several spatial analytical tools. Satellite images were used to characterise land use and suspected risk sources. These images were obtained from free downloads from Embrapa (Composed Landsat-TM bands 3, 4 and 5) and *Instituto Nacional de Pesquisas Espaciais* (INPE) (National Institute for Space Research) sites (raw and classified CBERS images).

Investigations involved the various levels of health agencies and non-governmental organisations. Outbreaks are detected, investigated and monitored by local health authorities, supported by a national task force. For instance, the cutaneous leishmaniosis outbreak was investigated by a task force composed of the Brazilian Health Ministry, Paraná State Health Secretary (SES), Mariluz Municipal Health Secretary (SMS), Research Institutes (Oswaldo Cruz Foundation, Brasilia University and Maringá University) and the Landless Workers' Movement (MST). This practice ensures the continuity and transparency of health prevention and promotion activities. The coordination was assumed by the Brazilian Health Ministry, through the Health Surveillance Secretary. Notification is a responsibility of local health services. The state health authority is accountable for laboratory case confirmation. These institutions must be integrated to ensure rapid and adequate information flux. Recently, a centre for strategic information in health surveillance (CIEVS) was created to coordinate emergency actions. This system is based on local health surveillance people who must be able to acquire and use the available spatial data and analytical tools to detect and notify disease clusters. Considering the stage of information availability in Brazil, these practices could be incorporated into routine health services. This work showed the feasibility of using low-cost digital mapping in localities with modest infrastructures, using available and free information and software.

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References

1. Bahia-Oliveira L.M.G., Jones J.L., Azevedo-Silva J., Oréfice F., Crespo C. & Addiss D. 2003. Highly endemic waterborne toxoplasmosis in north Rio de Janeiro state, Brazil. *Emerg Infect Dis*, **9**, 55-62.
2. Henkes W.E. & Barcellos C. 2004. Landscape ecology of hantavirosis in Rio Grande do Sul State (Brazil). *Rev Soc Bras Med Trop*, **37** (6), 505-507.
3. Learmonth A. 1988. Disease Ecology. Basil Blackwell, New York.
4. Lima A.P., Minelli L., Comunello E. & Teodoro U. 2002. Distribuição da leishmaniose tegumentar por imagens de sensoriamento remoto orbital, no Estado do Paraná, Sul do Brasil. *An Bras Dermatol*, **77**, 681-692.
5. Lonardoni M.V.C., Silveira T.G.V., Alves W.A., Maia-Elkhoury A.N.S., Membrive U.A., Membrive N.A., Membrive N.A., Rodrigues G., Reis N., Zanzarini P.D., Ishikawa E. & Teodoro U. 2006. Leishmaniose tegumentar americana humana e canina no Município de Mariluz, Estado do Paraná, Brasil. *Cad Saúde Pública,* **22** (12), 2713-2716.
6. Moura L., Bahia-Oliveira L.M., Wada M.Y., Jones J.L., Tuboi S.H., Carmo E.H., Ramalho W.M., Camargo N.J., Trevisan R., Graca R.M., daSilva A.J., Moura I., Dubey J.P. & Garrett D.O. 2006. Waterborne toxoplasmosis, Brazil, from field to gene. *Emerg Infect Dis*, **12** (2), 326-329.
7. Pavlowsky E. 1988. Nicho ecológico de las enfermedades trasmisibles en relación con el ambiente epidemiológico de las zoo-antroponoses. *In* El desafio de la epidemiologia. Organización Panamericana de Salud, Washington, 422-430.