GEOGRAPHIC INFORMATION SYSTEMS APPLIED TO PATIENT DISTRIBUTION FOR FAMILY HEALTH TEAMS IN PRIMARY HEALTH CARE

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Keywords: Geographic information systems (GIS), Public health, Community health, Nursing, Family nursing, Primary care physicians.

Abstract: Background: Family focused environment in Primary care is considered to be the future and help is required to implement new conceptualities. One theory consists in dividing patients accordingly to geographic clusters.
Aim: To study and implement methodologies for distribution of patients of a health unit, and develop a tool to aid in this process.
Methods: A health unit was selected to recollect and process bio-geographic data of patients. A manual division was executed and various methods were tested. An information system was developed in order to help divide and compare between manual and automatic.
Results: The original data contained a significant percentage of errors (25%). This led to the cross validation of addresses. This process took months. Only after, various patient division techniques could be applied. One showed itself as having the most advantages. A robust GIS system was developed.
Discussion: The analysis took a significant amount of time. The method of dividing the patients proved itself appropriate to this situation, and could probably be applied in many urban locations. The obtained GIS provided time saving and better data comprehension.
Conclusion: Technologies in general and the system developed in particular can help patient allocation and represent a breakthrough in time-saving.

1 BACKGROUND

1.1 Primary Health Care

Primary Health Care is a key element in any Health System. It is in the front line, being the first contact with the population. Health promotion, self-empowerment and disease prevention are the pillars to a successful Primary System (Atun, 2004).

Studies show, that in countries where an emphasis is given to Primary Care, global health costs are diminished (Atun, 2004). Home Care is prioritized and Professionals are encouraged to have a pro-active behavior and seek out the patient in his home environment.

Recently, a new paradigm on health is trying to be introduced, the methodology of allocate a "Family Health Team" to every patient (MS, 2007). It consists on a Physician and a Nurse. Also, one of the main theories nowadays talks about clustering patients in geographic areas, meaning, dividing them accordingly to their home address. These theories come, mainly, from the nursing area but are extensible to both areas (OE, 2002); (MS, 2007); (OE, 2007); (Joel and Stallknecht, 2000).

1.2 Geographic Information Systems

Geography takes a fundamental role in almost all decision we made. A GIS can be defined by: "a computer-based system for integrating and analyzing spatially referenced data"(Cromley, 2003).

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It is proven that the use of GIS in health care is effective (Graves, 2008) and useful in discovering new patterns and optimize existing resources.

As quoted by Dredger S: "if a picture is worth a 1000 words, then a map is worth 1000 pictures" (Dredger et al., 2007).

1.3 Motivation

This study results from a request made by the Clinical Council of "*Agrupamento de Centros de Saúde Porto Ocidental (ACES)"* and the execution of a master thesis in the same subject.

2 AIM

The aim of this study is to analyze and implement a distribution of patients of a health unit, and to develop a tool that can aid in this process. The distribution should be calculated throw various tested rules, using data from a health organization.

3 METHODS

This study followed this methodology: Select a health unit; compile biographic and geographic data; process it in order to filter errors; execute a manual division of patient; test various methods to divide; develop an information system; present the results to the health unit; compare manual to automatic division.

3.1 Family Health Unit Data

This study was made in Portugal, in the city of Porto, in the western Health Center (Agrupamento de Centros de Saúde Porto Ocidental") in order to help opening a new Family Health. For this unit, 5 lists of patients were needed because there were 5 Physicians and 5 Nurses. The data included 3 existing units as seen in table 1.

Table 1: Number of patients existing in original units.

	Health Units		
Existing patients (n)	Unit X	Unit Y	Unit Z
	5439	7252	2021

Mixing all 3 databases resulted in a total of 4714 patients. From these, only the patients that lived in Porto city where selected n = 12848; after that a new selection was made excluding all patients that lived outside the Health Unit influence area. This area comprehended 4 parishes within Porto city. .In this area we get a total of 8421 patients (table 2). Data was analyzed with the use of statistical measures and cross validation with central post databases of the country.

3.2 Distribution Criterions

The main methods that were used focused on dividing the population having in consideration their distance to the central location (the health unit), the discrepancy between different lists, the minimum weighing number of people to exist within a list (1917 to 2412) and the real number of existing people acceptable by professionals (1550 to 1800 - Division criterions are stated in table 2.

The division of patients was made by: Manual Division; Matrix Grid division; Circular cluster division; Concentric circles and Triangular expansive out method.

Table 2: Existing patients in used database and their weighting.

Age interval	Average weight	n	Weighting formula	Weighted n
[0 to 6[	1,5	347	*n * 1,5*	520,5
[6 to 65[	1	6590	*n*	6590
[65 to 75[	2	678	*n * 2*	1356
[>= 75]	2,5	806	*n * 2,5*	2015
Total		8421		10481,5

4 RESULTS

4.1 Data Analysis Results

The final selected amount of patients was as showed in table 2. Patients were divided using the criterions mentioned earlier.

Table 3: Number and percentage of errors found in database.

Error description	n	%
Missing door number	511	6,07
Missing City	13	0,15
Missing street	25	0,30
Address incorrect (street name non existing)	2137	25,38

Many errors were encountered within the database as shown in Table 3. These had to be addressed one by one in order to correctly input the coordinate in the map. This validation took months.

4.2 Patient Distribution Method

A variety of methods were used in order to divide the 8421 patients between 5 different groups.

The most common method used by Health Units is the manual one. Health professionals use printed maps and clipboards in order to distribute people. This method was used in order to primary divide people and lasted 9 months. Another method tested is systematized and implies a matrix division (grid display) of lists (shown in 1st capture of figure 1).

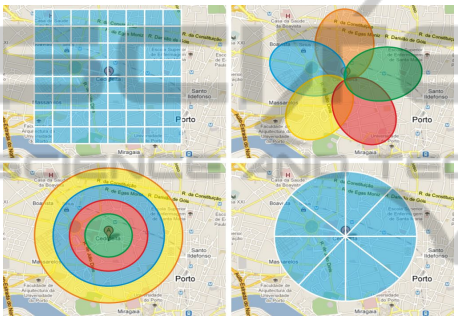

Figure 1: Representation of patient division methods used.

In Circular Cluster Division, circular clusters were drawn not having the Health unit as center (seen in 2nd capture of figure 1).

Using Concentric Circles, the unit was placed in the center of the map and concentric circles are drawn, from the inside to outside as seen in 3rd capture of figure 1. Finally we have the Triangular Expansive out method, in which we place the Health unit in the center and then lines are drawn similar to a circle division in slices (shown in 4th capture of figure 1).

4.3 GeoPrimaryHealth

The system obtained is a GIS destined to Health. It used HTML, CSS, Ajax, PHP and Javascript. The server has Apache and MySQL database manager. There is also use of Google Maps API 3.0.

Non-systematized division of the patients can be seen in fig. 2. In figure 3 we can see a glimpse of the patient distribution made using the method earlier chosen.

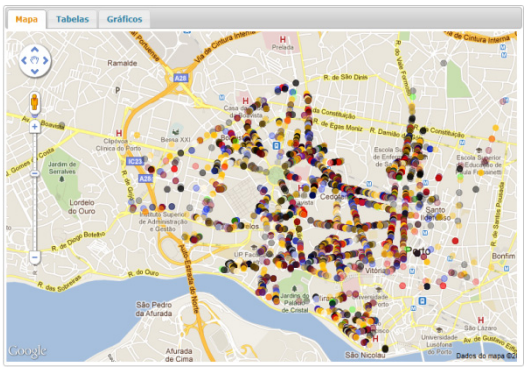

Figure 2: System showing the initial patient distribution.

5 DISCUSSION

5.1 Data Errors

It is vital to centralize the raw data of all population for health databases feeding. Addresses, phone numbers, birthdates are a few of fields that have to be validated and centralized in order to avoid patient process duplication or misinformation.

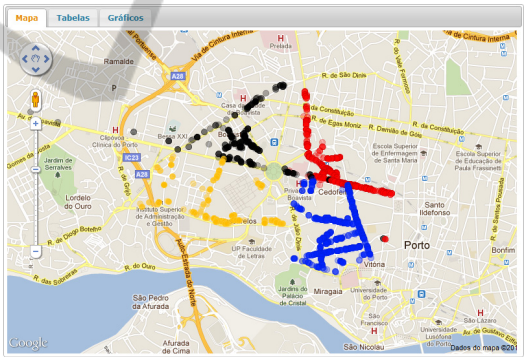

Figure 3: Representation of patient division methods used.

5.2 Division Method Chosen

The method that had the most benefits was the triangular expansive out because: with this distribution there's always a non-significant difference in terms of the distance between the patients and the central unit. Due to the fact that there's no perfect geometric division in cities, the method choose in the system was called: "Street based semi-automatic triangular expansive out".

5.3 Problems in the Division Process

One of the most important problems was the fact

that: if we really allocate cluster geographically, what will we do with the following future migrations within or without the major primary cluster. It's expected that families that today live in one cluster may move to another or outside the major one. Moving outside all clusters can be easily addressed, but moving within different cluster can be difficult.

Reality and legal environment shows that moving people from one physician to another is hard due to the lack of professionals. Also, in the beginning we are geographically dividing clusters of people in the assumption that it's better for work practice and for patient health. Changing the rules in the future destroys all of the primary purposes.

Another very common problem can be the constant cycle of in and out of health professionals (hiring, retiring, etc.). If we make a geographical cluster with all of its population, but in the same area there are other patients that have different Family Health Teams. In the beginning they're not considered to enter the cluster, but they actually live within its area. If the Team of the second groups moves away, a group of people emerges within an already full formed cluster. What to do? Have they not the same right as the other to belong in an existing formed cluster? Does the team have to enlarge its number limits and endanger healthcare quality? Have we the right to destroy a full formed and functional cluster? These are all questions rather difficult to answer.

5.4 GeoPrimaryHealth Suitability

Taking in consideration that the manual method used took 6 months and that with the help of the system developed time spent was only hours, its' suitability and advantage is significant. Of course, this is only due to the fact that polluted data was no longer present and a correct coordinate could be extracted without a doubt from patient addresses. This means that is still much to do in order to clean databases and obtain a reliable source of information.

6 CONCLUSIONS

After the completion of this work, we can conclude that the system developed, can help patient allocation and that represents a breakthrough in time-saving. Doing this automatically after the system is fully developed, took 1 hour in opposition to months doing it manually.

6.1 Future Work

One of the future work that can be developed is to follow the Health unit that adopted this distribution of Patients in order to identify what changes occurred. Finally, we can also distribute this system between all Health Units that may need it in order to verify if this method of distribute patients is usable in other scenarios (small villages, rural environments, islands, etc.).

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