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WHO CONSULTATION ON DEVELOPMENT AND APPLICATION OF GEOGRAPHICAL METHODS IN THE EPIDEMIOLOGY OF ZOONOSES

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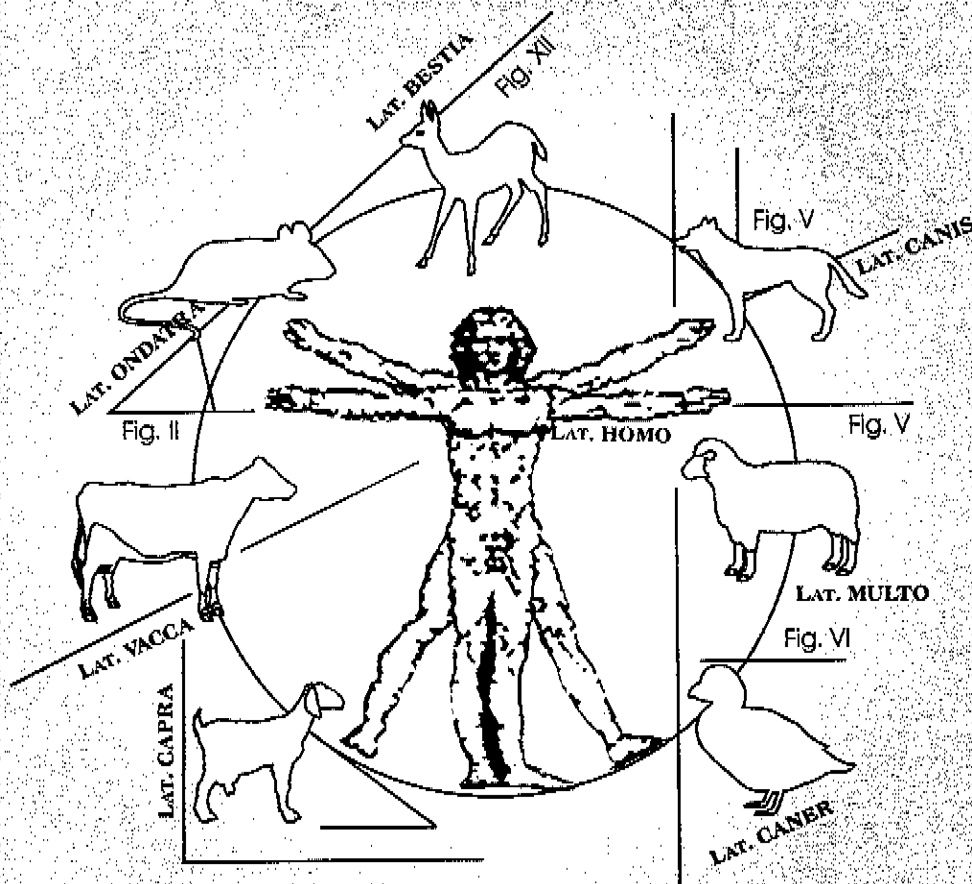

WORLD HEALTH ORGANIZATION
VETERINARY PUBLIC HEALTH UNIT

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1. INTRODUCTION

Following recommendations of the WHO Consultation on Development and Training in Veterinary Epidemiology, Hanover, 9-11 October 1991, the Veterinary Public Health unit of WHO, together with the Institute for Epidemiology at the Federal Research Institute of Virus Diseases of Animals, organized a consultation on the development and application of geographical information systems (GIS) in the epidemiology of zoonoses in Wusterhausen, Germany.

Dr H. Schlüter, Acting Director of the Institute, opened the meeting and welcomed the participants (Annex 1). He conveyed the greetings of Professor Moennig, President of the Federal Research Institute who regretted not being able to participate.

Dr Stöhr welcomed the participants on behalf of the Director-General of WHO and conveyed the thanks of Dr Meslin, Chief, Veterinary Public Health, to Dr Pittler, Federal Ministry of Agriculture, Germany and Professor Moennig for their financial support for the meeting.

The organization of the consultation was triggered by the rapid international development of new techniques and methods for the analysis of geographically referenced data.

GIS are now being used for many purposes and in numerous disciplines. However, it was felt that their potential benefit for the control of communicable diseases, particularly zoonoses, is much under-estimated and their application in zoonoses control greatly deficient.

The meeting's aim was to contribute to fostering the development and application of GIS in the field of geographical epidemiology of zoonotic diseases and had the following objectives: first, to review the progress made in the development of techniques displaying, analysing and relating geographical data with spatial and temporal distribution of animal diseases (with special reference to zoonoses). Secondly, to review available geographically related databases and evaluate their potential use in the field of epidemiology.

Participants presented 16 papers (Annex 2) on geographical epidemiology and GIS which were discussed in the plenary session. Three working groups were formed to review issues of GIS application and future research in the field of geographical epidemiology of zoonotic diseases.

2. CONCLUSIONS

2.1 Scope of GIS in the epidemiology of zoonotic diseases

Geographical Information Systems are computerized systems that allow for the input, storage, manipulation, analysis and display of geographically referenced data. This technique is a combination of computerized mapping system and databank management system. The advantage of using a GIS rather than a traditional databank management system is that the data can be viewed, queried and summarized visually through the graphical environment. A variety of spatial information processing functions which are not possible on a standard databank management system can be employed.

GIS have been used in recent years for a wide variety of purposes, including urban and regional planning, and utility management, land suitability assessment, environmental resource monitoring, emergency response management and ecological modelling. GIS are suited to any application where geographically referenced data are stored, manipulated and consulted.

The participants acknowledged the contribution that GIS can make to elucidate epidemiological patterns of zoonotic diseases. However, there is only little collaboration in the application of GIS in the field of infectious diseases in humans and animals. No compilation exists listing and analysing the existing applications of GIS and the problems tackled or solved in the field of veterinary public health and related subject areas.

2.2 Use and application of GIS

The three areas in which GIS are currently used are:

- Descriptive display
- Spatial analysis
- Temporal display and analysis

Nine general applications of GIS have been identified. These can currently be classified into four approaches: *descriptive*, *analytical*, *predictive* and *management/decision support*.

- Information dissemination. The objective is to inform the public, policy and decision makers and other professionals through the use of geographically represented data. The purpose is to increase awareness and commitment to action: "A map is worth a thousand words!"
- Integrating information from different sectors to promote collaboration or intersectoral collaboration
- Epidemiological studies
- Epidemiological surveillance
- Impact assessment
- Decision support systems
- Disease simulations
- Disease control planning
- Disease control management

2.3 Specific opportunities for GIS in zoonoses prevention and control

Embedded in the above-mentioned nine general applications of GIS for epidemiological disease analysis other specific effects of GIS application in zoonoses prevention and control may exist. They are:

- to enhance cooperation and communication between animal and human health and other disciplines. For example, in defining geographical areas of risk to inform physicians, veterinarians and producers of possible disease risks;
- to enhance the links between animal health and production sectors;
- to improve the assessment of the public health impact of zoonotic diseases;
- to improve knowledge on and understanding of the benefit epidemiology can bring to the public health sector.

GIS designed for the storage, manipulation and consultation of geographically referenced data are certainly suited for all diseases. However, the following zoonoses which are particularly influenced by geographical factors in one way or another appear to be specifically amenable to GIS application:

- Vector-borne diseases: Tick-borne, Trypanosomiasis, Leishmaniasis, Schistosomiasis, Fascioliasis, Arbovirus-infections
- Water-associated diseases: including food- and fishborne diseases, Leptospirosis, Tularaemia
- Wildlife-associated diseases: Rabies, TB and Brucellosis
- Movement/trade-associated diseases: Brucellosis, Anthrax, TB, Psittacosis
- Culture-related diseases: Trichinellosis, Toxoplasmosis, Paragonimiasis, Anasakiasis
- Production systems related diseases: Salmonellosis, Schistosomiasis, Clonorchis, Opisthorchis
- Foodborne infections: Salmonellosis, Campylobacteriosis
- Legislation and regulation enforcement-associated: Echinococcosis, Rabies

3. CONSTRAINTS OF GIS APPLICATION IN THE EPIDEMIOLOGY OF ZOONOTIC DISEASES

Whereas GIS is increasingly used in many sectors for a wide variety of purposes, geographical information systems are still greatly under-utilized for the epidemiological analysis of infectious and non-infectious diseases in humans and animals. This is mainly the case for managerial (education, training, collaboration, etc.) and methodological reasons (see 3.1 and 3.2. below).

The following problems in the implementation of GIS systems were recognized:

- Requirements for sound knowledge of geography as a science
- Data availability, format, price and quality
- Training requirements for many GIS systems
- Confidentiality of data
- Copyright/ownership of data

3.1 Managerial constraints

- The public health and the veterinary public health sectors are both chronologically and technically behind other sectors in the application of GIS.
- Whereas the use of epidemiological skills has gained some ground in the education and training of medical and veterinary students, knowledge on the true value of GIS is still lacking in the various medical sectors concerned and the possibilities that this method may offer to disease control and prevention are yet poorly understood.
- GIS application is also hampered by a widespread unawareness of the availability of GIS technology and its technical and financial requirements. In some cases this may lead to:
  - a reluctance on the part of managers to seek professional expertise in conducting a GIS application.
  - a failure by managers to commit the time and personnel needed to complete GIS projects with adequate quality.
- Lack of utilization and knowledge on:
  - the variety of demographic datasets available for GIS application;
  - readily available boundary files and other GIS digital mapping data.
- There is no international forum (association, symposia, etc.) offering opportunities for veterinary and human health epidemiologists utilizing GIS to exchange ideas, new techniques and common databases (e.g. boundary files, demographic datasets).
- There is currently no textbook available on the use of GIS in veterinary public health.
- Inter-institutional and intersectoral collaboration, a pre-requisite not only for zoonoses control but also for GIS application, is as yet greatly deficient in many countries.
- Multidisciplinary working groups exist in only a few countries, at national epidemiological institutes, universities or similar institutions dealing with specific aspects of disease surveillance and reporting including GIS.
- While the use of Spatial Decision Support Systems (SDSS) are widely discussed, the reality is that few have been implemented. SDSS is still a very new area and under constant development and redefinition. Ready-to-use applications do not exist yet and certainly will not be for several years. However, the potential possibilities and expected benefit from SDSS application justifies immediate support.

3.2 Methodological constraints

- Simple displays and epidemiological analyses of geographically referenced date on zoonotic diseases are being done, but much remains to be developed in terms of temporal and spatial analyses.
- Descriptive analysis features of GIS are extremely important particularly for information dissemination and public awareness.

- However, there are a number of problems associated with a pure descriptive display of geographically referenced data. For example, it can be misleading to rely on subjective visual interpretation of geographical representations and the use of shading and symbols may be misused and can easily lead to erroneous conclusions.
- Spatial analysis of geographically referenced data can be a very useful tool for the epidemiological analysis of zoonotic diseases. However, because of spatial dependence of data and their heterogeneity, standard statistical techniques are often inappropriate. This can lead to erroneous conclusions and involves the danger of error propagation.
- Temporal analysis of spatially related time-series data was found to be still inadequate.

Other constraints preventing the broader application of GIS are:

- in general, population demography data are gathered on an administrative unit basis, but for epidemiological purposes reference to natural features and socio-economic characteristics are more relevant.
- current data on wildlife are severely limited and generally rely on population sampling techniques which are not easy to apply to GIS.

4. DATABASES

The fundamental building blocks of GIS are the databases (mapping system and disease-related data) and value of results will mainly depend on their quality and the skills of the users. In the past, disease-related data-gathering, including their geographical reference was very often undertaken with no clear objective. Additionally, geographical analysis of disease-related data is often compromised by data derived from passive reporting rather than systematic disease surveillance mechanisms. They often do not differentiate between infection and disease.

The following sources of data were identified for obtaining boundary files and other GIS digital mapping data:

- Commercial mapping agencies
- Local planning offices
- Vendors of GIS software and/or hardware
- Academic institutions i.e. university/ academic networks
- GIS user groups
- Internet
- Cheap commercial sources e.g. Digital Chart of the World
- GLIS (Global Land Information System, available over Internet)
- National Geological Surveys
- Other potential users of the same data
- GISNET
- Manual of Federal Geographic Data Products, Federal Geographic Data committee, Falls Church, VA., Vigyan, Inc. 1994 (annually revised)
- GIS Source Book (published by GIS World)
- WHO Inventory of Administrative Boundary Files for Computerized geographical applications (WHO/ SCHISTO/94.109)

The following sources were identified for animal demographic data:

- Agricultural census data
- State veterinary service database
- Academic networks
- Internet
- CIESIN database[1]

The following issues are to be considered concerning databases:

Boundary files: Administrative boundary files at tertiary level or higher are essential.

Infrastructure: Geo-referenced data on infrastructural locations are increasingly available (e.g. Digital Chart of the World), but usually do not adequately attribute information (such as road quality, water volume).

Climate: Interpolated climate surfaces have improved and are available for many regions of the world. Real time meteorological data are not widely available in digital form and due to their volume might be difficult to handle.

Topography: Altitude, vegetation and land use are fundamental; however, vegetation and land use data at adequately high resolution are poorly available and are dynamic features that require frequent updating. Shortly, NOAA satellite 1 km resolution data will be available on a worldwide basis for ten-day intervals. These can be used to demonstrate and measure dynamic changes such as vegetation, hydrology, surface temperature etc.

Soils: the FAO global soil maps at 1: 1000000 is a standard, but for field research maps a 1:20000 scale is needed. Raw soil characteristics data rather than classifications will be more flexible for a wide range of analyses.

Socioeconomic: detailed socio-economic data are often not available, or not geo-referenced. Sample-based studies may not be directly usable in GIS studies.

5. RECOMMENDATIONS

- National authorities responsible for public health, veterinary medicine and epidemiology are strongly encouraged to establish multidisciplinary working groups for geographical epidemiology and GIS in the field of animal and human disease control. This could preferably be done in epidemiological institutes in the Human or Animal Health sector which could serve as liaison body and core group for the above mentioned groups. This will help overcome the problems identified above with regard to collaboration, training and education as well as research and application of GIS.

- The "true value" of GIS is not yet fully known and will not until it is used as a regular operational tool in the routine practice of disease control and prevention. It is desirable to test GIS applications in some rigorously monitored pilot studies involving operational programmes in disease control.

[1] The Consortium for International Earth Science Information Network (CIESIN) and the Center for International Research (CIR) of the United States Bureau of the Census have made available, since August 1994, CIR's georeferenced gridded population cell data for twenty foreign nations. In a 1992 report, Population Data and Global Environmental Change, the Working Group on Population Data of the International Social Science Council's Standing Committee on the Human Dimensions of Global Environmental Change identified CIR's population gridcell data as a component of the most important demographic data set needed by the international scientific community that studies global environmental change.

Until now, these data were only available for internal use by CIR and some United States government agencies.Over the last two years, CIESIN and CIR have worked together in CIESIN's Information Cooperative program to make these data more widely available to the public.The Information Cooperative is a group of national and international organizations that are collaborating to facilitate public and private access to data and information about global environmental change.

CIR's population grid celldata are said to be based on the best and most recent demographic data available for each country at the time of mapping the population distribution.

The twenty nations for which population grid cell data are currently available are Australia, Canada, Finland, Germany, Iraq, Japan, South Korea, Mali, Oman, Mexico, Malaysia, Netherlands, Portugal, Papua New Guinea, Philippines, Senegal, Spain, Sweden, Turkey, and the United States.

As new data for these and for additional countries become available, they will be incorporated into the collection.The data are available in three electronic formats-ARC/INFO, SYLK, and Excel-with accompanying digital documentation.For specific information about obtaining these data, contact CIESIN User Services at (517) 797-2727 or via e-mail at ciesin.info@ciesin.org.

CIESIN was founded in 1989. Its mission is to provide access to, and enhance the use of, information worldwide, advancing understanding of human interactions in the environment, and serving the needs of science and public and private decision making. As a consortium, CIESIN draws upon the expertise of universities and non-profit research organizations.

- There is a strong need to establish better links between all partners involved in the use and application of GIS. Furthermore, a forum for information exchange between groups using GIS in the field of zoonoses control is highly desirable. This could be achieved by:

  - establishing an international GIS working group of specialists (veterinarians, geographers, epidemiologists, public health workers, computer specialists, etc.).

    This group may primarily be composed of the participants of the consultation and work under the aegis of WHO. The terms of reference should be to consider data sources and applications in the field of GIS and VPH in order to foster information exchange and establish international collaboration. The group could serve as a core forum for a biannual workshop to provide the much needed possibility for veterinary epidemiologists utilizing GIS to exchange ideas, new techniques, and common databases (e.g. boundary files and demographic datasets).

  - establishing a Newsletter on "Geographical Information Systems and Human and Animal Disease Control". This Newsletter should help to spread information on current GIS applications, demographic datasets and GIS digital mapping data and maintain contact between the working group members. This should be backed up by an address list with keywords to indicate individual interests. Dr M. Hugh-Jones agreed to be the Editor of the Newsletter. Funds are required for the Newsletter and he will make a cost estimation.

- The diversity of sources of relevant information and the lack of readily available information on these sources necessitates the establishing of a compendium of data sources (both boundary files, other GIS digital mapping data and animal/human demographic data) relevant to the use of GIS in the field of veterinary public health.

  This compendium could also contain a compilation of animal and human disease problems which have been solved or which are in the process of being addressed using GIS.

  Such compilation would be useful:

  - to provide support to future requests for funds to support GIS projects in VPH;
  - to provide worked examples to others considering using GIS;
  - to provide examples to others already working with GIS.

  Establishment of this compendium could best be performed by a central coordinator with the support of all participants of the meeting.

- The group recommends that a central coordinator should be responsible for establishing and maintaining the compendium both in paper and electronic bulletin-format. During the plenary session it was indicated that a unique database already exists as the CG/UN/UNEP Inventory of Datasets. Participants were therefore encouraged to add to this existing database rather than create a new one.

- Having identified the need for education and training in methods of geographical epidemiology, a textbook on the use of GIS in veterinary public health (or broader in human and animal health disease control) should be worked out. It should be published in a variety of languages. A book being produced by Dr Freier appears to be an ideal solution.

- Training courses in the use of GIS in zoonoses control should be promoted.

- The following approach to choosing and using a GIS in the field of epidemiology of zoonotic diseases was recommended:

  1. Identify problem and the output required.
  2. Identify and localize the data required to resolve problem.
  3. Identify which GIS system is most appropriate to the problem.

4. Extract the subset of data required and use/store those only.
5. Apply GIS and evaluate/refine output.

- While potential uses of GIS for predictive modelling are attractive research objectives, the control of e.g. zoonotic and tropical diseases requires simple and robust applications to support current operations. The complex epidemiology of a number of bacterial, virus and parasitic diseases involving environment, animals and people must be simplified to a data collection and analysis which can be managed in the actual endemic areas.
- Disease-related data should preferably derive from systematic disease surveillance mechanisms. Any information-gathering should be assessed in advance and fulfil the following criteria:
  - clearly defined purpose for data-gathering which should be agreed upon by all partners before data collection starts;
  - the system for data analysis and interpretation should be worked out before data collection begins;
  - analysis of data should be carried out promptly after it is received;
  - there should be effective quality control procedures (to assure the validity of the findings);
  - prompt feed-back to the various suppliers of the data;
  - any data gathering exercise should have a defined endpoint or be subject to periodic review.
- Techniques (e.g. Global Positioning System [GPS] based) should be developed for better geo-referencing of population demography data. This information are usually gathered on an administrative unit basis, but for epidemiological purposes reference to natural features and socio-economic characteristics are more relevant.
- Analysis of geographically referenced data should not solely rely on descriptive display; it should always include comprehensive application of other epidemiological techniques.

ANNEX 1

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ANNEX 2

LIST OF PAPERS PRESENTED

1. Application of GIS in Animal Disease Control - Possibilities and Limits (Pfeiffer, Morris and Sanson)
2. New Geographical Approaches to Control of Tropical Diseases: Some Parasitic Zoonoses (Mott, Nuttall, Desjeux and Cattand)
3. Application of a Geographic Information System (GIS) for Area-related Cross-sectional Studies in Sudan (Baumann, Zessin and Carlton)
4. Predicting the Distributions of *Rhipicephalus appendiculatus* and Other Tick Vectors in Africa Using Geographical Information Systems (Perry)
5. Selected Geographical Data Bases and Possibilities for their Application (Hirschmann)
6. Incorporating Geographic Information Systems into Risk-based Epidemiologic Studies of Animal and Human Health: Estimating Spatial Influence on the Spread of Aujeszky's Disease in North Carolina, USA
(Cowen, McGinn, Krugler, Wray, Jackson and Morales)
7. Application of Geographic Information Systems for Animal and Human Health in North Carolina, USA (McGinn, Wray, Neal and Cowen)
8. Remote Sensing and Geographical Information Systems for the Identification of Tick Habitats (Hugh-Jones)
9. Development of GIS Software for the Control of Animal Diseases in the EU (Mackay)
10. Application of Remote Sensing to the Analysis of Rift Valley Fever Vector Habitats (Freier)
11. Utilization of Different Data Sources for Estimation of the Spatial Spread of Q Fever in middle Germany (Kramer)
12. The Spatial Distribution Pattern of Echinococcus (E.) multilocularis Among Red Foxes in an Endemic Focus in northwestern Brandenburg (Tackmann)
13. Epidemiological Investigations on Lyme Borreliosis in Dogs. A Serological Survey in Brandenburg State (Käsbohrer)
14. Temporal and Spatial Patterns of Human Salmonella Cases in Brandenburg State (Käsbohrer and Lehmacher)
15. WHO Project for Creating and Monitoring a "Salmonella-free" Production Chain for Chicken Meat (Blaha)
16. Application of Rabies-related Data for Estimating the Success of Oral Vaccination Campaigns in Red Foxes (Müller)