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Personal Opinions

Geographical information system for end-stage renal disease: SIGNe, an aid to public health decision making

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Introduction

Geographical information systems (GIS) favour interactions between epidemiologic, public health and geographic data, consolidating their spatial relationships [1]. They integrate several types of data, on populations, socio-economic conditions, access to health care and environmental characteristics, and they analyse their geographic variations. Besides their ability to integrate and analyse related data, GIS allow the representation and sharing of data using standard formats and a highly efficient communication tool: the map [2]. A map summarizes a great deal of information in a unique medium; it displays graphically, and through a quasi-intuitive symbolism, spatial relationships that are difficult to depict via other means. Spatial statistics provide tools for mapping distributions of diseases and for probing for spatial patterns in the distributions and spread of diseases, and they help to identify causes. Thus, the map is a potentially powerful tool for making public health decisions [3].

These properties of GIS have already been mobilized to collect data for disease surveillance [4,5]. We propose using GIS for making health care decisions regarding end-stage renal disease (ESRD).

ESRD, GIS and decision making

The quantitative and qualitative epidemiological changes of the last decade have shown that the incidence and prevalence of ESRD have increased. Patients with ESRD increasingly tend to be older and display more co-morbidities. The rising costs of ESRD treatment motivate the search for an optimal balance between the supply of care and the demand for it. Yet, despite the fact that the disease and the costs of treating it are increasing, the need to manage the care of ESRD patients better has received little attention, and GIS in this setting is all but neglected. Of all the PubMed-reviewed international literature, only 15 articles addressed GIS and medical decision making or health care planning, and none of these dealt with nephrology, chronic renal failure or ESRD.

Matching the supply of ESRD care to the demand for it could be facilitated using GIS to test changes in local health care delivery systems and assess the effects of modifying health behaviours. GIS would assist decision making for health care interventions [6] by implementing simulations and proposing specific public health scenarios. GIS could be suitable tools for managing medical as well as nursing supplies, e.g. clinical performance measures might be integrated into a GIS.

From data collection to health planning

GIS research is the meeting point for many subjects linked to information and communication. The three main components of GIS are: data collection and description, data analysis and support to decision making [7–9].

Collection and description

The progressive ubiquity of computer systems, interoperable systems and data warehouses offers the possibility of collecting spatial data useful for GIS. The possibility of linking and merging files from different sources creates new opportunities to generate medical or medico-economical databases and contain either individual or aggregated data. A medical data

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warehouse is a collection of patient-based data, integrated and historicized, that is organized to support decision making [10].

GIS and accessing them (via the Internet, for example) are the preliminary steps to take to advance the description of different phenomena. In the USA, for example, the Centers for Disease Control (CDC) already use GIS to study the causes or the diffusion of diseases [11,12].

Analysis

A statistical approach to the phenomena observed, in space or over time, is necessary to move from description to interpretation [13–15]. A comprehension of the principles and methods of epidemiology is necessary for structuring studies and interpreting their results. GIS and their related tools provide the means for efficiently capturing, organizing, storing and retrieving the required data. The map is an informational modality of great importance so long as the principles and methods of its use are respected. An appropriate knowledge of geomatics (geographical information data processing) is required to generalize, symbolize and classify the data so that the map becomes an efficient tool of communication and decision making. Geomatics is a field of activity which, using a systematic approach, integrates all the means used to acquire and manage spatial data required as part of scientific, administrative, legal and technical operations involved in the process of the production and management of spatial information. The details of the accessibility of health care that GIS technology allows call into question the continued use of crude empirical measures of accessibility [16]. To realize the full potential of GIS technology, collaborative efforts between epidemiologists, biostatisticians, environmental scientists, GIS specialists, medical geographers as well computer and information technologists are required. GIS technology may lead to innovative solutions to complex questions [17,18]. Various analytical tools have been reviewed recently [19] and their limitations discussed [20]. Access to georeferenced information via the Internet offers new opportunities to disseminate information to professionals, the research community, health care decision makers and the general public [21,22]. Online database querying and interactive mapping systems will emerge. However, any of these applications should carefully monitor and guard the confidentiality of personal medical information [23,24].

In a data warehouse, besides classical dimensions of analysis such as age, gender or time, geo-referenced axes can be integrated, given data such as district of birth, district of residence or location of the medical care unit. The United States Renal Disease System recently proposed the Renal Data Extraction and Referencing (RenDER) system, an online data querying application, allowing access to information regarding ESRD in the USA. Based upon the user's inquiries, it returns tabular data as well as interactive maps [25].

Decision making

GIS are useful not only for organizing, analysing and representing data sets, but also for data modelling, which may provide broad spatial perspectives and allow simulations that empower the development of health care programmes [26,27, this study]. GIS might depict those differences in outcomes and expenses in nephrology that are due to different medico-political systems in Europe. We hypothesized that GIS should help optimally match the supply of care to the demand for it, via an electronic, quality-controlled collection of observational data that allows better identification of the trajectories of care.

SIGNe (Système d'Information Géographique en Néphrologie)

France is a good example of GIS put into action with regards to ESRD. In practice, access to ESRD care is heterogeneously distributed [28]. The SIGNe program was dedicated to capitalize on the notion of GIS, accessible via the Internet, to aid in public health decision making for ESRD. It was introduced as part of the French Renal Epidemiology and Information Network (REIN) [29]. The multi-source information system is based on an n-tier architecture that allows the supply of a data warehouse [30,31]. This architecture provides a clear separation between the user interface, data repositories and application programs. Users enter data via a web browser. Data are encrypted and transferred via a secure Internet connection. The data are integrated into a data warehouse. SIGNe is aimed at providing the representation, analysis and prediction necessary for decision making in public health; and the spatio-temporal approach was favoured for developing methodologies based upon the means used in the domain of geographical information.

Figure 1 is the result of the following question: what is the attractiveness of the three dialysis units of Limoges? The map was constructed interactively using the information stored in the data warehouse via the SIGNe interface. The lines connect the patients' place of residence (points) and the Limoges dialysis units. The attractiveness of Limoges' dialysis units projects beyond the limits of the department of Haute-Vienne and even of the Limousin region. Many patients are coming from Corrèze or Creuse, despite the presence of dialysis units in these departments. This result suggest other questions concerning, for example, demographic characteristics (age at which renal replacement therapy was initiated, gender, etc.), medical data [diabetes, presence of co-morbidity, type of initial nephropathy, type of dialysis (haemodialysis or peritoneal dialysis), co-morbidity, etc.] and socio-economic criteria [handicap, remoteness from the dialysis unit, distribution

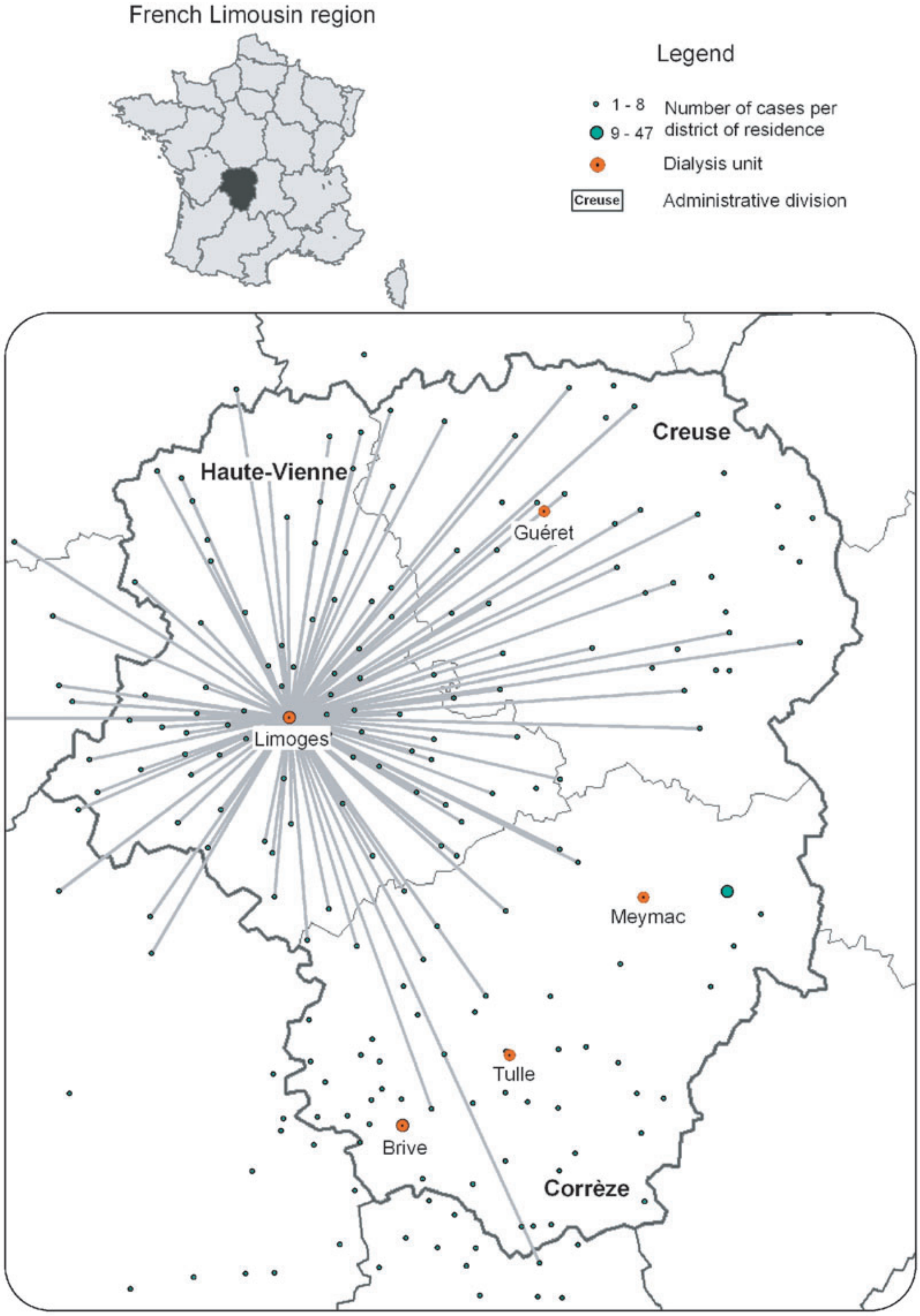

Fig. 1. Map of the attractiveness of the Limoges dialysis units for ESRD patients. It was obtained using SIGNe, which is a GIS applied to ESRD. It depicts the supply and demand of care for ESRD patients in the French Limousin region. Patients' affiliations according to their district of residence (points) are linked to the location of their dialysis unit. It shows that Limoges attracts patients beyond the limits of the Haute-Vienne department despite the presence of other dialysis units in the adjoining departments. Further maps can be obtained in order to substantiate this observation.

of care units (dialysis centres, autodialysis), geographic distribution of nephrologists, etc.] of this set of patients. Complementary maps can be then easily obtained.

Such a figure, a map of several different types of data, provides medical professionals and administrators with information about the match between supply and demand. Our program is oriented towards describing more precisely a cartographical representation. For example, it would also allow exploration of the impact of spatio-temporal fluctuations such as ageing, organ donation activity and regional disparities in access to waiting lists or to transplantation.

The approach is generic, however, and it is not limited to a single country. We developed this program in Shanghai, China, as the 'Generic Epidemiological Network in Nephrology and Rheumatology' (GENNERE), a project funded in 2002 by the Asia IT&C Program [32]. The design of the application and the software was implemented in order to support multilingualism and various medical domains, to facilitate the maintenance and evolution of the system. Generic aspects have also been considered at the levels of events design, and thesaurus structure with international transcodifications.

Conclusion

We proposed using GIS for making health care decisions regarding ESRD. The properties of GIS appeared appropriate for implementing new solutions since they allow a view that combines individual and population approaches. GIS are suitable for giving a broader view of the complex relationships between multiple variables that may impact the health of ESRD patients. Scenarios can be implemented further considering spatial, thematic or temporal dimensions. SIGNe was designed to match this concept as an operational implementation for ESRD. It provides interactive maps that appeared to be a powerful tool for synthesizing information.

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